

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

(MINISTRY OF ROAD TRANSPORT & HIGHWAYS, GOVT. OF INDIA)

3RD FLOOR, PTI BUILDING, 4-PARLIAMENT STREET, NEW DELHI - 110001



Consultancy Services for Feasibility Study, Preparation of Detailed Project Report and providing Pre-Construction Services for upgradation to 2 lane with paved shoulder from (i) Km 44.500 to Km 142.000 of Chattroo Village & (ii) Km 235.000 (Vailoo Village) to Km 269.000 (Khanabal) of Khellani - Kishtwar - Chattroo-Khanabal Section of NH 244 in the state of Jammu and Kashmir.



FINAL DETAILED PROJECT REPORT

KHELLANI TO CHATTROO SECTION

Volume - II-B : Design Report (Structures)

Package-IV: Design CH. Km 80+675 to Km 95+550 (Kishtwar Bypass)

=14.875 km & A Link Road to Kishtwar town of 1.871 km

February 2021



Rodic Consultants Pvt. Ltd.

In JV with

Monarch Surveyors and Engineering Consultants Pvt. Ltd



DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
81+924

Details of Superstructure:**FOR MINOR BRIDGE AT CH-81+924**

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 23.750m	23.750m
Thickness of Expansion Joint	= 0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	= 25.000m	25.00m
Type of Superstructure	= CAST IN SITU RCC GIRDER	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on one side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 300 kN/m²
SBC of soil-Normal Case = 350 kN/m² Assumed
SBC of soil-Seismic Case = 438 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 2.285m	
Height of Trapering portion	= 0.304m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion = 1.850m 1.850m
Width of Abutmentcap at bottom of Tapering Portion = 1.000m 1.000m
Projection of Abutment Cap (Span Side) = 0.400m 0.400m

Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.137m	1.137m
Thickness of Abutment shaft at Bottom	=	1.400m	1.400m

Solid Return Wall

Length of Return wall	=	5.600m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.750m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	10.800m	
abutment pedestal width	=	1.400m	
abutment pedestal Height	=	1.500m	
Width of Toe Slab	=	3.800m	
Width of Heel Slab	=	5.600m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.500m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.500m	
Width of backfill on heel slab	=	5.600m	
Thickness of heel slab at back fill edge	=	1.500m	
Height of back fill at bottom edge of heel slab	=	10.929m	
Height of back fill at back fill edge of heel slab	=	9.929m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1163.000m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1162.858m	Height of Superstructure	=	2.070m
Deck level at center line =	1163.000m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1160.865m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1160.340m	Height of Pedestal (3)	=	0.475m
Abutment cap bottom IV (uniform portion ends)	1160.040m	Height of Pedestal (4)	=	0.550m
Abutment cap bottom IV (corbel portion ends)	1159.740m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1159.740m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1155.428m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1153.000m	Height (Avg.) of Dirt Wall	=	2.589m
Foundation level =	1151.500m	Abutment shaft Above G.L	=	4.312m
HFL =	1157.428m	Abutment Shaft below G.L	=	2.428m
		Height of abutment shaft	=	6.740m
		MSL	=	1153.500m
		Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z = Zone factor	=	0.36	
I = Importance factor	=	1.2	
R = Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)**FOR MINOR BRIDGE AT CH-81+924**

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	576.79 4.50
DL Reaction on Bearing No.-2	=	553.86 1.50
DL Reaction on Bearing No.-3	=	553.86 -4.50
DL Reaction on Bearing No.-4	=	576.79 -1.50
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2261.29 0.030

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	169.870 4.50
SIDL Reaction on Bearing No.-2	=	-69.896 1.50
SIDL Reaction on Bearing No.-3	=	-69.896 -4.50
SIDL Reaction on Bearing No.-4	=	169.870 -1.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		199.95 3.597

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	75.474 4.50
SIDL Reaction on Bearing No.-2	=	82.335 1.50
SIDL Reaction on Bearing No.-3	=	82.335 -4.50
SIDL Reaction on Bearing No.-4	=	75.474 -1.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		315.62 -0.065

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	-4.500
Pedestal 4	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.2160 m ³	-0.237

VOLUME CALCULATION

FOR C.G. Of Footing = 5.400 m
 C.G. Of shaft from toe tip = 4.500 m
 Distance between c.g. of shaft and footing = 0.900 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	2.285	8.569	-0.800	0.100	-5.300	0.000
-Trapering portion	1	12.50	0.300	0.304	1.139	-0.800	0.100	-5.300	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	-0.200	-5.600	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-1.050	-0.150	-5.550	0.000
Cap (uniform portion)	1	12.50	1.850	0.300	6.938	-0.025	0.875	-4.525	0.000
Cap (Corbel Portion)	1	12.50	1.850	0.300	5.263	-0.025	0.875	-4.525	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.069	2.312	30.883	0.165	1.065	-4.335	0.000
Shaft below HFL	1	12.50	1.269	3.928	62.289	0.063	0.963	-4.437	0.000
Solid Return Wall	2	5.60	0.625	10.500	73.500	-3.500	-2.600	-8.000	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.700	0.200	-5.200	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.700	0.200	-5.200	0.000
Footing									
Heel Slab	1	12.50	5.600	1.000	70.000		-2.133	-7.533	0.000
Toe Slab	1	12.50	3.800	1.000	47.500		3.183	-2.217	0.000
Portion between Heel and Toe	1	12.50	1.400	1.500	26.250		0.900	-4.500	0.000
Back filling above HFL over Heel Slab	1	12.50	5.600	5.572	390.040		-2.600	-8.000	0.000
Back filling below HFL over Heel Slab	1	12.50	5.600	4.928	344.960		-2.695	-8.095	0.000
Backfill above Heel slab	1	12.50	5.600	10.429	730.013		-2.645	-8.045	0.000
Front Filling over Toe Slab	1	12.50	3.800	2.928	139.080		3.392	-2.008	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.800	1.000	47.500		2.283	-3.117	0.000
Side filling between heel and toe	1	0.00	1.400	2.928	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	-0.200	-5.600	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.137	5.572	9.557		0.368	-5.032	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.263	4.928	16.188		0.288	-5.112	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN	-0.800	0.100	-5.300

SECTIONAL PROPERTIES

Width of Footing (B) = 10.800 m
 Length of Footing (L) = 12.500 m

A = 10.800 x 12.500 = 135.000 m²
 ZL = 12.500 x 19.440 = 243.000 m³
 ZT = IT1 + IT2
 distance of extreme point from centre

IT1 = 10.800 x 162.760 = 1757.81 m⁴
 IT2 (moment of inertia of triangle) = 10.800 x 0.000 + 0.500 x 10.800 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴
 Total moment of inertia = 1757.81 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 281.250 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

FOR MINOR BRIDGE AT CH-81+924	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Servicibility Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

F(Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 9.240 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 11.013 m

Abutment Cap Top Level - Foundation Level
= 8.840 m

Dimensions of Abutment Shaft

Length = 12.50 m
Width = 1.20 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.350 m^4
Moment of Inertia , $I_{\text{transverse}}$ = 195.313 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 177.375 KN
D = 2776.86 KN
T = 0.2502 sec

Transverse Direction

Force = 20020.496 KN
D = 3046.858 KN
T = 0.0247 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.370

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.370

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.370

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.370

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.296

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.296	In Transverse direction
Av	=	0.197	In Vertical direction

For Design of Foundation

(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.296	In Transverse direction
Av	=	0.197	In Vertical direction

Earth Pressure : Normal Dry Case

FOR MINOR BRIDGE AT CH-81+924

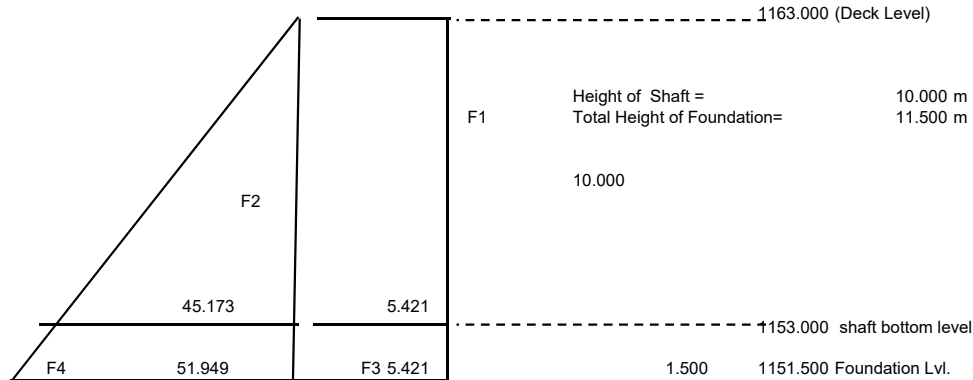
Properties of backfill material :

c	=	0	
ϕ	=	35 degree	0.611 radians
θ	=	90.00 degree	1.571 radians
θ_1	=	90.00 degree	1.571 radians
β	=	0	0 radians
δ	=	22.5 degree	0.393 radians
Kah	=	0.226 active component	
Kph	=	5.249 Passive component	
γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height

1.2 m

Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1153.000 m (at Shaft Base)			
@ RL				1151.500 m (at Foundation Level)			
Due to Live Load Surcharge							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m^2
F1	=	5.421	x	10.000	x	12.500	= 677.601 kN
M1	=	677.60	x	5.00	=	3388.004	kN.m at Shaft Bottom
F3	=	5.421	x	11.500	x	12.500	= 779.241 kN
M3	=	779.241	x	5.750	=	4480.636	kN.m at Foundation
Due to Active Earth Pressure							
Intensity for triangular portion (At Shaft bottom level)							
	=	0.226	x	20	x	10.000	= 45.173 kN/m^2
F2	=	0.5	x	45.17	x	10.000	x 12.50
	=	2823.337	kN				
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)							
M2	=	2823.34	x	4.20	=	11858.015	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.226	x	20	x	11.500	= 51.949 kN/m^2
F4	=	0.5	x	51.95	x	11.500	x 12.50
	=	3733.863	kN				
M4	=	3733.86	x	4.83	=	18034.559	kN.m at Foundation
Force Due To Fluid Pressure							
As per Cl. 214.1 of IRC :6 -2014				γ fluid	=	4.8	kN/m^3
Intensity for triangular portion (At Shaft bottom level)							
	=	4.800	x	10.000	=	48.000	kN/m^2
F	=	0.5	x	48.000	x	10.000	x 12.500
	=	3000.000	kN				
M	=	3000.00	x	3.333	=	10000.000	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	4.800	x	11.500	=	55.20	kN/m^2
F	=	0.5	x	55.200	x	11.50	x 12.500
	=	3967.500	kN				
M	=	3967.50	x	3.833	=	15208.750	kN.m at Foundation
Intensity of Passive pressure							
	=	5.249	x	20	x	0.000	= 0.000 kN/m^2

Force due to passive @ Foundation, F
 = $0.5 \times$ 0.000 x 0.000 x 12.50
 = **0.000 kN**

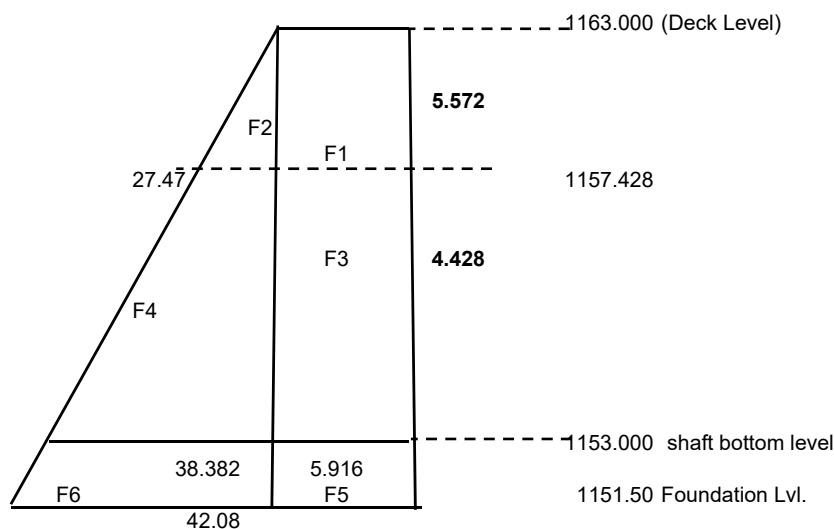
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = **0.000 kN.m** at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	11858.015	18034.559	2823.337	3733.863
Due to Minimum Fluid Pressure	10000.000	15208.750	3000.000	3967.500
Governing of Two	11858.015	18034.559	3000.000	3967.500
Due to Live Load Surcharge	3388.004	4480.636	677.601	779.241
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
FOR MINOR BRIDGE AT CH-81+924	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1153.0 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	10.000	x	12.500	=	739.441 kN
M1	=	739.44	x	5.00	=	3697.204 kN.m		at Shaft Bottom
F3	=	5.916	x	11.500	x	12.500	=	850.357 kN
M3	=	850.36	x	5.75	=	4889.552 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	5.572	=	27.468 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	4.428	=	10.914 kN/m ²
F2	=	0.5	x	27.47	x	5.572	x	12.50
	=	956.565 kN						
F4	=	$\left(\frac{27.47 + 38.38}{2} \right)$	x	4.43	x	12.50		
	=	1822.389 kN						
Total Force	=	2778.954 kN						
M2	=	956.56	x	6.77	=	6474.260 kN.m		
M4	=	1822.39	x	2.09	=	3811.858 kN.m		

Total Moment = 10286.12 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 5.572 = 27.468 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.928 = 14.611 \text{ kN/m}^2$$

$$F2 = 0.5 \times 27.47 \times 5.572 \times 12.50 = 956.565 \text{ kN}$$

$$F6 = \left(\frac{27.47 + 42.08}{2} \right) \times 5.93 \times 12.50 = 2576.712 \text{ kN}$$

Total Force = 3533.276 kN

$$M2 = 956.56 \times 8.27 = 7909.107 \text{ kN.m}$$

$$M6 = 2576.71 \times 2.76 = 7102.519 \text{ kN.m}$$

Total Moment = 15011.63 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	10286.118	15011.625	2778.954	3533.276
Due to Minimum Fluid Pressure	10000.000	15208.750	3000.000	3967.500
Governing of Two	10286.118	15208.750	3000.000	3967.500
Due to Live Load Surcharge	3697.204	4889.552	739.441	850.357
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry CaseFOF **As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

$$\begin{aligned} \alpha h &= 0.180 \\ \alpha v &= 0.197 \\ \phi &= 35.00 & 0.611 \\ \delta &= 22.50 & 0.393 \\ \alpha &= 0.00 & 0.000 \\ \beta &= 0.00 & 0.000 \end{aligned}$$

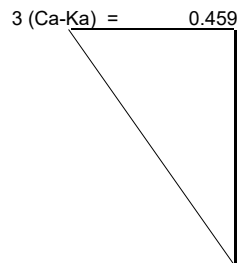
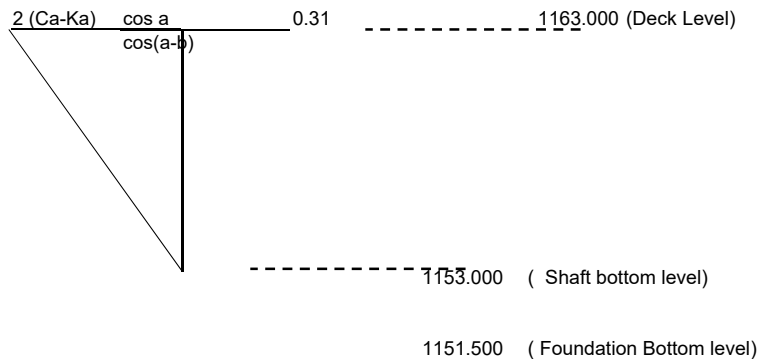
$$\begin{aligned} \alpha h &= \text{HORIZONTAL SEISMIC COEFFICIENT} \\ \alpha v &= \text{VERTICAL SEISMIC COEFFICIENT} \\ \phi &= \text{ANGLE OF INTERNAL FRICTION OF SOIL} \\ \delta &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL} \\ \alpha &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,} \\ \beta &= \text{SLOPE OF EARTH FILL} \end{aligned}$$

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.149 \\ 0.221 \end{matrix}$$

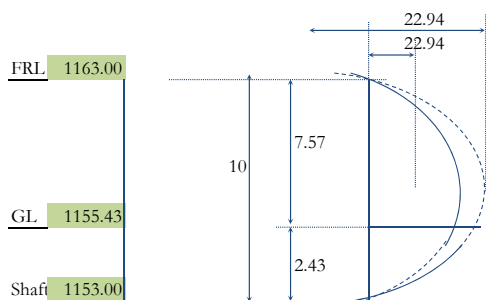
$$\begin{aligned} C_a &= \begin{matrix} 1 & 2 \\ 0.379 & 0.301 \end{matrix} \\ Ca &= 0.379 \\ Ka &= 0.226 \\ \text{Dynamic Increment} &= 0.379 \quad -0.226 \quad \mathbf{0.153} \end{aligned}$$

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height = 1.2 m

Assuming $\gamma_{\text{dry}} = 20 \text{ kN/m}^3$
 $\gamma_{\text{water}} = 10.00 \text{ kN/m}^3$ **Active Earth Pressure****Surcharge Earth Pressure****Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.306	x	20.00	x	1.2	=	7.342 kN/m ²
at Shaft Bottom Level								
E1	=	0.50 x		7.342	x	10.000	x	12.500
	=	458.849 kN						
at Foundation Bottom Level								
M1	=	458.849	x	6.700			=	3074.290 kN.m
E2	=	0.50 x		7.342	x	10.000	x	12.500
	=	458.849 kN						
M2	=	458.849	x	8.200			=	3762.564 kN.m

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p _{mid_height}	=	22.94 t/m ²
h	=	10 m
y	=	2.572 m
L	=	12.500 m

Parabola below Water Level

p _{mid_height}	=	22.94 t/m ²
h	=	10 m
y	=	-2.572 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa T	cy m
Parabola above Water Level	1628.5	5.6
Parabola below Water Level	283.4	1.6
Total Dynamic Earth Pressure	1911.9	5.0

$$E3 = 1911.872 \text{ kN}$$

$$E4 = 1911.872 \text{ kN}$$

$$M3 = 1911.87 \times 5.00 = 9559.360 \text{ kN.m (Shaft bottom level)}$$

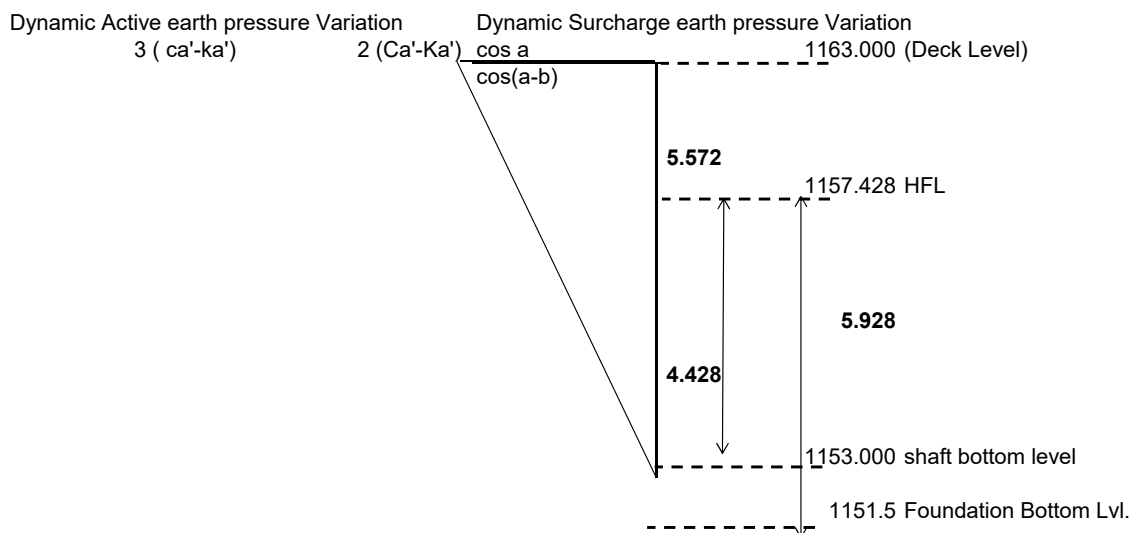
$$M4 = 1911.87 \times 6.50 = 12427.168 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	11858.015	18034.559	2823.337	3733.863
Due to active Earth Pressure (dynamic Increment)	9559.360	12427.168	1911.872	1911.872
Total Earth Pressure	21417.375	30461.726	4735.209	5645.735
Due to Minimum Fluid Pressure	10000.000	15208.750	3000.000	3967.500
Governing of Two	11858.015	30461.726	4735.209	5645.735
Due to Live Load Surcharge (Static)	3388.004	4480.636	677.601	779.241
Due to Live Load Surcharge(Dynamic)	3074.290	3762.564	458.849	458.849
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

FOR MINOR BR	αh	=	0.180		
	αv	=	0.197		
	ϕ	=	35.00	0.611	
	δ	=	11.25	0.196	
	α	=	0.00	0.000	
	β	=	0.00	0.000	
	Ws	=	20.00	Kn/m3	2.00 gm/cm3
	λ	=	$\tan^{-1} \frac{Ws}{Ws-1}$	$\frac{\alpha h}{(1 \pm \alpha v)}$	= 0.292 0.422
	C_a'	=	¹ 0.552	² 0.515	
	Ca'	=		0.552	
	Ka'	=		0.246	
	Dynamic Increment	=	0.552	-0.246	0.305
	Dynamic Increment	=		0.305	
	γ_d	=		20 kN/m ³	
	γ_{sat}	=		10 kN/m ³	
	γ_{water}	=		10 kN/m ³	
	Equivalent Live Load Surcharge height	=		1.2 m	
	Foundation	=		10.80 m	

**Earth Pressure Diagram**

h'	=	4.428
h	=	10.000

Dynamic active earth pressure

3 (ca-ka)	=	0.459 at deck level
3 (ca'-ka')	=	0.916 at deck level
3 (ca'-ka')h'/h	=	0.406 at HFL level

Dynamic Surcharge earth pressure

2 (Ca'-Ka') $\frac{\cos a}{\cos(a-b)}$	=	0.611 at deck level	Pressure	=	14.66 kN/m ²
	=	0.270 at HFL level	Pressure	=	6.49 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.342 kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	6.49 kN/m ²

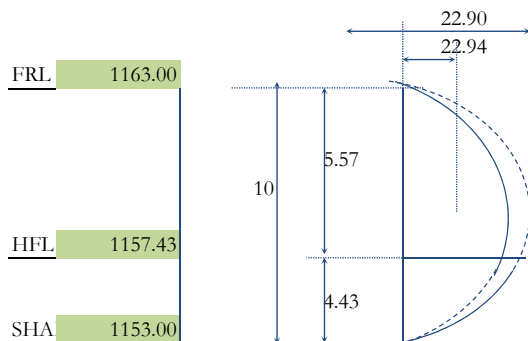
at Shaft Bottom Level

F1	=	6.916	x	5.572	x	12.500	=	481.705 kN
M1	=	481.70	x	7.21	=	3475.019 kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 6.491 \times 4.428 \times 12.500 \\
 &= \mathbf{179.626 \text{ kN}} \\
 M2 &= 179.63 \times 2.97 = \mathbf{532.909 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 661.331 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 4007.927 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 6.916 \times 5.572 \times 12.500 = \mathbf{481.705 \text{ kN}} \\
 M3 &= 481.70 \times 8.71 = \mathbf{4197.576 \text{ kN.m}} \\
 F4 &= 0.500 \times 6.491 \times 4.428 \times 12.500 \\
 &= \mathbf{179.626 \text{ kN}} \\
 M4 &= 179.63 \times 4.47 = \mathbf{802.348 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 661.331 \text{ kN} \\
 \text{Total Moment at Founding level} &= 4999.924 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 22.94 \text{ t/m}^2 \\
 h &= 10 \text{ m} \\
 y &= 0.572 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 22.90 \text{ t/m}^2 \\
 h &= 10 \text{ m} \\
 y &= -0.572 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1119.3	6.6
Parabola below Water Level	791.3	2.8
Total Dynamic Earth Pressure	1910.5	5.0

Total Force (F1 + F2)	=	1910.513 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	1910.513 kN	at Foundation Bottom Level

$$M1 = 1910.51 \times 5.00 = \mathbf{9555.560 \text{ kN.m}}$$

Total Mome = 9555.560 kN.m at Shaft Bottom

$$M1 = 1910.51 \times 6.50 = \mathbf{12421.330 \text{ kN.m}}$$

Total Mome = 12421.330 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	10286.118	15011.625	2778.954	3533.276
Due to active Earth Pressure (Dynamic Increment)	9555.560	12421.330	1910.513	1910.513
Total Earth Pressure	19841.677	27432.955	4689.468	5443.790
Due to Minimum Fluid Pressure	10000.000	15208.750	3000.000	3967.500
Governing of Two	19841.677	27432.955	4689.468	5443.790
Due to Live Load Surcharge(Static)	3697.204	4889.552	739.441	850.357
Due to Live Load Surcharge (Dynamic Increment)	4007.927	4999.924	661.331	661.331
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

FOR MINOR BRIDGE AT CH-81+924

Type of bearing

-

SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2261.29	1.35	1.35	3052.74	3052.74	
SIDL except wc	=	199.95	1.35	1.35	269.93	269.93	
WC	=	315.62	1.75	1.75	552.33	552.33	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW)
CWLLmax-Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax-Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3875.00	0	193.750	193.750	-193.750	193.750	
DL+SIDL+LL-Max Reaction case	4311.01	341.55	215.550	386.325	126.000	386.325	(1-70RW)
	5804.82	0	290.241	290.241	-290.241	290.241	SV Loading
DL+SIDL+LL-Min Reaction case	5464.00	341.55	273.200	443.975	68.350	443.975	(1-70RW)
	5801.19	0	290.060	290.060	-290.060	290.060	SV Loading
DL+SIDL+LL-Max Transv. Moment case	5089.29	341.55	254.465	425.240	87.085	425.240	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	3875.00	1499.50	193.750	943.502	1305.753	1499.503	
DL+SIDL+LL-Max Reaction case		3933.14	1545.04	196.657	969.178	1348.386	1545.043	Dry Case
DL+SIDL+LL-Min Reaction case		4086.87	1545.04	204.344	976.865	1340.700	1545.043	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4036.91	1545.04	201.845	974.367	1343.198	1545.043	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	3875.00	449.851	193.750	418.676	256.101	449.851	
DL+SIDL+LL-Max Reaction case		3933.14	495.391	196.657	444.352	298.734	495.391	Dry Case

DL+SIDL+LL-Min Reaction case		4086.87	495.391	204.344	452.039	291.047	495.391	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4036.91	495.391	201.845	449.541	293.545	495.391	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2261.29	1.35	1.35	3052.74	3052.74
SIDL except wc	=	199.95	1.35	1.35	269.93	269.93
WC	=	315.62	1.75	1.75	552.33	552.33
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax-Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3875.00	0.000	193.750	193.750	-193.750	193.750	
DL+SIDL+LL-Max Reaction case	4311.01	341.550	215.550	386.325	126.000	386.325	(1-70RW)
	5804.82	0.000	290.241	290.241	-290.241	290.241	SV Loading
DL+SIDL+LL-Min Reaction case	5464.00	341.550	273.200	443.975	68.350	443.975	(1-70RW)
	5801.19	0.000	290.060	290.060	-290.060	290.060	SV Loading
DL+SIDL+LL-Max Transv. Moment case	5089.29	341.550	254.465	425.240	87.085	425.240	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	3875.00	2024.33	193.750	1205.915	1830.579	2024.329	
DL+SIDL+LL-Max Reaction case		4093.01	2069.87	204.650	1239.585	1865.219	2069.869	Dry Case
DL+SIDL+LL-Min Reaction case		4669.50	2069.87	233.475	1268.410	1836.394	2069.869	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4482.15	2069.87	224.107	1259.042	1845.762	2069.869	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	3875.00	607.299	193.750	497.400	413.549	607.299	
DL+SIDL+LL-Max Reaction case		4093.01	652.839	204.650	531.070	448.188	652.839	Dry Case

DL+SIDL+LL-Min Reaction case		4669.50	652.839	233.475	559.895	419.364	652.839	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4482.15	652.839	224.107	550.527	428.731	652.839	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2261.29	1	1.00	2261.29	2261.29
SIDL except wc	=	199.95	1	1.00	199.95	199.95
WC	=	315.62	1	1.00	315.62	315.62
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax-Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	0.000	138.843	138.843	-138.843	138.843	
DL+SIDL+LL-Max Reaction case	3067.53	227.700	153.376	267.226	74.324	267.226	(1-70RW)
	4270.67	0.000	213.533	213.533	-213.533	213.533	SV Loading
DL+SIDL+LL-Min Reaction case	3836.19	227.700	191.809	305.659	35.891	305.659	(1-70RW)
	4703.05	0.000	235.152	235.152	-235.152	235.152	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3586.38	227.700	179.319	293.169	48.381	293.169	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	1349.553	138.843	813.619	1210.710	1349.553	
DL+SIDL+LL-Max Reaction case	2834.99	1395.093	141.750	839.296	1253.343	1395.093	Dry Case
DL+SIDL+LL-Min Reaction case	2988.72	1395.093	149.436	846.983	1245.657	1395.093	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2938.76	1395.093	146.938	844.485	1248.155	1395.093	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	404.866	138.843	341.276	266.023	404.866	
DL+SIDL+LL-Max Reaction case	2834.99	450.406	141.750	366.952	308.656	450.406	Dry Case
DL+SIDL+LL-Min Reaction case	2988.72	450.406	149.436	374.639	300.970	450.406	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2938.76	450.406	146.938	372.141	303.468	450.406	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2261.29	1.1	1.10	2487.42	2487.42
SIDL except wc	=	199.95	1.1	1.10	219.94	219.94
WC	=	315.62	1.35	1.35	426.08	426.08
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3133.45	0.000	156.672	156.672	-156.672	156.672	
DL+SIDL+LL-Max Reaction case	3569.45	341.550	178.472	349.247	163.078	349.247	(1-70RW)
	4627.26	0.000	231.363	231.363	-231.363	231.363	SV Loading
DL+SIDL+LL-Min Reaction case	4722.45	341.550	236.122	406.897	105.428	406.897	(1-70RW)
	5059.64	0.000	252.982	252.982	-252.982	252.982	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4347.73	341.550	217.387	388.162	124.163	388.162	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	3133.45	2024.33	156.672	1168.837	1867.657	2024.329	
DL+SIDL+LL-Max Reaction case		3133.45	2024.33	156.672	1168.837	1867.657	2024.329	Dry Case
DL+SIDL+LL-Min Reaction case		3133.45	2024.33	156.672	1168.837	1867.657	2024.329	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3133.45	2024.33	156.672	1168.837	1867.657	2024.329	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2776.86	3133.45	607.299	156.672	460.322	450.626	607.299	
DL+SIDL+LL-Max Reaction case		3133.45	607.299	156.672	460.322	450.626	607.299	Dry Case
DL+SIDL+LL-Min Reaction case		3133.45	607.299	156.672	460.322	450.626	607.299	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3133.45	607.299	156.672	460.322	450.626	607.299	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2261.29	1	1	1	2261.29	2261.29	2261.29
SIDL except wc	=	199.95	1	1	1	199.95	199.95	199.95
WC	=	315.62	1.20	1.20	1.20	378.74	378.74	378.74
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax- Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)		
DL+SIDL	2839.98	0.000	141.999	141.999	-141.999	141.999		
DL+SIDL+LL-Max Reaction case	3130.65	227.700	156.532	270.382	71.168	270.382	(1-70RW)	Dry Case
	4333.79	0.000	216.690	216.690	-216.690	216.690	SV Loading	
DL+SIDL+LL-Min Reaction case	3899.31	227.700	194.966	308.816	32.734	308.816	(1-70RW)	HFL Case
	4766.17	0.000	238.309	238.309	-238.309	238.309	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	3649.51	227.700	182.475	296.325	45.225	296.325		

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2839.98	0.000	141.999	141.999	-141.999	141.999	
DL+SIDL+LL-Max Reaction case	3057.98	170.775	152.899	238.287	17.876	238.287	Dry Case
DL+SIDL+LL-Min Reaction case	3634.48	170.775	181.724	267.112	-10.949	267.112	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3447.12	170.775	172.356	257.744	-1.581	257.744	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2839.98	0.000	141.999	141.999	-141.999	141.999	
DL+SIDL+LL-Max Reaction case	2839.98	0.000	141.999	141.999	-141.999	141.999	Dry Case
DL+SIDL+LL-Min Reaction case	2839.98	0.000	141.999	141.999	-141.999	141.999	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2839.98	0.000	141.999	141.999	-141.999	141.999	

Centrifugal Force Calculation**FOR MINOR BRIDGE AT CH-81+924**

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

FOR MINOR BRIDGE AT CH- 81+924	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

FOR M Foundation Lvl = 1151.500 m

Properties of Footing Base:

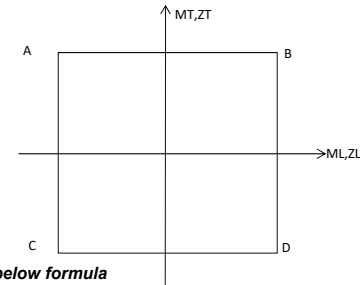
A	=	135.000	m ²
ZL	=	243.000	m ³
ZT	=	281.250	m ³

For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			2261.292	0.900	2035.163	0.030	68.807
SIDL except Wearing Course	1			199.948	0.900	179.953	3.597	719.298
Wearing Course	1			315.618	0.900	284.056	-0.065	-20.584
Bearing Pedestal	1	25	1.216	30.400	0.900	27.360	-0.237	-7.200
				2807.258		2526.532		760.322
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	8.569	214.219	0.100	21.422	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.139	28.477	0.100	2.848	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.200	-5.625	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	-0.150	-2.109	0.000	0.000
Cap - (uniform portion)	1	25	6.938	173.438	0.875	151.758	0.000	0.000
Cap - (corbel portion)	1	25	5.263	131.567	0.875	115.121	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.200	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.200	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.100	2.800	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.200	-32.813	0.000	0.000
				781.950		253.402		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	73.500	1837.500	-2.600	-4777.500	0.000	0.000
Abutment Shaft	1	25	93.171	2329.280	0.963	2244.097	0.000	0.000
Back filling over heel slab	1	20	730.013	14600.250	-2.645	-38613.983	0.000	0.000
Front Filling over toe slab	1	20	139.080	2781.600	3.392	9434.767	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	70.000	1750.000	-2.133	-3733.333	0.000	0.000
Toe slab	1	25	47.500	1187.500	3.183	3780.208	0.000	0.000
portion between heel & toe	1	25	26.250	656.250	0.900	590.625	0.000	0.000
Vertical Components of active earth pressure	1			1643.392	-5.400	-8874.318	0.000	0.000
				27300.664		-39780.642		0.000
Total				30889.871		-37000.708		760.322

**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	2035.163	-4.500	-9158.233
0.900	179.953	-4.500	-809.789
1.000	315.618	-4.500	-1420.279
0.900	27.360	-4.500	-123.120
	2558.094		-11511.422
0.900	192.797	-5.300	-1021.823
0.900	25.629	-5.300	-135.833
0.900	25.313	-5.600	-141.750
0.900	12.656	-5.550	-70.242
0.900	156.094	-4.525	-706.324
0.900	118.410	-4.525	-535.807
0.900	0.000	-5.200	0.000
0.900	0.000	-5.200	0.000
0.900	25.200	-5.300	-133.560
0.900	147.656	-5.600	-826.875
	703.755		-3572.215
0.900	1653.750	-8.000	-13230.000
0.900	2096.352	-4.437	-9300.616
0.900	13140.225	-8.045	-105709.800
0.900	2503.440	-2.008	-5027.286
0.900	0.000	0.000	0.000
0.900	1575.000	-7.533	-11865.000
0.900	1068.750	-2.217	-2369.063
0.900	590.625	-4.500	-2657.813
0.900	1479.053	-10.800	-15973.773
	24570.597		-168465.158
	27832.446		-183548.795

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	138.843	1160.865	1300.264
due to Earth pressure	1	3967.500		18034.559

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		156.672	1160.865	1467.237
due to Earth pressure	1.5	5951.250		27051.838
		6107.922		28519.075

Summary of Forces For SBC

P	30889.871	kN
ML	-17665.886	kNm
MT	760.322	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		30889.871		-37000.708		760.322
CWLL-Max. Reaction case	1	1059.332	0.900	953.399	0.950	1006.366
Vertical Components of LL Surcharge	1	322.772	-5.400	-1742.970	0.000	0.000
Total		32271.976		-37790.279		1766.687

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	267.226	1160.865	2502.574
due to Earth pressure	1	3967.500		18034.559
due to Live load surcharge	1	779.241		4480.636

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		349.247	1160.865	3270.703
due to Earth pressure	1.5	5951.250		27051.838
due to Live load surcharge	1.2	935.089		5376.763
		7235.587		35699.304

Summary of Forces For SBC

P	32271.976	kN
ML	-12772.510	kNm
MT	1766.687	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
138.84	1300.26	0.00	0.00
3967.50	18034.56	0.00	0.00
4106.343	19334.822	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
156.67	1467.24	0.00	0.00
5951.25	27051.84	0.00	0.00
6107.922	28519.075	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	27832.44587		-183548.79
0.000		-4.500	0.00
0.900		-10.800	-3137.35
	27832.446		-186686.14

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
267.23	2502.57	0.00	0.00
3967.50	18034.56	0.00	0.00
779.241	4480.636	0.000	0.000
5013.97	25017.77	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
349.25	3270.70	0.00	0.00
5951.25	27051.84	0.00	0.00
935.09	5376.76	0.00	0.00
7235.587	35699.304	0.000	0.000

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2807.258		2526.532		760.322
Substructure & Foundation -Portion 1				781.950		253.402		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	73.500	1837.500	-2.600	-4777.500	0.000	0.000
Shaft above HFL	1	25	30.883	772.067	1.065	822.223	0.000	0.000
Shaft below HFL	1	15	62.289	934.328	0.963	900.159	0.000	0.000
Back filling above HFL over heel slab	1	20	390.040	7800.800	-2.600	-20282.080	0.000	0.000
Back filling below HFL over heel slab	1	10	344.960	3449.600	-2.695	-9295.627	0.000	0.000
Front Filling over toe slab	1	10	139.080	1390.800	2.283	3175.660	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	70.000	1050.000	-2.133	-2240.000	0.000	0.000
Toe slab	1	15	47.500	712.500	3.183	2268.125	0.000	0.000
Portion between Heel & Toe	1	15	26.250	393.750	0.900	354.375	0.000	0.000
Vertical Components of active earth pressure	1			1643.392	-5.400	-8874.318	0.000	0.000
				20337.750		-37832.078		0.000
Total				23926.958		-35052.144		760.322

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	138.843	1160.865	1300.264
due to Earth pressure	1	3967.500		15208.750

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		156.672	1160.865	1467.237
due to Earth pressure	1.5	5951.250		22813.125
		6107.922		24280.362

Summary of Forces For SBC

P	23926.958	kN
ML	-18543.130	kNm
MT	760.322	kNm

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2558.094		-11511.422
	703.755		-3572.215
0.900	1653.750	-8.000	-13230.000
0.900	694.861	-4.335	-3012.246
0.900	840.895	-4.437	-3730.690
0.900	7020.720	-8.000	-56165.760
0.900	3104.640	-8.095	-25131.120
0.900	1251.720	-3.117	-3901.194
0.900	0.000	0.000	0.000
0.900	945.000	-7.533	-7119.000
0.900	641.250	-2.217	-1421.438
0.900	354.375	-4.500	-1594.688
0.900	1479.053	-10.800	-15973.773
	18303.975		-132890.336
	21565.824		-147973.972

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
138.84	1300.26	0.00	0.00
3967.50	15208.75	0.00	0.00
4106.34	16509.01	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
156.67	1467.24	0.00	0.00
5951.25	22813.13	0.00	0.00
6107.92	24280.36	0.00	0.00

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		23926.958		-35052.144		760.322
CWLL-Min. Reaction case	1	290.668	0.900	261.601	0.950	276.134
Vertical Components of LL Surcharge	1	352.229	-5.400	-1902.039	0.000	0.000
Total		24569.855		-36692.582		1036.456

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	21565.824		-147973.972
0.000	0.000	-4.500	0
0.900	317.006	-10.800	-3423.669
	21882.830		-151397.642

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	305.659	1160.865	2862.501
due to Earth pressure	1	3967.500		15208.750
due to Live load surcharge	1	850.357		4889.552

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
305.66	2862.50	0.00	0.00
3967.50	15208.75	0.00	0.00
850.357	4889.552	0.000	0.000
5123.52	22960.80	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		406.897	1160.865	3810.593
due to Earth pressure	1.5	5951.250		22813.125
due to live load surcharge	1.2	1020.428		5867.463
		7378.576		32491.181

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
406.90	3810.59	0.00	0.00
5951.25	22813.13	0.00	0.00
1020.428	5867.463	0.000	0.000
7378.58	32491.18	0.00	0.00

Summary of Forces For SBC

P	24569.855	kN
ML	-13731.778	kNm
MT	1036.456	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

ah= 0.243 In Longitudinal direction

ah= 0.296 In Transverse direction

av= 0.197 In Vertical direction

Weight of shaft below Ground level

Weight of back fill below Ground level

= 906.329 KN

= 3399.200 KN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			2261.292		200.762	133.841	0.900	2035.163	120.457	1162.245		0.030	68.807	2157.188
SIDL except Wearing Course	1			199.948		17.752	11.835	0.900	179.953	10.651	1163.449		3.597	719.298	212.115
Wearing Course	1			315.618		28.021	18.681	0.900	284.056	16.813	1163.000		-0.065	-20.584	322.243
Bearing Pedestal	1	25	1.216	30.400		2.699	1.799	0.900	27.360	1.619			-0.237	-7.200	
				2807.258		249.234	166.156		2526.532	149.540				760.322	2691.545
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	8.569	214.219	52.055	19.019	12.679	0.100	21.422	1.268	1161.858	539.161	0.000	0.000	196.987
Dirt Wall-Tapered portion	1	25	1.139	28.477	6.920	2.528	1.685	0.100	2.848	0.169	1160.563	62.715	0.000	0.000	22.913
Bracket - Uniform portion	1	25	1.125	28.125				-0.200	-5.625						
Bracket - Tapered portion	1	25	0.563	14.063				-0.150	-2.109						
Cap - (uniform portion)	1	25	6.938	173.438	42.145	15.398	10.265	0.875	151.758	8.982	1160.190	366.243	0.000	0.000	133.810
Cap - (corbel portion)	1	25	5.263	131.567	31.971	11.681	7.787	0.875	115.121	6.814	1159.890	268.235	0.000	0.000	98.002
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	1163.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	1163.000	0.000	0.000	0.000	0.000

RCC Railing or Crash Barrier	1			28.000				0.100	2.800				0.000	0.000	
Approach Slab	1	25	6.563	164.063				-0.200	-32.813				0.000	0.000	
Substructure & Foundation -Portion 2				781.950	133.091	48.626	32.417		253.402	17.232		1236.354		0.000	451.712
Solid Return wall	1	25	73.500	1837.500	446.513	163.137	108.758	-2.600	-4777.500	-282.771	1157.786	2806.610	0.000	0.000	1025.417
Abutment Shaft	1	25	93.171	2329.280	345.777	126.332	84.222	0.963	2244.097	81.142	1157.584	2103.708	0.000	0.000	768.607
Back filling over heel slab	1	20	730.013	14600.250	0.000	0.000	0.000	-2.645	-38613.983	0.000	1157.786	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	139.080	2781.600				3.392	9434.767				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	70.000	1750.000				-2.133	-3733.333				0.000	0.000	
Toe slab	1	25	47.500	1187.500				3.183	3780.208				0.000	0.000	
portion between heel & toe	1	25	26.250	656.250				0.900	590.625				0.000	0.000	
Vertical component of active earth pressure	1			1546.617				-5.400	-8351.730				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			791.923				-5.400	-4276.386				0.000	0.000	
				27995.811	792.290	289.469	192.980		-43534.439	-201.629		4910.319		0.000	1794.024
Total =				31585.019	925.381	587.329	391.553		-40754.506	-34.856		6146.673		760.322	4937.281
								-391.553		34.856					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.9			2035.163	120.457	-4.500	-9158.233	-542.057
SIDL except Wearing Course	0.9			179.953	10.651	-4.500	-809.789	-47.930
Wearing Course	1.00			315.618	18.681	-4.500	-1420.279	-84.063
Bearing Pedestal	0.9	25	1.216	27.360		-4.500	-123.120	
				2558.094	149.789		-11511.422	-674.051
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	8.569	192.797	11.411	-5.300	-1021.823	-60.480
Dirt Wall-Tapered portion	0.9	25	1.139	25.629	1.517	-5.300	-135.833	-8.040
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	6.938	156.094	9.239	-4.525	-706.324	-41.806
Cap - (corbel portion)	0.9	25	5.263	118.410	7.008	-4.525	-535.807	-31.713
Cantilever Return Wall-Rectangle portion	0.9	25	0.000	0.000	0.000	-5.200	0.000	0.000
Cantilever Return Wall-Traingle portion	0.9	25	0.000	0.000	0.000	-5.200	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.300	-133.560	
Approach Slab	0.9	25	6.563	147.656		-5.600	-826.875	
				703.755	29.176		-3360.223	-142.039
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	93.171	2096.352	70.435	-4.437	-9300.616	-312.490
Solid Return wall	0.9	25	73.500	1653.750	97.882	-8.000	-13230.000	-783.057
Back filling over heel slab	0.9	20	730.013	13140.225	0.000	-8.045	-105709.8	0.000
Front Filling over toe	0.9	20	139.080	2503.440		-2.008	-5027.286	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	70.000	1575.000		-7.533	-11865.000	
Toe slab	0.9	25	47.500	1068.750		-2.217	-2369.063	
portion between heel & toe	0.9	25	26.250	590.625		-4.500	-2657.813	
Vertical component of active earth pressure	0.9			1479.053		-10.800	-15973.773	
Vertical component of dynamic increment of earth pressure	0.9			712.731		-10.800	-7697.494	
				25283.328	168.317		-176162.65	-1095.547

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	52.055	1161.858	539.161
1.0	6.920	1160.563	62.715
1.0	42.145	1160.190	366.243
1.0	31.971	1159.890	268.235
1.0	0.000	1163.000	0.000
1.0	0.000	1163.000	0.000
	133.091		1236.354
1.0	321.306	1157.584	1954.828
1.0	446.513	1157.786	2806.610
1.0	0.000	1157.786	0.000
	767.819		4761.438

Total =				28545.177	347.282		-191034.30	-1911.636
					-347.282			1911.636

	900.910		5997.792

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1349.553	249.234	1160.865	12638.562	2691.545
due to Substructure	1	925.381	338.095		6146.673	2245.736
due to Earth pressure	1	5645.735			30461.726	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1349.55	12638.56	0.00	0.00	0.00	0.00	249.23	2691.55
925.38	6146.67	0.00	0.00	0.00	0.00	338.10	2245.74
5645.74	30461.73						
7920.67	49246.96	0.00	0.00	0.00	0.00	587.33	4937.28

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		2024.329	1160.865	18957.84
due to Substructure	1.5	1351.365		8996.69
due to Active Earth pressure	1	3733.863		18034.56
due to dynamic Earth pressure	1.5	2867.808		18640.75
		9977.365		64629.842

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
2024.33	18957.84	0.00	0.00
1351.36	8996.69	0.00	0.00
3733.863	18034.559	0.000	0.000
2867.808	18640.752	0.000	0.000
9977.37	64629.84	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	31976.572	31193.466	kN
ML	8457.600	8527.312	kNm
MT	5697.602	5697.602	kNm

Summary of Restoring Forces

Vertical Load	28197.895	kN
Moment	-192945.933	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2807.258		249.234	166.156		2526.532	149.540				760.322	2691.545
Forces from Substructure				28777.761	925.381	338.095	225.397		-43281.038	-184.397		6146.673		0.000	2245.736
CWLL-Max. Reaction case	0.20			211.87		18.810	12.540	0.900	190.680	11.286	1164.200		0.950	201.273	238.886
Vertical component of LL Surcharge	0.20			64.55				-5.400	-348.594				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			38.01				-5.400	-205.267				0.000	0.000	
Total =				31899.452	925.381	606.139	404.093		-41117.686	-23.570		6146.673		961.595	5176.167
							-404.093			23.570					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2558.094	149.789	0.000	-11511.42	-674.051
Forces from Substructure				25987.083	197.493	0.000	-179522.88	-1237.586
CWLL-Max. Reaction case	0.00			0.00	0.000	-4.500	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-10.800	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.800	0.00	

Total =				28545.177	347.282		-191034.30	-1911.636
					-347.282			1911.636

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1395.093	268.044	1160.865	13065.044	2930.431
due to Substructure	1	925.381	338.095		6146.673	2245.736
due to Earth pressure	1	5645.735			30461.726	
due to Live load surcharge	0.20	247.618			1648.640	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1395.09	13065.04	0.00	0.00	0.00	0.00	268.04	2930.43
925.38	6146.67	0.00	0.00	0.00	0.00	338.10	2245.74
5645.74	30461.73						
247.62	1648.64						
8213.83	51322.08	0.00	0.00	0.00	0.00	606.14	5176.17

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		2024.329	1160.865	18957.843
due to Substructure	1.5	1351.365		8996.688
due to Active Earth pressure	1	3733.863		18034.559
due to dynamic Earth pressure	1.5	2867.808		18640.7516
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9977.365		64629.842

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
2024.33	18957.84	0.00	0.00
1351.36	8996.69	0.00	0.00
3733.863	18034.559		
2867.808	18640.752		
0.000	0.000		
0.000	0.000		
9977.37	64629.84	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	32303.545	31495.359	kN
ML	10180.827	10227.967	kNm
MT	6137.761	6137.761	kNm

Summary of Restoring Forces

Vertical Load	28197.895	kN
Moment	-192945.933	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Lloads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Pxel1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Pxet	MTs due to FT
Superstructure				2807.258		249.234	166.156		2526.532	149.540				760.322	2691.545
Substructure & Foundation -Portion 1				781.950	133.091	48.626	32.417		253.402	17.232		1236.354		0.000	451.712
Substructure & Foundation -Portion 2															
Solid Return wall	1		73.50	1837.50	446.513	163.137	108.758	-2.60	-4777.500	-282.771	1157.79	2806.610	0.00	0.000	1025.417
Shaft above HFL	1	25	30.883	772.067	187.612	68.546	45.697	1.065	822.223	48.666	1158.584	1329.046	0.000	0.000	485.577
Shaft below HFL	1	15	62.289	934.328	158.165	57.787	38.525	0.963	900.159	37.116	1156.428	779.436	0.000	0.000	284.773
Back filling above HFL over heel slab	1	20	390.040	7800.800	0.000	0.000	0.000	-2.600	-20282.080	0.000	1160.214	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	344.960	3449.600	0.000	0.000	0.000	-2.695	-9295.627	0.000	1154.839	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	139.080	1390.800				2.283	3175.660				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	70.000	1050.000				-2.133	-2240.000				0.000	0.000	
Toe slab	1	15	47.500	712.500				3.183	2268.125				0.000	0.000	
portion between heel & toe	1	15	26.250	393.750				0.900	354.375				0.000	0.000	
Vertical component of active earth pressure	1			1463.531				-5.400	-7903.067				0.000	0.000	

Vertical component of dynamic increment of earth pressure	1			791.361				-5.400	-4273.347				0.000	0.000	
				20949.249	878.072	320.810	213.874		-41251.079	-196.989		5375.458		0.000	1963.966
Total =				24538.457	1011.163	618.670	412.447		-38471.145	-30.216		6611.812		760.322	5107.223
								-412.447		30.216					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				2558.094	149.789		-11511.422	-674.051
Substructure & Foundation -Portion 1				703.755	29.176		-3360.223	-142.039
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	73.5	1653.750	97.882	-8.00	-13230.000	-783.057
Shaft above HFL	0.9	25	30.883	694.861	41.127	-4.335	-3012.246	-178.289
Shaft below HFL	0.9	15	62.289	840.895	29.308	-4.437	-3730.690	-130.026
Back filling above HFL over heel slab	0.9	20	390.040	7020.720	0.000	-8.000	-56165.760	0.000
Back filling below HFL over heel slab	0.9	10	344.960	3104.640	0.000	-8.095	-25131.120	0.000
Front Filling ovetoe	0.9	10	139.080	1251.720		-3.117	-3901.194	
Side filling between heel and toe	0.9	10	0.000	0.000		0.000	0.000	
Heel slab	0.9	15	70.000	945.000		-7.533	-7119.000	
Toe slab	0.9	15	47.500	641.250		-2.217	-1421.438	
portion between heel & toe	0.9	15	26.250	354.375		-4.500	-1594.688	
Vertical component of active earth pressure	0.9			1317.178		-10.800	-14225.521	
Vertical component of dynamic increment of earth pressure	0.9			712.225		-10.800	-7692.025	
Total =				18854.324	187.122		-138834.11	-1186.689
				-366.086		2002.779		

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	133.091		1236.354
1.0	446.513	1157.786	2806.610
1.0	187.612	1158.584	1329.046
1.0	133.694	1156.428	658.844
1.0	0.000	1160.214	0.000
1.0	0.000	1154.839	0.000
Total =	767.819		4794.500
	900.910		6030.854

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1349.553	249.234	1160.865	12638.562	2691.545
due to Substructure	1	1011.163	369.436		6611.812	2415.678
due to Earth pressure	1	5443.790			27432.955	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		2024.329	1160.865	18957.843
due to Substructure	1.5	1351.365		9046.281
due to Active Earth pressure	1	3533.276		15011.625
due to dynamic Earth pressure	1.5	2865.770		18631.995
		9774.741		61647.745

Summary of Forces For SBC

	Downward	Upward	
P	24950.904	24126.010	KN
ML	8181.968	8242.401	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1349.55	12638.56	0.00	0.00	0.00	0.00	249.23	2691.55
1011.16	6611.81	0.00	0.00	0.00	0.00	369.44	2415.68
5443.79	27432.96						
7804.51	46683.33	0.00	0.00	0.00	0.00	618.67	5107.22

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
2024.33	18957.84	0.00	0.00
1351.36	9046.28	0.00	0.00
3533.276	15011.625		
2865.770	18631.995		
9774.74	61647.74	0.00	0.00

Summary of Restoring Forces

Vertical Load	21750.087	kN

MT	5867.545	5867.545	kNm

Moment	-155708.531	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2807.258		249.234	166.156		2526.532	149.540				760.322	2691.545
Forces from Substructure				21731.199	1011.163	369.436	246.291		-40997.677	-179.757		6611.812		0.000	2415.678
CWLL-Max. Reaction case	0.20			58.13		5.161	3.441	0.900	52.320	3.097	1164.200		0.950	55.227	65.547
Vertical component of LL Surcharge	0.20			70.45				-5.400	-380.408				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			54.79				-5.400	-295.847				0.000	0.000	
Total =				24721.823	1011.163	623.831	415.888		-39095.080	-27.120		6611.812		815.548	5172.770

-415.888

27.120

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2558.094	149.789		-11511.422	-674.051
Forces from Substructure				19558.079	216.297		-142194.33	-1328.728
CWLL-Max. Reaction case	0.00			0.00	0.00		-4.50	0.00
Vertical component of LL Surcharge	0.00			0.00		-4.500	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.800	0.000	0.000
Total =				22116.173	366.086		-153710.25	-2002.779

-366.086

2002.779

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1395.093	254.395	1160.865	13065.044	2757.093
due to Substructure	1	1011.163	369.436		6611.812	2415.678
due to Earth pressure	1	5443.790			27432.955	
due to Live load surcharge	0.20	302.338			1977.895	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1395.09	13065.04	0.00	0.00	0.00	0.00	254.40	2757.09
1011.16	6611.81	0.00	0.00	0.00	0.00	369.44	2415.68
5443.79	27432.96						
302.34	1977.90						
8152.38	49087.71	0.00	0.00	0.00	0.00	623.83	5172.77

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		2024.329	1160.865	18957.843
due to Substructure	1.5	1351.365		9046.28111
due to Active Earth pressure	1	3533.276		15011.625
due to dynamic Earth pressure	1.5	2865.770		18631.9947
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9774.741		61647.745

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
2024.33	18957.84	0.00	0.00
1351.36	9046.28	0.00	0.00
3533.276	15011.625		
2865.770	18631.995		
0.000	0.000		
0.000	0.000		
9774.74	61647.74	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	25137.711	24305.935	kN
ML	9965.507	10019.747	kNm
MT	5988.319	5988.319	kNm

Summary of Restoring Forces

Vertical Load	21750.087	kN
Moment	-155713.031	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2807.258		830.780	166.156		2526.532	149.540				760.322	8971.817
Substructure & Foundation -Portion 1				781.950	39.927	162.086	32.417		253.402	17.232		370.906		0.000	1505.706
Substructure & Foundation -Portion 2				27995.811	237.687	964.898	192.980		-43534.439	-201.629		1473.096		0.000	5980.079
Total =				31585.019	277.614	1957.764	391.553		-40754.506	-34.856		1844.002		760.322	16457.603
							-391.553			34.856					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2558.094	149.789		-11511.42	-674.051
Substructure & Foundation -Portion 1				703.755	29.176		-3360.22	-142.039
Substructure & Foundation -Portion 2				25283.328	168.317		-176162.65	-1095.547
Total =				28545.177	347.282		-191034.30	-1911.636
					-347.282			1911.636

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	133.091		1236.354
	767.819		4761.438
	900.910		5997.792

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	404.866	830.780	1160.865	3791.569	8971.817
due to Substructure	1	277.614	1126.984		1844.002	7485.785
due to Earth pressure	1	5645.735			30461.726	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
404.87	3791.57	0.00	0.00	0.00	0.00	830.78	8971.82
277.61	1844.00	0.00	0.00	0.00	0.00	1126.98	7485.79
5645.74	30461.73						
6328.22	36097.30	0.00	0.00	0.00	0.00	1957.76	16457.60

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		607.299	1160.865	5687.353
due to Substructure	1.5	1351.365		8996.68786
due to Active Earth pressure	1	3733.863		18034.5588
due to dynamic Earth pressure	1.5	860.342		5592.22548
		6552.869		38310.825

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
607.30	5687.35	0.00	0.00
1351.36	8996.69	0.00	0.00
3733.863	18034.559		
860.342	5592.225		
6552.87	38310.83	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	31976.572	31193.466	kN
ML	-4692.065	-4622.352	kNm

Summary of Restoring Forces

Vertical Load	28197.895	kN
Moment	-192945.933	kNm

MT	17217.924	17217.924	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	31899.452	404.093	-41117.69	-23.570	961.595
		-404.093		23.570	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	450.406	893.479	1160.865	4218.051	9768.104
due to Substructure	1	277.614	1126.984		1844.002	7485.785
due to Earth pressure	1	5645.735			30461.726	
due to Live load surcharge	0.2	247.618			1648.640	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		607.30	1160.865	5687.353
due to Substructure	1.5	405.41		2699.006
due to Active Earth pressure	1	3733.86		18034.559
due to dynamic Earth pressure	1.5	860.34		5592.225
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5606.91		32013.144

Summary of Forces For SBC

	Downward	Upward	
P	32303.545	31495.359	kN
ML	-2968.838	-2921.697	kNm
MT	18215.484	18215.484	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure	2807.258	166.156	2526.532	149.540	760.322
Substructure & Foundation -Portion 1	781.950	32.417	253.402	17.232	0.000
Substructure & Foundation -Portion 2	20949.249	213.874	-41251.079	-196.989	0.000
Total =	24538.457	412.447	-38471.145	-30.216	760.322
		-412.447		30.216	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	28545.177	347.282	-191034.30	-1911.636
		-347.282		1911.636

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
450.41	4218.05	0.00	0.00	0.00	0.00	893.48	9768.10
277.61	1844.00	0.00	0.00	0.00	0.00	1126.98	7485.79
5645.74	30461.73						
247.62	1648.64						
6621.37	38172.42	0.00	0.00	0.00	0.00	2020.46	17253.89

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
607.30	5687.35	0.00	0.00
405.41	2699.01	0.00	0.00
3733.863	18034.559		
860.342	5592.225		
0.000	0.000		
0.000	0.000		
5606.91	32013.14	0.00	0.00

Summary of Restoring Forces

Vertical Load	28197.895	kN
Moment	-192945.933	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure	2558.094	149.789		-11511.422	-674.051
Substructure & Foundation	703.755	29.176		-3360.223	-142.039
Substructure & Foundation	18854.324	187.122		-138834.108	-1186.689
Total =	22116.173	366.086		-153705.753	-2002.779
		-366.086			2002.779

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	404.87	830.78	1160.87	3791.57	8971.82
due to Substructure	1	303.35	1231.45		1983.54	8052.26
due to Earth pressure	1	5443.79			27432.96	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		607.299	1160.865	5687.35
due to Substructure	1.5	405.409		2713.88
due to Active Earth pressure	1	3533.276		15011.63
due to dynamic Earth pressure	1.5	859.731		5589.60
		5405.716		29002.46

Summary of Forces For SBC

	Downward	Upward	
P	24950.904	24126.010	kN
ML	-5293.294	-5232.861	kNm
MT	17784.399	17784.399	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL_1$	MLs due to F_v	$MT = P \times eT$
Total =	24721.823	415.888	-39095.08	-27.120	815.548
		-415.888		27.120	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	450.406	847.98364	1160.865	4218.051	9190.30866
due to Substructure	1	303.349	1231.4545		1983.544	8052.25962
due to Earth pressure	1	5443.790			27432.955	
due to Live load surcharge	0.2	302.338			1977.895	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		607.30	1160.865	5687.35
due to Substructure	1.5	405.41		2713.88
due to Active Earth pressure	1	3533.28		15011.63
due to dynamic Earth pressure	1.5	859.73		5589.60
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
404.87	3791.57	0.00	0.00	0.00	0.00	830.78	8971.82
303.35	1983.54	0.00	0.00	0.00	0.00	1231.45	8052.26
5443.79	27432.96						
6152.00	33208.07	0.00	0.00	0.00	0.00	2062.23	17024.08

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
607.30	5687.35	0.00	0.00
405.41	2713.88	0.00	0.00
3533.276	15011.625		
859.731	5589.598		
5405.72	29002.46	0.00	0.00

Summary of Restoring Forces

Vertical Load	21750.087	kN
Moment	-155708.531	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL_2$	MLs due to F_v
Total =	22116.173	366.086		-153710.25	-2002.779
		-366.086			2002.779

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
450.41	4218.05	0.00	0.00	0.00	0.00	847.98	9190.31
303.35	1983.54	0.00	0.00	0.00	0.00	1231.45	8052.26
5443.79	27432.96						
302.34	1977.90						
6499.88	35612.44	0.00	0.00	0.00	0.00	2079.44	17242.57

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
607.30	5687.35	0.00	0.00
405.41	2713.88	0.00	0.00
3533.276	15011.625		
859.731	5589.598		
0.000	0.000		
0.000	0.000		

5405.72 29002.46 5405.72 29002.46 0.00 0.00

Summary of Forces For SBC			
	Downward	Upward	
P	25137.711	24305.935	KN
ML	-3509.755	-3455.515	kNm
MT	18058.117	18058.117	kNm

Summary of Restoring Forces	
Vertical Load	21750.087 kN
Moment	-155713.031 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00
Transverse Moment due to C.F. = 0.000 x (1164.200 -

1151.500) = 0.000 KN
0.000 kNm

Normal

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00
Transverse Moment due to C.F. = 0.000 x (1164.200 -

1151.500) = 0.000 KN
0.000 kNm

Seismic

0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = $P/A - ML/ZL + MT/ZT$
Base pressure on corner B = σ_B = $P/A + ML/ZL + MT/ZT$
Base pressure on corner C = σ_C = $P/A - ML/ZL - MT/ZT$
Base pressure on corner D = σ_D = $P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force = $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_p$	FOS
FOR MINOR BRIDGE AT CH-81+92	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	30889.871	-17665.886	760.322	304.216	158.818	298.810	153.411	304.216	153.411	6107.922	19482.712	3.19	28519.075	183548.79	6.44
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	32271.976	-12772.510	1766.687	297.895	192.771	285.332	180.208	297.895	180.208	7235.587	19482.712	2.69	35699.304	186686.14	5.23
								SAFE	SAFE			SAFE			SAFE
Normal HFL Case															
Case 3 : DL+SIDL-Normal HFL Case	23926.958	-18543.130	760.322	256.249	103.631	250.843	98.224	256.249	98.224	6107.922	15096.077	2.47	24280.362	147973.97	6.09
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	24569.855	-13731.778	1036.456	242.193	129.175	234.823	121.804	242.193	121.804	7378.576	15317.981	2.08	32491.181	151397.64	4.66
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	31976.572	8527.312	5697.602	222.030	292.213	181.514	251.697	292.213	181.514	9977.365	19738.527	1.98	64629.842	192945.93	2.99
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	32303.545	10227.967	6137.761	219.018	303.199	175.372	259.553	303.199	175.372	9977.365	19738.527	1.98	64629.842	192945.93	2.99
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	24950.904	8242.401	5867.545	171.765	239.603	130.040	197.878	239.603	130.040	9774.741	15225.061	1.56	61647.745	155708.53	2.53
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	25137.711	10019.747	5988.319	166.264	248.731	123.680	206.147	248.731	123.680	9774.741	15225.061	1.56	61647.745	155713.03	2.53
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	31976.572	-4622.352	17217.924	317.105	279.061	194.666	156.622	317.105	156.622	6552.869	19738.527	3.01	38310.825	192945.93	5.04
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	32303.545	-2921.697	18215.484	316.075	292.028	186.543	162.496	316.075	162.496	5606.914	19738.527	3.52	32013.144	192945.93	6.03
								SAFE	SAFE			SAFE			SAFE

Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	24950.904	-5232.861	17784.399	269.589	226.521	143.123	100.054	269.589	100.054	5405.716	15225.061	2.82	29002.461	155708.53	5.37
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	25137.711	-3455.515	18058.117	264.632	236.192	136.219	107.778	264.632	107.778	5405.716	15225.061	2.82	29002.461	155713.03	5.37
								SAFE	SAFE			SAFE			SAFE

***DESIGN OF PIER P1 AND
ITS FOUNDATION
FOR MINOR BRIDGE AT CH- 81+924***

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle : 0 degree 0 Radian

	<u>Left span</u>		<u>Right span</u>		<u>Unit</u>
	<u>Right</u>	<u>Skew</u>	<u>Right</u>	<u>Skew</u>	
SPAN DETAILS					
C/C Expansion joint	= 25.000	25.000	25.000	25.00	m
C/C Expansion joint to C.L. brg	= 0.625	0.625	0.625	0.63	m
Expansion gap	= 50	50	50	50	mm
C/C bearing	= 23.750	23.750	23.750	23.750	m

SUPERSTRUCTURE DETAILS

	Left Span	Right Span
Overall deck width of bridge	= 12.50 m	12.50 m
Carriage way width	= 11.50 m	11.50 m
Crash barrier width	= 0.50 m	0.50 m
Height of crash barrier	= 1.00 m	1.00 m
C.g of Crash barrier from bottom	= 0.40 m	0.40 m
Cross-slope	= 2.50 %	2.50 %
Wearing coat thickness	= 65 mm	65 mm
Nos. of Bearing	= 4	4
Spacing of Bearing	= 3.00 m	3.00 m
Depth of Girder	= 1.900 m	1.900 m
Depth of slab	= 0.22 m	0.22 m
Depth of superstructure	= 2.120 m	2.120 m
Bearing + Pedestal height	= 0.40 m	0.40 m
Width of main girder at top	= 1.00 m	1.00 m
Width of cross girder	= 0.40 m	0.40 m
Nos. of cross-girders	= 2	2
FRL to Soffit	= 2.22 m	2.22 m
Type of Bearing		OR SPHERICAL BR

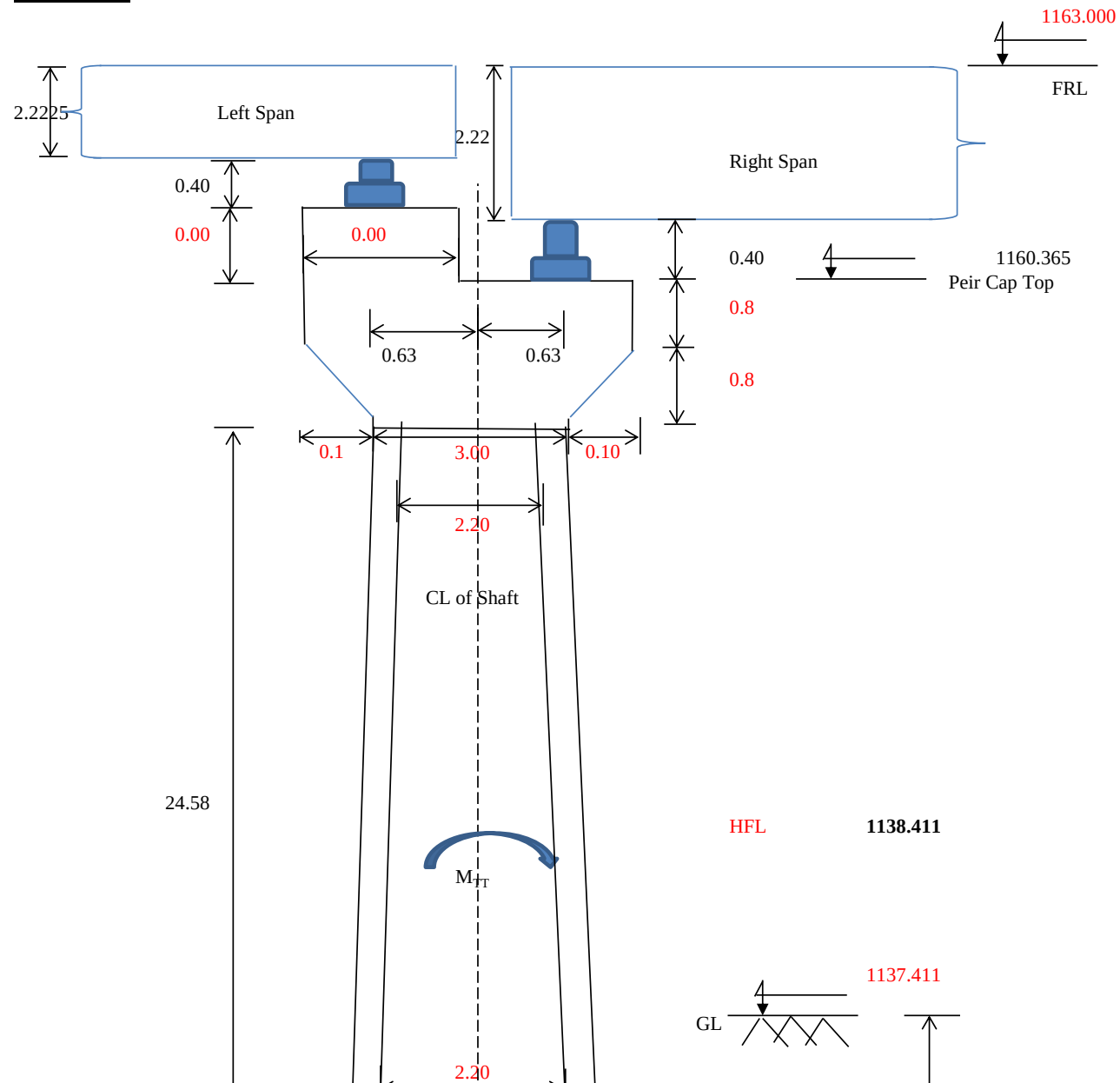
LEVEL DETAILS

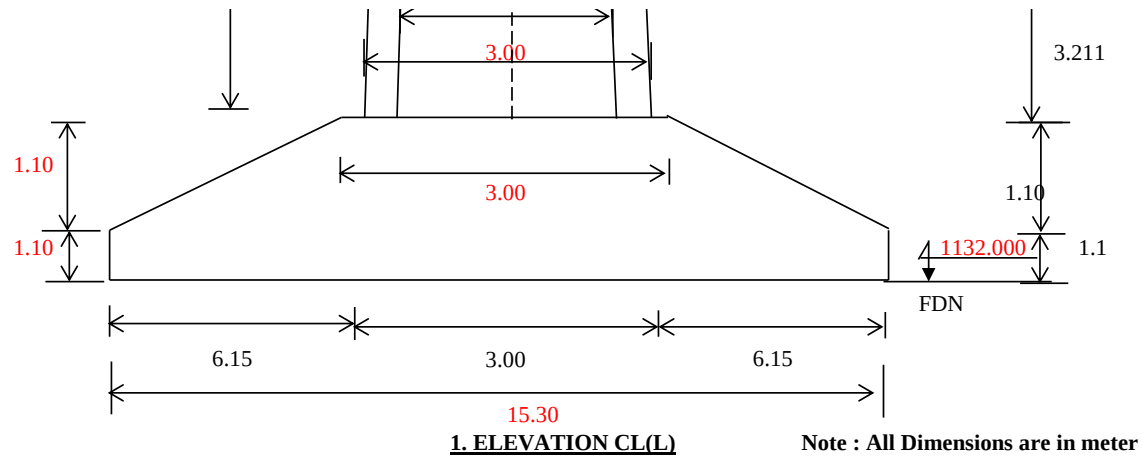
Formation level	= 1163.000 m
Pier cap top level	= 1160.365 m
HFL	= 1138.411 m
Ground level	= 1137.411 m
MSL (Normal)/Rock Level	= 1137.411 m
MSL (Seismic)/Rock Level	= 1137.411 m
Pier shaft bottom/Footing top level	= 1134.188 m
Founding level	= 1132.000 m

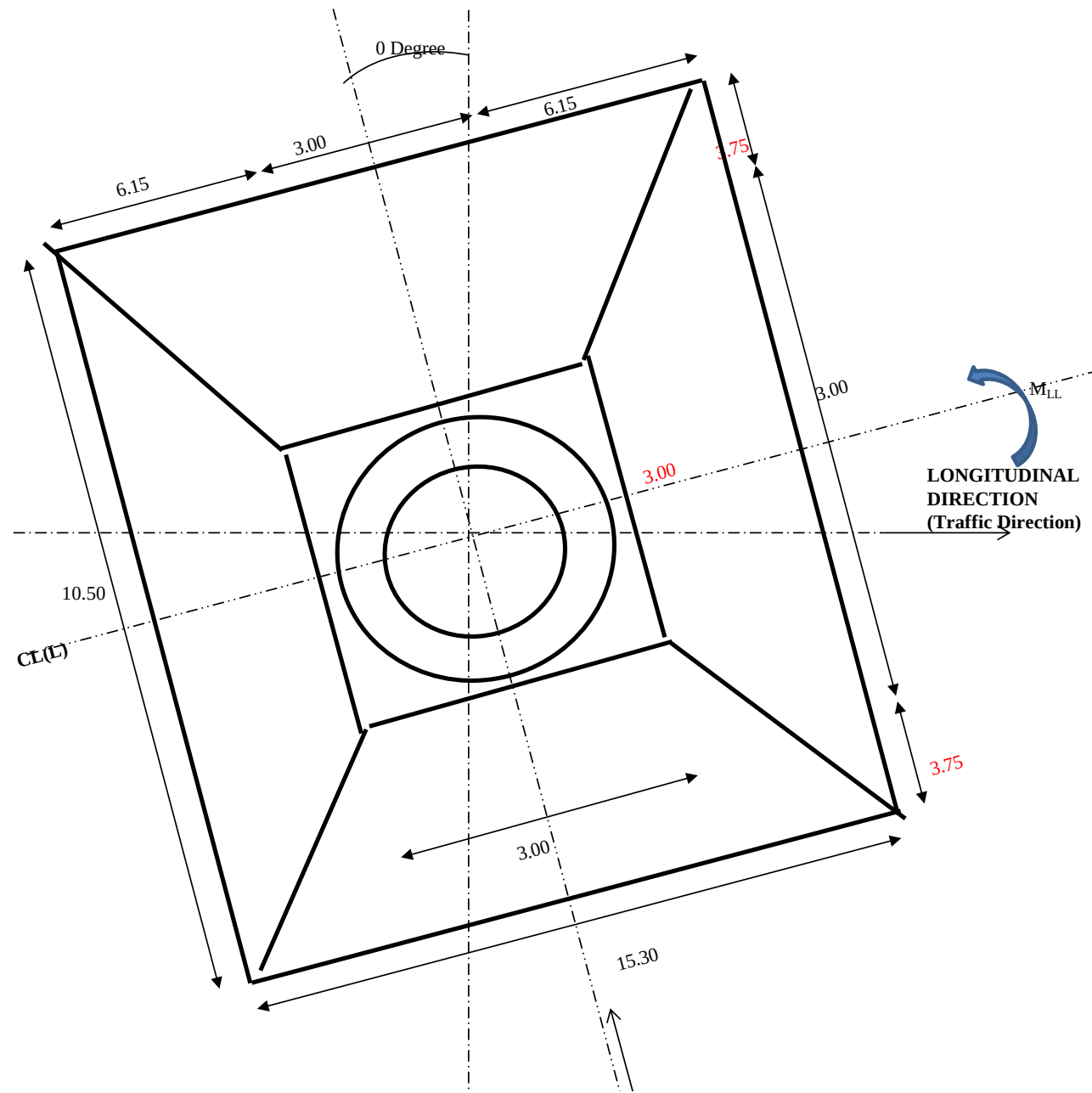
DIMENSION DETAILS

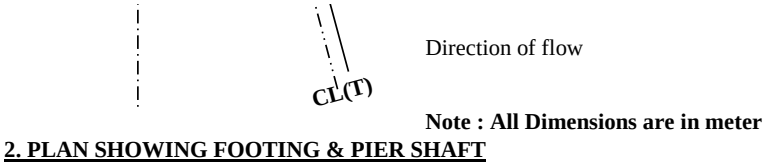
Pier cap:	Right	Skew
Width of pier cap at top	= 3.20 m	3.20 m
Width of pier cap at bottom	= 3.20 m	3.20 m

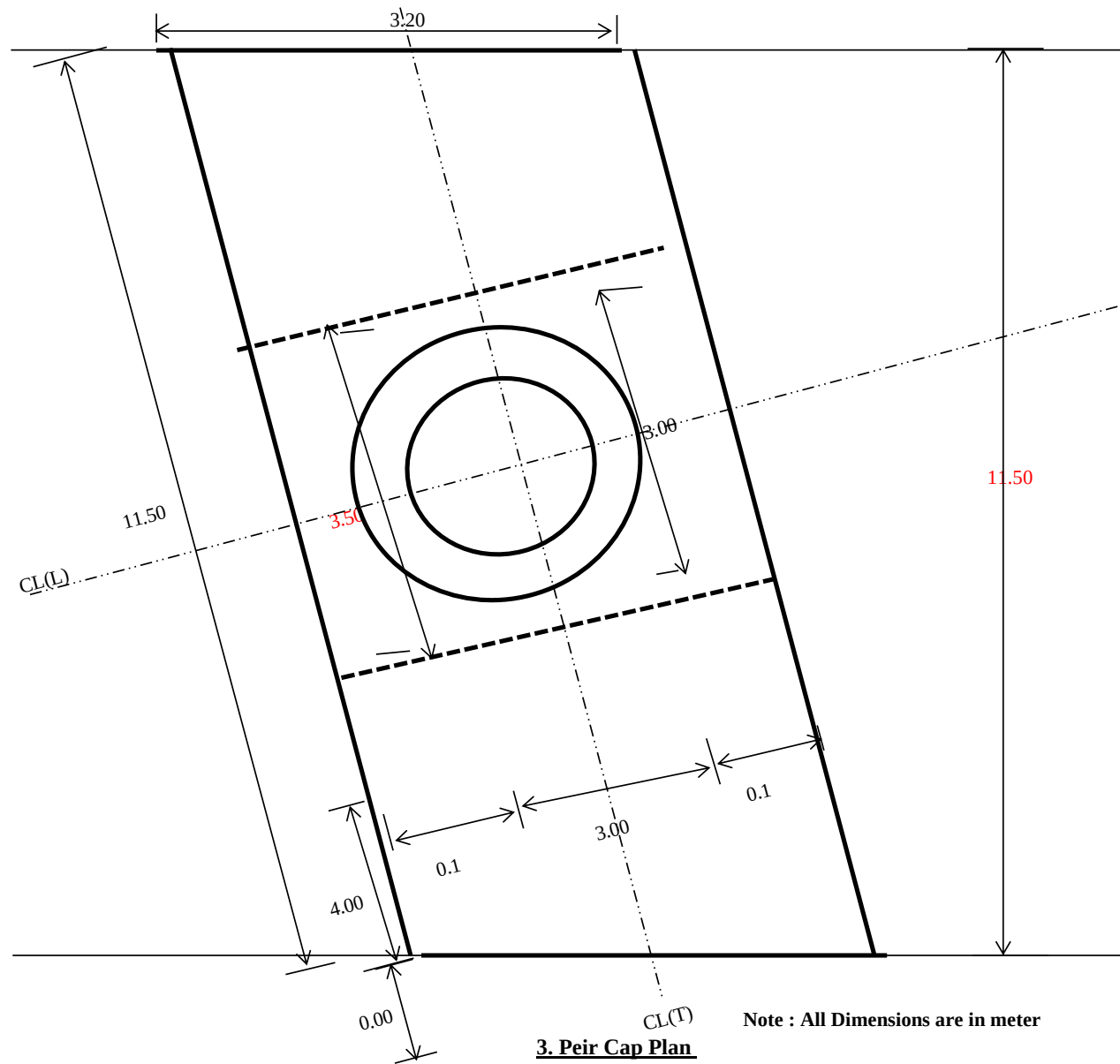
Length of pier cap at top	=	11.50 m	11.50 m
Length of pier cap at bottom	=	3.50 m	3.50 m
Thickness of uniform portion	=	0.80 m	0.80 m
Thickness of tapered portion	=	0.80 m	0.80 m
Pier shaft:			
Width of pier at top	=	3.00 m	3.00 m
Width of pier at bottom	=	3.00 m	3.00 m
Length of pier (rectangle portion)	=	0.00 m	0.00 m
Length of pier(end circular portion Top)	=	1.50 m	1.50 m
Length of pier (end circular portion Bottom)	=	1.50 m	1.50 m
Total length of pier shaft at top	=	3.00 m	3.00 m
Total length of pier shaft at bottom	=	3.00 m	3.00 m
Footing:			
Width of footing at top	=	3.00 m	3.00 m
Width of footing at bottom	=	15.30 m	15.30 m
Length of footing	=	10.50 m	10.50 m
Thickness at tip	=	1.10 m	1.10 m
Maximum thickness	=	2.20 m	2.20 m

DIAGRAMS:









2. MATERIALS DETAILS**CONCRETE:**

Grade of concrete	fck	=	M 35	
Mean value of concrete compressive strength, fcm		=	M 45 (28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447 x fck	(Basic and Seismic combination)
		=	15.633 Mpa	
Secant modulus of elasticity, Ecm		=	32000 Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8 Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5 t/m ³	

SOIL :

Density dry		=	2 t/m ³	
Density Saturated		=	2.3 t/m ³	
Soil density (submerged)		=	2 t/m ³	
Angle of Internal friction ϕ		=	35	
Cohesion c		=	0	
Gross bearing capacity		=	35.00 t/m ²	(Normal case)
		=	43.75 t/m ²	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	16.069 m ²	
Perimeter in contact with atmosphere , u		=	15.425 m	
Notional size , ho = 2Ac/u		=	2083 mm	
Age of concrete at the time of loading to		=	90 days	
	t _a	=	25550 days	
	f(α 90)	=	1.2 (Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32 (increased by 10%)	
Creep co-efficient for foundation		=	1.0 (as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793 Mpa	Ecm ' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500 Mpa	
Modulus of elasticity	Es	=	200000 Mpa	

3. PERMISSIBLE STRESSES**MAXIMUM PERMISSIBLE STRESS IN CONCRETE:**

Rare combination		=	0.48 x fck	
		=	16.8 Mpa	
Quasi permanent combination		=	0.36 x fck	
		=	12.6 Mpa	

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300 Mpa	
Permissible crack width	W _{k,max}	=	0.3 mm	

4. SEISMIC PARAMETERS

Seismic zone		=	V
Type of soil		=	Type2(Medium)
Zone factor	Z	=	0.36
Importance factor	I	=	1.20
Response Reduction Factor(Long)	R	=	3
Response Reduction Factor(Trans)	R	=	3

5. ENVIRONMENTAL PARAMETERS

Relative humidity		=	80%
Condition of exposure		=	Moderate

6. OTHER PARAMETERS

Mean velocity of water current flow		=	4.00 m/s
Design Speed	V	=	40 Kmph
Radius of Curvature	R	=	0 m

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew	=	0 °	=	0.000 Radian
No. of Bearing	=		4.00	
			Right	Skew
c/c of bearing in Transverse Direction	=	3.000	m	3.000 m
c/c bearing on Longitudinal Direction	=	1.250	m	1.250 m
Impact Factor for Design of Pier Cap				= 1.15

Left Span								
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min
	DL	SIDL						
	2261.29	199.95						
Total Load	2461.24		315.62	0.000	1059.33	290.67	0.00	0.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000

Right Span								
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min
	DL	SIDL						
	2261.29	199.95						
Total Load	2461.24		315.62	0.00	1059.33	290.67	0.00	0.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	0.950	1.000	1.000



Live Load(SV Load) max	Live Load(SV Load) min
1926.19	1493.81
0.300	0.300

Live Load(SV Load) max	Live Load(SV Load) min
1926.19	1493.81
0.300	0.300

8. VOLUME OF SUBSTRUCTURE**PIER CAP****Uniform portion**

No.		L(m)	B(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	11.500	0.000	0.000	0.000	1.600	0.000	26.1775	28.38
2	1	11.500	3.200	0.800	29.440	0.000	0.000	25.7775	27.98

Tapered portion

2a	Rectangle	3.500	3.200	0.800	8.960	0.000	0.000	24.978	27.178
	Triangle	4.000	3.200	0.800	10.240	0.000	0.000	25.111	27.311
Total				Inc. 10%	53.504	0.000	0.000	23.173	25.173

PIER SHAFT**Above HFL****Rectangular/Triangular Portion**

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	3.000	2.200	20.366	66.543	0.000	0.000	14.394	16.594
2	0	3.000	0.000	20.366	0.000	-1.500	0.000	11.000	13.200
3	0	3.000	0.000	20.366	0.000	1.500	0.000	11.000	13.200

Cylinder/Conical Frustum portion

4	0.000	1.100	1.5	20.366	0.000	0.000	0.000	14.394	16.594
Total					66.543	0.000	0.000	14.394	16.594

Below HFL**Rectangular/Triangular Portion**

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	3.000	2.200	4.211	13.758	0.000	0.000	2.106	4.306
2	0	3.000	0.000	4.211	0.000	0.000	0.000	0.000	0.000
3	0	3.000	0.000	4.211	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.500	1.100	4.211	0.000	0.000	0.000	2.106	4.306
Total					13.759	0.000	0.000	2.105	4.305

Above LBL**Rectangular/Triangular Portion**

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	3.000	2.200	21.366	69.810	0.000	0.000	13.894	16.094
2	0.0	3.000	0.000	21.366	0.000	-1.100	0.000	10.333	12.533
3	0.0	3.000	0.000	21.366	0.000	1.100	0.000	10.333	12.533

Cylinder/Conical Frustum portion

4	0.000	1.100	1.100	21.366	0.000	0.000	0.000	14.228	16.428
Total					69.810	0.000	0.000	13.894	16.094

Below LBL**Rectangular/Triangular Portion**

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	3.000	2.200	3.211	10.491	0.000	0.000	1.606	3.806
2	0	3.000	0.000	3.211	0.000	0.000	0.000	0.000	0.000
3	0	3.000	0.000	3.211	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.5	1.100	3.211	0.000	0.000	0.000	1.474	3.674
Total					10.491	0.000	0.000	1.606	3.806

FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	3.000	2.20	69.300	0.000	0.000	-1.100	1.100
2	1	10.500	6.15	1.650	106.549	-4.233	0.000	-1.344	0.856
3	1	10.500	6.150	1.650	106.549	4.233	0.000	-1.344	0.856
Total					282.3975	0.000	0.000	-1.284	0.916

EARTH ABOVE FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	15.300	5.411	869.277	0.000	0.000	0.506	2.706
2	-1	Shaft Below LBL			-10.491	0.000	0.000	1.606	3.806
3	-1	Footing			-282.398	0.000	0.000	-1.284	0.916
Total					576.388	0.000	0.000	1.362	3.562

9. CALCULATION OF SEISMIC FORCE

$$\text{Time Period } C \cdot T = 2 \sqrt{\frac{D}{1000 F}}$$

$$\begin{aligned} D &= \text{Approximate DL of super-structure \& LL in Tonne (DL+20\% LL)} \\ &= 5553.72 \text{ KN} + 211.866 \text{ KN} \\ &= 5766 \text{ KN} \end{aligned}$$

$$F =$$

Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction; and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

$$F = \frac{6 E I}{x^2(3L-x)} \quad \text{for 1 mm deflection at } x$$

$$E = 32000 \text{ N/mm}^2$$

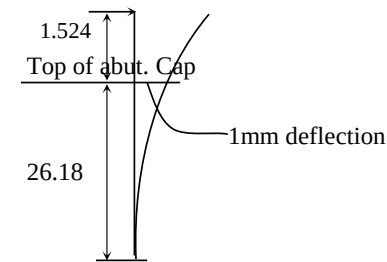
Column Cross-Section

$$D1 = 3.00 \text{ m (Average Outer Dia)}$$

$$D2 = 2.20 \text{ m (Average Inner Dia)}$$

$$I_{TT} = 2.12E+12 \text{ mm}^4 \quad 2.8E+12$$

$$I_{LL} = 2.12E+12 \text{ mm}^4$$



$$\text{Force required in Long. Dir. } F_L = 11 \text{ KN}$$

$$\text{Force required in Trans. Dir. } F_T = 10 \text{ KN}$$

$$\text{Time Period -Longitudinal Seismic Case} = 1.426 \text{ seconds}$$

$$\text{Time Period -Transverse Seismic Case} = 1.487 \text{ seconds}$$

$$S_a/g \text{ -Longitudinal Seismic Case} = 0.954$$

$$S_a/g \text{ -Transverse Seismic Case} = 0.915$$

$$\text{Seismic Zone} = V$$

$$\text{Zone Factor } Z = 0.36$$

Importance Factor	I	=	1.20	
Response reduction Factor	R	=	3.00	Longitudinal
	R	=	3.00	Transverse
Avg response acceleration	S_a/g	=	0.954	Longitudinal
Avg response acceleration	S_a/g	=	0.915	Transverse
Elastic Seismic Coefficient		=	$Z/2 \times (S_a/g) \times (I/R)$	
In longitudinal direction		=	0.206	/R
In Transverse direction		=	0.198	/R

			Substructure	Foundation
Enhancement factor				1.35
Design	Long. Ah		0.069	0.093
Seismic	Trans. At		0.066	0.089
coefficient	Vert. Av		0.046	0.062

CALCULATION OF SEISMIC FORCES

SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPLL :

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVF	W	eVS	eVF
	Tonnes	(m)	(m)		(m)	(m)
Total Super-Structure DL	452.26	28.06	30.26	452.26	28.06	30.26
Total Super-Structure SIDL	39.99	29.20	31.40	39.99	29.20	31.40
Total Super-Structure WC	63.12	28.83	31.03	63.12	28.83	31.03
Total Super-Structure FPLL	0.00	28.83	31.03	0.00	28.83	31.03
Total	555.37	28.23	30.43	555.37	26.13	28.17

* Bearing level	26.58	28.78		26.58	28.78

SEISMIC COMPONENT OF SUB-STRUCTURE :

Description	W	eVS	eVF
	Tonnes	(m)	(m)
Total weight of shaft and pier cap	334.51	16.64	18.76

Total weight of foundation	705.99	-1.28	0.92

SEISMIC COMPONENT OF LIVE LOAD(70R+Class A) :

Description	W	W	eVS	eVF
	Tonnes	Tonnes	(m)	(m)
	70R + Class A	70R + Class A		
Maximum Live Load	105.93	0.00	30.00	32.2
Minimum Live Load	29.07	0.00	30.00	32.2

Summary of Seismic force at shaft and foundation**Super structure**

Dead load - Super structure about shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		38.14		1013.658	
Seismic Transverse direction			36.58		994.07
Seismic Vertical Direction	25.43				

Dead load - Super structure about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		51.49		1481.71	
Seismic Transverse direction			49.378		1446.71
Seismic Vertical Direction	34.33				

Dead load Left span Dislodged- about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		25.74		740.857	
Seismic Transverse direction			24.69		695.45
Seismic Vertical Direction	17.16				

Sub structure

Dead load - Sub structure Shaft about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		22.97		382.28	
Seismic Transverse direction			22.03		366.61
Seismic Vertical Direction	15.31				

Dead load - Sub structure foundation about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		31.0127		581.82	
Seismic Transverse direction			29.74		557.97
Seismic Vertical Direction	20.68				

Live Load - Max**70R + Class A**

Live load - Max shaft about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.40		41.86
Seismic Vertical Direction	0.97				

Live load - Max foundation about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.88		60.66
Seismic Vertical Direction	1.31				

70R

Live load - Max shaft about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.40		41.86
Seismic Vertical Direction	0.97				

Live load - Max foundation about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.88		60.66

Seismic Vertical Direction	1.31				

Live Load - Min**70R + Class A**

Live load - Min shaft	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.38		11.49
Seismic Vertical Direction		0.27				

Live load - Min foundation	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.52		16.64
Seismic Vertical Direction		0.36				

70R

Live load - Min shaft	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.38		11.49
Seismic Vertical Direction		0.27				

Live load - Min foundation	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.52		16.64
Seismic Vertical Direction		0.36				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)**1. Normal Max Reaction on Fix End****Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 226.129 + \text{Total SIDL load } 51.56 + \text{CWLL } 0.00) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane } 0.2 \times 100 + \text{Class A on third Lane } 0.05 \times 54 \\ &+ 0.1 \times 0 + 0.05 \times 0 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 226.129 + \text{Total SIDL load } 51.56 + \text{CWLL } 29.07) \\ &= 15.34 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq) \text{ and } F_h - \mu (Rg + Rq)) \\ &= 26.69 \text{ Ton} \\ F_{hr} &= 26.69 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 26.69 - 13.88 \\ &= 12.80 \text{ Ton} \end{aligned}$$

2. Normal Min Reaction on Fix End**Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 226.129 + \text{Total SIDL load } 51.56 + \text{CWLL } 0.00) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 54 \\
 F_h &= 22.7 \text{ Ton} \\
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{19.18} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{105.93} \right) \\
 &= 19.18 \text{ Ton} \\
 \text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q)) & \\
 F_{hr} &= 30.53 \text{ Ton} \\
 F_{hl} &= 30.53 \text{ Ton} \\
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 30.53 - 13.88 \\
 &= 16.65 \text{ Ton}
 \end{aligned}$$

3. Seismic Max Reaction on Fix End**Left Span**

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{13.88} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\
 F_{hl} &= 13.88 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 19.070 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 25.744 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 23.610 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 30.284 \text{ Ton}
 \end{aligned}$$

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{5.81} \right)$$

$$= 14.17497 \text{ Ton}$$

Max of (Fh/2 + $\mu (Rg + Rq)$ and Fh - $\mu (Rg + Rq)$)

Fhr for shaft = 28.25 Ton

Fhr for foundation = 31.59 Ton

Horizontal force for shaft = Fhr - Fhl = 28.25 - 13.88 = 14.37 Ton

Horizontal force for foundation = Fhr - Fhl = 31.59 - 13.88 = 17.70 Ton

4. Seismic Min Reaction on Fix End

Left Span

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right)$$

$$= 13.88 \text{ Ton}$$

Fhl = 13.88 Ton

Right Span

Beaking Force = $\frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 10.8$

Fh = 4.54 Ton

Seismic Horizontal force(Shaft) = 19.070 Ton (Including safty factor 1.5)

Seismic Horizontal force(foundation) = 25.744 Ton (Including safty factor 1.5 and 35 % inc.)

Total Horizontal force for Shaft(Fh) = 23.610 Ton

Total Horizontal force for foundation(Fh) = 30.284 Ton

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{21.19} \right)$$

$$= 14.94363 \text{ Ton}$$

Max of (Fh/2 + $\mu (Rg + Rq)$ and Fh - $\mu (Rg + Rq)$)

	Fhr for shaft	=	29.02	Ton
	Fhr for foundation	=	32.36	Ton
Horizontal force for shaft	=	Fhr	-	Fhl
	=	29.02	-	13.88
	=	15.13	Ton	
Horizontal force for foundation	=	Fhr	-	Fhl
	=	32.36	-	13.88
	=	18.47	Ton	

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 226.129 + \text{Total SIDL load } 51.56 + \text{CWLL } 0.00) \\ &= 13.88 \text{ Ton} \\ Fhl &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\text{Beaking Force} = 0.2 \times \text{Class 70R on First two Lane } 100 + 0.05 \times \text{Class A on third Lane } 0.00$$

$$Fh = 20 \text{ Ton}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 226.129 + \text{Total SIDL load } 51.56 + \text{CWLL } 29.07) \\ &= 15.34 \text{ Ton} \end{aligned}$$

$$\text{Max of } (Fh/2 + \mu (Rg + Rq) \text{ and } Fh - \mu (Rg + Rq))$$

$$= 25.34 \text{ Ton}$$

$$Fhr = 25.34 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= Fhr - Fhl \\ &= 25.34 - 13.88 \\ &= 11.45 \text{ Ton} \end{aligned}$$

6. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= 0.2 \times \frac{\text{Class 70R on First two Lane}}{100} + 0.05 \times \frac{\text{Class A on third Lane}}{0} \\ F_h &= 20 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{105.93} \right) \\ &= 19.18 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq) \text{ and } F_h - \mu (Rg + Rq)) \\ &= 29.18 \text{ Ton} \\ F_{hr} &= 29.18 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 29.18 - 13.88 \\ &= 15.30 \text{ Ton} \end{aligned}$$

7. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 20 + 0.05 \times 0 \\
 \\
 F_h &= 4 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 19.070 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 25.744 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 23.070 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 29.744 \text{ Ton} \\
 \\
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (226.129 + 51.56 + 5.81) \\
 &= 14.17497 \text{ Ton} \\
 \\
 \text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q)) & \\
 \\
 F_{hr} \text{ for shaft} &= 27.71 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 31.05 \text{ Ton} \\
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 27.71 - 13.88 \\
 &= 13.83 \text{ Ton} \\
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 31.05 - 13.88 \\
 &= 17.16 \text{ Ton}
 \end{aligned}$$

8. Seismic Min Reaction on Fix End**Left Span**

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (226.129 + 51.56 + 0.00) \\
 &= 13.88 \text{ Ton} \\
 F_{hl} &= 13.88 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 20 + 0.05 \times 0 \\
 \\
 F_h &= 4 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 19.070 \text{ Ton} \quad (\text{Including safty factor 1.5})
 \end{aligned}$$

Seismic Horizontal force(foundation)	=	25.744	Ton	(Including safty factor 1.5 and 35 %
Total Horizontal force for Shaft(Fh)	=	23.070	Ton	inc.)
Total Horizontal force for foundation(Fh)	=	29.744	Ton	
		Total DL	Total SIDL load	CWLL
$\mu (Rg + Rq)$	=	0.05 x (226.129	+ 51.56	+ 21.19)
	=	14.94363	Ton	
Max of	(Fh/2 + $\mu (Rg + Rq)$	and	Fh - $\mu (Rg + Rq)$	)
	Fhr for shaft	=	28.48	Ton
	Fhr for foundation	=	31.82	Ton
Horizontal force for shaft	=	Fhr	-	Fhl
	=	28.48	-	13.88
	=	14.59	Ton	
Horizontal force for foundation	=	Fhr	-	Fhl
	=	31.82	-	13.88
	=	17.93	Ton	

BOTH SPAN POSITION CONDITION(Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

$\mu (Rg + Rq)$	=	0.05	x (	Total DL	+	Total SIDL load	+	CWLL
	=			226.129	+	51.56	+	0.00)
	=			13.88	Ton			
Fhl	=			13.88	Ton			

Right Span

$\mu (Rg + Rq)$	=	0.05	x (	Total DL	+	Total SIDL load	+	CWLL
	=			226.129	+	51.56	+	149.38)
	=			21.35	Ton			
Fhr	=			21.35	Ton			
Horizontal force	=	Fhr	-	Fhl				
	=	21.35	-	13.88				
	=	7.47	Ton					

10. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{192.62} \right) \\ &= 23.52 \text{ Ton} \\ F_{hr} &= 23.52 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 23.52 - 13.88 \\ &= 9.63 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hr} &= 13.88 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \end{aligned}$$

$$= 13.88 - 13.88$$

$$= 0.00 \text{ Ton}$$

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right)$$

$$= 13.8843 \text{ Ton}$$

$$F_{hr} = 13.8843 \text{ Ton}$$

$$\text{Horizontal force} = F_{hr} - F_{hl}$$

$$= 13.8843 - 0.000$$

$$= 13.8843 \text{ Ton}$$

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 0 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 0 \text{ Ton}$$

$$\begin{aligned} \text{Seismic Horizontal force (Shaft)} &= 19.070 \text{ Ton} && \text{(Including safty factor 1.5)} \\ \text{Seismic Horizontal force (foundation)} &= 25.744 \text{ Ton} && \text{(Including safty factor 1.5 and 35 \% inc.)} \\ \text{Total Horizontal force for Shaft (Fh)} &= 19.070 \text{ Ton} \\ \text{Total Horizontal force for foundation (Fh)} &= 25.744 \text{ Ton} \end{aligned}$$

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right)$$

$$= 13.8843 \text{ Ton}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

	Fhr for shaft	=	23.42	Ton
	Fhr for foundation	=	26.76	Ton
Horizontal force for shaft	=	Fhr	-	Fhl
	=	23.42	-	0.00
	=	23.42	Ton	
Horizontal force for foundation	=	Fhr	-	Fhl
	=	26.76	-	0.00
	=	26.76	Ton	

Summary of forces			
Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	12.80	12.80
	2. Normal Min Reaction on Fix End	16.65	16.65
	3. Seismic Max Reaction on Fix End	14.37	17.70
	4. Seismic Min Reaction on Fix End	15.13	18.47
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.45	11.45
	6. Normal Min Reaction on Fix End	15.30	15.30
	7. Seismic Max Reaction on Fix End	13.83	17.16
	8. Seismic Min Reaction on Fix End	14.59	17.93
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	7.47	7.47
	10. Normal Min Reaction on Fix End	9.63	9.63
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	13.88	13.88
	13. Seismic Span Dislodge Condition	23.42	26.76

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$C = \frac{WV^2}{127R}$$

70R + Class A**Maxium Reaction**

Live Load	W	=	105.93	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

$$C = 0.00 \text{ t}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0.00	30.00	32.20

Minimum Reaction

Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

$$C = 0.00 \text{ t}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0	30.00	32.20

70R**Maxium Reaction**

Live Load	W	=	105.93	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0	30.00	32.20

Minimum Reaction

Live Load	W	=	29.07	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

C = 0 KN

C (t)	e _{VS} (m)	e _{VF} (m)
0	30.00	32.20

Special Vehicle

Maxium Reaction				
Live Load	W	=	192.62	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0	30.00	32.20

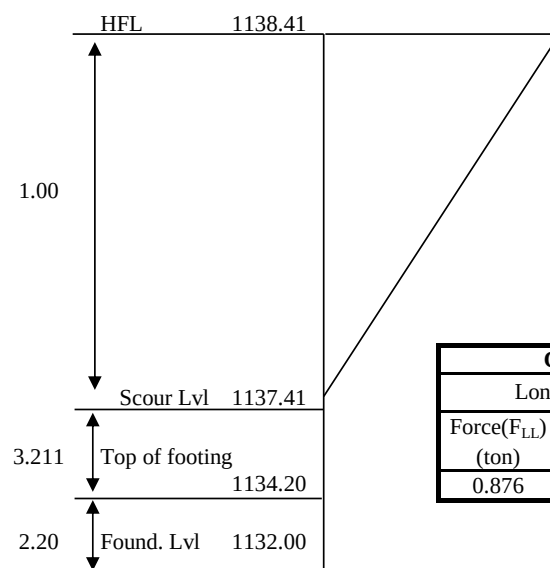
Minimum Reaction				
Live Load	W	=	149.38	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0	30.00	32.20

12. WATER CURRENT FORCES**NORMAL CASE****Water current forces**

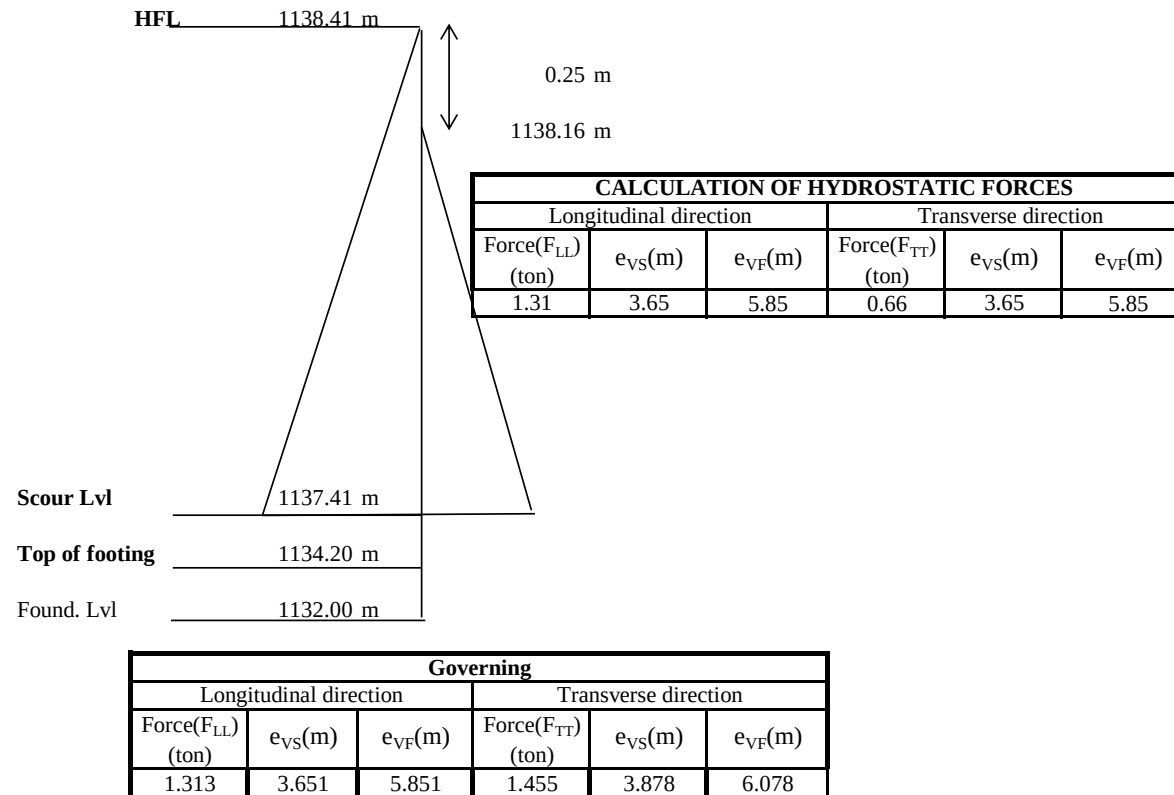
HFL	=	1138.411 m	
MSL (NORMAL)	=	1137.411 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL	(Trans direction)	=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL	(Long direction)	=	0.29 t/m ² 53 K (vsinq) ²



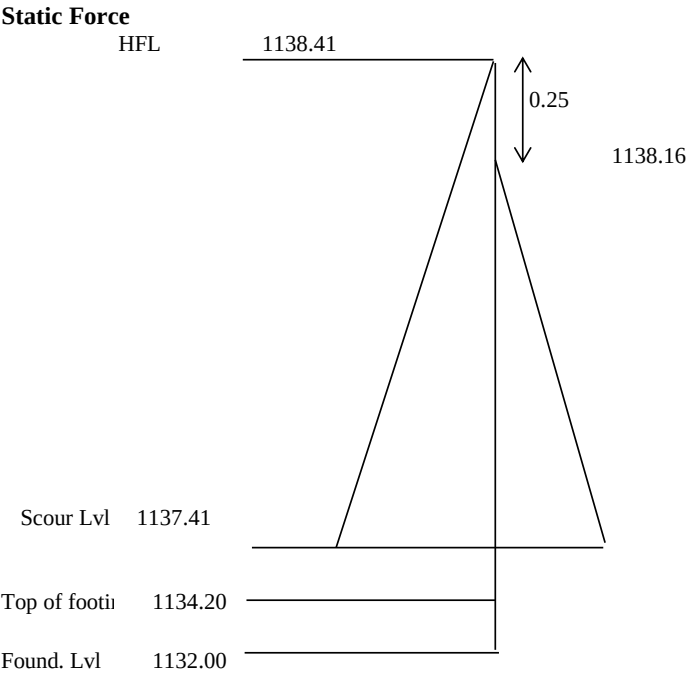
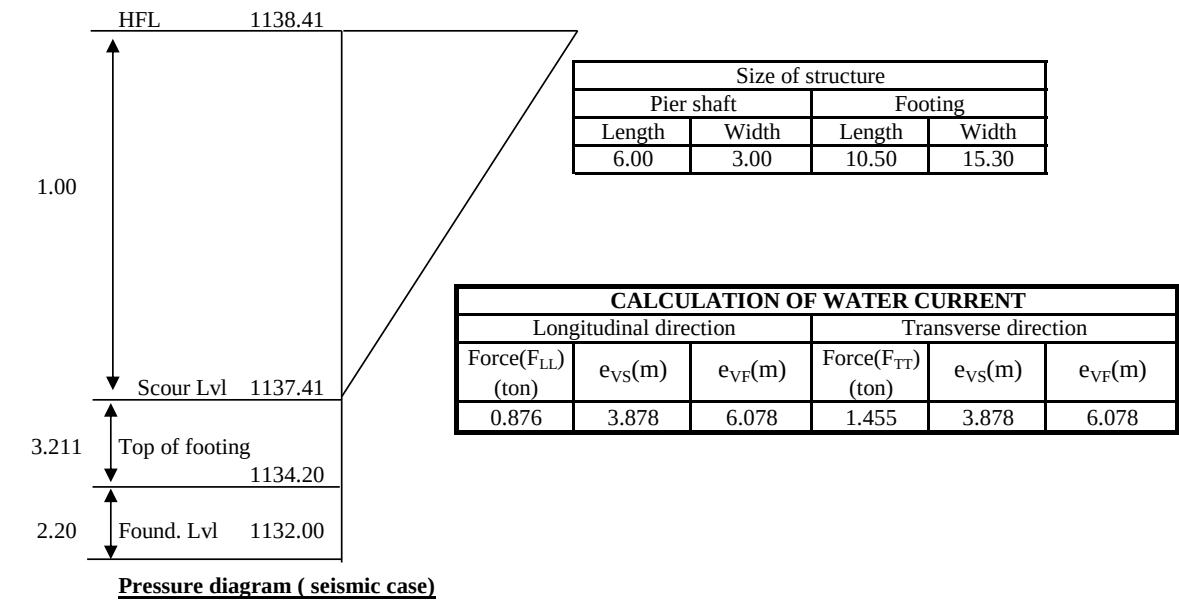
Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
6.00	3.00	10.50	15.30

CALCULATION OF WATER CURRENT FORCES					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.876	3.878	6.078	1.455	3.878	6.078

Pressure diagram (Normal case)

Static Force**SEISMIC CASE**

HFL	=	1138.411 m		
MSL (SEISMIC)	=	1137.41 m		
Water current pressure	P	=	52 KV ²	Kg/m ²
For piers with square ends	K	=	1.5	
For piers with semicircular ends	K	=	0.66	
Mean velocity of water current	V_{mean}	=	4.00 m/s	
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00	
		=	5.66 m/s	
Angle of variation		=	20 degree	
Water current pressure at HFL	(Trans direction)	=	0.97 t/m ²	52 K (vcosq) ²
Water current pressure at HFL	(Long direction)	=	0.29 t/m ²	53 K (vsinq) ²



CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
1.31	3.65	5.85	0.66	3.65	5.85

Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
1.313	3.651	5.851	1.455	3.878	6.078

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

LC -1 ULS NORMAL LWL MAX REACTION
 LC -2 ULS NORMAL LWL SPAN DISLOGED

LC - 5 ULS MAX REACTION $1X + 0.3Y + 0.3Z$
 LC - 6 ULS MAX REACTION $0.3X + 1Y + 0.3Z$

LC - 9 ULS NORMAL SV MAX REACTION

SLS

LC -1 RARE NORMAL MAX REACTION
 LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

LC - 1 ULS NORMAL MAX REACTION(70R + Class A)
 LC - 2 ULS NORMAL SPAN DISLOGED

LC - 5 ULS NORMAL MAX REACTION(70R)

LC - 7 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R + \text{Class A})$
 LC - 8 ULS SPAN DISLOGED $1X + 0.3Y + 0.3Z$

LC - 9 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{Class A})$
 LC - 10 ULS SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 15 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC - 16 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION $(70R + \text{Class A})$
 LC - 2 NORMAL SPAN DISLOGED

LC - 5 0
 LC - 6 SEISMIC SPAN DISLODGED $1X + 0.3Y + 0.3Z$
 LC - 7 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{class A})$
 LC - 8 SEISMIC LWL SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 13 SEISMIC NORMAL MAX REACTION $(70R)$

LC - 15 SEISMIC MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC - 16 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 13 NORMAL LWL SV MAX REACTION

14.A DESIGN FORCES FOR PIER SHAFT(ULS CASES)**LC -1 ULS NORMAL LWL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			30.000	0.0	0.000	1.5	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				12.803			26.578	340.281		1.5	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1385.49	599.80	135.86

LC -2 ULS NORMAL LWL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			30.000	0.000	0.000	1.5	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				13.884			26.578	369.010		1.5	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
839.09	795.70	0.00

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			246.124		-0.63	0.000		-153.828	0.000	1.35	
2	Surfacing			31.562		-0.63	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.63	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.63	0.950		0.000	0.000	0.2	1
5	LL (Class-A)			0.000		-0.63	1.000		0.000	0.000	0.2	1
	Right Span											
6	DL (superstructure)			246.124		0.63	0.000		153.828	0.000	1.35	
7	Surfacing			31.562		0.63	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.63	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.63	0.950		66.208	100.6	0.2	1
10	LL (Class-A)			0.000		0.63	1.000		0.000	0.0	0.2	1
11	Centifugal force				0.000			30.000	0.0	0.0	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				14.366			26.578	381.802		1.000	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1.000	
18	Seismic											
	Super structure											
	Longitudinal				38.140				1013.66		1.5	
	Transverse				36.576					994.06877	0.45	
	Vertical			25.426							0.45	
	Sub structure											
	Longitudinal				22.972				382.28		1.5	
	Transverse				22.031					366.60882	0.45	
	Vertical			15.315							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.395					41.859945	0.45	
	Vertical			0.970							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1266.550	2488.95	651.27

LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.63	0.00		-153.83	0.00	1.35	
2	Surfacing			31.562		-0.63	0.00		-19.73	0.00	1.75	
3	FLL			0.000		-0.63	0.00		0.00	0.00	0.2	
4	LL (70R)			0.000		-0.63	0.95		0.00	0.00	0.2	1
5	LL (Class-A)			0.000		-0.63	1.00		0.00	0.00	0.2	1
Right Span												
6	DL (superstructure)			246.124		0.63	0.00		153.83	0.00	1.35	
7	Surfacing			31.562		0.63	0.00		19.73	0.00	1.75	
8	FLL			0.000		0.63	0.00		0.00	0.00	0.2	
9	LL (70R)			105.933		0.63	0.95		66.21	100.64	0.2	1
10	LL (Class-A)			0.000		0.63	1.00		0.00	0.00	0.2	1
11	Centifugal force				0.000			30.000	0.0	0.000	0.2	
12	Pier cap	53.504	2.500	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.500	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.500	26.228		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				14.366			26.578	381.802		1.000	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1.000	
18	Seismic											
	Super structure											
	Longitudinal				38.140				1013.66		0.45	
	Transverse				36.576					994.069	1.5	
	Vertical			25.426							0.45	
	Sub structure											
	Longitudinal				22.972				382.28		0.45	
	Transverse				22.031					366.609	1.5	
	Vertical			15.315							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.395					41.860	1.5	
	Vertical			0.970							0.45	

SUMMARY OF FACTORED FORCES		

V(ton)	MTT (tm)	MLL(tm)
1266.550	1023.21	2123.93

LC - 9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1.35	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
7	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centifugal force				0.000			30.000	0.000		1	
10	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
15	Horizontal Force(F _{LL})				7.469			26.578	198.509		1.5	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1419.21	418.15	57.79

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)**LC -1 RARE NORMAL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			30.000	0.000	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			3.651	0.000		1	
	Water Current Force(F _{TT})				0.000			3.878		0.000	1	
17	Horizontal Force(F _{LL})				12.803			26.578	340.281		1	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1008.44	399.87	90.57

LC-2 RARE NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centifugal force(F _{LL})				0.000			30.000	0.000	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			3.651	0.000		1	
	Water Current Force(F _{TT})				0.000			3.878		0.000	1	
17	Horizontal Force(F _{LL})				13.884			26.578	369.010		1	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
618.51	546.51	0.00

LC -5 QP NORMAL

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	0	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			30.000	0.000	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			3.651	0.000		0	
	Water Current Force(F _{TT})				0.000			3.878		0.000	0	
17	Horizontal Force(F _{LL})				0.000			26.578	0.000		0	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
902.51	0.00	0.00

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			30.000	0.000	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F _{LL})				0.000			3.651	0.000		0	
	Water Current Force(F _{TT})				0.000			3.878		0.000	0	
17	Horizontal Force(F _{LL})				13.884			26.578	369.010		1	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
618.51	546.51	0.00

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
7	FLL			0.000		0.625	0.000		0.000	0.000	1	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centifugal force				0.000			30.000	0.000		1	
10	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			3.651	0.000		1	
	Water Current Force(F _{TT})				0.000			3.878		0.000	1	
15	Horizontal Force(F _{LL})				7.469			26.578	198.509		1	
	Horizontal Force(F _{TT})				0.000			26.578		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1095.13	318.90	57.79

15. DESIGN FORCES FOR FOUNDATION**LC -1 ULS NORMAL MAX REACTION(70R +Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
	Right Span											
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			32.200	0.0	0.000	1.5	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				12.803			28.778	368.45		1.5	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1.5	
18	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
3878.94	642.05	135.86

LC -2 ULS NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			32.200	0.000	0.000	1.5	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				13.884			28.778	399.555		1.5	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1.5	
18	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
3348.43	841.52	0.00

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			32.200	0.0	0.000	1.5	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				11.453			28.778	329.60		1.5	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1.5	
18	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2322.695	583.78	135.86

LC - 7 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			32.200	0.0	0.000	0.2	
12	Pier cap	53.504	2.500	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.500	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.500	26.228		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				17.703			28.778	509.44		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.00	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				51.489				1481.7		1.5	
	Transverse				49.378					1446.7	0.45	
	Vertical			34.326							0.45	
	Sub structure											
	Longitudinal				31.013				581.8		1.5	
	Transverse				29.741					557.97465	0.45	
	Vertical			20.68							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.884					60.65506	0.45	
	Vertical			1.309							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3782.509	3617.99	951.78

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.00	0.000	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				26.756			28.778	769.98		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				25.744				740.86		1.5	
	Transverse				24.689					695.44602	0.45	
	Vertical			17.163							0.45	
Sub structure												
	Longitudinal				31.013				581.8		1.5	
	Transverse				29.741					557.97465	0.45	
	Vertical			20.675							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3365.460	2788.53	564.04

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			32.200	0.0	0.000	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				17.703			28.778	509.44		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				51.489			1481.7			0.45	
	Transverse				49.378					1446.713	1.5	
	Vertical			34.326							0.45	
	Sub structure											
	Longitudinal				31.013				581.8		0.45	
	Transverse				29.741					557.975	1.5	
	Vertical			20.675							0.45	

a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.884					60.655	1.5	
	Vertical			1.309							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3782.509	1451.28	3143.11

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.00	0.000	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				26.756			28.778	769.98		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				25.744			740.86			0.45	
	Transverse				24.689					695.44602	1.5	
	Vertical			17.163							0.45	

	Sub structure											
	Longitudinal				31.013				581.8		0.45	
	Transverse				29.741					557.97465	1.5	
	Vertical			20.675							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3365.460	1399.71	1880.13

LC -15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m³)	Unit weight (t/m³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.0	0.000	0.2	
12	Pier cap	53.504	2.500	133.760		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	69.810	2.500	174.525		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.491	2.500	26.228		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				17.163			28.778	493.90		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.00	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				51.489			1481.7			1.5	
	Transverse				49.378					1446.7	0.45	
	Vertical			34.326							0.45	
Sub structure												
	Longitudinal				31.013			581.8			1.5	
	Transverse				29.741					557.97465	0.45	
	Vertical			20.68							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.884					60.66	0.45	
	Vertical			1.309							0.45	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.517					16.643167	0.45	0.3

	Vertical			0.359							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3782.509	3602.45	951.78

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
	Left Span											
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.0	0.000	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				17.163			28.778	493.90		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				51.489			1481.7			0.45	
	Transverse				49.378					1446.713	1.5	
	Vertical			34.326							0.45	
	Sub structure											
	Longitudinal				31.013			581.8			0.45	
	Transverse				29.741					557.975	1.5	
	Vertical			20.675							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.884					60.655	1.5	
	Vertical			1.309							0.45	

b)	Min Live Load											
	Longitudinal										0.45	0.3

	Transverse				0.517					16.643167	1.5	1
	Vertical			0.359							0.45	0.3
SUMMARY OF FACTORED FORCES												
	V(ton)	MTT (tm)	MLL(tm)									
	3782.509	1435.74	3143.11									

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
7	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centifugal force				0.000			32.200	0.0	0.000	1	
10	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
15	Horizontal Force(F _{LL})				7.469			28.778	214.94		1.5	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1.5	
16	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
3928.55	442.80	57.79

16. DESIGN FORCES FOR BASE PRESSURE**LC -1 NORMAL MAX REACTION(70R+Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centifugal force				0.000			32.200	0.0	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				12.803			28.778	368.45		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2843.99	428.04	90.57

LC -2 NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centifugal force				0.000			32.200	0.000	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				13.884			28.778	399.555		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2470.97	573.11	0.00

573.109 0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.00	0.000	0	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	

	Water Current Force(F_{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F_{LL})				26.756			28.778	769.98		1	
	Horizontal Force(F_{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				25.744				740.86		1	
	Transverse				18.288					515.1452	0.3	
	Vertical			12.713							0.3	
	Sub structure											
	Longitudinal				31.013				581.8		1	
	Transverse				29.741					557.97	0.3	
	Vertical			20.675							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M_{TT} (tm)	M_{LL} (tm)
2480.986	2112.39	321.94

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			32.200	0.00	0.000	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				26.756			28.778	769.98		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				0.000			0.00			0.3	
	Transverse				18.288					515.1452	1	
	Vertical			12.713							0.3	
	Sub structure											
	Longitudinal				31.013				581.8		0.3	
	Transverse				29.741					557.97465	1	
	Vertical			20.675							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2480.986	964.26	1073.12

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			32.200	0.0	0.000	1	
12	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				11.453			28.778	329.60		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2843.99	389.19	90.57

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
	Left Span											
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.0	0.000	0.2	
12	Pier cap	53.504	2.500	133.760		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	69.810	2.500	174.525		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.491	2.500	26.228		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				17.163			28.778	493.90		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.00	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				51.489			1481.7			1	
	Transverse				49.378					1446.7	0.3	
	Vertical			34.326							0.3	
	Sub structure											
	Longitudinal				31.013			581.8			1	
	Transverse				29.741					557.97	0.3	
	Vertical			20.68							0.3	
a)	Max Live Load											
	Longitudinal										1	
	Transverse				1.884					60.66	0.3	
	Vertical			1.309							0.3	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.517					16.643167	0.45	0.3
	Vertical			0.359							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2786.783	2570.68	641.98

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centifugal force				0.000			32.200	0.0	0.000	0.2	
12	Pier cap	53.50	2.50	133.76		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	69.81	2.50	174.52		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.49	2.50	26.23		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			5.851	0.00		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
17	Horizontal Force(F _{LL})				17.163			28.778	493.90		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
18	Footing	282.40	2.50	705.99		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	576.39	2.00	1152.78		0.00	0.00		0.00	0.00	1	
20	Seismic											
Super structure												
	Longitudinal				51.489				1481.7		0.3	
	Transverse				49.378					1446.7	1	
	Vertical			34.326							0.3	
Sub structure												
	Longitudinal				31.013				581.8		0.3	
	Transverse				29.741					557.97	1	
	Vertical			20.675							0.3	

a)	Max Live Load											
	Longitudinal										0.3	
	Transverse				1.884					60.66	1	
	Vertical			1.309							0.3	
b)	Min Live Load											
	Longitudinal										0.45	0.3
	Transverse				0.517					16.6	1.5	1
	Vertical			0.359							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2786.783	1126.21	2110.44

LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
7	FLL			0.000		0.625	0.000		0.000	0.000	1	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centifugal force				0.000			32.200	0.0	0.000	1	
10	Pier cap	53.504	2.5	133.760		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	69.810	2.5	174.525		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	10.491	2.5	26.228		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F _{LL})				0.000			5.851	0.000		1	
	Water Current Force(F _{TT})				0.000			6.078		0.000	1	
15	Horizontal Force(F _{LL})				7.469			28.778	214.94		1	
	Horizontal Force(F _{TT})				0.000			28.778		0.000	1	
16	Footing	282.40	2.5	705.994		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	576.39	2	1152.777		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)

2941.27	335.33	57.79

DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
82+425

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 0 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 28.700m	28.700m
Thickness of Expansion Joint	= 0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.625m	0.625m
Slab projection Beyond C/L of Bearing (Span Side) =	0.625m	0.625m
Span -c/c of E.J.	= 30.000m	30.00m
Type of Superstructure	= Steel Composite Girder	
Width of Crash barrier (Both Side)	= 0.450m	
Width of Carriageway	= 11.000m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on one side	= 0.000m	
Railing/kerb on footpath edge	= 0.250m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

No of Bearings = 2
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 7.500m (Right) 7.500 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 300 kN/m²
SBC of soil-Normal Case = 335 kN/m² (as per geotechnical report)
SBC of soil-Seismic Case = 419 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1.5 Normal Case
= 1.25 Seismic Case

Permissible FOS against Overturning = 2 Normal Case
= 1.5 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 2.085m	
Height of Trapering portion	= -0.122m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion = 1.750m 1.750m
Width of Abutmentcap at bottom of Tapering Portion = 1.000m 1.000m
Projection of Abutment Cap (Span Side) = 0.275m 0.275m

Projection of Abutment Cap Back Side	=	0.475m	0.475m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.088m	1.088m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.500m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.000m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	10.500m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	1.200m	
Width of Toe Slab	=	3.800m	
Width of Heel Slab	=	5.500m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.200m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.200m	
Width of backfill on heel slab	=	5.500m	
Thickness of heel slab at back fill edge	=	1.200m	
Height of back fill at bottom edge of heel slab	=	11.028m	
Height of back fill at back fill edge of heel slab	=	10.328m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1163.000m	Cross Slope (Bi-directional)	=	2.500%	
Deck level at Outer Edge =	1162.856m	Height of Superstructure	=	1.920m	
Deck level at center line =	1163.000m	Min. Height of Footpath Side Pedestal (1)	=	0.500m	
Soffit Level at center of bridge =	1161.015m	Height of Pedestal (2)	=	0.500m	
Abutment cap top level =	1160.965m	Height of Pedestal (3)	=	0.000m	
Abutment cap bottom lvl (uniform portion ends	1160.665m	Height of Pedestal (4)	=	0.000m	
Abutment cap bottom lvl (corbel portion ends)	1160.365m	Height of Pedestal (5)	=	0.000m	
Abutment shaft top level =	1160.365m	Height of Pedestal (6)	=	0.000m	
Ground level/LBL =	1154.933m	Distance of nearest girder to c.l. of deck	=	1.500m	
Abutment shaft bottom level =	1152.600m	Height (Avg.) of Dirt Wall	=	1.963m	
Foundation level =	1151.400m	Abutment shaft Above G.L	=	5.432m	
HFL	=	1156.933m	Abutment Shaft below G.L	=	2.333m
			Height of abutment shaft	=	7.765m
			MSL	=	1153.400m
			Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z = Zone factor	=	0.36	
I = Importance factor	=	1.2	
R = Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	624.03 3.75
DL Reaction on Bearing No.-2	=	624.03 -3.75
DL Reaction on Bearing No.-3	=	0.00 0.00
DL Reaction on Bearing No.-4	=	0.00 0.00
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		1248.06 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	120.000 3.75
SIDL Reaction on Bearing No.-2	=	120.000 -3.75
SIDL Reaction on Bearing No.-3	=	0.000 0.00
SIDL Reaction on Bearing No.-4	=	0.000 0.00
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		240.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	164.450 3.75
SIDL Reaction on Bearing No.-2	=	164.450 -3.75
SIDL Reaction on Bearing No.-3	=	0.000 0.00
SIDL Reaction on Bearing No.-4	=	0.000 0.00
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		328.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 2-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1110.64	KN	Corr. Transv	=	1055.109 kNm	ecc.	0.95
min	=	239.36	KN	Corr. Transv	=	227.391 kNm	ecc.	0.95

SV Loading

max	=	1890.94	KN	Corr. Transv	=	567.282 kNm	ecc.	0.30
min	=	1709.06	KN	Corr. Transv	=	512.718 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	843.25	KN	Corr. Transv	=	2660.446 kNm	ecc.	3.16
min	=	156.75	KN	Corr. Transv	=	494.554 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.065
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.065
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.500 x	0.800 x	0.800 =	0.3200 m ³	3.750
Pedestal 2	=	0.500 x	0.800 x	0.800 =	0.3200 m ³	-3.750
Pedestal 3	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 4	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					0.6400 m ³	0.000

VOLUME CALCULATION

C.G. Of Footing	=	5.250 m
C.G. Of shaft from toe tip	=	4.400 m
Distance between c.g. of shaft and footing	=	0.850 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	2.085	7.819	-0.825	0.025	-5.225	0.000
-Trapering portion	1	12.50	0.300	-0.122	-0.457	-0.825	0.025	-5.225	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.125	-0.275	-5.525	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-1.075	-0.225	-5.475	0.000
Cap (uniform portion)	1	12.50	1.750	0.300	6.563	-0.100	0.750	-4.500	0.000
Cap (Corbel Portion)	1	12.50	1.750	0.300	5.091	-0.100	0.750	-4.500	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.044	3.432	44.796	0.078	0.928	-4.322	0.000
Shaft below HFL	1	12.50	1.144	3.833	54.821	0.027	0.877	-4.373	0.000
Solid Return Wall	2	5.50	0.750	10.750	88.688	-3.350	-2.500	-7.750	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.500	0.000	0.000	-0.600	0.250	-5.000	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.750	0.000	0.000	-0.600	0.250	-5.000	0.000
Footing									
Heel Slab	1	12.50	5.500	0.850	58.438		-2.123	-7.373	0.000
Toe Slab	1	12.50	3.800	0.850	40.375		3.089	-2.161	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		0.850	-4.400	0.000
Back filling above HFL over Heel Slab	1	12.50	5.500	6.067	417.106		-2.500	-7.750	0.000
Back filling below HFL over Heel Slab	1	12.50	5.500	4.683	321.956		-2.569	-7.819	0.000
Backfill above Heel slab	1	12.50	5.500	10.678	734.121		-2.530	-7.780	0.000
Front Filling over Toe Slab	1	12.50	3.800	2.683	127.442		3.267	-1.983	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.800	1.150	54.625		2.307	-2.943	0.000
Side filling between heel and toe	1	0.00	1.200	2.683	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.125	-0.275	-5.525	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.088	6.067	6.704		0.330	-4.920	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.112	4.683	6.533		0.287	-4.963	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN		-0.825	0.025	-5.225

SECTIONAL PROPERTIES

Width of Footing (B)	=	10.500 m						
Length of Footing (L)	=	12.500 m						
A	=	10.500	x	12.500	=	131.250 m ²		
ZL	=	12.500	x	18.375	=	229.688 m ³		
ZT	=	IT1	+	IT2				
		distance of extreme point from centre						
IT1	=	10.500	x	162.760	=	1708.98 m ⁴		
IT2 (moment of inertia of triangle)	=	10.500	x	0.000	+	0.500 x 10.500 x	0.000 x	39.063
from centre of footing	=	0.000	m ⁴					
Moment of inertia of two triangle	=	0.000	m ⁴					
Total moment of inertia	=	1708.98	m ⁴					
Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250 m		
Total Section modulus (ZT)	=	273.438	m ³					

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Servicibility Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 10.065 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 11.422 m

Abutment Cap Top Level - Foundation Level

= 9.565 m

Dimensions of Abutment Shaft

Length = 12.50 m
Width = 1.10 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.040 m^4
Moment of Inertia , $I_{\text{transverse}}$ = 179.036 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 106.798 KN
D = 1816.96 KN
T = 0.2609 sec

Transverse Direction

Force = 15358.162 KN
D = 2086.961 KN
T = 0.0233 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.350

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.350

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.350

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.350

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.292

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.292	In Transverse direction
Av	=	0.194	In Vertical direction

For Design of Foundation

(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

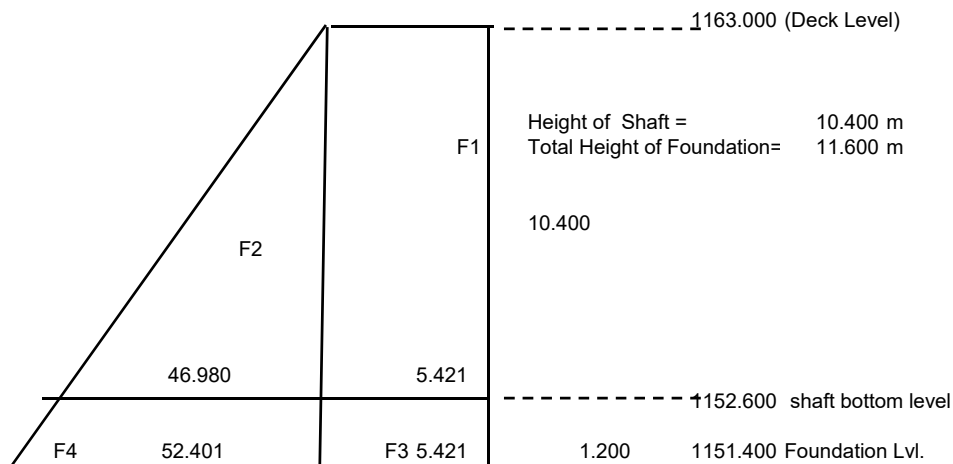
Ah	=	0.243	In Longitudinal direction
Ah	=	0.292	In Transverse direction
Av	=	0.194	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m

Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL					1152.600 m (at Shaft Base)			
@ RL					1151.400 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421 kN/m^2
F1	=	5.421	x	10.400	x	12.500	=	704.705 kN
M1	=	704.70	x	5.20	=	3664.465 kN.m	at Shaft Bottom	
F3	=	5.421	x	11.600	x	12.500	=	786.017 kN
M3	=	786.017	x	5.800	=	4558.899 kN.m	at Foundation	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
	=	0.226	x	20	x	10.400	= 46.980 kN/m ²
F2	=	0.5	x	46.98	x	10.400	x 12.50
	=	3053.721 kN					

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)

M2	=	3053.72	x	4.37	=	13338.654 kN.m	at Shaft Bottom

Intensity for triangular portion (At Foundation level)							
	=	0.226	x	20	x	11.600	= 52.401 kN/m ²
F4	=	0.5	x	52.40	x	11.600	x 12.50
	=	3799.082 kN					
M4	=	3799.08	x	4.87	=	18509.128 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014	γ fluid	=	4.8 kN/m ³

Intensity for triangular portion (At Shaft bottom level)							
	=	4.800	x	10.400	=	49.920 kN/m ²	

$$F = 0.5 \times 49.920 \times 10.400 \times 12.500 = 3244.800 \text{ kN}$$

$$M = 3244.80 \times 3.467 = 11248.640 \text{ kN.m at Shaft Bottom}$$

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 11.600 = 55.68 \text{ kN/m}^2$$

$$F = 0.5 \times 55.680 \times 11.60 \times 12.500 = 4036.800 \text{ kN}$$

$$M = 4036.80 \times 3.867 = 15608.960 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 5.249 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

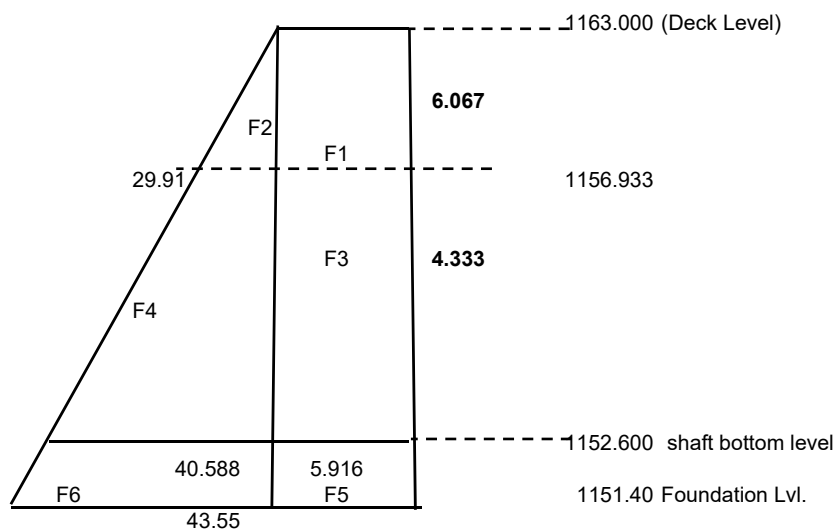
$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	13338.654	18509.128	3053.721	3799.082
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	13338.654	18509.128	3244.800	4036.800
Due to Live Load Surcharge	3664.465	4558.899	704.705	786.017
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1152.6 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	10.400	x	12.500	=	769.018 kN
M1	=	769.02	x	5.20	=	3998.896 kN.m		at Shaft Bottom
F3	=	5.916	x	11.600	x	12.500	=	857.751 kN
M3	=	857.75	x	5.80	=	4974.958 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	6.067	=	29.908 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	4.333	=	10.680 kN/m ²
F2	=	0.5	x	29.91	x	6.067	x	12.50
	=	1134.071 kN						
F4	=	$\left(\frac{29.91 + 40.59}{2} \right) \times$				4.33	x	12.50
	=	1909.115 kN						
Total Force	=	3043.186 kN						
M2	=	1134.07	x	6.88	=	7803.699 kN.m		
M4	=	1909.11	x	2.06	=	3927.227 kN.m		

Total Moment = 11730.93 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 6.067 = 29.908 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.533 = 13.638 \text{ kN/m}^2$$

$$F2 = 0.5 \times 29.91 \times 6.067 \times 12.50 = 1134.071 \text{ kN}$$

$$F6 = \left(\frac{29.91 + 43.55}{2} \right) \times 5.53 \times 12.50 = 2540.117 \text{ kN}$$

Total Force = 3674.187 kN

$$M2 = 1134.07 \times 8.08 = 9164.584 \text{ kN.m}$$

$$M6 = 2540.12 \times 2.60 = 6592.329 \text{ kN.m}$$

Total Moment = 15756.91 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	11730.926	15756.914	3043.186	3674.187
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	11730.926	15756.914	3244.800	4036.800
Due to Live Load Surcharge	3998.896	4974.958	769.018	857.751
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

$$\begin{aligned} \alpha h &= 0.180 \\ \alpha v &= 0.194 \\ \phi &= 35.00 & 0.611 \\ \delta &= 22.50 & 0.393 \\ \alpha &= 0.00 & 0.000 \\ \beta &= 0.00 & 0.000 \end{aligned}$$

$$\begin{aligned} \alpha h &= \text{HORIZONTAL SEISMIC COEFFICIENT} \\ \alpha v &= \text{VERTICAL SEISMIC COEFFICIENT} \\ \phi &= \text{ANGLE OF INTERNAL FRICTION OF SOIL} \\ \delta &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL} \\ \alpha &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,} \\ \beta &= \text{SLOPE OF EARTH FILL} \end{aligned}$$

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.150 \\ 0.220 \end{matrix}$$

$$C_a = \begin{matrix} 1 & 2 \\ 0.378 & 0.301 \end{matrix}$$

$$C_a = 0.378$$

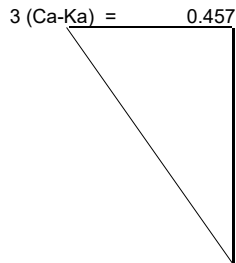
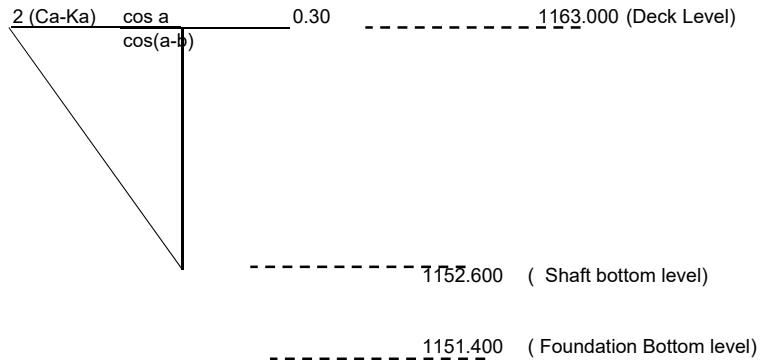
$$K_a = 0.226$$

$$\text{Dynamic Increment} = 0.378 \quad -0.226 \quad 0.152$$

3 Earth Pressure : DRY CASE (Seismic case)

$$\text{Equivalent Live Load Surcharge height} = 1.2 \text{ m}$$

$$\begin{aligned} \text{Assuming } \gamma_{\text{dry}} &= 20 \text{ kN/m}^3 \\ \gamma_{\text{water}} &= 10.00 \text{ kN/m}^3 \end{aligned}$$

Active Earth Pressure**Surcharge Earth Pressure****Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

$$= 0.305 \quad \times \quad 20.00 \quad \times \quad 1.2 \quad = \quad 7.312 \text{ kN/m}^2$$

at Shaft Bottom Level

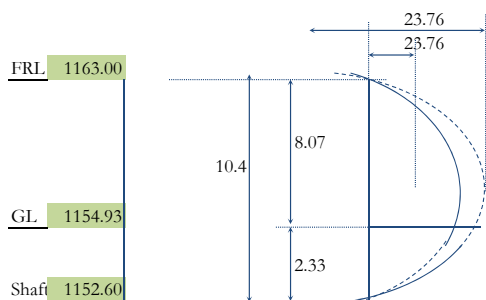
$$\begin{aligned} E1 &= 0.50 \times 7.312 \times 10.400 = 12.500 \\ &= 475.290 \text{ kN} \end{aligned}$$

$$M1 = 475.290 \times 6.968 = 3311.818 \text{ kN.m}$$

at Foundation Bottom Level

$$\begin{aligned} E2 &= 0.50 \times 7.312 \times 10.400 = 12.500 \\ &= 475.290 \text{ kN} \end{aligned}$$

$$M2 = 475.290 \times 8.168 = 3882.166 \text{ kN.m}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p _{mid_height}	=	23.76 t/m ²
h	=	10.4 m
y	=	2.867 m
L	=	12.500 m

Parabola below Water Level

p _{mid_height}	=	23.76 t/m ²
h	=	10.4 m
y	=	-2.867 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa T	cy m
Parabola above Water Level	1795.2	5.7
Parabola below Water Level	264.4	1.5
Total Dynamic Earth Pressure	2059.6	5.2

$$E3 = 2059.588 \text{ kN}$$

$$E4 = 2059.588 \text{ kN}$$

$$M3 = 2059.59 \times 5.20 = 10709.860 \text{ kN.m} \quad (\text{ Shaft bottom level})$$

$$M4 = 2059.59 \times 6.40 = 13181.366 \text{ kN.m} \quad (\text{ Foundation Bottom level})$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	13338.654	18509.128	3053.721	3799.082
Due to active Earth Pressure (dynamic Increment)	10709.860	13181.366	2059.588	2059.588
Total Earth Pressure	24048.514	31690.495	5113.310	5858.671
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	13338.654	31690.495	5113.310	5858.671
Due to Live Load Surcharge (Static)	3664.465	4558.899	704.705	786.017
Due to Live Load Surcharge(Dynamic)	3311.818	3882.166	475.290	475.290
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

αh	=	0.180			
αv	=	0.194			
ϕ	=	35.00		0.611	
δ	=	11.25		0.196	
α	=	0.00		0.000	
β	=	0.00		0.000	
W_s	=	20.00	Kn/m3	2.00	gm/cm3
λ	=	$\tan^{-1} \frac{W_s}{W_s - 1}$		$\frac{\alpha h}{(1 \pm \alpha v)}$	=
					0.293
					0.420
C_a'	=	0.551		0.515	
Ca'	=			0.551	
Ka'	=			0.246	
Dynamic Increment	=			0.551	-0.246
					0.305
Dynamic Increment	=				0.305
γ_d	=				20 kN/m ³
γ_{sat}	=				10 kN/m ³
γ_{water}	=				10 kN/m ³
Equivalent Live Load Surcharge height	=				1.2 m
Foundation	=				10.50 m
Dynamic Active earth pressure Variation					
$3 (ca' - ka')$					
Dynamic Surcharge earth pressure Variation					
$2 (Ca' - Ka')$					
$\cos a$					
$\cos(a-b)$					
					1163.000 (Deck Level)
					6.067
					1156.933 HFL
					5.533
					4.333
					1152.600 shaft bottom level
					1151.4 Foundation Bottom Lvl.

Earth Pressure Diagram

h'	=	4.333
h	=	10.400

Dynamic active earth pressure

$3 (ca - ka)$	=	0.457 at deck level
$3 (ca' - ka')$	=	0.915 at deck level
$3 (ca' - ka')h'/h$	=	0.381 at HFL level

Dynamic Surcharge earth pressure

$2 (Ca' - Ka')$	$\frac{\cos a}{\cos(a-b)}$	=	0.610 at deck level	Pressure	=	14.63 kN/m ²
		=	0.254 at HFL level	Pressure	=	6.10 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.312 kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	6.10 kN/m ²

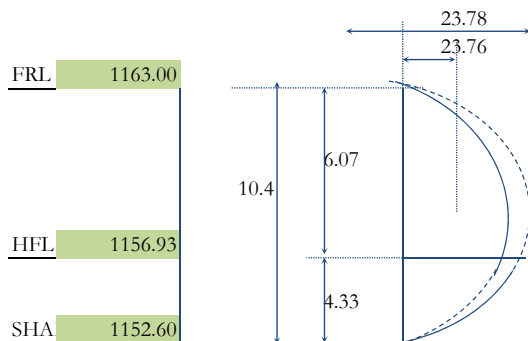
at Shaft Bottom Level

F1	=	6.705	x	6.067	x	12.500	=	508.473 kN
M1	=	508.47	x	7.37	=	3745.667 kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 6.097 \times 4.333 \times 12.500 \\
 &= \mathbf{165.125 \text{ kN}} \\
 M2 &= 165.13 \times 2.90 = \mathbf{479.376 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 673.598 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 4225.043 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 6.705 \times 6.067 \times 12.500 = \mathbf{508.473 \text{ kN}} \\
 M3 &= 508.47 \times 8.57 = \mathbf{4355.835 \text{ kN.m}} \\
 F4 &= 0.500 \times 6.097 \times 4.333 \times 12.500 \\
 &= \mathbf{165.125 \text{ kN}} \\
 M4 &= 165.13 \times 4.10 = \mathbf{677.526 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 673.598 \text{ kN} \\
 \text{Total Moment at Founding level} &= 5033.361 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 23.76 \text{ t/m}^2 \\
 h &= 10.4 \text{ m} \\
 y &= 0.867 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 23.78 \text{ t/m}^2 \\
 h &= 10.4 \text{ m} \\
 y &= -0.867 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1285.0	6.7
Parabola below Water Level	775.2	2.7
Total Dynamic Earth Pressure	2060.1	5.2

Total Force (F1 + F2)	=	2060.149 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	2060.149 kN	at Foundation Bottom Level

$$M1 = 2060.15 \times 5.20 = \mathbf{10711.400 \text{ kN.m}}$$

Total Mome = 10711.400 kN.m at Shaft Bottom

$$M1 = 2060.15 \times 6.40 = \mathbf{13183.579 \text{ kN.m}}$$

Total Mome = 13183.579 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	11730.926	15756.914	3043.186	3674.187
Due to active Earth Pressure (Dynamic Increment)	10711.400	13183.579	2060.149	2060.149
Total Earth Pressure	22442.327	28940.492	5103.334	5734.336
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	22442.327	28940.492	5103.334	5734.336
Due to Live Load Surcharge(Static)	3998.896	4974.958	769.018	857.751
Due to Live Load Surcharge (Dynamic Increment)	4225.043	5033.361	673.598	673.598
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1248.06	1.35	1.35	1684.88	1684.88	
SIDL except wc	=	240.00	1.35	1.35	324.00	324.00	
WC	=	328.90	1.75	1.75	575.58	575.58	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1110.64	1.5	0.20	1665.96	222.13	(1-70RW + 2-CLASS A)
CWLLmax-Reaction case	=	1890.94	1	0.20	1890.94	378.19	SV Loading
CWLLmin	=	239.36	1.5	0.20	359.04	47.87	(1-70RW + 2-CLASS A)
CWLLmin	=	1709.06	1	0.20	1709.06	341.81	SV Loading
CWLLmax-Transv. Moment Case		843.25	1.5	0.20	1264.87	168.65	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2584.46	0	129.223	129.223	-129.223	129.223	
DL+SIDL+LL-Max Reaction case	2943.50	341.55	147.175	317.950	194.375	317.950	(1-70RW + 2-CLASS A)
	4652.56	0	232.628	232.628	-232.628	232.628	SV Loading
DL+SIDL+LL-Min Reaction case	4250.42	341.55	212.521	383.296	129.029	383.296	(1-70RW + 2-CLASS A)
	4475.40	0	223.770	223.770	-223.770	223.770	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3849.33	341.55	192.466	363.241	149.084	363.241	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	2584.46	981.16	129.223	619.802	851.936	981.159	
DL+SIDL+LL-Max Reaction case		2632.33	1026.70	131.616	644.966	895.082	1026.699	Dry Case
DL+SIDL+LL-Min Reaction case		2806.59	1026.70	140.329	653.679	886.370	1026.699	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2753.11	1026.70	137.655	651.005	889.043	1026.699	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	2584.46	294.348	129.223	276.397	165.125	294.348	
DL+SIDL+LL-Max Reaction case		2632.33	339.888	131.616	301.560	208.271	339.888	Dry Case

DL+SIDL+LL-Min Reaction case		2806.59	339.888	140.329	310.273	199.558	339.888	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2753.11	339.888	137.655	307.599	202.232	339.888	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1248.06	1.35	1.35	1684.88	1684.88
SIDL except wc	=	240.00	1.35	1.35	324.00	324.00
WC	=	328.90	1.75	1.75	575.58	575.58
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	1110.64	1.5	0.75	1665.96	832.98
CWLLmax-Transv. Moment Case	=	843.25	1.5	0.75	1264.87	632.44
CWLLmin	=	239.36	1.5	0.75	359.04	179.52

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2584.46	0.000	129.223	129.223	-129.223	129.223	
DL+SIDL+LL-Max Reaction case	2943.50	341.550	147.175	317.950	194.375	317.950	(1-70RW + 2-CLASS A)
	4652.56	0.000	232.628	232.628	-232.628	232.628	SV Loading
DL+SIDL+LL-Min Reaction case	4250.42	341.550	212.521	383.296	129.029	383.296	(1-70RW + 2-CLASS A)
	4475.40	0.000	223.770	223.770	-223.770	223.770	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3849.33	341.550	192.466	363.241	149.084	363.241	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	2584.46	1324.56	129.223	791.505	1195.342	1324.564	
DL+SIDL+LL-Max Reaction case		2763.98	1370.10	138.199	823.251	1231.906	1370.104	Dry Case
DL+SIDL+LL-Min Reaction case		3417.44	1370.10	170.872	855.924	1199.232	1370.104	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3216.89	1370.10	160.845	845.897	1209.260	1370.104	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	2584.46	397.369	129.223	327.908	268.146	397.369	
DL+SIDL+LL-Max Reaction case		2763.98	442.909	138.199	359.653	304.710	442.909	Dry Case

DL+SIDL+LL-Min Reaction case		3417.44	442.909	170.872	392.327	272.037	442.909	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3216.89	442.909	160.845	382.299	282.065	442.909	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1248.06	1	1.00	1248.06	1248.06
SIDL except wc	=	240.00	1	1.00	240.00	240.00
WC	=	328.90	1	1.00	328.90	328.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	1110.64	1	0.20	1110.64	222.13
CWLLmax-Transv. Moment Case		843.25	1	0.20	843.25	168.65
CWLLmin	=	239.36	1	0.20	239.36	47.87

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	0.000	90.848	90.848	-90.848	90.848	
DL+SIDL+LL-Max Reaction case	2056.32	227.700	102.816	216.666	124.884	216.666	(1-70RW + 2-CLASS A)
	3526.02	0.000	176.301	176.301	-176.301	176.301	SV Loading
DL+SIDL+LL-Min Reaction case	2927.60	227.700	146.380	260.230	81.320	260.230	(1-70RW + 2-CLASS A)
	3707.90	0.000	185.395	185.395	-185.395	185.395	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2660.21	227.700	133.010	246.860	94.690	246.860	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	883.043	90.848	532.369	792.195	883.043	
DL+SIDL+LL-Max Reaction case	1864.83	928.583	93.242	557.533	835.341	928.583	Dry Case
DL+SIDL+LL-Min Reaction case	2039.09	928.583	101.954	566.246	826.628	928.583	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1985.61	928.583	99.281	563.572	829.302	928.583	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	264.913	90.848	223.304	174.065	264.913	
DL+SIDL+LL-Max Reaction case	1864.83	310.453	93.242	248.468	217.211	310.453	Dry Case
DL+SIDL+LL-Min Reaction case	2039.09	310.453	101.954	257.181	208.498	310.453	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1985.61	310.453	99.281	254.507	211.172	310.453	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1248.06	1.1	1.10	1372.87	1372.87
SIDL except wc	=	240.00	1.1	1.10	264.00	264.00
WC	=	328.90	1.35	1.35	444.02	444.02
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1110.64	1.5	0.00	1665.96	0.00
CWLLmax- Transv. Moment Case		843.25	1.5	0.00	1264.87	0.00
CWLLmin	=	239.36	1.5	0.00	359.04	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2080.88	0.000	104.044	104.044	-104.044	104.044	
DL+SIDL+LL-Max Reaction case	2439.92	341.550	121.996	292.771	219.554	292.771	(1-70RW + 2-CLASS A)
	3789.94	0.000	189.497	189.497	-189.497	189.497	SV Loading
DL+SIDL+LL-Min Reaction case	3746.84	341.550	187.342	358.117	154.208	358.117	(1-70RW + 2-CLASS A)
	3971.82	0.000	198.591	198.591	-198.591	198.591	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3345.75	341.550	167.288	338.063	174.262	338.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	2080.88	1324.56	104.044	766.326	1220.520	1324.564	
DL+SIDL+LL-Max Reaction case		2080.88	1324.56	104.044	766.326	1220.520	1324.564	Dry Case
DL+SIDL+LL-Min Reaction case		2080.88	1324.56	104.044	766.326	1220.520	1324.564	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2080.88	1324.56	104.044	766.326	1220.520	1324.564	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1816.96	2080.88	397.369	104.044	302.729	293.325	397.369	
DL+SIDL+LL-Max Reaction case		2080.88	397.369	104.044	302.729	293.325	397.369	Dry Case
DL+SIDL+LL-Min Reaction case		2080.88	397.369	104.044	302.729	293.325	397.369	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2080.88	397.369	104.044	302.729	293.325	397.369	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1248.06	1	1	1	1248.06	1248.06	1248.06
SIDL except wc	=	240.00	1	1	1	240.00	240.00	240.00
WC	=	328.90	1.20	1.20	1.20	394.68	394.68	394.68
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	1110.64	1	0.75	0	1110.64	832.98	0.00
CWLLmax- Transv. Moment Case	=	843.25	1	0.75	0	843.25	632.44	0.00
CWLLmin	=	239.36	1	0.75	0	239.36	179.52	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1882.74	0.000	94.137	94.137	-94.137	94.137	
DL+SIDL+LL-Max Reaction case	2122.10	227.700	106.105	219.955	121.595	219.955	(1-70RW + 2-CLASS A)
	3591.80	0.000	179.590	179.590	-179.590	179.590	SV Loading
DL+SIDL+LL-Min Reaction case	2993.38	227.700	149.669	263.519	78.031	263.519	(1-70RW + 2-CLASS A)
	3773.68	0.000	188.684	188.684	-188.684	188.684	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2725.99	227.700	136.299	250.149	91.401	250.149	

Dry Case

HFL Case

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1882.74	0.000	94.137	94.137	-94.137	94.137	
DL+SIDL+LL-Max Reaction case	2062.26	170.775	103.113	188.501	67.662	188.501	Dry Case
DL+SIDL+LL-Min Reaction case	2715.72	170.775	135.786	221.174	34.989	221.174	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2515.18	170.775	125.759	211.146	45.016	211.146	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1882.74	0.000	94.137	94.137	-94.137	94.137	
DL+SIDL+LL-Max Reaction case	1882.74	0.000	94.137	94.137	-94.137	94.137	Dry Case
DL+SIDL+LL-Min Reaction case	1882.74	0.000	94.137	94.137	-94.137	94.137	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1882.74	0.000	94.137	94.137	-94.137	94.137	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	0.00	kmph	0.00	kmph
Live Load	W	=	1110.64	kN	1110.64	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1151.400 m

Properties of Footing Base:

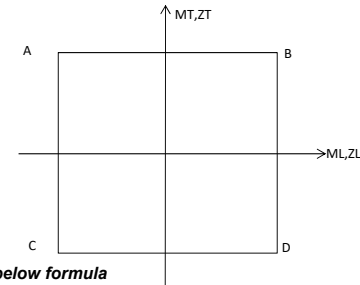
A	=	131.250	m ²
ZL	=	229.688	m ³
ZT	=	273.438	m ³

For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1248.061	0.850	1060.852	0.000	0.000
SIDL except Wearing Course	1			240.000	0.850	204.000	0.000	0.000
Wearing Course	1			328.900	0.850	279.565	0.000	0.000
Bearing Pedestal	1	25	0.640	16.000	0.850	13.600	0.000	0.000
				1832.961		1558.017		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	7.819	195.469	0.025	4.887	0.000	0.000
Dirt Wall-Tapered portion	1	25	-0.457	-11.426	0.025	-0.286	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.275	-7.734	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	-0.225	-3.164	0.000	0.000
Cap - (uniform portion)	1	25	6.563	164.063	0.750	123.047	0.000	0.000
Cap - (corbel portion)	1	25	5.091	127.277	0.750	95.458	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.250	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.250	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.025	0.700	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.275	-45.117	0.000	0.000
				709.633		167.790		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	88.688	2217.188	-2.500	-5542.969	0.000	0.000
Abutment Shaft	1	25	99.618	2490.438	0.877	2185.228	0.000	0.000
Back filling over heel slab	1	20	734.121	14682.422	-2.530	-37147.201	0.000	0.000
Front Filling over toe slab	1	20	127.442	2548.850	3.267	8328.064	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	58.438	1460.938	-2.123	-3100.911	0.000	0.000
Toe slab	1	25	40.375	1009.375	3.089	3118.177	0.000	0.000
portion between heel & toe	1	25	18.000	450.000	0.850	382.500	0.000	0.000
Vertical Components of active earth pressure	1			1672.097	-5.250	-8778.511	0.000	0.000
				26796.042		-40473.926		0.000
Total				29338.636		-38748.119		0.000

**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1123.255	-4.400	-4942.320
0.900	216.000	-4.400	-950.400
1.000	328.900	-4.400	-1447.160
0.900	14.400	-4.400	-63.360
	1682.555		-7403.240
0.900	175.922	-5.225	-919.192
0.900	-10.283	-5.225	53.730
0.900	25.313	-5.525	-139.852
0.900	12.656	-5.475	-69.293
0.900	147.656	-4.500	-664.453
0.900	114.550	-4.500	-515.473
0.900	0.000	-5.000	0.000
0.900	0.000	-5.000	0.000
0.900	25.200	-5.225	-131.670
0.900	147.656	-5.525	-815.801
	638.670		-3202.004
0.900	1995.469	-7.750	-15464.883
0.900	2241.394	-4.373	-9800.613
0.900	13214.180	-7.780	-102806.924
0.900	2293.965	-1.983	-4548.058
0.900	0.000	0.000	0.000
0.900	1314.844	-7.373	-9693.750
0.900	908.438	-2.161	-1962.938
0.900	405.000	-4.400	-1782.000
0.900	1504.888	-10.500	-15801.320
	24116.438		-163032.735
	26437.662		-173637.980

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	90.848	1161.015	873.504
due to Earth pressure	1	4036.800		18509.128

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		104.044	1161.015	1000.384
due to Earth pressure	1.5	6055.200		27763.693
		6159.244		28764.076

Summary of Forces For SBC

P	29338.636	kN
ML	-19365.487	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		29338.636		-38748.119		0.000
CWLL-Max. Reaction case	1	1110.641	0.850	944.045	0.950	1055.109
Vertical Components of LL Surcharge	1	325.579	-5.250	-1709.289	0.000	0.000
Total		30774.855		-39513.364		1055.109

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	216.666	1161.015	2083.244
due to Earth pressure	1	4036.800		18509.128
due to Live load surcharge	1	786.017		4558.899

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		292.771	1161.015	2814.993
due to Earth pressure	1.5	6055.200		27763.693
due to Live load surcharge	1.2	943.220		5470.678
		7291.191		36049.364

Summary of Forces For SBC

P	30774.855	kN
ML	-14362.093	kNm
MT	1055.109	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
90.85	873.50	0.00	0.00
4036.80	18509.13	0.00	0.00
4127.648	19382.632	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
104.04	1000.38	0.00	0.00
6055.20	27763.69	0.00	0.00
6159.244	28764.076	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	26437.66217		-173637.98
0.000		-4.400	0.00
0.900		-10.500	-3076.72
	26437.662		-176714.70

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
216.67	2083.24	0.00	0.00
4036.80	18509.13	0.00	0.00
786.017	4558.899	0.000	0.000
5039.48	25151.27	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
292.77	2814.99	0.00	0.00
6055.20	27763.69	0.00	0.00
943.22	5470.68	0.00	0.00
7291.191	36049.364	0.000	0.000

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1832.961		1558.017		0.000
Substructure & Foundation -Portion 1				709.633		167.790		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	88.688	2217.188	-2.500	-5542.969	0.000	0.000
Shaft above HFL	1	25	44.796	1119.903	0.928	1038.809	0.000	0.000
Shaft below HFL	1	15	54.821	822.321	0.877	721.543	0.000	0.000
Back filling above HFL over heel slab	1	20	417.106	8342.125	-2.500	-20855.313	0.000	0.000
Back filling below HFL over heel slab	1	10	321.956	3219.562	-2.569	-8269.479	0.000	0.000
Front Filling over toe slab	1	10	127.442	1274.425	2.307	2940.412	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	58.438	876.563	-2.123	-1860.547	0.000	0.000
Toe slab	1	15	40.375	605.625	3.089	1870.906	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	0.850	229.500	0.000	0.000
Vertical Components of active earth pressure	1			1672.097	-5.250	-8778.511	0.000	0.000
				20619.214		-38442.640		0.000
Total				23161.808		-36716.833		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1682.555		-7403.240
	638.670		-3202.004
0.900	1995.469	-7.750	-15464.883
0.900	1007.912	-4.322	-4356.612
0.900	740.089	-4.373	-3236.078
0.900	7507.913	-7.750	-58186.322
0.900	2897.606	-7.819	-22654.964
0.900	1146.982	-2.943	-3375.287
0.900	0.000	0.000	0.000
0.900	788.906	-7.373	-5816.250
0.900	545.063	-2.161	-1177.763
0.900	243.000	-4.400	-1069.200
0.900	1504.888	-10.500	-15801.320
	18557.293		-132024.162
	20878.517		-142629.406

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	90.848	1161.015	873.504
due to Earth pressure	1	4036.800		15756.914

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
90.85	873.50	0.00	0.00
4036.80	15756.91	0.00	0.00
4127.65	16630.42	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		104.044	1161.015	1000.384
due to Earth pressure	1.5	6055.200		23635.370
		6159.244		24635.754

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
104.04	1000.38	0.00	0.00
6055.20	23635.37	0.00	0.00
6159.24	24635.75	0.00	0.00

Summary of Forces For SBC

P	23161.808	kN
ML	-20086.416	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		23161.808		-36716.833		0.000
CWLL-Min. Reaction case	1	239.359	0.850	203.455	0.950	227.391
Vertical Components of LL Surcharge	1	355.292	-5.250	-1865.284	0.000	0.000
Total		23756.459		-38378.662		227.391

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	20878.517		-142629.406
0.000	0.000	-4.400	0
0.900	319.763	-10.500	-3357.511
	21198.280		-145986.918

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.230	1161.015	2502.112
due to Earth pressure	1	4036.800		15756.914
due to Live load surcharge	1	857.751		4974.958

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
260.23	2502.11	0.00	0.00
4036.80	15756.91	0.00	0.00
857.751	4974.958	0.000	0.000
5154.78	23233.98	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		358.117	1161.015	3443.296
due to Earth pressure	1.5	6055.200		23635.370
due to live load surcharge	1.2	1029.302		5969.949
		7442.619		33048.616

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
358.12	3443.30	0.00	0.00
6055.20	23635.37	0.00	0.00
1029.302	5969.949	0.000	0.000
7442.62	33048.62	0.00	0.00

Summary of Forces For SBC

P	23756.459	kN
ML	-15144.679	kNm
MT	227.391	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

ah= 0.243 In Longitudinal direction
ah= 0.292 In Transverse direction
av= 0.194 In Vertical direction

Weight of shaft below Ground level

= 799.751 kN

Weight of back fill below Ground level

= 3207.875 kN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1248.061		109.157	72.771	0.850	1060.852	61.856	1162.295		0.000	0.000	1189.265
SIDL except Wearing Course	1			240.000		20.991	13.994	0.850	204.000	11.895	1163.449		0.000	0.000	252.915
Wearing Course	1			328.900		28.766	19.177	0.850	279.565	16.301	1163.000		0.000	0.000	333.686
Bearing Pedestal	1	25	0.640	16.000		1.399	0.933	0.850	13.600	0.793			0.000	0.000	
				1832.961		160.313	106.875		1558.017	90.844				0.000	1775.866
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	7.819	195.469	47.499	17.096	11.397	0.025	4.887	0.285	1161.958	501.470	0.000	0.000	180.490
Dirt Wall-Tapered portion	1	25	-0.457	-11.426	-2.776	-0.999	-0.666	0.025	-0.286	-0.017	1160.976	-26.587	0.000	0.000	-9.569
Bracket - Uniform portion	1	25	1.125	28.125				-0.275	-7.734						
Bracket - Tapered portion	1	25	0.563	14.063				-0.225	-3.164						
Cap - (uniform portion)	1	25	6.563	164.063	39.867	14.349	9.566	0.750	123.047	7.175	1160.815	375.350	0.000	0.000	135.097
Cap - (corbel portion)	1	25	5.091	127.277	30.928	11.132	7.421	0.750	95.458	5.566	1160.515	281.912	0.000	0.000	101.467
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	1163.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	1163.000	0.000	0.000	0.000	0.000

RCC Railing or Crash Barrier	1			28.000				0.025	0.700				0.000	0.000	
Approach Slab	1	25	6.563	164.063				-0.275	-45.117				0.000	0.000	
Substructure & Foundation -Portion 2				709.633	115.518	41.578	27.718		167.790	13.009		1132.144		0.000	407.485
Solid Return wall	1	25	88.688	2217.188	538.777	193.918	129.279	-2.500	-5542.969	-323.197	1157.661	3373.246	0.000	0.000	1214.108
Abutment Shaft	1	25	99.618	2490.438	410.837	147.870	98.580	0.877	2185.228	86.498	1157.649	2567.320	0.000	0.000	924.037
Back filling over heel slab	1	20	734.121	14682.422	0.000	0.000	0.000	-2.530	-37147.201	0.000	1157.661	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	127.442	2548.850				3.267	8328.064				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	58.438	1460.938				-2.123	-3100.911				0.000	0.000	
Toe slab	1	25	40.375	1009.375				3.089	3118.177				0.000	0.000	
portion between heel & toe	1	25	18.000	450.000				0.850	382.500				0.000	0.000	
Vertical component of active earth pressure	1			1573.631				-5.250	-8261.565				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			853.109				-5.250	-4478.825				0.000	0.000	
				27550.686	949.613	341.788	227.858		-44435.805	-236.698		5940.566		0.000	2138.145
Total =				30093.279	1065.131	543.678	362.452		-42709.998	-132.845		7072.710		0.000	4321.496
								-362.452		132.845					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.9			1123.255	65.494	-4.400	-4942.320	-288.174
SIDL except Wearing Course	0.9			216.000	12.594	-4.400	-950.400	-55.415
Wearing Course	1.00			328.900	19.177	-4.400	-1447.160	-84.380
Bearing Pedestal	0.9	25	0.64	14.400		-4.400	-63.360	
				1682.555	97.266		-7403.240	-427.970
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	7.819	175.922	10.258	-5.225	-919.192	-53.596
Dirt Wall-Tapered portion	0.9	25	-0.457	-10.283	-0.600	-5.225	53.730	3.133
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	6.563	147.656	8.609	-4.500	-664.453	-38.743
Cap - (corbel portion)	0.9	25	5.091	114.550	6.679	-4.500	-515.473	-30.056
Cantilever Return Wall-Rectangle portion	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
Cantilever Return Wall-Traingle portion	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.225	-131.670	
Approach Slab	0.9	25	6.563	147.656		-5.525	-815.801	
				638.670	24.947		-2992.859	-119.261
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	99.618	2241.394	84.059	-4.373	-9800.613	-367.551
Solid Return wall	0.9	25	88.688	1995.469	116.351	-7.750	-15464.883	-901.719
Back filling over heel slab	0.9	20	734.121	13214.180	0.000	-7.780	-102806.9	0.000
Front Filling over toe	0.9	20	127.442	2293.965		-1.983	-4548.058	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	58.438	1314.844		-7.373	-9693.750	
Toe slab	0.9	25	40.375	908.438		-2.161	-1962.938	
portion between heel & toe	0.9	25	18.000	405.000		-4.400	-1782.000	
Vertical component of active earth pressure	0.9			1504.888		-10.500	-15801.320	
Vertical component of dynamic increment of earth pressure	0.9			767.799		-10.500	-8061.885	
				24884.236	200.409		-171094.62	-1269.269

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	47.499	1161.958	501.470
1.0	-2.776	1160.976	-26.587
1.0	39.867	1160.815	375.350
1.0	30.928	1160.515	281.912
1.0	0.000	1163.000	0.000
1.0	0.000	1163.000	0.000
	115.518		1132.144
1.0	389.244	1157.649	2432.383
1.0	538.777	1157.661	3373.246
1.0	0.000	1157.661	0.000
	928.020		5805.630

Total =				27205.461	322.622		-181490.72	-1816.501		1043.538		6937.774
					-322.622			1816.501				

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	883.043	160.313	1161.015	8490.458	1775.866
due to Substructure	1	1065.131	383.365		7072.710	2545.630
due to Earth pressure	1	5858.671			31690.495	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1324.564	1161.015	12735.69
due to Substructure	1.5	1565.307		10406.66
due to Active Earth pressure	1	3799.082		18509.13
due to dynamic Earth pressure	1.5	3089.383		19772.05
		9778.337		61423.525

Summary of Forces For SBC

	Downward	Upward	
P	30455.731	29730.827	kN
ML	4410.819	4676.510	kNm
MT	4321.496	4321.496	kNm

Summary of Restoring Forces

Vertical Load	26882.839	kN
Moment	-183307.221	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1832.961		160.313	106.875		1558.017	90.844				0.000	1775.866
Forces from Substructure				28260.319	1065.131	383.365	255.577		-44268.015	-223.689		7072.710		0.000	2545.630
CWLL-Max. Reaction case	0.20			222.13		19.428	12.952	0.850	188.809	11.009	1164.200		0.950	211.022	248.673
Vertical component of LL Surcharge	0.20			65.12				-5.250	-341.858				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			39.37				-5.250	-206.715				0.000	0.000	
Total =				30419.897	1065.131	563.106	375.404		-43069.762	-121.836		7072.710		211.022	4570.169
							-375.404			121.836					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1682.555	97.266	0.000	-7403.24	-427.970
Forces from Substructure				25522.906	225.356	0.000	-174087.48	-1388.531
CWLL-Max. Reaction case	0.00			0.00	0.000	-4.400	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-10.500	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.500	0.00	

Total =				27205.461	322.622		-181490.72	-1816.501
					-322.622			1816.501

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	928.583	179.741	1161.015	8928.325	2024.539
due to Substructure	1	1065.131	383.365		7072.710	2545.630
due to Earth pressure	1	5858.671			31690.495	
due to Live load surcharge	0.20	252.261			1688.213	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
928.58	8928.32	0.00	0.00	0.00	0.00	179.74	2024.54
1065.13	7072.71	0.00	0.00	0.00	0.00	383.37	2545.63
5858.67	31690.49						
252.26	1688.21						
8104.65	49379.74	0.00	0.00	0.00	0.00	563.11	4570.17

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1324.564	1161.015	12735.686
due to Substructure	1.5	1565.307		10406.661
due to Active Earth pressure	1	3799.082		18509.128
due to dynamic Earth pressure	1.5	3089.383		19772.0493
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9778.337		61423.525

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1324.56	12735.69	0.00	0.00
1565.31	10406.66	0.00	0.00
3799.082	18509.128		
3089.383	19772.049		
0.000	0.000		
0.000	0.000		
9778.34	61423.53	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	30795.301	30044.494	kN
ML	6188.144	6431.817	kNm
MT	4781.191	4781.191	kNm

Summary of Restoring Forces

Vertical Load	26882.839	kN
Moment	-183307.221	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1832.961		160.313	106.875		1558.017	90.844				0.000	1775.866
Substructure & Foundation -Portion 1				709.633	115.518	41.578	27.718		167.790	13.009		1132.144		0.000	407.485
Substructure & Foundation -Portion 2															
Solid Return wall	1		88.69	2217.19	538.777	193.918	129.279	-2.50	-5542.969	-323.197	1157.66	3373.246	0.00	0.000	1214.108
Shaft above HFL	1	25	44.796	1119.903	272.136	97.948	65.299	0.928	1038.809	60.570	1158.649	1972.716	0.000	0.000	710.026
Shaft below HFL	1	15	54.821	822.321	138.701	49.921	33.281	0.877	721.543	29.202	1155.933	628.729	0.000	0.000	226.294
Back filling above HFL over heel slab	1	20	417.106	8342.125	0.000	0.000	0.000	-2.500	-20855.313	0.000	1159.967	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	321.956	3219.562	0.000	0.000	0.000	-2.569	-8269.479	0.000	1154.467	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	127.442	1274.425				2.307	2940.412				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	58.438	876.563				-2.123	-1860.547				0.000	0.000	
Toe slab	1	15	40.375	605.625				3.089	1870.906				0.000	0.000	
portion between heel & toe	1	15	18.000	270.000				0.850	229.500				0.000	0.000	
Vertical component of active earth pressure	1			1521.898				-5.250	-7989.966				0.000	0.000	

Vertical component of dynamic increment of earth pressure	1			853.342				-5.250	-4480.043				0.000	0.000	
				21322.356	998.069	359.228	239.485		-42197.144	-233.424		6259.549		0.000	2252.954
Total =				23864.950	1113.587	561.118	374.079		-40471.338	-129.571		7391.693		0.000	4436.305
								-374.079		129.571					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1682.555	97.266		-7403.240	-427.970
Substructure & Foundation -Portion 1				638.670	24.947		-2992.859	-119.261
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	88.6875	1995.469	116.351	-7.75	-15464.883	-901.719
Shaft above HFL	0.9	25	44.796	1007.912	58.769	-4.322	-4356.612	-254.023
Shaft below HFL	0.9	15	54.821	740.089	25.290	-4.373	-3236.078	-110.581
Back filling above HFL over heel slab	0.9	20	417.106	7507.913	0.000	-7.750	-58186.322	0.000
Back filling below HFL over heel slab	0.9	10	321.956	2897.606	0.000	-7.819	-22654.964	0.000
Front Filling over toe	0.9	10	127.442	1146.982		-2.943	-3375.287	
Side filling between heel and toe	0.9	10	0.000	0.000		0.000	0.000	
Heel slab	0.9	15	58.438	788.906		-7.373	-5816.250	
Toe slab	0.9	15	40.375	545.063		-2.161	-1177.763	
portion between heel & toe	0.9	15	18.000	243.000		-4.400	-1069.200	
Vertical component of active earth pressure	0.9			1369.708		-10.500	-14381.938	
Vertical component of dynamic increment of earth pressure	0.9			768.007		-10.500	-8064.077	
Total =				19190.121	210.874		-138668.86	-1317.953
				21511.345		333.086	-149064.96	
							-1865.184	

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	115.518		1132.144
1.0	538.777	1157.661	3373.246
1.0	272.136	1158.649	1972.716
1.0	117.107	1155.933	530.847
1.0	0.000	1159.967	0.000
1.0	0.000	1154.467	0.000
Total =	928.020		5876.810
	1043.538		7008.954

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	883.043	160.313	1161.015	8490.458	1775.866
due to Substructure	1	1113.587	400.805		7391.693	2660.439
due to Earth pressure	1	5734.336			28940.492	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1324.564	1161.015	12735.686
due to Substructure	1.5	1565.307		10513.431
due to Active Earth pressure	1	3674.187		15756.914
due to dynamic Earth pressure	1.5	3090.223		19775.368
		9654.282		58781.400

Summary of Forces For SBC

	Downward	Upward	
P	24239.029	23490.871	KN
ML	4221.734	4480.876	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
883.04	8490.46	0.00	0.00	0.00	0.00	160.31	1775.87
1113.59	7391.69	0.00	0.00	0.00	0.00	400.81	2660.44
5734.34	28940.49						
7730.97	44822.64	0.00	0.00	0.00	0.00	561.12	4436.30

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1324.56	12735.69	0.00	0.00
1565.31	10513.43	0.00	0.00
3674.187	15756.914		
3090.223	19775.368		
9654.28	58781.40	0.00	0.00

Summary of Restoring Forces

Vertical Load	21178.259	kN

MT	4436.305	4436.305	kNm

Moment	-150930.142	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure	0.20			1832.961	1113.587	160.313	106.875		1558.017	90.844	1164.200	7391.693		0.000	1775.866
Forces from Substructure			22031.989	400.805		267.204		-42029.354	-220.415				0.000	2660.439	
CWLL-Max. Reaction case			47.87	4.187		2.791	0.850	40.691	2.373				0.950	45.478	53.593
Vertical component of LL Surcharge			71.06			-5.250	-373.057		0.000	0.000					
Vertical component of dynamic increment LL Surcharge			55.80			-5.250	-292.964		0.000	0.000					
Total =				24039.683	1113.587	565.305	376.870		-41096.667	-127.199		7391.693		45.478	4489.897
-376.870 127.199															

MT	14404.985	14404.985	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	30419.897	375.404	-43069.76	-121.836	211.022
		-375.404		121.836	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	310.453	599.135	1161.015	2985.004	6748.464
due to Substructure	1	319.539	1277.884		2121.813	8485.433
due to Earth pressure	1	5858.671			31690.495	
due to Live load surcharge	0.2	252.261			1688.213	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		397.37	1161.015	3820.706
due to Substructure	1.5	469.59		3121.998
due to Active Earth pressure	1	3799.08		18509.128
due to dynamic Earth pressure	1.5	926.81		5931.615
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5592.86		31383.447

Summary of Forces For SBC

	Downward	Upward	
P	30795.301	30044.494	kN
ML	-4706.073	-4462.401	kNm
MT	15444.918	15444.918	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure	1832.961	106.875	1558.017	90.844	0.000
Substructure & Foundation -Portion 1	709.633	27.718	167.790	13.009	0.000
Substructure & Foundation -Portion 2	21322.356	239.485	-42197.144	-233.424	0.000
Total =	23864.950	374.079	-40471.338	-129.571	0.000
		-374.079		129.571	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	27205.461	322.622	-181490.72	-1816.501
		-322.622		1816.501

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
310.45	2985.00	0.00	0.00	0.00	0.00	599.14	6748.46
319.54	2121.81	0.00	0.00	0.00	0.00	1277.88	8485.43
5858.67	31690.49						
252.26	1688.21						
6740.92	38485.52	0.00	0.00	0.00	0.00	1877.02	15233.90

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
397.37	3820.71	0.00	0.00
469.59	3122.00	0.00	0.00
3799.082	18509.128		
926.815	5931.615		
0.000	0.000		
0.000	0.000		
5592.86	31383.45	0.00	0.00

Summary of Restoring Forces

Vertical Load	26882.839	kN
Moment	-183307.221	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure	1682.555	97.266		-7403.240	-427.970
Substructure & Foundation	638.670	24.947		-2992.859	-119.261
Substructure & Foundation	19190.121	210.874		-138668.858	-1317.953
Total =	21511.345	333.086		-149064.958	-1865.184
		-333.086			1865.184

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	264.91	534.38	1161.02	2547.14	5919.55
due to Substructure	1	334.08	1336.02		2217.51	8868.13
due to Earth pressure	1	5734.34			28940.49	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		397.369	1161.015	3820.71
due to Substructure	1.5	469.592		3154.03
due to Active Earth pressure	1	3674.187		15756.91
due to dynamic Earth pressure	1.5	927.067		5932.61
		5468.216		28664.26

Summary of Forces For SBC

	Downward	Upward
P	24239.029	23490.871 kN
ML	-6895.771	-6636.629 kNm
MT	14787.682	14787.682 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL_1$	MLs due to F_v	$MT = P \times eT$
Total =	24039.683	376.870	-41096.67	-127.199	45.478
		-376.870		127.199	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	310.453	548.33319	1161.015	2985.004	6098.19483
due to Substructure	1	334.076	1336.0179		2217.508	8868.12987
due to Earth pressure	1	5734.336			28940.492	
due to Live load surcharge	0.2	306.270			2001.664	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		397.37	1161.015	3820.71
due to Substructure	1.5	469.59		3154.03
due to Active Earth pressure	1	3674.19		15756.91
due to dynamic Earth pressure	1.5	927.07		5932.61
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
264.91	2547.14	0.00	0.00	0.00	0.00	534.38	5919.55
334.08	2217.51	0.00	0.00	0.00	0.00	1336.02	8868.13
5734.34	28940.49						
6333.32	33705.14	0.00	0.00	0.00	0.00	1870.39	14787.68

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
397.37	3820.71	0.00	0.00
469.59	3154.03	0.00	0.00
3674.187	15756.914		
927.067	5932.610		
5468.22	28664.26	0.00	0.00

Summary of Restoring Forces

Vertical Load	21178.259 kN
Moment	-150930.142 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL_2$	MLs due to F_v
Total =	21511.345	333.086		-149069.36	-1865.184
		-333.086			1865.184

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
310.45	2985.00	0.00	0.00	0.00	0.00	548.33	6098.19
334.08	2217.51	0.00	0.00	0.00	0.00	1336.02	8868.13
5734.34	28940.49						
306.27	2001.66						
6685.13	36144.67	0.00	0.00	0.00	0.00	1884.35	14966.32

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
397.37	3820.71	0.00	0.00
469.59	3154.03	0.00	0.00
3674.187	15756.914		
927.067	5932.610		
0.000	0.000		
0.000	0.000		

0.00

Downward Upward

	Downward	Upward	
P	24416.553	23662.813	KN
ML	-5079.198	-4824.801	kNm
MT	15011.803	15011.803	kNm

Centrifugal Force (C.F.)	=	1.00	x	0.00
Transverse Moment due to C.F.	=	0.000	x (	1164.200 -

Centrifugal Force (C.F.)	=	0.20	x	0.00
Transverse Moment due to C.F.	=	0.000	x (	1164.200 -

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

Vertical Load	21178.259	kN
Moment	-150934.542	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

=	0.000 KN	Normal
=	0.000 kNm	

Seismic	0.00	0.00	0.00	0.00

=	0.000 KN	Seismic
=	0.000 kNm	

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force = $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_p$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	29338.636	-19365.487	0.000	307.845	139.220	307.845	139.220	307.845	139.220	6159.244	18506.364	3.00	28764.076	173637.98	6.04
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	30774.855	-14362.093	1055.109	300.863	175.805	293.145	168.088	300.863	168.088	7291.191	18506.364	2.54	36049.364	176714.70	4.90
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	23161.808	-20086.416	0.000	263.922	89.020	263.922	89.020	263.922	89.020	6159.244	14614.962	2.37	24635.754	142629.41	5.79
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	23756.459	-15144.679	227.391	247.769	115.897	246.106	114.234	247.769	114.234	7442.619	14838.796	1.99	33048.616	145986.92	4.42
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	30455.731	4676.510	4321.496	227.488	268.208	195.879	236.600	268.208	195.879	9778.337	18817.987	1.92	61423.525	183307.22	2.98
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	30795.301	6431.817	4781.191	224.114	280.119	189.143	245.148	280.119	189.143	9778.337	18817.987	1.92	61423.525	183307.22	2.98
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	24239.029	4480.876	4436.305	181.394	220.411	148.946	187.963	220.411	148.946	9654.282	14824.781	1.54	58781.400	150930.14	2.57
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	24416.553	6292.705	4535.376	175.221	230.014	142.048	196.841	230.014	142.048	9654.282	14824.781	1.54	58781.400	150934.54	2.57
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	30455.731	-6217.708	14404.985	311.795	257.654	206.433	152.292	311.795	152.292	6688.574	18817.987	2.81	38668.110	183307.22	4.74
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	30795.301	-4462.401	15444.918	310.543	271.687	197.575	158.718	310.543	158.718	5592.858	18817.987	3.36	31383.447	183307.22	5.84
								SAFE	SAFE			SAFE			SAFE

Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	24239.029	-6636.629	14787.682	267.653	209.865	159.492	101.703	267.653	101.703	5468.216	14824.781	2.71	28664.259	150930.14	5.27
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	24416.553	-4824.801	15011.803	261.937	219.925	152.137	110.125	261.937	110.125	5468.216	14824.781	2.71	28664.259	150934.54	5.27
								SAFE	SAFE			SAFE			SAFE

DESIGN OF ABUTMENT(A2) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
82+425

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 0 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 38.800m	38.800m
Thickness of Expansion Joint	= 0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.575m	0.575m
Slab projection Beyond C/L of Bearing (Span Side) =	0.575m	0.575m
Span -c/c of E.J.	= 40.000m	40.00m
Type of Superstructure	= Steel Composite Girder	
Width of Crash barrier (Both Side)	= 0.450m	
Width of Carriageway	= 11.000m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on one side	= 0.000m	
Railing/kerb on footpath edge	= 0.250m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

No of Bearings = 2
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 7.500m (Right) 7.500 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 300 kN/m²
SBC of soil-Normal Case = 359 kN/m² (as per geotechnical report)
SBC of soil-Seismic Case = 448 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1.5 Normal Case
= 1.25 Seismic Case

Permissible FOS against Overturning = 2 Normal Case
= 1.5 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 2.585m	
Height of Trapering portion	= -0.022m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion = 1.750m 1.750m
Width of Abutmentcap at bottom of Tapering Portion = 1.000m 1.000m
Projection of Abutment Cap (Span Side) = 0.325m 0.325m

Projection of Abutment Cap Back Side	=	0.425m	0.425m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.014m	1.014m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.500m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.000m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	10.500m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	1.200m	
Width of Toe Slab	=	3.800m	
Width of Heel Slab	=	5.500m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.200m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.200m	
Width of backfill on heel slab	=	5.500m	
Thickness of heel slab at back fill edge	=	1.200m	
Height of back fill at bottom edge of heel slab	=	11.028m	
Height of back fill at back fill edge of heel slab	=	10.328m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1163.000m	
Deck level at Outer Edge =	1162.856m	
Deck level at center line =	1163.000m	
Soffit Level at center of bridge =	1160.415m	
Abutment cap top level =	1160.365m	
Abutment cap bottom lvl (uniform portion ends)	1160.065m	
Abutment cap bottom lvl (corbel portion ends)	1159.765m	
Abutment shaft top level =	1159.765m	
Ground level/LBL =	1157.269m	
Abutment shaft bottom level =	1152.600m	
Foundation level =	1151.400m	
HFL	=	1159.269m

Cross Slope (Bi-directional)	=	2.500%
Height of Superstructure	=	2.520m
Min. Height of Footpath Side Pedestal (1)	=	0.500m
Height of Pedestal (2)	=	0.500m
Height of Pedestal (3)	=	0.000m
Height of Pedestal (4)	=	0.000m
Height of Pedestal (5)	=	0.000m
Height of Pedestal (6)	=	0.000m
Distance of nearest girder to c.l. of deck	=	1.500m
Height (Avg.) of Dirt Wall	=	2.563m
Abutment shaft Above G.L	=	2.496m
Abutment Shaft below G.L	=	4.669m
Height of abutment shaft	=	7.165m
MSL	=	1153.400m
Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z = Zone factor	=	0.36	
I = Importance factor	=	1.2	
R = Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	867.55 3.75
DL Reaction on Bearing No.-2	=	867.55 -3.75
DL Reaction on Bearing No.-3	=	0.00 0.00
DL Reaction on Bearing No.-4	=	0.00 0.00
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		1735.10 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	160.000 3.75
SIDL Reaction on Bearing No.-2	=	160.000 -3.75
SIDL Reaction on Bearing No.-3	=	0.000 0.00
SIDL Reaction on Bearing No.-4	=	0.000 0.00
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		320.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	220.000 3.75
SIDL Reaction on Bearing No.-2	=	220.000 -3.75
SIDL Reaction on Bearing No.-3	=	0.000 0.00
SIDL Reaction on Bearing No.-4	=	0.000 0.00
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		440.00 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:
(1-70RW + 2-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1175.71	KN	Corr. Transv	=	1779.874 kNm	ecc.	1.51
min	=	222.89	KN	Corr. Transv	=	533.396 kNm	ecc.	2.39

SV Loading

max	=	2331.19	KN	Corr. Transv	=	699.356 kNm	ecc.	0.30
min	=	1268.81	KN	Corr. Transv	=	380.644 kNm	ecc.	0.30

**MAXIMUM TRASVERSE MOMENT CASE:
(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	882.76	KN	Corr. Transv	=	2785.117 kNm	ecc.	3.16
min	=	117.24	KN	Corr. Transv	=	369.883 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.050
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.050
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.500 x	0.800 x	0.800 =	0.3200 m ³	3.750
Pedestal 2	=	0.500 x	0.800 x	0.800 =	0.3200 m ³	-3.750
Pedestal 3	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 4	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					0.6400 m ³	0.000

VOLUME CALCULATION

C.G. Of Footing = 5.250 m
 C.G. Of shaft from toe tip = 4.400 m
 Distance between c.g. of shaft and footing = 0.850 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	2.585	9.694	-0.775	0.075	-5.175	0.000
-Trapering portion	1	12.50	0.300	-0.022	-0.082	-0.775	0.075	-5.175	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.075	-0.225	-5.475	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-1.025	-0.175	-5.425	0.000
Cap (uniform portion)	1	12.50	1.750	0.300	6.563	-0.050	0.800	-4.450	0.000
Cap (Corbel Portion)	1	12.50	1.750	0.300	5.091	-0.050	0.800	-4.450	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.007	0.496	6.243	0.097	0.947	-4.303	0.000
Shaft below HFL	1	12.50	1.107	6.169	85.358	0.045	0.895	-4.355	0.000
Solid Return Wall	2	5.50	0.750	10.750	88.688	-3.350	-2.500	-7.750	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.500	0.000	0.000	-0.600	0.250	-5.000	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.750	0.000	0.000	-0.600	0.250	-5.000	0.000
Footing									
Heel Slab	1	12.50	5.500	0.850	58.438		-2.123	-7.373	0.000
Toe Slab	1	12.50	3.800	0.850	40.375		3.089	-2.161	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		0.850	-4.400	0.000
Back filling above HFL over Heel Slab	1	12.50	5.500	3.731	256.506		-2.500	-7.750	0.000
Back filling below HFL over Heel Slab	1	12.50	5.500	7.019	482.556		-2.546	-7.796	0.000
Backfill above Heel slab	1	12.50	5.500	10.678	734.121		-2.530	-7.780	0.000
Front Filling over Toe Slab	1	12.50	3.800	5.019	238.402		3.306	-1.944	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.800	1.150	54.625		2.307	-2.943	0.000
Side filling between heel and toe	1	0.00	1.200	5.019	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.075	-0.225	-5.475	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.014	3.731	0.646		0.347	-4.903	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.186	7.019	16.333		0.312	-4.938	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN	-0.775	0.075	-5.175

SECTIONAL PROPERTIES

Width of Footing (B) = 10.500 m
 Length of Footing (L) = 12.500 m

A = 10.500 x 12.500 = 131.250 m²
 ZL = 12.500 x 18.375 = 229.688 m³
 ZT = IT1 + IT2

distance of extreme point from centre

IT1 = 10.500 x 162.760 = 1708.98 m⁴
 IT2 (moment of inertia of triangle) = 10.500 x 0.000 + 0.500 x 10.500 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1708.98 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 273.438 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Servicibility Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 9.465 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 11.222 m

Abutment Cap Top Level - Foundation Level

= 8.965 m

Dimensions of Abutment Shaft

Length = 12.50 m
Width = 1.10 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.040 m^4
Moment of Inertia , $I_{\text{transverse}}$ = 179.036 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 129.080 KN
D = 2495.10 KN
T = 0.2781 sec

Transverse Direction

Force = 17482.705 KN
D = 2774.818 KN
T = 0.0252 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.378

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.378

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.378

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.378

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.298

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.298	In Transverse direction
Av	=	0.198	In Vertical direction

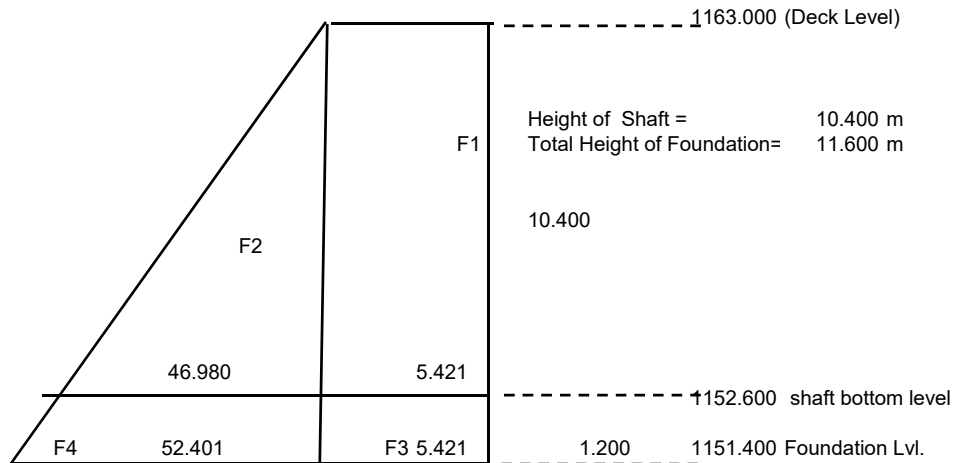
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.298	In Transverse direction
Av	=	0.198	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1152.600 m (at Shaft Base)			
@ RL					1151.400 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421 kN/m^2
F1	=	5.421	x	10.400	x	12.500	=	704.705 kN
M1	=	704.70	x	5.20	=	3664.465 kN.m	at Shaft Bottom	
F3	=	5.421	x	11.600	x	12.500	=	786.017 kN
M3	=	786.017	x	5.800	=	4558.899 kN.m	at Foundation	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)	=	0.226	x	20	x	10.400	= 46.980 kN/m ²
F2	=	0.5	x	46.98	x	10.400	x 12.50
	=	3053.721 kN					

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)

M2	=	3053.72	x	4.37	=	13338.654 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)	=	0.226	x	20	x	11.600	= 52.401 kN/m ²
F4	=	0.5	x	52.40	x	11.600	x 12.50
	=	3799.082 kN					
M4	=	3799.08	x	4.87	=	18509.128 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014	γ fluid	=	4.8 kN/m ³
Intensity for triangular portion (At Shaft bottom level)	=	4.800	x 10.400
	=	49.920 kN/m ²	

$$F = 0.5 \times 49.920 \times 10.400 \times 12.500 = 3244.800 \text{ kN}$$

$$M = 3244.80 \times 3.467 = 11248.640 \text{ kN.m at Shaft Bottom}$$

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 11.600 = 55.68 \text{ kN/m}^2$$

$$F = 0.5 \times 55.680 \times 11.60 \times 12.500 = 4036.800 \text{ kN}$$

$$M = 4036.80 \times 3.867 = 15608.960 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 5.249 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

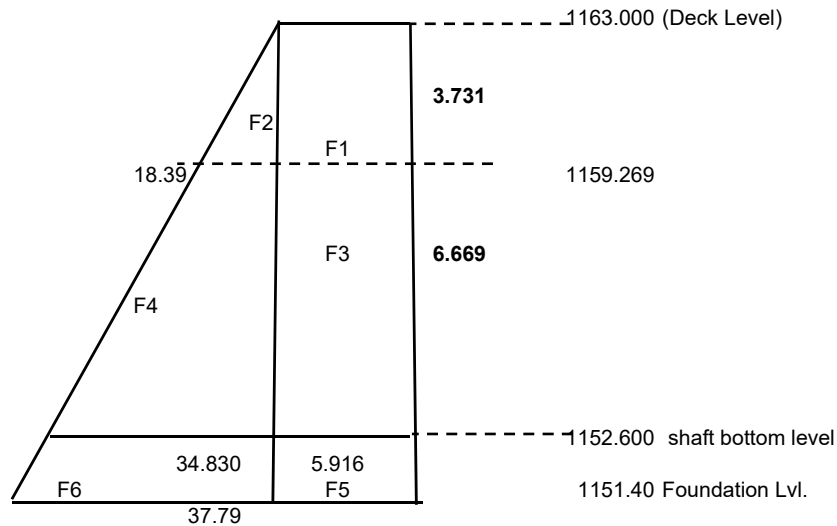
$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	13338.654	18509.128	3053.721	3799.082
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	13338.654	18509.128	3244.800	4036.800
Due to Live Load Surcharge	3664.465	4558.899	704.705	786.017
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1152.6 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	10.400	x	12.500	=	769.018 kN
M1	=	769.02	x	5.20	=	3998.896 kN.m		at Shaft Bottom
F3	=	5.916	x	11.600	x	12.500	=	857.751 kN
M3	=	857.75	x	5.80	=	4974.958 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	3.731	=	18.392 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	6.669	=	16.438 kN/m ²
F2	=	0.5	x	18.39	x	3.731	x	12.50
	=	428.887 kN						
F4	=	(18.39 + 34.83) x				6.67	x	12.50
	=	2218.380 kN						
Total Force	=	2647.266 kN						
M2	=	428.89	x	8.24	=	3532.320 kN.m		
M4	=	2218.38	x	2.99	=	6635.646 kN.m		

Total Moment = 10167.97 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 3.731 = 18.392 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 7.869 = 19.396 \text{ kN/m}^2$$

$$\text{F2} = 0.5 \times 18.39 \times 3.731 \times 12.50 = 428.887 \text{ kN}$$

$$\text{F6} = \left(\frac{18.39 + 37.79}{2} \right) \times 7.87 \times 12.50 = 2763.015 \text{ kN}$$

Total Force = 3191.901 kN

$$\text{M2} = 428.89 \times 9.44 = 4046.984 \text{ kN.m}$$

$$\text{M6} = 2763.01 \times 3.48 = 9620.046 \text{ kN.m}$$

Total Moment = 13667.03 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	10167.966	13667.030	2647.266	3191.901
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	11248.640	15608.960	3244.800	4036.800
Due to Live Load Surcharge	3998.896	4974.958	769.018	857.751
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

$$\begin{aligned} \alpha h &= 0.180 \\ \alpha v &= 0.198 \\ \phi &= 35.00 & 0.611 \\ \delta &= 22.50 & 0.393 \\ \alpha &= 0.00 & 0.000 \\ \beta &= 0.00 & 0.000 \end{aligned}$$

$$\begin{aligned} \alpha h &= \text{HORIZONTAL SEISMIC COEFFICIENT} \\ \alpha v &= \text{VERTICAL SEISMIC COEFFICIENT} \\ \phi &= \text{ANGLE OF INTERNAL FRICTION OF SOIL} \\ \delta &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL} \\ \alpha &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,} \\ \beta &= \text{SLOPE OF EARTH FILL} \end{aligned}$$

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.149 \\ 0.221 \end{matrix}$$

$$C_a = \begin{matrix} 1 & 2 \\ 0.379 & 0.300 \end{matrix}$$

$$C_a = 0.379$$

$$K_a = 0.226$$

$$\text{Dynamic Increment} = 0.379 \quad -0.226 \quad 0.153$$

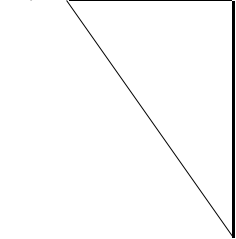
3 Earth Pressure : DRY CASE (Seismic case)

$$\text{Equivalent Live Load Surcharge height} = 1.2 \text{ m}$$

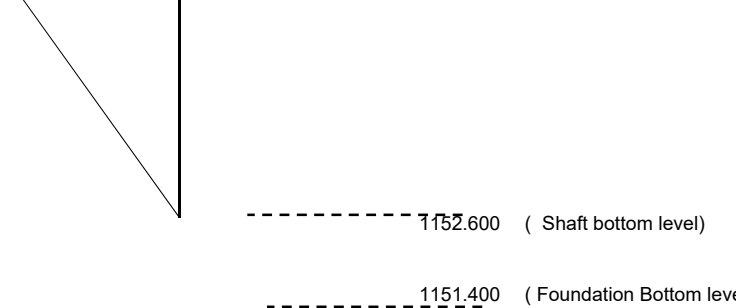
$$\begin{aligned} \text{Assuming } \gamma_{\text{dry}} &= 20 \text{ kN/m}^3 \\ \gamma_{\text{water}} &= 10.00 \text{ kN/m}^3 \end{aligned}$$

Active Earth Pressure

$$3 (C_a - K_a) = 0.460$$

**Surcharge Earth Pressure**

$$2 (C_a - K_a) \frac{\cos \alpha}{\cos(\alpha - \beta)} = 0.31$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

$$= 0.306 \times 20.00 \times 1.2 = 7.353 \text{ kN/m}^2$$

at Shaft Bottom Level

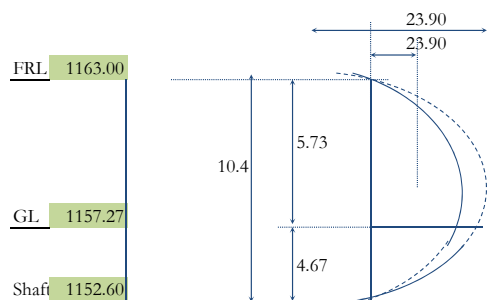
$$\begin{aligned} E1 &= 0.50 \times 7.353 \times 10.400 = 12.500 \\ &= 477.941 \text{ kN} \end{aligned}$$

$$M1 = 477.941 \times 6.968 = 3330.294 \text{ kN.m}$$

at Foundation Bottom Level

$$\begin{aligned} E2 &= 0.50 \times 7.353 \times 10.400 = 12.500 \\ &= 477.941 \text{ kN} \end{aligned}$$

$$M2 = 477.941 \times 8.168 = 3903.824 \text{ kN.m}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p _{mid_height}	=	23.90 t/m ²
h	=	10.4 m
y	=	0.531 m
L	=	12.500 m

Parabola below Water Level

p _{mid_height}	=	23.90 t/m ²
h	=	10.4 m
y	=	-0.531 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa T	cy m
Parabola above Water Level	1193.6	6.9
Parabola below Water Level	877.5	2.9
Total Dynamic Earth Pressure	2071.1	5.2

$$E3 = 2071.079 \text{ kN}$$

$$E4 = 2071.079 \text{ kN}$$

$$M3 = 2071.08 \times 5.20 = 10769.609 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 2071.08 \times 6.40 = 13254.903 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	13338.654	18509.128	3053.721	3799.082
Due to active Earth Pressure (dynamic Increment)	10769.609	13254.903	2071.079	2071.079
Total Earth Pressure	24108.263	31764.032	5124.800	5870.161
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	13338.654	31764.032	5124.800	5870.161
Due to Live Load Surcharge (Static)	3664.465	4558.899	704.705	786.017
Due to Live Load Surcharge(Dynamic)	3330.294	3903.824	477.941	477.941
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

α	h	=	0.180		
α	v	=	0.198		
ϕ		=	35.00	0.611	
δ		=	11.25	0.196	
α		=	0.00	0.000	
β		=	0.00	0.000	
W_s		=	20.00	Kn/m ³	2.00 gm/cm ³
λ		=	$\tan^{-1} \frac{W_s}{W_s - 1}$	$\frac{\alpha h}{(1 \pm \alpha v)}$	= 0.292 0.422
C_a'		=	0.552	0.515	
Ca'		=		0.552	
Ka'		=		0.246	
Dynamic Increment		=	0.552	-0.246	0.306
Dynamic Increment		=		0.306	
γ_d		=		20 kN/m ³	
γ_{sat}		=		10 kN/m ³	
γ_{water}		=		10 kN/m ³	
Equivalent Live Load Surcharge height		=		1.2 m	
Foundation		=		10.50 m	
Dynamic Active earth pressure Variation					
3 ($ca'-ka'$)					
Dynamic Surcharge earth pressure Variation					
2 ($Ca'-Ka'$) $\cos a$					
$\cos(a-b)$ 1163.000 (Deck Level)					
3.731					
1159.269 HFL					
6.669					
1152.600 shaft bottom level					
1151.4 Foundation Bottom Lvl.					
7.869					

Earth Pressure Diagram

h'	=	6.669
h	=	10.400

Dynamic active earth pressure

3 ($ca-ka$)	=	0.460 at deck level
3 ($ca'-ka'$)	=	0.917 at deck level
3 ($ca'-ka'$) h'/h	=	0.588 at HFL level

Dynamic Surcharge earth pressure

2 ($Ca'-Ka'$) $\frac{\cos a}{\cos(a-b)}$	=	0.611 at deck level	Pressure	=	14.67 kN/m ²
	=	0.392 at HFL level	Pressure	=	9.41 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.353 kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	9.41 kN/m ²

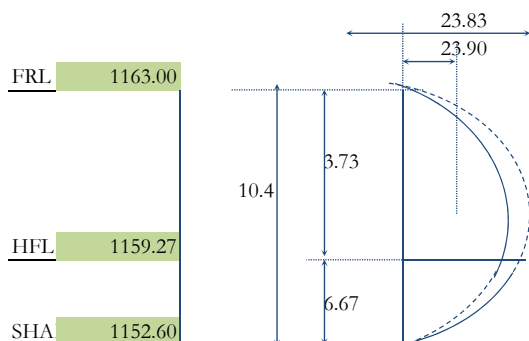
at Shaft Bottom Level

F1	=	8.379	x	3.731	x	12.500	=	390.779 kN
M1	=	390.78	x	8.53	=	3335.099 kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 9.405 \times 6.669 \times 12.500 \\
 &= \mathbf{392.020 \text{ kN}} \\
 M2 &= 392.02 \times 4.47 = \mathbf{1751.635 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 782.798 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 5086.734 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 8.379 \times 3.731 \times 12.500 = \mathbf{390.779 \text{ kN}} \\
 M3 &= 390.78 \times 9.73 = \mathbf{3804.034 \text{ kN.m}} \\
 F4 &= 0.500 \times 9.405 \times 6.669 \times 12.500 \\
 &= \mathbf{392.020 \text{ kN}} \\
 M4 &= 392.02 \times 5.67 = \mathbf{2222.058 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 782.798 \text{ kN} \\
 \text{Total Moment at Founding level} &= 6026.092 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 23.90 \text{ t/m}^2 \\
 h &= 10.4 \text{ m} \\
 y &= -1.469 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 23.83 \text{ t/m}^2 \\
 h &= 10.4 \text{ m} \\
 y &= 1.469 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	608.4	8.0
Parabola below Water Level	1458.8	4.0
Total Dynamic Earth Pressure	2067.2	5.2

Total Force (F1 + F2)	=	2067.206 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	2067.206 kN	at Foundation Bottom Level

$$M1 = 2067.21 \times 5.20 = \mathbf{10754.000 \text{ kN.m}}$$

Total Mome = 10754.000 kN.m at Shaft Bottom

$$M1 = 2067.21 \times 6.40 = \mathbf{13234.648 \text{ kN.m}}$$

Total Mome = 13234.648 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	10167.966	13667.030	2647.266	3191.901
Due to active Earth Pressure (Dynamic Increment)	10754.000	13234.648	2067.206	2067.206
Total Earth Pressure	20921.966	26901.678	4714.473	5259.108
Due to Minimum Fluid Pressure	11248.640	15608.960	3244.800	4036.800
Governing of Two	20921.966	26901.678	4714.473	5259.108
Due to Live Load Surcharge(Static)	3998.896	4974.958	769.018	857.751
Due to Live Load Surcharge (Dynamic Increment)	5086.734	6026.092	782.798	782.798
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1735.10	1.35	1.35	2342.38	2342.38	
SIDL except wc	=	320.00	1.35	1.35	432.00	432.00	
WC	=	440.00	1.75	1.75	770.00	770.00	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1175.71	1.5	0.20	1763.57	235.14	(1-70RW + 2-CLASS A)
CWLLmax-Reaction case	=	2331.19	1	0.20	2331.19	466.24	SV Loading
CWLLmin	=	222.89	1.5	0.20	334.33	44.58	(1-70RW + 2-CLASS A)
CWLLmin	=	1268.81	1	0.20	1268.81	253.76	SV Loading
CWLLmax-Transv. Moment Case		882.76	1.5	0.20	1324.14	176.55	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3544.38	0	177.219	177.219	-177.219	177.219	
DL+SIDL+LL-Max Reaction case	3878.71	341.55	193.936	364.711	147.614	364.711	(1-70RW + 2-CLASS A)
	5147.53	0	257.376	257.376	-257.376	257.376	SV Loading
DL+SIDL+LL-Min Reaction case	5307.95	341.55	265.398	436.173	76.152	436.173	(1-70RW + 2-CLASS A)
	5875.57	0	293.778	293.778	-293.778	293.778	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4868.53	341.55	243.426	414.201	98.124	414.201	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	3544.38	1347.35	177.219	850.896	1170.134	1347.353	
DL+SIDL+LL-Max Reaction case		3588.96	1392.89	179.448	875.895	1213.445	1392.893	Dry Case
DL+SIDL+LL-Min Reaction case		3779.53	1392.89	188.976	885.423	1203.917	1392.893	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3720.94	1392.89	186.047	882.493	1206.846	1392.893	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	3544.38	404.206	177.219	379.322	226.987	404.206	
DL+SIDL+LL-Max Reaction case		3588.96	449.746	179.448	404.321	270.298	449.746	Dry Case

DL+SIDL+LL-Min Reaction case		3779.53	449.746	188.976	413.849	260.770	449.746	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3720.94	449.746	186.047	410.920	263.699	449.746	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1735.10	1.35	1.35	2342.38	2342.38
SIDL except wc	=	320.00	1.35	1.35	432.00	432.00
WC	=	440.00	1.75	1.75	770.00	770.00
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	1175.71	1.5	0.75	1763.57	881.78
CWLLmax-Transv. Moment Case	=	882.76	1.5	0.75	1324.14	662.07
CWLLmin	=	222.89	1.5	0.75	334.33	167.17

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3544.38	0.000	177.219	177.219	-177.219	177.219	
DL+SIDL+LL-Max Reaction case	3878.71	341.550	193.936	364.711	147.614	364.711	(1-70RW + 2-CLASS A)
	5147.53	0.000	257.376	257.376	-257.376	257.376	SV Loading
DL+SIDL+LL-Min Reaction case	5307.95	341.550	265.398	436.173	76.152	436.173	(1-70RW + 2-CLASS A)
	5875.57	0.000	293.778	293.778	-293.778	293.778	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4868.53	341.550	243.426	414.201	98.124	414.201	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	3544.38	1818.93	177.219	1086.682	1641.708	1818.927	
DL+SIDL+LL-Max Reaction case		3711.55	1864.47	185.577	1117.811	1678.889	1864.467	Dry Case
DL+SIDL+LL-Min Reaction case		4426.17	1864.47	221.308	1153.542	1643.158	1864.467	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4206.45	1864.47	210.323	1142.556	1654.144	1864.467	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	3544.38	545.678	177.219	450.058	368.459	545.678	
DL+SIDL+LL-Max Reaction case		3711.55	591.218	185.577	481.186	405.641	591.218	Dry Case

DL+SIDL+LL-Min Reaction case		4426.17	591.218	221.308	516.917	369.910	591.218	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4206.45	591.218	210.323	505.932	380.895	591.218	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1735.10	1	1.00	1735.10	1735.10
SIDL except wc	=	320.00	1	1.00	320.00	320.00
WC	=	440.00	1	1.00	440.00	440.00
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	1175.71	1	0.20	1175.71	235.14
CWLLmax-Transv. Moment Case		882.76	1	0.20	882.76	176.55
CWLLmin	=	222.89	1	0.20	222.89	44.58

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	0.000	124.755	124.755	-124.755	124.755	
DL+SIDL+LL-Max Reaction case	2717.99	227.700	135.899	249.749	91.801	249.749	(1-70RW + 2-CLASS A)
	3763.91	0.000	188.196	188.196	-188.196	188.196	SV Loading
DL+SIDL+LL-Min Reaction case	3670.81	227.700	183.541	297.391	44.159	297.391	(1-70RW + 2-CLASS A)
	4826.28	0.000	241.314	241.314	-241.314	241.314	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3377.86	227.700	168.893	282.743	58.807	282.743	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	1212.618	124.755	731.064	1087.863	1212.618	
DL+SIDL+LL-Max Reaction case	2539.68	1258.158	126.984	756.063	1131.174	1258.158	Dry Case
DL+SIDL+LL-Min Reaction case	2730.24	1258.158	136.512	765.591	1121.646	1258.158	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2671.65	1258.158	133.583	762.661	1124.575	1258.158	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	363.785	124.755	306.648	239.030	363.785	
DL+SIDL+LL-Max Reaction case	2539.68	409.325	126.984	331.646	282.342	409.325	Dry Case
DL+SIDL+LL-Min Reaction case	2730.24	409.325	136.512	341.175	272.813	409.325	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2671.65	409.325	133.583	338.245	275.743	409.325	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1735.10	1.1	1.10	1908.61	1908.61
SIDL except wc	=	320.00	1.1	1.10	352.00	352.00
WC	=	440.00	1.35	1.35	594.00	594.00
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1175.71	1.5	0.00	1763.57	0.00
CWLLmax- Transv. Moment Case		882.76	1.5	0.00	1324.14	0.00
CWLLmin	=	222.89	1.5	0.00	334.33	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2854.61	0.000	142.730	142.730	-142.730	142.730	
DL+SIDL+LL-Max Reaction case	3188.94	341.550	159.447	330.222	182.103	330.222	(1-70RW + 2-CLASS A)
	4123.42	0.000	206.171	206.171	-206.171	206.171	SV Loading
DL+SIDL+LL-Min Reaction case	4618.18	341.550	230.909	401.684	110.641	401.684	(1-70RW + 2-CLASS A)
	5185.79	0.000	259.290	259.290	-259.290	259.290	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4178.75	341.550	208.938	379.713	132.612	379.713	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	2854.61	1818.93	142.730	1052.194	1676.196	1818.927	
DL+SIDL+LL-Max Reaction case		2854.61	1818.93	142.730	1052.194	1676.196	1818.927	Dry Case
DL+SIDL+LL-Min Reaction case		2854.61	1818.93	142.730	1052.194	1676.196	1818.927	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2854.61	1818.93	142.730	1052.194	1676.196	1818.927	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2495.10	2854.61	545.678	142.730	415.569	402.948	545.678	
DL+SIDL+LL-Max Reaction case		2854.61	545.678	142.730	415.569	402.948	545.678	Dry Case
DL+SIDL+LL-Min Reaction case		2854.61	545.678	142.730	415.569	402.948	545.678	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2854.61	545.678	142.730	415.569	402.948	545.678	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1735.10	1	1	1	1735.10	1735.10	1735.10
SIDL except wc	=	320.00	1	1	1	320.00	320.00	320.00
WC	=	440.00	1.20	1.20	1.20	528.00	528.00	528.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	1175.71	1	0.75	0	1175.71	881.78	0.00
CWLLmax- Transv. Moment Case	=	882.76	1	0.75	0	882.76	662.07	0.00
CWLLmin	=	222.89	1	0.75	0	222.89	167.17	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2583.10	0.000	129.155	129.155	-129.155	129.155	
DL+SIDL+LL-Max Reaction case	2805.99	227.700	140.299	254.149	87.401	254.149	(1-70RW + 2-CLASS A)
	3851.91	0.000	192.596	192.596	-192.596	192.596	SV Loading
DL+SIDL+LL-Min Reaction case	3758.81	227.700	187.941	301.791	39.759	301.791	(1-70RW + 2-CLASS A)
	4914.28	0.000	245.714	245.714	-245.714	245.714	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3465.86	227.700	173.293	287.143	54.407	287.143	

Dry Case

HFL Case

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2583.10	0.000	129.155	129.155	-129.155	129.155	
DL+SIDL+LL-Max Reaction case	2750.26	170.775	137.513	222.901	33.262	222.901	Dry Case
DL+SIDL+LL-Min Reaction case	3464.88	170.775	173.244	258.632	-2.469	258.632	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3245.17	170.775	162.259	247.646	8.516	247.646	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2583.10	0.000	129.155	129.155	-129.155	129.155	
DL+SIDL+LL-Max Reaction case	2583.10	0.000	129.155	129.155	-129.155	129.155	Dry Case
DL+SIDL+LL-Min Reaction case	2583.10	0.000	129.155	129.155	-129.155	129.155	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2583.10	0.000	129.155	129.155	-129.155	129.155	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	0.00	kmph	0.00	kmph
Live Load	W	=	1175.71	kN	1175.71	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1151.400 m

Properties of Footing Base:

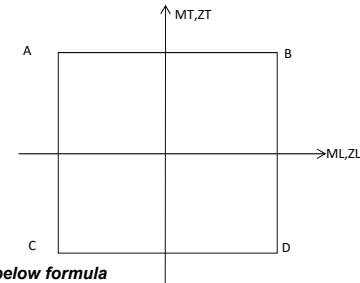
A	=	131.250	m ²
ZL	=	229.688	m ³
ZT	=	273.438	m ³

For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1735.098	0.850	1474.834	0.000	0.000
SIDL except Wearing Course	1			320.000	0.850	272.000	0.000	0.000
Wearing Course	1			440.000	0.850	374.000	0.000	0.000
Bearing Pedestal	1	25	0.640	16.000	0.850	13.600	0.000	0.000
				2511.098		2134.434		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	9.694	242.344	0.075	18.176	0.000	0.000
Dirt Wall-Tapered portion	1	25	-0.082	-2.051	0.075	-0.154	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.225	-6.328	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	-0.175	-2.461	0.000	0.000
Cap - (uniform portion)	1	25	6.563	164.063	0.800	131.250	0.000	0.000
Cap - (corbel portion)	1	25	5.091	127.277	0.800	101.822	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.250	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.250	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.075	2.100	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.225	-36.914	0.000	0.000
				765.883		207.491		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	88.688	2217.188	-2.500	-5542.969	0.000	0.000
Abutment Shaft	1	25	91.600	2290.012	0.895	2050.097	0.000	0.000
Back filling over heel slab	1	20	734.121	14682.422	-2.530	-37147.201	0.000	0.000
Front Filling over toe slab	1	20	238.402	4768.050	3.306	15762.384	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	58.438	1460.938	-2.123	-3100.911	0.000	0.000
Toe slab	1	25	40.375	1009.375	3.089	3118.177	0.000	0.000
portion between heel & toe	1	25	18.000	450.000	0.850	382.500	0.000	0.000
Vertical Components of active earth pressure	1			1672.097	-5.250	-8778.511	0.000	0.000
				28889.651		-33144.607		0.000
Total				32166.632		-30802.683		0.000

**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1561.589	-4.400	-6870.989
0.900	288.000	-4.400	-1267.200
1.000	440.000	-4.400	-1936.000
0.900	14.400	-4.400	-63.360
	2303.989		-10137.549
0.900	218.109	-5.175	-1128.716
0.900	-1.846	-5.175	9.552
0.900	25.313	-5.475	-138.586
0.900	12.656	-5.425	-68.660
0.900	147.656	-4.450	-657.070
0.900	114.550	-4.450	-509.746
0.900	0.000	-5.000	0.000
0.900	0.000	-5.000	0.000
0.900	25.200	-5.175	-130.410
0.900	147.656	-5.475	-808.418
	689.295		-3432.055
0.900	1995.469	-7.750	-15464.883
0.900	2061.011	-4.355	-8975.220
0.900	13214.180	-7.780	-102806.924
0.900	4291.245	-1.944	-8342.890
0.900	0.000	0.000	0.000
0.900	1314.844	-7.373	-9693.750
0.900	908.438	-2.161	-1962.938
0.900	405.000	-4.400	-1782.000
0.900	1504.888	-10.500	-15801.320
	26000.686		-166328.470
	28993.969		-179898.074

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	124.755	1160.415	1124.666
due to Earth pressure	1	4036.800		18509.128

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		142.730	1160.415	1286.715
due to Earth pressure	1.5	6055.200		27763.693
		6197.930		29050.407

Summary of Forces For SBC

P	32166.632	kN
ML	-11168.889	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		32166.632		-30802.683		0.000
CWLL-Max. Reaction case	1	1175.712	0.850	999.355	1.514	1779.874
Vertical Components of LL Surcharge	1	325.579	-5.250	-1709.289	0.000	0.000
Total		33667.923		-31512.617		1779.874

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	249.749	1160.415	2251.490
due to Earth pressure	1	4036.800		18509.128
due to Live load surcharge	1	786.017		4558.899

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		330.222	1160.415	2976.951
due to Earth pressure	1.5	6055.200		27763.693
due to Live load surcharge	1.2	943.220		5470.678
		7328.642		36211.322

Summary of Forces For SBC

P	33667.923	kN
ML	-6193.100	kNm
MT	1779.874	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
124.75	1124.67	0.00	0.00
4036.80	18509.13	0.00	0.00
4161.555	19633.794	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
142.73	1286.71	0.00	0.00
6055.20	27763.69	0.00	0.00
6197.930	29050.407	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	28993.96862		-179898.07
0.000		-4.400	0.00
0.900		-10.500	-3076.72
	28993.969		-182974.79

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
249.75	2251.49	0.00	0.00
4036.80	18509.13	0.00	0.00
786.017	4558.899	0.000	0.000
5072.57	25319.52	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
330.22	2976.95	0.00	0.00
6055.20	27763.69	0.00	0.00
943.22	5470.68	0.00	0.00
7328.642	36211.322	0.000	0.000

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2511.098		2134.434		0.000
Substructure & Foundation -Portion 1				765.883		207.491		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	88.688	2217.188	-2.500	-5542.969	0.000	0.000
Shaft above HFL	1	25	6.243	156.073	0.947	147.728	0.000	0.000
Shaft below HFL	1	15	85.358	1280.363	0.895	1146.225	0.000	0.000
Back filling above HFL over heel slab	1	20	256.506	5130.125	-2.500	-12825.313	0.000	0.000
Back filling below HFL over heel slab	1	10	482.556	4825.562	-2.546	-12284.479	0.000	0.000
Front Filling over toe slab	1	10	238.402	2384.025	2.307	5500.533	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	58.438	876.563	-2.123	-1860.547	0.000	0.000
Toe slab	1	15	40.375	605.625	3.089	1870.906	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	0.850	229.500	0.000	0.000
Vertical Components of active earth pressure	1			1672.097	-5.250	-8778.511	0.000	0.000
				19593.863		-32341.483		0.000
Total				22870.844		-29999.559		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2303.989		-10137.549
	689.295		-3432.055
0.900	1995.469	-7.750	-15464.883
0.900	140.466	-4.303	-604.490
0.900	1152.327	-4.355	-5018.115
0.900	4617.112	-7.750	-35782.622
0.900	4343.006	-7.796	-33856.814
0.900	2145.622	-2.943	-6314.038
0.900	0.000	0.000	0.000
0.900	788.906	-7.373	-5816.250
0.900	545.063	-2.161	-1177.763
0.900	243.000	-4.400	-1069.200
0.900	1504.888	-10.500	-15801.320
	17634.477		-121688.337
	20627.760		-135257.941

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	124.755	1160.415	1124.666
due to Earth pressure	1	4036.800		15608.960

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
124.75	1124.67	0.00	0.00
4036.80	15608.96	0.00	0.00
4161.55	16733.63	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		142.730	1160.415	1286.715
due to Earth pressure	1.5	6055.200		23413.440
		6197.930		24700.155

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
142.73	1286.71	0.00	0.00
6055.20	23413.44	0.00	0.00
6197.93	24700.15	0.00	0.00

Summary of Forces For SBC

P	22870.844	kN
ML	-13265.933	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		22870.844		-29999.559		0.000
CWLL-Min. Reaction case	1	222.888	0.850	189.455	2.393	533.396
Vertical Components of LL Surcharge	1	355.292	-5.250	-1865.284	0.000	0.000
Total		23449.024		-31675.388		533.396

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	20627.760		-135257.941
0.000	0.000	-4.400	0
0.900	319.763	-10.500	-3357.511
	20947.523		-138615.453

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	297.391	1160.415	2680.976
due to Earth pressure	1	4036.800		15608.960
due to Live load surcharge	1	857.751		4974.958

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
297.39	2680.98	0.00	0.00
4036.80	15608.96	0.00	0.00
857.751	4974.958	0.000	0.000
5191.94	23264.89	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		401.684	1160.415	3621.180
due to Earth pressure	1.5	6055.200		23413.440
due to live load surcharge	1.2	1029.302		5969.949
		7486.185		33004.569

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
401.68	3621.18	0.00	0.00
6055.20	23413.44	0.00	0.00
1029.302	5969.949	0.000	0.000
7486.19	33004.57	0.00	0.00

Summary of Forces For SBC

P	23449.024	kN
ML	-8410.495	kNm
MT	533.396	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

ah= 0.243 In Longitudinal direction

ah= 0.298 In Transverse direction

av= 0.198 In Vertical direction

Weight of shaft below Ground level

Weight of back fill below Ground level

= 1604.211 kN

= 6419.875 kN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1735.098		154.929	103.286	0.850	1474.834	87.793	1162.095		0.000	0.000	1656.965
SIDL except Wearing Course	1			320.000		28.573	19.049	0.850	272.000	16.191	1163.449		0.000	0.000	344.276
Wearing Course	1			440.000		39.288	26.192	0.850	374.000	22.263	1163.000		0.000	0.000	455.742
Bearing Pedestal	1	25	0.640	16.000		1.429	0.952	0.850	13.600	0.810			0.000	0.000	
				2511.098		224.219	149.479		2134.434	127.057				0.000	2456.983
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	9.694	242.344	58.890	21.639	14.426	0.075	18.176	1.082	1161.708	607.004	0.000	0.000	223.046
Dirt Wall-Tapered portion	1	25	-0.082	-2.051	-0.498	-0.183	-0.122	0.075	-0.154	-0.009	1160.426	-4.498	0.000	0.000	-1.653
Bracket - Uniform portion	1	25	1.125	28.125				-0.225	-6.328						
Bracket - Tapered portion	1	25	0.563	14.063				-0.175	-2.461						
Cap - (uniform portion)	1	25	6.563	164.063	39.867	14.649	9.766	0.800	131.250	7.813	1160.215	351.429	0.000	0.000	129.134
Cap - (corbel portion)	1	25	5.091	127.277	30.928	11.365	7.576	0.800	101.822	6.061	1159.915	263.355	0.000	0.000	96.771
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	1163.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	1163.000	0.000	0.000	0.000	0.000

RCC Railing or Crash Barrier	1			28.000				0.075	2.100			0.000	0.000	
Approach Slab	1	25	6.563	164.063				-0.225	-36.914			0.000	0.000	
Substructure & Foundation -Portion 2				765.883	129.187	47.470	31.647		207.491	14.947		1217.290	0.000	447.297
Solid Return wall	1	25	88.688	2217.188	538.777	197.975	131.983	-2.500	-5542.969	-329.959	1157.661	3373.246	0.000	1239.511
Abutment Shaft	1	25	91.600	2290.012	166.650	61.236	40.824	0.895	2050.097	36.547	1158.517	1186.046	0.000	435.816
Back filling over heel slab	1	20	734.121	14682.422	0.000	0.000	0.000	-2.530	-37147.201	0.000	1157.661	0.000	0.000	0.000
Front Filling over toe	1	20	238.402	4768.050				3.306	15762.384				0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000
Heel slab	1	25	58.438	1460.938				-2.123	-3100.911				0.000	0.000
Toe slab	1	25	40.375	1009.375				3.089	3118.177				0.000	0.000
portion between heel & toe	1	25	18.000	450.000				0.850	382.500				0.000	0.000
Vertical component of active earth pressure	1			1573.631				-5.250	-8261.565				0.000	0.000
Vertical component of dynamic increment of earth pressure	1			857.869				-5.250	-4503.811				0.000	0.000
				29649.054	705.426	259.211	172.807		-37131.473	-293.412		4559.292	0.000	1675.327
Total =				32926.035	834.613	530.900	353.933		-34789.548	-151.407		5776.582	0.000	4579.607
-353.933 151.407														

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.9			1561.589	92.957	-4.400	-6870.989	-409.012
SIDL except Wearing Course	0.9			288.000	17.144	-4.400	-1267.200	-75.433
Wearing Course	1.00			440.000	26.192	-4.400	-1936.000	-115.245
Bearing Pedestal	0.9	25	0.64	14.400		-4.400	-63.360	
				2303.989	136.293		-10137.549	-599.691
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	9.694	218.109	12.983	-5.175	-1128.716	-67.190
Dirt Wall-Tapered portion	0.9	25	-0.082	-1.846	-0.110	-5.175	9.552	0.569
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	6.563	147.656	8.790	-4.450	-657.070	-39.114
Cap - (corbel portion)	0.9	25	5.091	114.550	6.819	-4.450	-509.746	-30.344
Cantilever Return Wall-Rectangle portion	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
Cantilever Return Wall-Traingle portion	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.175	-130.410	
Approach Slab	0.9	25	6.563	147.656		-5.475	-808.418	
				689.295	28.482		-3224.809	-136.079
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	91.600	2061.011	27.192	-4.355	-8975.220	-118.415
Solid Return wall	0.9	25	88.688	1995.469	118.785	-7.750	-15464.883	-920.585
Back filling over heel slab	0.9	20	734.121	13214.180	0.000	-7.780	-102806.9	0.000
Front Filling over toe	0.9	20	238.402	4291.245		-1.944	-8342.890	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	58.438	1314.844		-7.373	-9693.750	
Toe slab	0.9	25	40.375	908.438		-2.161	-1962.938	
portion between heel & toe	0.9	25	18.000	405.000		-4.400	-1782.000	
Vertical component of active earth pressure	0.9			1504.888		-10.500	-15801.320	
Vertical component of dynamic increment of earth pressure	0.9			772.082		-10.500	-8106.861	
				26772.768	145.977		-174435.33	-1039.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	58.890	1161.708	607.004
1.0	-0.498	1160.426	-4.498
1.0	39.867	1160.215	351.429
1.0	30.928	1159.915	263.355
1.0	0.000	1163.000	0.000
1.0	0.000	1163.000	0.000
	129.187		1217.290
1.0	123.336	1158.517	877.782
1.0	538.777	1157.661	3373.246
1.0	0.000	1157.661	0.000
	662.113		4251.028

Total =				29766.051	310.753		-187797.69	-1774.769
					-310.753			1774.769

	791.299		5468.319

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1212.618	224.219	1160.415	10931.749	2456.983
due to Substructure	1	834.613	306.681		5776.582	2122.624
due to Earth pressure	1	5870.161			31764.032	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1212.62	10931.75	0.00	0.00	0.00	0.00	224.22	2456.98
834.61	5776.58	0.00	0.00	0.00	0.00	306.68	2122.62
5870.16	31764.03						
7917.39	48472.36	0.00	0.00	0.00	0.00	530.90	4579.61

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1818.927	1160.415	16397.62
due to Substructure	1.5	1186.949		8202.48
due to Active Earth pressure	1	3799.082		18509.13
due to dynamic Earth pressure	1.5	3106.618		19882.35
		9911.576		62991.586

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1818.93	16397.62	0.00	0.00
1186.95	8202.48	0.00	0.00
3799.082	18509.128	0.000	0.000
3106.618	19882.355	0.000	0.000
9911.58	62991.59	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	33279.968	32572.101	kN
ML	13531.408	13834.222	kNm
MT	4579.607	4579.607	kNm

Summary of Restoring Forces

Vertical Load	29455.298	kN
Moment	-189572.458	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2511.098		224.219	149.479		2134.434	127.057				0.000	2456.983
Forces from Substructure				30414.936	834.613	306.681	204.454		-36923.982	-278.465		5776.582		0.000	2122.624
CWLL-Max. Reaction case	0.20			235.14		20.996	13.997	0.850	199.871	11.898	1164.200		1.514	355.975	268.751
Vertical component of LL Surcharge	0.20			65.12				-5.250	-341.858				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			39.59				-5.250	-207.868				0.000	0.000	
Total =				33265.887	834.613	551.896	367.931		-35139.403	-139.510		5776.582		355.975	4848.358

-367.931

139.510

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2303.989	136.293	0.000	-10137.55	-599.691
Forces from Substructure				27462.062	174.459	0.000	-177660.14	-1175.079
CWLL-Max. Reaction case	0.00			0.00	0.000	-4.400	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-10.500	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.500	0.00	

Total =				29766.051	310.753		-187797.69	-1774.769
					-310.753			1774.769

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1258.158	245.215	1160.415	11342.293	2725.733
due to Substructure	1	834.613	306.681		5776.582	2122.624
due to Earth pressure	1	5870.161			31764.032	
due to Live load surcharge	0.20	252.792			1692.545	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1258.16	11342.29	0.00	0.00	0.00	0.00	245.22	2725.73
834.61	5776.58	0.00	0.00	0.00	0.00	306.68	2122.62
5870.16	31764.03						
252.79	1692.54						
8215.72	50575.45	0.00	0.00	0.00	0.00	551.90	4848.36

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1818.927	1160.415	16397.624
due to Substructure	1.5	1186.949		8202.478
due to Active Earth pressure	1	3799.082		18509.128
due to dynamic Earth pressure	1.5	3106.618		19882.3548
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9911.576		62991.586

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1818.93	16397.62	0.00	0.00
1186.95	8202.48	0.00	0.00
3799.082	18509.128		
3106.618	19882.355		
0.000	0.000		
0.000	0.000		
9911.58	62991.59	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	33633.818	32897.956	kN
ML	15296.538	15575.557	kNm
MT	5204.332	5204.332	kNm

Summary of Restoring Forces

Vertical Load	29455.298	kN
Moment	-189572.458	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				2511.098		224.219	149.479		2134.434	127.057				0.000	2456.983
Substructure & Foundation -Portion 1				765.883	129.187	47.470	31.647		207.491	14.947		1217.290		0.000	447.297
Substructure & Foundation -Portion 2															
Solid Return wall	1		88.69	2217.19	538.777	197.975	131.983	-2.50	-5542.969	-329.959	1157.66	3373.246	0.00	0.000	1239.511
Shaft above HFL	1	25	6.243	156.073	37.926	13.936	9.291	0.947	147.728	8.794	1159.517	307.843	0.000	0.000	113.118
Shaft below HFL	1	15	85.358	1280.363	128.724	47.300	31.533	0.895	1146.225	28.230	1158.269	884.205	0.000	0.000	324.904
Back filling above HFL over heel slab	1	20	256.506	5130.125	0.000	0.000	0.000	-2.500	-12825.313	0.000	1161.135	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	482.556	4825.562	0.000	0.000	0.000	-2.546	-12284.479	0.000	1155.635	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	238.402	2384.025				2.307	5500.533				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	58.438	876.563				-2.123	-1860.547				0.000	0.000	
Toe slab	1	15	40.375	605.625				3.089	1870.906				0.000	0.000	
portion between heel & toe	1	15	18.000	270.000				0.850	229.500				0.000	0.000	
Vertical component of active earth pressure	1			1322.129				-5.250	-6941.177				0.000	0.000	

Vertical component of dynamic increment of earth pressure	1			856.265				-5.250	-4495.391				0.000	0.000	
				20100.159	748.253	274.948	183.299		-35054.982	-292.935		4758.828		0.000	1748.647
Total =				23377.141	877.440	546.637	364.425		-32713.058	-150.931		5976.118		0.000	4652.927
								-364.425		150.931					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				2303.989	136.293		-10137.549	-599.691
Substructure & Foundation -Portion 1				689.295	28.482		-3224.809	-136.079
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	88.6875	1995.469	118.785	-7.75	-15464.883	-920.585
Shaft above HFL	0.9	25	6.243	140.466	8.362	-4.303	-604.490	-35.984
Shaft below HFL	0.9	15	85.358	1152.327	18.831	-4.355	-5018.115	-82.003
Back filling above HFL over heel slab	0.9	20	256.506	4617.112	0.000	-7.750	-35782.622	0.000
Back filling below HFL over heel slab	0.9	10	482.556	4343.006	0.000	-7.796	-33856.814	0.000
Front Filling ovetoe	0.9	10	238.402	2145.622		-2.943	-6314.038	
Side filling between heel and toe	0.9	10	0.000	0.000		0.000	0.000	
Heel slab	0.9	15	58.438	788.906		-7.373	-5816.250	
Toe slab	0.9	15	40.375	545.063		-2.161	-1177.763	
portion between heel & toe	0.9	15	18.000	243.000		-4.400	-1069.200	
Vertical component of active earth pressure	0.9			1189.916		-10.500	-12494.118	
Vertical component of dynamic increment of earth pressure	0.9			770.638		-10.500	-8091.704	
				18090.144	155.419		-126472.84	-1085.172
Total =				21083.427	320.195		-139835.20	-1820.941

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	129.187		1217.290
1.0	538.777	1157.661	3373.246
1.0	37.926	1159.517	307.843
1.0	85.410	1158.269	586.683
1.0	0.000	1161.135	0.000
1.0	0.000	1155.635	0.000
	662.113		4267.772
	791.299		5485.063

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1212.618	224.219	1160.415	10931.749	2456.983
due to Substructure	1	877.440	322.418		5976.118	2195.944
due to Earth pressure	1	5259.108			26901.678	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1818.927	1160.415	16397.624
due to Substructure	1.5	1186.949		8227.594
due to Active Earth pressure	1	3191.901		13667.030
due to dynamic Earth pressure	1.5	3100.810		19851.972
		9298.587		58144.221

Summary of Forces For SBC

	Downward	Upward	
P	23741.565	23012.716	kN
ML	10945.557	11247.418	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1212.62	10931.75	0.00	0.00	0.00	0.00	224.22	2456.98
877.44	5976.12	0.00	0.00	0.00	0.00	322.42	2195.94
5259.11	26901.68						
7349.17	43809.55	0.00	0.00	0.00	0.00	546.64	4652.93

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1818.93	16397.62	0.00	0.00
1186.95	8227.59	0.00	0.00
3191.901	13667.030		
3100.810	19851.972		
9298.59	58144.22	0.00	0.00

Summary of Restoring Forces

Vertical Load	20763.232	kN

MT	4652.927	4652.927	kNm

Moment	-141656.139	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2511.098		224.219	149.479		2134.434	127.057				0.000	2456.983
Forces from Substructure				20866.042	877.440	322.418	214.945		-34847.492	-277.988		5976.118		0.000	2195.944
CWLL-Max. Reaction case	0.20			44.58		3.980	2.654	0.850	37.891	2.256	1164.200		2.393	106.679	50.949
Vertical component of LL Surcharge	0.20			71.06				-5.250	-373.057				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			64.85				-5.250	-340.458				0.000	0.000	
Total =				23557.626	877.440	550.617	367.078		-33388.682	-148.675		5976.118		106.679	4703.876

-367.078

148.675

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2303.989	136.293		-10137.549	-599.691
Forces from Substructure				18779.438	183.901		-129697.65	-1221.250
CWLL-Max. Reaction case	0.00			0.00	0.00		-4.40	0.00
Vertical component of LL Surcharge	0.00			0.00		-4.400	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.500	0.000	0.000
Total =				21083.427	320.195		-139839.60	-1820.941

-320.195

1820.941

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1258.158	228.199	1160.415	11342.293	2507.932
due to Substructure	1	877.440	322.418		5976.118	2195.944
due to Earth pressure	1	5259.108			26901.678	
due to Live load surcharge	0.20	328.110			2200.210	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1258.16	11342.29	0.00	0.00	0.00	0.00	228.20	2507.93
877.44	5976.12	0.00	0.00	0.00	0.00	322.42	2195.94
5259.11	26901.68						
328.11	2200.21						
7722.82	46420.30	0.00	0.00	0.00	0.00	550.62	4703.88

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1818.927	1160.415	16397.624
due to Substructure	1.5	1186.949		8227.59431
due to Active Earth pressure	1	3191.901		13667.030
due to dynamic Earth pressure	1.5	3100.810		19851.972
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9298.587		58144.221

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1818.93	16397.62	0.00	0.00
1186.95	8227.59	0.00	0.00
3191.901	13667.030		
3100.810	19851.972		
0.000	0.000		
0.000	0.000		
9298.59	58144.22	0.00	0.00

MT	15265.357	15265.357	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	33265.887	367.931	-35139.40	-139.510	355.975
		-367.931		139.510	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	409.325	817.383	1160.415	3690.068	9085.777
due to Substructure	1	250.384	1022.271		1732.975	7075.414
due to Earth pressure	1	5870.161			31764.032	
due to Live load surcharge	0.2	252.792			1692.545	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		545.68	1160.415	4919.287
due to Substructure	1.5	356.08		2460.743
due to Active Earth pressure	1	3799.08		18509.128
due to dynamic Earth pressure	1.5	931.99		5964.706
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5632.83		31853.866

Summary of Forces For SBC

	Downward	Upward	
P	33633.818	32897.956	kN
ML	3600.706	3879.725	kNm
MT	16517.167	16517.167	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure	2511.098	149.479	2134.434	127.057	0.000
Substructure & Foundation -Portion 1	765.883	31.647	207.491	14.947	0.000
Substructure & Foundation -Portion 2	20100.159	183.299	-35054.982	-292.935	0.000
Total =	23377.141	364.425	-32713.058	-150.931	0.000
		-364.425		150.931	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	29766.051	310.753	-187797.69	-1774.769
		-310.753		1774.769

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
409.33	3690.07	0.00	0.00	0.00	0.00	817.38	9085.78
250.38	1732.97	0.00	0.00	0.00	0.00	1022.27	7075.41
5870.16	31764.03						
252.79	1692.54						
6782.66	38879.62	0.00	0.00	0.00	0.00	1839.65	16161.19

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
545.68	4919.29	0.00	0.00
356.08	2460.74	0.00	0.00
3799.082	18509.128		
931.985	5964.706		
0.000	0.000		
0.000	0.000		
5632.83	31853.87	0.00	0.00

Summary of Restoring Forces

Vertical Load	29455.298	kN
Moment	-189572.458	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure	2303.989	136.293		-10137.549	-599.691
Substructure & Foundation	689.295	28.482		-3224.809	-136.079
Substructure & Foundation	18090.144	155.419		-126472.839	-1085.172
Total =	21083.427	320.195		-139835.198	-1820.941
		-320.195			1820.941

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	363.79	747.40	1160.42	3279.52	8189.94
due to Substructure	1	263.23	1074.73		1792.84	7319.81
due to Earth pressure	1	5259.11			26901.68	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		545.678	1160.415	4919.29
due to Substructure	1.5	356.085		2468.28
due to Active Earth pressure	1	3191.901		13667.03
due to dynamic Earth pressure	1.5	930.243		5955.59
		5023.907		27010.19

Summary of Forces For SBC

	Downward	Upward	
P	23741.565	23012.716	kN
ML	-889.950	-588.089	kNm
MT	15509.757	15509.757	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	23557.626	367.078	-33388.68	-148.675	106.679
		-367.078		148.675	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	409.325	760.66417	1160.415	3690.068	8359.77208
due to Substructure	1	263.232	1074.7271		1792.835	7319.81449
due to Earth pressure	1	5259.108			26901.678	
due to Live load surcharge	0.2	328.110			2200.210	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		545.68	1160.415	4919.29
due to Substructure	1.5	356.08		2468.28
due to Active Earth pressure	1	3191.90		13667.03
due to dynamic Earth pressure	1.5	930.24		5955.59
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
363.79	3279.52	0.00	0.00	0.00	0.00	747.40	8189.94
263.23	1792.84	0.00	0.00	0.00	0.00	1074.73	7319.81
5259.11	26901.68						
5886.13	31974.04	0.00	0.00	0.00	0.00	1822.12	15509.76

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
545.68	4919.29	0.00	0.00
356.08	2468.28	0.00	0.00
3191.901	13667.030		
930.243	5955.592		
5023.91	27010.19	0.00	0.00

Summary of Restoring Forces

Vertical Load	20763.232	kN
Moment	-141656.139	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Total =	21083.427	320.195		-139839.60	-1820.941
		-320.195			1820.941

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
409.33	3690.07	0.00	0.00	0.00	0.00	760.66	8359.77
263.23	1792.84	0.00	0.00	0.00	0.00	1074.73	7319.81
5259.11	26901.68						
328.11	2200.21						
6259.78	34584.79	0.00	0.00	0.00	0.00	1835.39	15679.59

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
545.68	4919.29	0.00	0.00
356.08	2468.28	0.00	0.00
3191.901	13667.030		
930.243	5955.592		
0.000	0.000		
0.000	0.000		

5023.91 27010.19 5023.91 27010.19 0.00 0.00

Summary of Forces For SBC			
	Downward	Upward	
P	23924.704	23190.548	KN
ML	1047.434	1344.785	kNm
MT	15786.266	15786.266	kNm

Summary of Restoring Forces	
Vertical Load	20763.232 kN
Moment	-141660.539 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00
Transverse Moment due to C.F. = 0.000 x (1164.200 -

1151.400) = 0.000 KN
0.000 kNm

Normal

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00
Transverse Moment due to C.F. = 0.000 x (1164.200 -

1151.400) = 0.000 KN
0.000 kNm

Seismic

0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = $P/A - ML/ZL + MT/ZT$
Base pressure on corner B = σ_B = $P/A + ML/ZL + MT/ZT$
Base pressure on corner C = σ_C = $P/A - ML/ZL - MT/ZT$
Base pressure on corner D = σ_D = $P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force = $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_p$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	32166.632	-11168.889	0.000	293.706	196.453	293.706	196.453	293.706	196.453	6197.930	20295.778	3.27	29050.407	179898.07	6.19
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	33667.923	-6193.100	1779.874	289.990	236.064	276.971	223.045	289.990	223.045	7328.642	20295.778	2.77	36211.322	182974.79	5.05
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	22870.844	-13265.933	0.000	232.010	116.498	232.010	116.498	232.010	116.498	6197.930	14439.432	2.33	24700.155	135257.94	5.48
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	23449.024	-8410.495	533.396	217.227	143.993	213.326	140.091	217.227	140.091	7486.185	14663.266	1.96	33004.569	138615.45	4.20
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	33279.968	13834.222	4579.607	210.079	330.541	176.583	297.044	330.541	176.583	9911.576	20618.709	2.08	62991.586	189572.46	3.01
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	33633.818	15575.557	5204.332	207.479	343.103	169.413	305.037	343.103	169.413	9911.576	20618.709	2.08	62991.586	189572.46	3.01
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	23741.565	11247.418	4652.927	148.936	246.873	114.903	212.840	246.873	114.903	9298.587	14534.262	1.56	58144.221	141656.14	2.44
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	23924.704	13180.292	4810.555	142.493	257.260	107.307	222.074	257.260	107.307	9298.587	14534.262	1.56	58144.221	141660.54	2.44
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	33279.968	2138.390	15265.357	300.079	318.699	188.424	207.044	318.699	188.424	6463.695	20618.709	3.19	37595.600	189572.46	5.04
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	33633.818	3879.725	16517.167	299.772	333.555	178.961	212.743	333.555	178.961	5632.830	20618.709	3.66	31853.866	189572.46	5.95
								SAFE	SAFE			SAFE			SAFE

Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	23741.565	-588.089	15509.757	240.170	235.049	126.727	121.606	240.170	121.606	5023.907	14534.262	2.89	27010.187	141656.14	5.24
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	23924.704	1344.785	15786.266	234.161	245.871	118.696	130.406	245.871	118.696	5023.907	14534.262	2.89	27010.187	141660.54	5.24
								SAFE	SAFE			SAFE			SAFE

***DESIGN OF PIER P5 AND
ITS FOUNDATION
FOR MAJOR BRIDGE AT CH-82+425***

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle : 0 degree 0 Radian

	<u>Left span</u>		<u>Right span</u>		<u>Unit</u>
	<u>Right</u>	<u>Skew</u>	<u>Right</u>	<u>Skew</u>	
SPAN DETAILS					
C/C Expansion joint	= 40.000	40.000	40.000	40.00	m
C/C Expansion joint to C.L. brg	= 0.600	0.600	0.600	0.60	m
Expansion gap	= 50	50	50	50	mm
C/C bearing	= 38.800	38.800	38.800	38.800	m

SUPERSTRUCTURE DETAILS

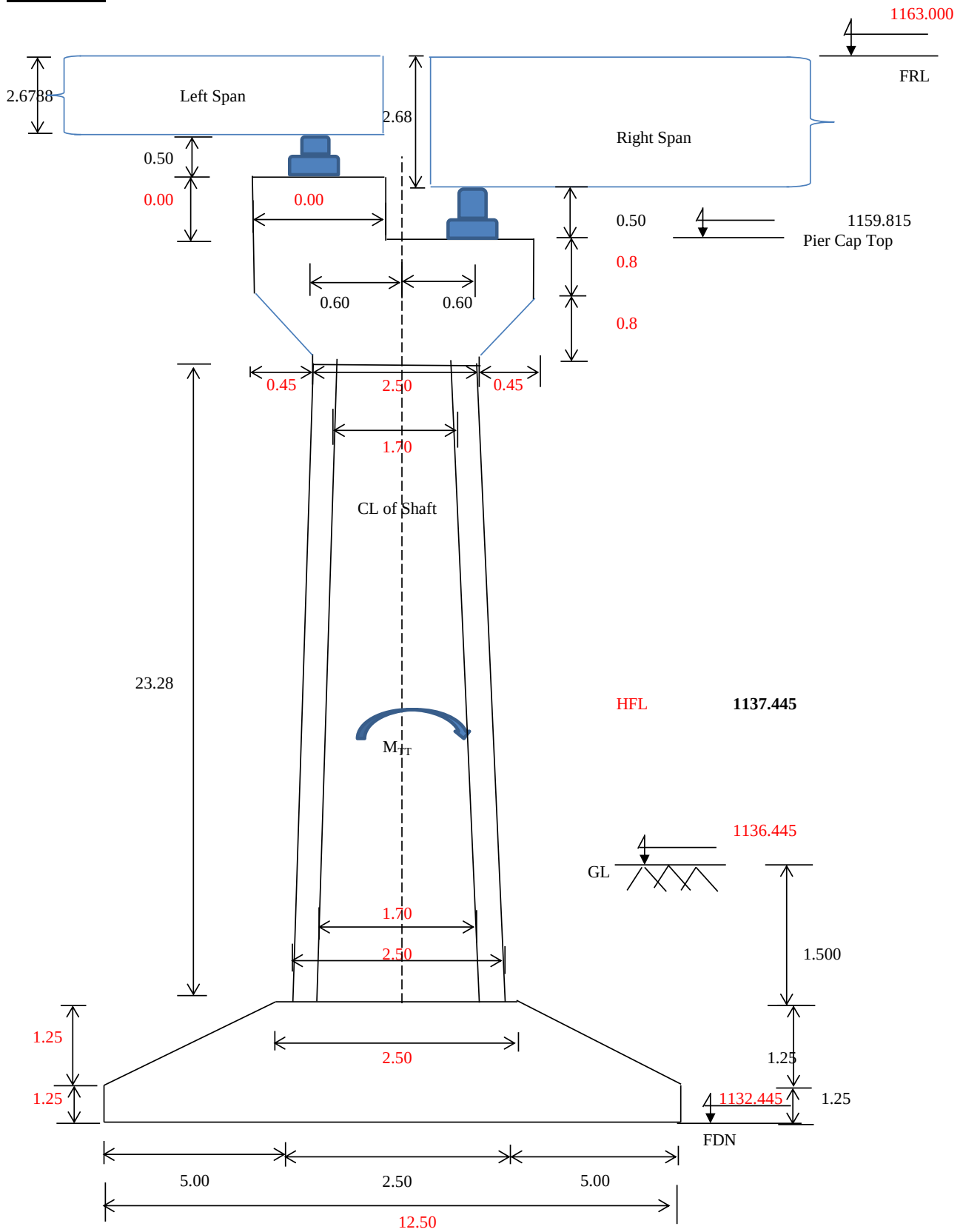
	<u>Left Span</u>		<u>Right Span</u>		
Overall deck width of bridge	= 12.50	m	12.50	m	
Carriage way width	= 11.50	m	11.50	m	
Crash barrier width	= 0.45	m	0.45	m	
Height of crash barrier	= 1.00	m	1.00	m	
C.g of Crash barrier from bottom	= 0.40	m	0.40	m	
Cross-slope	= 2.50	%	2.50	%	
Wearing coat thickness	= 65	mm	65	mm	
Nos. of Bearing	= 4		4		
Spacing of Bearing	= 7.50	m	7.50	m	
Depth of Girder	= 2.300	m	2.300	m	
Depth of slab	= 0.22	m	0.22	m	
Depth of superstructure	= 2.520	m	2.520	m	
Bearing + Pedestal height	= 0.50	m	0.50	m	
Width of main girder at top	= 0.50	m	0.50	m	
Width of cross girder	= 0.30	m	0.30	m	
Nos. of cross-girders	= 2		2		
FRL to Soffit	= 2.68	m	2.68	m	
Type of Bearing					OR SPHERICAL BRG

LEVEL DETAILS

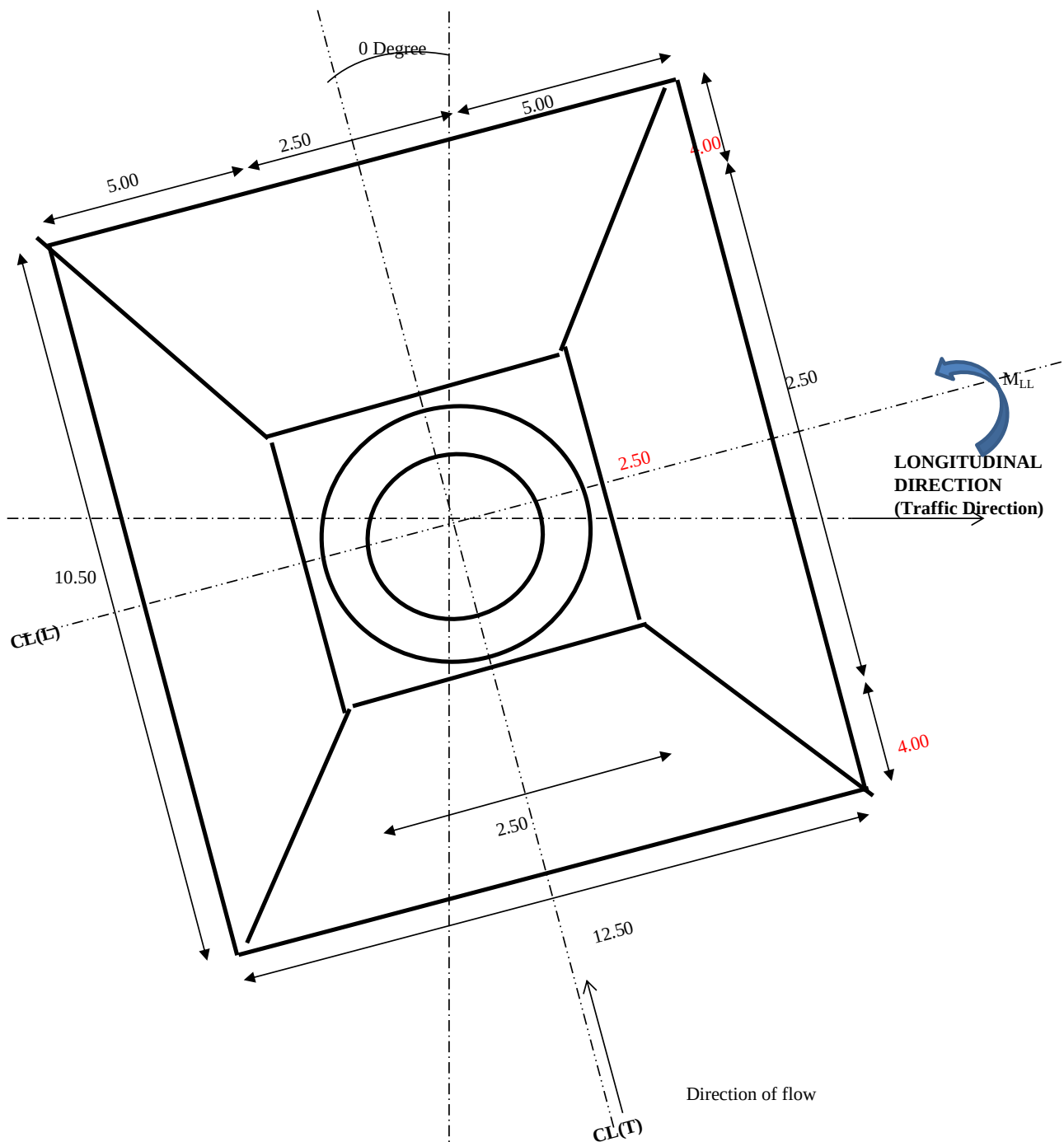
Formation level	= 1163.000	m
Pier cap top level	= 1159.815	m
HFL	= 1136.445	m
Ground level	= 1136.445	m
MSL (Normal)/Rock Level	= 1136.445	m
MSL (Seismic)/Rock Level	= 1136.445	m
Pier shaft bottom/Footing top level	= 1134.939	m
Founding level	= 1132.445	m

DIMENSION DETAILS

Pier cap:		<u>Right</u>	<u>Skew</u>
Width of pier cap at top	= 3.40	m	3.40
Width of pier cap at bottom	= 3.40	m	3.40
Length of pier cap at top	= 9.00	m	9.00
Length of pier cap at bottom	= 2.50	m	2.50
Thickness of uniform portion	= 0.80	m	0.80
Thickness of tapered portion	= 0.80	m	0.80
Pier shaft:			
Width of pier at top	= 2.50	m	2.50
Width of pier at bottom	= 2.50	m	2.50
Length of pier (rectangle portion)	= 0.00	m	0.00
Length of pier(end circular portion Top)	= 1.25	m	1.25
Length of pier (end circular portion Bottom)	= 1.25	m	1.25
Total length of pier shaft at top	= 2.50	m	2.50
Total length of pier shaft at bottom	= 2.50	m	2.50
Footing:			
Width of footing at top	= 2.50	m	2.50
Width of footing at bottom	= 12.50	m	12.50
Length of footing	= 10.50	m	10.50
Thickness at tip	= 1.25	m	1.25
Maximum thickness	= 2.50	m	2.50

DIAGRAMS:

Note : All Dimensions are in meter



2. PLAN SHOWING FOOTING & PIER SHAFT



2. MATERIALS DETAILS**CONCRETE:**

Grade of concrete	fck	=	M 35	
Mean value of concrete compressive strength, fcm		=	M 45 (28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447 x fck	(Basic and Seismic combination)
		=	15.633 Mpa	
Secant modulus of elasticity, Ecm		=	32000 Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8 Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5 t/m ³	

SOIL :

Density dry		=	2 t/m ³	
Density Saturated		=	2.3 t/m ³	
Soil density (submerged)		=	2 t/m ³	
Angle of Internal friction ϕ		=	35	
Cohesion c		=	0	
Gross bearing capacity		=	35.00 t/m ²	(Normal case)
		=	43.75 t/m ²	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	11.159 m ²	
Perimeter in contact with atmosphere, u		=	12.854 m	
Notional size, ho = 2Ac/u		=	1736 mm	
Age of concrete at the time of loading to		=	90 days	
	t _a	=	25550 days	
	f(α 90)	=	1.2 (Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32 (increased by 10%)	
Creep co-efficient for foundation		=	1.0 (as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793 Mpa	Ecm' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500 Mpa	
Modulus of elasticity	Es	=	200000 Mpa	

3. PERMISSIBLE STRESSES**MAXIMUM PERMISSIBLE STRESS IN CONCRETE:**

Rare combination		=	0.48 x fck	
		=	16.8 Mpa	
Quasi permanent combination		=	0.36 x fck	
		=	12.6 Mpa	

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300 Mpa	
Permissible crack width	W _{k,max}	=	0.3 mm	

4. SEISMIC PARAMETERS

Seismic zone		=	V	
Type of soil		=	Type2(Medium)	
Zone factor	Z	=	0.36	
Importance factor	I	=	1.20	
Response Reduction Factor(Long)	R	=	3	
Response Reduction Factor(Trans)	R	=	3	

5. ENVIRONMENTAL PARAMETERS

Relative humidity		=	80%	
Condition of exposure		=	Moderate	

6.OTHER PARAMETERS

Mean velocity of water current flow		=	4.00 m/s	
Design Speed V		=	40 Kmph	
Radius of Curvature R		=	200 m	

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew = **0 °** = **0.000 Radian**
No. of Bearing = 4.00
Right
c/c of bearing in Transverse Direction = 7.500 m 7.500 m
c/c bearing on Longitudinal Direction = 1.200 m 1.200 m
Impact Factor for Design of Pier Cap = 1.10

Left Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	1735.10	320.00								
Total Load	2055.10		440.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000	0.300	0.300

Right Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	1735.10	320.00								
Total Load	2055.10		440.00	0.00	1175.71	222.89	0.00	0.00	2331.19	1268.81
Resultant Transverse Ecc.	0.000		0.000	0.000	1.510	2.390	1.000	1.000	0.300	0.300

8. VOLUME OF SUBSTRUCTURE

PIER CAP

Uniform portion

No.		L(m)	B(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	9.000	0.000	0.000	0.000	1.700	0.000	24.87625	27.38
2	1	9.000	3.400	0.800	24.480	0.000	0.000	24.47625	26.98

Tapered portion

2a	Rectangle	2.500	3.400	0.800	6.800	0.000	0.000	23.676	26.176
	Triangle	3.250	3.400	0.800	8.840	0.000	0.000	23.810	26.310
Total Inc. 10%					44.132	0.000	0.000	21.994	24.267

PIER SHAFT

Above HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	21.776	57.466	0.000	0.000	12.388	14.888
2	0	2.500	0.000	21.776	0.000	-1.250	0.000	8.759	11.259
3	0	2.500	0.000	21.776	0.000	1.250	0.000	8.759	11.259

Cylinder/Conical Frustum portion

4	0.000	0.850	1.25	21.776	0.000	0.000	0.000	12.388	14.888
Total					57.466	0.000	0.000	12.388	14.888

Below HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	1.500	3.958	0.000	0.000	0.750	3.250
2	0	2.500	0.000	1.500	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	1.500	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.250	0.850	1.500	0.000	0.000	0.000	0.750	3.250
Total					3.959	0.000	0.000	0.750	3.250

Above LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	21.776	57.466	0.000	0.000	12.388	14.888
2	0.0	2.500	0.000	21.776	0.000	-0.850	0.000	8.759	11.259
3	0.0	2.500	0.000	21.776	0.000	0.850	0.000	8.759	11.259

Cylinder/Conical Frustum portion

4	0.000	0.850	0.850	21.776	0.000	0.000	0.000	11.783	14.283
Total					57.466	0.000	0.000	12.388	14.888

Below LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	1.5	3.958	0.000	0.000	0.750	3.250
2	0	2.500	0.000	1.5	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	1.5	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.25	0.850	1.5	0.000	0.000	0.000	0.632	3.132
Total					3.958	0.000	0.000	0.750	3.250

FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	2.500	2.50	65.625	0.000	0.000	-1.250	1.250
2	1	10.500	5	1.875	98.438	-3.472	0.000	-1.528	0.972
3	1	10.500	5.000	1.875	98.438	3.472	0.000	-1.528	0.972
Total					262.5	0.000	0.000	-1.458	1.042

EARTH ABOVE FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	12.500	4.000	525.000	0.000	0.000	-0.500	2.000
2	-1	Shaft Below LBL			-3.958	0.000	0.000	0.750	3.250
3	-1	Footing			-262.500	0.000	0.000	-1.458	1.042
Total					258.542	0.000	0.000	0.454	2.954

9. CALCULATION OF SEISMIC FORCE

$$\text{Time Period (T)} = 2 \sqrt{\frac{H}{1000 F}}$$

$$D = \text{Approximate DL of super-structure \& LL in Tonne (DL+20\% LL)} \\ = 499.26 \text{ KN} + 235.142 \text{ KN} \\ = 5225 \text{ KN}$$

F =

Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

$$F = \frac{6EI}{x^3(3L-x)} \text{ for 1 mm deflection at } x$$

$$E = 32000 \text{ N/mm}^2$$

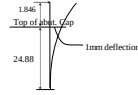
$$\text{Column Cross-Section}$$

$$D1 = 250 \text{ mm (Average Outer Dia)}$$

$$D2 = 120 \text{ mm (Average Inner Dia)}$$

$$I_{T1} = \text{mm}^4$$

$$I_{T2} = \text{mm}^4$$



$$\text{Force required in Long. Dir. } F_L = 7 \text{ KN}$$

$$\text{Force required in Trans. Dir. } F_T = 6 \text{ KN}$$

$$\text{Time Period - Longitudinal Seismic Case} = 1.722 \text{ seconds}$$

$$\text{Time Period - Transverse Seismic Case} = 1.815 \text{ seconds}$$

$$S_a/g \text{ - Longitudinal Seismic Case} = 0.790$$

$$S_a/g \text{ - Transverse Seismic Case} = 0.749$$

$$\text{Seismic Zone} = V$$

$$\text{Zone Factor } Z = 0.36$$

$$\text{Importance Factor } I = 1.20$$

$$\text{Response reduction Factor } R = 3.00$$

$$R = 3.00$$

$$\text{Avg response acceleration } S_a/g = 0.790$$

$$\text{Avg response acceleration } S_a/g = 0.749$$

$$\text{Elastic Seismic Coefficient} = Z/2 \times (S_a/g) \times (I/R)$$

$$\text{In longitudinal direction} = 0.171 / R$$

$$\text{In Transverse direction} = 0.162 / R$$

Enhancement factor		Substructure	Foundation
Design	Long. A _h	0.057	0.077
Seismic coefficient	Trans. A _t	0.054	0.073
	Vert. A _v	0.038	0.051

CALCULATION OF SEISMIC FORCES**SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPL:**

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVT	W	eVS	eVT
Total Super-Structure DL	347.02	27.16	29.66	347.02	27.16	29.66
Total Super-Structure SIDL	64.00	28.46	30.36	64.00	28.46	30.36
Total Super-Structure WC	88.00	28.09	30.28	88.00	28.09	30.28
Total Super-Structure FPL	0.00	28.09	30.28	0.00	28.09	30.28
Total	499.02	27.49	29.90	499.02	27.49	29.90

* Bearing level	25.38	27.88	25.38	27.88

SEISMIC COMPONENT OF SUB-STRUCTURE:

Description	W	eVS	eVT
Total weight of shaft and pier cap	263.00	15.92	18.27
Total weight of foundation	626.25	11.46	1.04

SEISMIC COMPONENT OF LIVE LOAD(20R+Class A):

Description	W	W	eVS	eVT
	Tonnes	Tonnes	(m)	(m)
20R + Class A	20R + Class A	20R + Class A		
Maximum Live Load	117.57	0.00	29.26	31.70
Minimum Live Load	22.29	0.00	29.26	31.70

Summary of Seismic force at shaft and foundation**Super structure**

Description	V	H.L.	H.T.	M.TT	M.L.L.
	Tonnes	Tonnes	Tonnes	tonne-metre	tonne-metre
Dead load - Super structure about shaft					
Seismic longitudinal direction	26.38			720.188	
Seismic Transverse direction			26.50		699.99
Seismic Vertical Direction	18.92				
Dead load - Super structure about foundation					
Seismic longitudinal direction	98.31			1058.04	
Seismic Transverse direction			36.345		1017.87
Seismic Vertical Direction	25.54				
Dead load - Left open Ditchlog-log about foundation					
Seismic longitudinal direction			19.16		534.019
Seismic Transverse direction			18.17		472.86
Seismic Vertical Direction	12.77				

Sub structure

Description	V	H.L.	H.T.	M.TT	M.L.L.
	Tonnes	Tonnes	Tonnes	tonne-metre	tonne-metre
Dead load - Sub structure about shaft					
Seismic longitudinal direction	15.01			278.65	
Seismic Transverse direction			14.24		227.33
Seismic Vertical Direction	10.01				
Dead load - Sub structure about foundation					
Seismic longitudinal direction			20.261		274.25
Seismic Transverse direction			19.27		253.12
Seismic Vertical Direction	13.51				

Live Load - Max

Description	V	H.L.	H.T.	M.TT	M.L.L.
	Tonnes	Tonnes	Tonnes	tonne-metre	tonne-metre
Live load - Max about shaft					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			1.27		17.11
Seismic Vertical Direction	0.89				
Live load - Max about foundation					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			1.71		68.38
Seismic Vertical Direction	1.20				

20R

Description	V	H.L.	H.T.	M.TT	M.L.L.
	Tonnes	Tonnes	Tonnes	tonne-metre	tonne-metre
Live load - Max about shaft					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			1.27		17.11
Seismic Vertical Direction	0.89				
Live load - Max about foundation					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			1.71		68.38
Seismic Vertical Direction	1.20				

Live Load - Min

Description	V	H.L.	H.T.	M.TT	M.L.L.
	Tonnes	Tonnes	Tonnes	tonne-metre	tonne-metre
Live load - Min about shaft					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			0.24		7.04
Seismic Vertical Direction	0.17				
Live load - Min about foundation					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			0.52		10.31
Seismic Vertical Direction	0.23				

20R

Description	V	H.L.	H.T.	M.TT	M.L.L.
	Tonnes	Tonnes	Tonnes	tonne-metre	tonne-metre
Live load - Min about shaft					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			0.24		7.04
Seismic Vertical Direction	0.17				
Live load - Min about foundation					
Seismic longitudinal direction			Not to be considered - IRC 6 219.5.2		
Seismic Transverse direction			0.52		10.31
Seismic Vertical Direction	0.23				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)**1. Normal Max Reaction on Fix End****Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ &+ 0.1 \times 0 + 0.05 \times 0 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 22.29) \\ &= 13.59 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 24.94 \text{ Ton} \\ F_{hr} &= 24.94 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 24.94 - 12.48 \\ &= 12.46 \text{ Ton} \end{aligned}$$

2. Normal Min Reaction on Fix End**Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 117.57) \\ &= 18.35 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 29.70 \text{ Ton} \\ F_{hr} &= 29.70 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 29.70 - 12.48 \\
 &= 17.23 \text{ Ton}
 \end{aligned}$$

3. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 173.510 + \text{Total SIDL load } 76.00 + \text{CWLL } 0.00) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= 0.2 \times \text{Class 70R on First two Lane } 20 + 0.05 \times \text{Class A on third Lane } 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 14.190 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 19.157 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 18.730 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 23.697 \text{ Ton} \\
 \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 173.510 + \text{Total SIDL load } 76.00 + \text{CWLL } 4.46) \\
 &= 12.69838 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (Rg + Rq) \text{ and } F_h - \mu (Rg + Rq))$$

$$\begin{aligned}
 F_{hr} \text{ for shaft} &= 24.33 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 26.82 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 24.33 - 12.48 \\
 &= 11.86 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 26.82 - 12.48 \\
 &= 14.34 \text{ Ton}
 \end{aligned}$$

4. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (Rg + Rq) &= 0.05 \times (\text{Total DL } 173.510 + \text{Total SIDL load } 76.00 + \text{CWLL } 0.00) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= 0.2 \times \text{Class 70R on First two Lane } 20 + 0.05 \times \text{Class A on third Lane } 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 14.190 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 19.157 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \%})
 \end{aligned}$$

$$\begin{aligned}
 \text{Total Horizontal force for Shaft}(F_h) &= 18.730 \text{ Ton} \quad \text{inc.)} \\
 \text{Total Horizontal force for foundation}(F_h) &= 23.697 \text{ Ton} \\
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{23.51} \right) \\
 &= 13.651204 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Max of } & \left(\frac{F_h}{2} + \mu (R_g + R_q) \right) \text{ and } \left(F_h - \mu (R_g + R_q) \right) \\
 F_{hr} \text{ for shaft} &= 25.29 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 27.77 \text{ Ton} \\
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 25.29 - 12.48 \\
 &= 12.81 \text{ Ton} \\
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 27.77 - 12.48 \\
 &= 15.29 \text{ Ton}
 \end{aligned}$$

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0.00$$

$$F_h = 20 \text{ Ton}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{22.29} \right) \\
 &= 13.59 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } \left(\frac{F_h}{2} + \mu (R_g + R_q) \right) \text{ and } \left(F_h - \mu (R_g + R_q) \right)$$

$$\begin{aligned}
 F_{hr} &= 23.59 \text{ Ton} \\
 F_{hr} &= 23.59 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 23.59 - 12.48 \\
 &= 11.11 \text{ Ton}
 \end{aligned}$$

6. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\
 &= 12.48 \text{ Ton}
 \end{aligned}$$

$$F_{hl} = 12.48 \text{ Ton}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 20 \text{ Ton}$$

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{117.57} \right) = 18.35 \text{ Ton}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$= 28.35 \text{ Ton}$$

$$F_{hr} = 28.35 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 28.35 - 12.48 \\ &= 15.88 \text{ Ton} \end{aligned}$$

7. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 4 \text{ Ton}$$

$$\text{Seismic Horizontal force (Shaft)} = 14.190 \text{ Ton}$$

$$\text{Seismic Horizontal force (foundation)} = 19.157 \text{ Ton}$$

$$\text{Total Horizontal force for Shaft (Fh)} = 18.190 \text{ Ton}$$

$$\text{Total Horizontal force for foundation (Fh)} = 23.157 \text{ Ton}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{4.46} \right) \\ &= 12.69838 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 23.79 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 26.28 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 23.79 - 12.48 \\ &= 11.32 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 26.28 - 12.48 \\ &= 13.80 \text{ Ton} \end{aligned}$$

8. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= 0.2 \times 20 + 0.05 \times 0 \\ F_h &= 4 \text{ Ton} \\ \text{Seismic Horizontal force (Shaft)} &= 14.190 \text{ Ton} \quad (\text{Including safety factor 1.5}) \\ \text{Seismic Horizontal force (foundation)} &= 19.157 \text{ Ton} \quad (\text{Including safety factor 1.5 and 35 \% inc.}) \\ \text{Total Horizontal force for Shaft (F}_h) &= 18.190 \text{ Ton} \\ \text{Total Horizontal force for foundation (F}_h) &= 23.157 \text{ Ton} \\ \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 23.51) \\ &= 13.651204 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 24.75 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 27.23 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 24.75 - 12.48 \\ &= 12.27 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 27.23 - 12.48 \\ &= 14.75 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION (Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 126.88) \\ &= 18.82 \text{ Ton} \\ F_{hr} &= 18.82 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 18.82 - 12.48 \\ &= 6.34 \text{ Ton} \end{aligned}$$

10. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 24.13 \text{ Ton} \\ F_{hr} &= 24.13 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 24.13 - 12.48 \\ &= 11.66 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hr} &= 12.48 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 12.48 - 12.48 \\ &= 0.00 \text{ Ton} \end{aligned}$$

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.475492 \text{ Ton} \\ F_{hr} &= 12.47549 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 12.47549 - 0.000 \\
 &= 12.47549 \text{ Ton}
 \end{aligned}$$

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 0 + 0.05 \times 0
 \end{aligned}$$

$$F_h = 0 \text{ Ton}$$

$$\begin{aligned}
 \text{Seismic Horizontal force(Shaft)} &= 14.190 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 19.157 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\
 \text{Total Horizontal force for Shaft}(F_h) &= 14.190 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 19.157 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.475492 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned}
 F_{hr} \text{ for shaft} &= 19.57 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 22.05 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 19.57 - 0.00 \\
 &= 19.57 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 22.05 - 0.00 \\
 &= 22.05 \text{ Ton}
 \end{aligned}$$

Summary of forces			
Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	12.46	12.46
	2. Normal Min Reaction on Fix End	17.23	17.23
	3. Seismic Max Reaction on Fix End	11.86	14.34
	4. Seismic Min Reaction on Fix End	12.81	15.29
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.11	11.11
	6. Normal Min Reaction on Fix End	15.88	15.88
	7. Seismic Max Reaction on Fix End	11.32	13.80
	8. Seismic Min Reaction on Fix End	12.27	14.75
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	6.34	6.34
	10. Normal Min Reaction on Fix End	11.66	11.66
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	12.48	12.48
	13. Seismic Span Dislodge Condition	19.57	22.05

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$C = \frac{WV^2}{127R}$$

70R + Class A

Maxium Reaction				
Live Load	W	=	117.57	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	7.41	t	

C (t)	e _{VS} (m)	e _{VF} (m)
7.41	29.26	31.76

Minimum Reaction				
Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0	29.26	31.76

70R

Maxium Reaction				
Live Load	W	=	117.57	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	7.4060597	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
7.40606	29.26	31.76

Minimum Reaction				
Live Load	W	=	22.29	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	1.404019	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
1.404019	29.26	31.76

Special Vehicle**Maxium Reaction**

Live Load	W	=	233.12	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	200	m

$$C = 0.2294474 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0.229447	29.26	31.76

Minimum Reaction

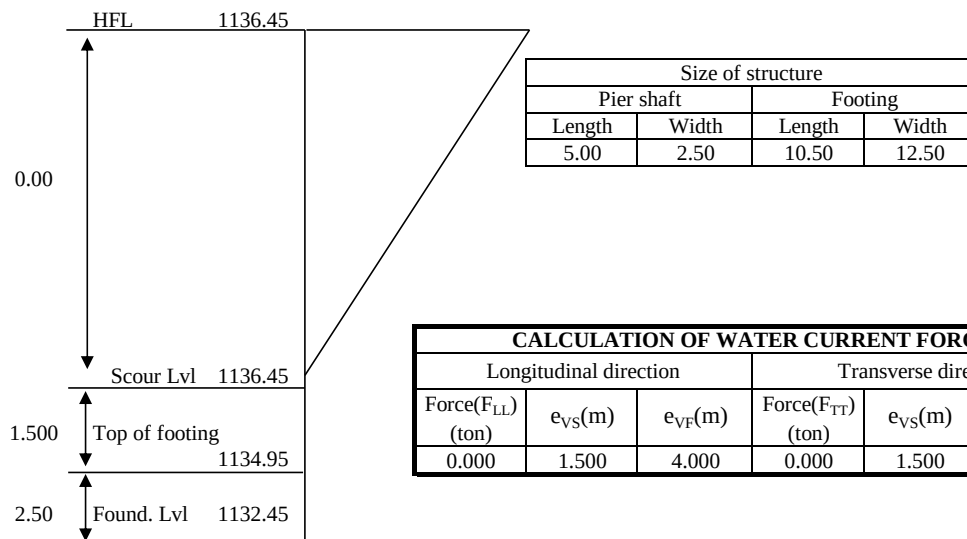
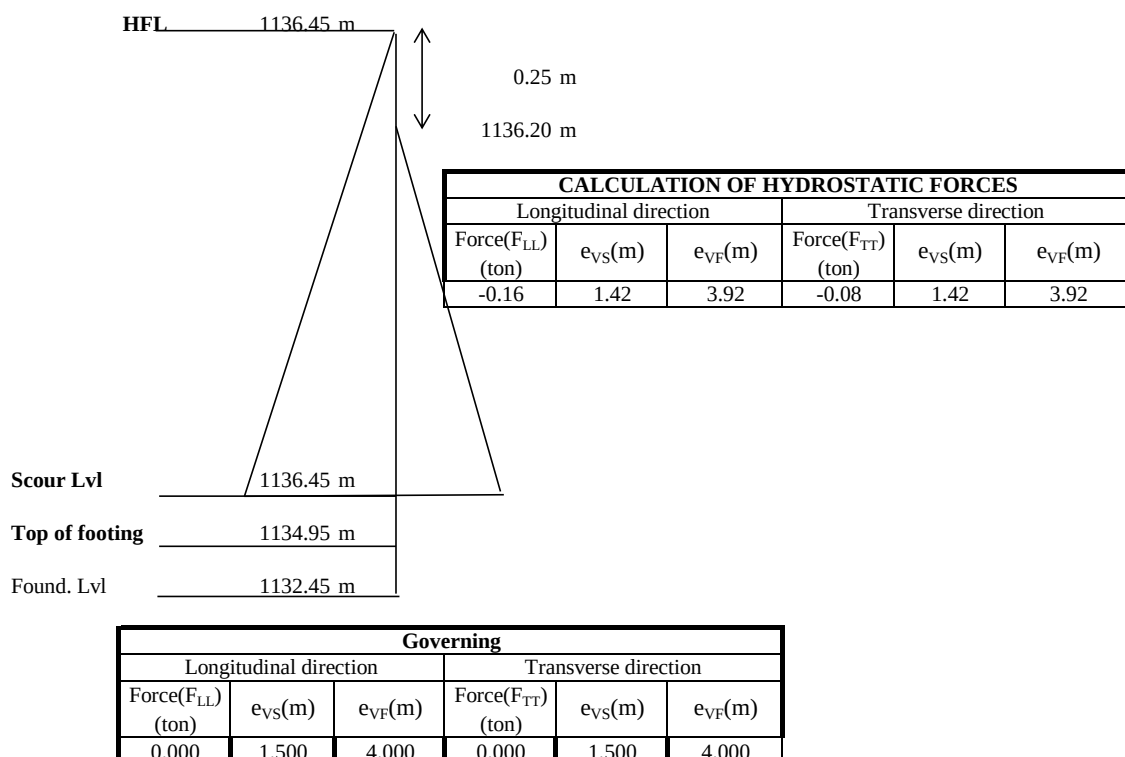
Live Load	W	=	126.88	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	200	m

$$C = 0.1248833 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0.124883	29.26	31.76

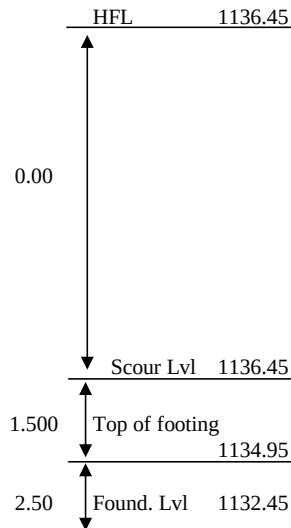
12. WATER CURRENT FORCES**NORMAL CASE****Water current forces**

HFL	=	1136.445 m	
MSL (NORMAL)	=	1136.445 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL (Trans direction)		=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ² 53 K (vsinq) ²

**Pressure diagram (Normal case)****Static Force**

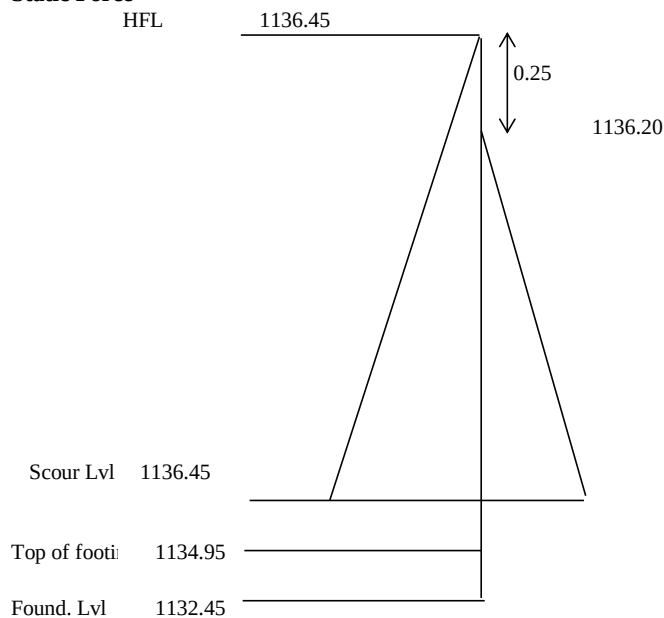
SEISMIC CASE

HFL	=	1136.445 m	
MSL (SEISMIC)	=	1136.45 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2} \times 4.00$
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL (Trans direction)		=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ² 53 K (vsinq) ²

**Pressure diagram (seismic case)**

Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
5.00	2.50	10.50	12.50

CALCULATION OF WATER CURRENT					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.000	1.500	4.000	0.000	1.500	4.000

Static Force

CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
-0.16	1.42	3.92	-0.08	1.42	3.92

Governing					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.000	1.500	4.000	0.000	1.500	4.000

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

- LC -1 ULS NORMAL LWL MAX REACTION
 LC -2 ULS NORMAL LWL SPAN DISLOGED
- LC - 5 ULS MAX REACTION $1X + 0.3Y + 0.3Z$
 LC - 6 ULS MAX REACTION $0.3X + 1Y + 0.3Z$
- LC - 9 ULS NORMAL SV MAX REACTION

SLS

- LC -1 RARE NORMAL MAX REACTION
 LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

- LC - 1 ULS NORMAL MAX REACTION(70R +Class A)
 LC - 2 ULS NORMAL SPAN DISLOGED
- LC - 5 ULS NORMAL MAX REACTION(70R)
- LC - 7 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R + \text{Class A})$
 LC - 8 ULS SPAN DISLODGED $1X + 0.3Y + 0.3Z$
 LC - 9 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{Class A})$
 LC - 10 ULS SPAN DISLODGED $0.3X + 1Y + 0.3Z$
- LC - 15 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC - 16 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R)$
- LC - 19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION(70R+Class A)

LC - 2 NORMAL SPAN DISLOGED

LC - 5 0

LC - 6 SEISMIC SPAN DISLODGED $1X + 0.3Y + 0.3Z$ LC - 7 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{class A})$ LC - 8 SEISMIC LWL SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 13 SEISMIC NORMAL MAX REACTION(70R)

LC - 15 SEISMIC MAX REACTION $1X + 0.3Y + 0.3Z(70R)$ LC - 16 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 13 NORMAL LWL SV MAX REACTION

14A DESIGN FORCES FOR PIER SHAFT(ULS CASES)

LC -1 ULS NORMAL LWL MAX REACTION

Sr. No.	Description	Volume (m³)	Unit weight (t/m³)	Vertical Load (V in ton)	Horizontal Load(ton)	e ₁ (m)	e ₂ (m)	e ₃ (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510	-0.600	0.000			-123.306	0.000	1.35	
2	Surfacing			44.000	-0.600	0.000			-26.400	0.000	1.75	
3	P.L.L			0.000	-0.600	0.000			0.000	0.000	1.5	
4	LL (70R)			0.000	-0.600	0.950			0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000	-0.600	1.000			0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510	0.600	0.000			123.306	0.000	1.35	
7	Surfacing			44.000	0.600	0.000			26.400	0.000	1.75	
8	P.L.L			0.000	0.600	0.000			0.000	0.000	1.5	
9	LL (70R)			117.571	0.600	1.510			70.543	177.533	1.5	0.9
10	LL (Class-A)			0.000	0.600	1.000			0.000	0.000	1.5	0.9
11	Centrifugal force				7.406				29.255	0.0	216.664	1.5
12	Pier cap	44.132	2.5	110.330	0.000	0.000			0.000	0.000	1.35	
13	Pier (above LRL)	57.466	2.5	143.665	0.000	0.000			0.000	0.000	1.35	
14	Pier (below LRL)	3.958	2.5	9.896	0.000	0.000			0.000	0.000	1.5	
17	Horizontal Force(F _{L1})				12.464				25.376	316.301		
	Horizontal Force(F _{L2})				0.000				25.376	0.000		

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1241.49	565.68	564.67

LC -2 ULS NORMAL LWL SPAN DISLOGED

Sr. No.	Description	Volume (m³)	Unit weight (t/m³)	Vertical Load (V in ton)	Horizontal Load(ton)	e ₁ (m)	e ₂ (m)	e ₃ (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000	-0.600	0.000			0.000	0.000	1.35	
2	Surfacing			0.000	-0.600	0.000			0.000	0.000	1.75	
3	P.L.L			0.000	-0.600	0.000			0.000	0.000	1.5	
4	LL (70R)			0.000	-0.600	0.950			0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000	-0.600	1.000			0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510	0.600	0.000			123.306	0.000	1.35	
7	Surfacing			44.000	0.600	0.000			26.400	0.000	1.75	
8	P.L.L			0.000	0.600	0.000			0.000	0.000	1.5	
9	LL (70R)			0.000	0.600	1.510			0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000	0.600	1.000			0.000	0.000	1.5	0.9
11	Centrifugal force				0.000				29.255	0.000	0.000	1.5
12	Pier cap	44.132	2.5	110.330	0.000	0.000			0.000	0.000	1.35	
13	Pier (above LRL)	57.466	2.5	143.665	0.000	0.000			0.000	0.000	1.35	
14	Pier (below LRL)	3.958	2.5	9.896	0.000	0.000			0.000	0.000	1.35	
17	Horizontal Force(F _{L1})				12.475				25.376	316.301		
	Horizontal Force(F _{L2})				0.000				25.376	0.000		

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
710.69	687.53	0.00

LC -5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m³)	Unit weight (t/m³)	Vertical Load (V in ton)	Horizontal Load(ton)	e ₁ (m)	e ₂ (m)	e ₃ (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510	-0.60	0.000			-123.306	0.000	1.35	
2	Surfacing			44.000	-0.60	0.000			-26.400	0.000	1.75	
3	P.L.L			0.000	-0.60	0.000			0.000	0.000	1.5	
4	LL (70R)			0.000	-0.60	0.950			0.000	0.000	0.2	1
5	LL (Class-A)			0.000	-0.60	1.000			0.000	0.000	0.2	1
Right Span												
6	DL (superstructure)			205.510	0.60	0.000			123.306	0.000	1.35	
7	Surfacing			44.000	0.60	0.000			26.400	0.000	1.75	
8	P.L.L			0.000	0.60	0.000			0.000	0.000	0.2	
9	LL (70R)			117.571	0.60	1.510			70.543	177.5	0.2	1
10	LL (Class-A)			0.000	0.60	1.000			0.000	0.0	0.2	1
11	Centrifugal force				7.406				29.255	0.0	216.7	0.2
12	Pier cap	44.13	2.50	110.33	0.00	0.000			0.000	0.000	1.35	
13	Pier (above LRL)	57.47	2.50	143.67	0.00	0.000			0.000	0.000	1.35	
14	Pier (below LRL)	3.96	2.50	9.90	0.00	0.000			0.000	0.000	1.5	
17	Horizontal Force(F _{L1})				11.858				25.376	300.911		
	Horizontal Force(F _{L2})				0.000				25.376	0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				20.300				720.19		1.5	
	Transverse				26.922					690.98708	0.45	
	Vertical			18.920							0.45	
Sub structure												
	Longitudinal				15.000				239.65		1.5	
	Transverse				14.237					227.33268	0.45	
	Vertical			10.005							0.45	
a)	Max Live Load										1.5	
	Longitudinal									37.112345	0.45	
	Transverse				1.269						0.45	
	Vertical			0.892							0.45	

SUMMARY OF FACTORED FORCES

V(ton)	MTT (tm)	MLL(tm)
1102.062	1754.77	588.78

LC -6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m³)	Unit weight (t/m³)	Vertical Load (V in ton)	Horizontal Load(ton)	e ₁ (m)	e ₂ (m)	e ₃ (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510	-0.60	0.00			-123.31	0.00	1.35	
2	Surfacing			44.000	-0.60	0.00			-26.40	0.00	1.75	
3	P.L.L			0.000	-0.60	0.00			0.00	0.00	0.2	
4	LL (70R)			0.000	-0.60	0.95			0.00	0.00	0.2	1
5	LL (Class-A)			0.000	-0.60	1.00			0.00	0.00	0.2	1
Right Span												
6	DL (superstructure)			205.510	0.60	0.00			123.31	0.00	1.35	
7	Surfacing			44.000	0.60	0.00			26.40	0.00	1.75	
8	P.L.L			0.000	0.60	0.00			0.00	0.00	0.2	
9	LL (70R)			117.571	0.60	1.51			70.54	177.53	0.2	1
10	LL (Class-A)			0.000	0.60	1.00			0.00	0.00	0.2	1
11	Centrifugal force				7.406				29.255	0.0	216.664	0.2
12	Pier cap	44.132	2.500	110.330	0.000	0.000			0.000	0.000	1.35	
13	Pier (above LRL)	57.466	2.500	143.665	0.000	0.000			0.000	0.000	1.35	
14	Pier (below LRL)	3.958	2.500	9.896	0.000	0.000			0.000	0.000	1.5	
17	Horizontal Force(F _{L1})				11.858				25.376	300.911		
	Horizontal Force(F _{L2})				0.000				25.376	0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				20.300				720.19		0.45	
	Transverse				26.922					690.987	1.5	
	Vertical			18.920							0.45	
Sub structure												
	Longitudinal				15.000				239.65		0.45	
	Transverse				14.237					227.333	1.5	
	Vertical			10.005							0.45	
a)	Max Live Load										1.5	
	Longitudinal									37.112	0.45	
	Transverse				1.269						0.45	
	Vertical			0.892							0.45	

SUMMARY OF FACTORED FORCES

V(ton)	MTT (tm)	MLL(tm)
1102.062	746.95	1511.99

LC -9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e ₁ (m)	e ₂ (m)	e ₃ (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)	205.510		-0.600	0.000				-123.306	0.000	1.35	
2	Surfacing	44.000		-0.600	0.000				-26.400	0.000	1.75	
3	P.L.L	0.000		-0.600	0.000				0.000	0.000	1.5	
4	LL	0.000		-0.600	0.300				0.000	0.000	1	1
Right Span												
5	DL (superstructure)	205.510		0.600	0.000				123.306	0.000	1.35	
6	Surfacing	44.000		0.600	0.000				26.400	0.000	1.75	
7	P.L.L	0.000		0.600	0.000				0.000	0.000	1.5	
8	LL	233.119		0.600	0.300				139.871	69.936	1	1
Centrifugal force												
9	Pier cap	44.132	2.5	110.330	0.000	0.000		29.252	6.712	0.000	1	
10	Pier (below LRL)	27.466	2.5	68.665	0.000	0.000		0.000	0.000	0.000	1.35	
11	Pier (below LRL)	1.958	2.5	4.895	0.000	0.000		0.000	0.000	0.000	1.5	
12	Horizontal Force(F _H)				6.344			25.376	160.989	0.000	1.5	

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)**LC -1 RARE NORMAL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				7.406			29.255	0.000	216.664	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			1.500	0.000		1	
	Water Current Force(F _{TT})				0.000			1.500		0.000	1	
17	Horizontal Force(F _{LL})				12.464			25.376	316.301		1	
	Horizontal Force(F _{TT})				0.000			25.376		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
898.08	379.79	376.44

LC-2 RARE NORMAL SPAN DISLODGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force(F _{LL})				0.000			29.255	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			1.500	0.000		1	
	Water Current Force(F _{TT})				0.000			1.500		0.000	1	
17	Horizontal Force(F _{LL})				12.475			25.376	316.581		1	
	Horizontal Force(F _{TT})				0.000			25.376		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
522.20	471.57	0.00

LC -5 QP NORMAL

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	0	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			29.255	0.000	216.664	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			1.500	0.000		0	
	Water Current Force(F _{TT})				0.000			1.500		0.000	0	
17	Horizontal Force(F _{LL})				0.000			25.376	0.000		0	
	Horizontal Force(F _{TT})				0.000			25.376		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
780.51	0.00	216.66

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			29.255	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F _{LL})				0.000			1.500	0.000		0	
	Water Current Force(F _{TT})				0.000			1.500		0.000	0	
17	Horizontal Force(F _{LL})				12.475			25.376	316.581		1	
	Horizontal Force(F _{TT})				0.000			25.376		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
522.20	471.57	0.00

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
7	FLL			0.000		0.600	0.000		0.000	0.000	1	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			29.255	6.712		1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			1.500	0.000		1	
	Water Current Force(F _{TT})				0.000			1.500		0.000	1	
15	Horizontal Force(F _{LL})				6.344			25.376	160.989		1	
	Horizontal Force(F _{TT})				0.000			25.376		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1013.63	307.57	69.94

15. DESIGN FORCES FOR FOUNDATION**LC -1 ULS NORMAL MAX REACTION(70R +Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				7.406			31.755	0.0	235.179	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				12.464			27.876	347.46		1.5	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2807.85	616.43	592.44

LC -2 ULS NORMAL SPAN DISLODGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			31.755	0.000	0.000	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				12.475			27.876	347.770		1.5	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2294.69	734.32	0.00

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			31.755	0.0	235.179	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				11.114			27.876	309.83		1.5	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2109.789	559.98	592.44

LC - 7 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				7.406			31.755	0.0	235.179	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	57.466	2.500	143.665		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	3.958	2.500	9.896		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				14.341			27.876	399.78		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				38.314				1068.0		1.5	
	Transverse				36.345					1017.9	0.45	
	Vertical			25.542							0.45	
	Sub structure											
	Longitudinal				20.261				372.3		1.5	
	Transverse				19.220					353.12213	0.45	
	Vertical			13.51							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.713					54.383127	0.45	
	Vertical			1.204							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2690.789	2574.33	725.35

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			31.755	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.00		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				22.054			27.876	614.78		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				19.157				534.02		1.5	
	Transverse				18.172					472.8615	0.45	
	Vertical			12.771							0.45	
	Sub structure											
	Longitudinal				20.261				372.3		1.5	
	Transverse				19.220					353.12213	0.45	
	Vertical			13.507							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2306.517	2020.39	371.69

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				7.406			31.755	0.0	235.179	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{L1})				0.000			4.000	0.00		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{L1})				14.341			27.876	399.78		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				38.314			1068.0			0.45	
	Transverse				36.345					1017.867	1.5	
	Vertical			25.542							0.45	
Sub structure												
	Longitudinal				20.261			372.3			0.45	
	Transverse				19.220					353.122	1.5	
	Vertical			13.507							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.713					54.383	1.5	
	Vertical			1.204							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2690.789	1062.02	2236.07

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			31.755	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{L1})				0.000			4.000	0.00		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{L1})				22.054			27.876	614.78		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				19.157			534.02			0.45	
	Transverse				18.172					472.8615	1.5	
	Vertical			12.771							0.45	
Sub structure												
	Longitudinal				20.261			372.3			0.45	
	Transverse				19.220					353.12213	1.5	
	Vertical			13.507							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2306.517	1068.80	1238.98

LC -15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			31.755	235.2	0.000	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	57.466	2.500	143.665		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	3.958	2.500	9.896		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				13.801			27.876	384.73		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				38.314				1068.0		1.5	
	Transverse				36.345					1017.9	0.45	
	Vertical			25.542							0.45	
Sub structure												
	Longitudinal				20.261				372.3		1.5	
	Transverse				19.220					353.12213	0.45	
	Vertical			13.51							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.713					54.38	0.45	
	Vertical			1.204							0.45	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.325					10.309793	0.45	0.3
	Vertical			0.228							0.45	0.3
SUMMARY OF FACTORED FORCES												
		V(ton)	MTT (tm)	MLL(tm)								
		2690.789	2606.31	678.32								

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			31.755	235.2	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			4.000	0.00		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				13.801			27.876	384.73		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				38.314				1068.0		0.45	
	Transverse				36.345					1017.867	1.5	
	Vertical			25.542							0.45	
Sub structure												
	Longitudinal				20.261				372.3		0.45	
	Transverse				19.220					353.122	1.5	
	Vertical			13.507							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.713					54.383	1.5	
	Vertical			1.204							0.45	
b)	Min Live Load											
	Longitudinal										0.45	0.3
	Transverse				0.325					10.309793	1.5	1
	Vertical			0.228							0.45	0.3
SUMMARY OF FACTORED FORCES												
		V(ton)	MTT (tm)	MLL(tm)								
		2690.789	1094.00	2189.03								

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VT} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
7	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			31.755	0.0	7.286	1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
15	Horizontal Force(F _{LL})				6.344			27.876	176.85		1.5	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1.5	
16	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2882.25	405.14	77.22

16. DESIGN FORCES FOR BASE PRESSURE**LC -1 NORMAL MAX REACTION(70R+Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				7.406			31.755	0.0	235.179	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				12.464			27.876	347.46		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2042.06	410.95	394.96

LC -2 NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			31.755	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				12.475			27.876	347.770		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1686.73	497.48	0.00

497.476 0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	

11	Centrifugal force				0.000			31.755	0.00	0.000	0	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F_{LL})				0.000			4.000	0.00		1	
	Water Current Force(F_{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F_{LL})				22.054			27.876	614.78		1	
	Horizontal Force(F_{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				19.157			534.02			1	
	Transverse				13.461				350.26778		0.3	
	Vertical			9.460							0.3	
	Sub structure											
	Longitudinal				20.261			372.3			1	
	Transverse				19.220				353.12		0.3	
	Vertical			13.507							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1693.625	1547.45	211.02

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			31.755	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F_{LL})				0.000			4.000	0.00		1	
	Water Current Force(F_{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F_{LL})				22.054			27.876	614.78		1	
	Horizontal Force(F_{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				0.000			0.00			0.3	
	Transverse				13.461				350.26778		1	
	Vertical			9.460							0.3	
	Sub structure											
	Longitudinal				20.261			372.3			0.3	
	Transverse				19.220				353.12213		1	
	Vertical			13.507							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1693.625	752.86	703.39

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centifugal force				7.406			31.755	0.0	235.179	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				11.114			27.876	309.83		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2042.06	373.32	394.96

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centifugal force				7.406			31.755	235.2	0.000	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	57.466	2.500	143.665		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	3.958	2.500	9.896		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				13.801			27.876	384.73		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1	
20	Seismic											
Super structure												
	Longitudinal				38.314				1068.0		1	
	Transverse				36.345					1017.9	0.3	
	Vertical			25.542							0.3	
Sub structure												
	Longitudinal				20.261				372.3		1	
	Transverse				19.220					353.12	0.3	
	Vertical			13.51							0.3	
a)	Max Live Load											
	Longitudinal										1	
	Transverse				1.713					54.38	0.3	
	Vertical			1.204							0.3	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.325					10.309793	0.45	0.3
	Vertical			0.228							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1971.865	1886.16	464.51

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			31.755	235.2	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	57.47	2.50	143.67		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	3.96	2.50	9.90		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			4.000	0.00		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
17	Horizontal Force(F _{LL})				13.801			27.876	384.73		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	258.54	2.00	517.08		0.00	0.00		0.00	0.00	1	
20	Seismic											
Super structure												
	Longitudinal				38.314				1068.0		0.3	
	Transverse				36.345					1017.9	1	
	Vertical			25.542							0.3	
Sub structure												
	Longitudinal				20.261				372.3		0.3	
	Transverse				19.220					353.12	1	
	Vertical			13.507							0.3	
a)	Max Live Load											
	Longitudinal										0.3	
	Transverse				1.713					54.38	1	
	Vertical			1.204							0.3	
b)	Min Live Load											
	Longitudinal										0.45	0.3
	Transverse				0.325					10.3	1.5	1
	Vertical			0.228							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1971.865	877.96	1476.34

LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
7	FLL			0.000		0.600	0.000		0.000	0.000	1	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			31.755	0.0	7.286	1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	57.466	2.5	143.665		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	3.958	2.5	9.896		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F _{LL})				0.000			4.000	0.000		1	
	Water Current Force(F _{TT})				0.000			4.000		0.000	1	
15	Horizontal Force(F _{LL})				6.344			27.876	176.85		1	
	Horizontal Force(F _{TT})				0.000			27.876		0.000	1	
16	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	258.54	2	517.083		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2169.36	316.72	77.22

***DESIGN OF PIER P6 AND
ITS FOUNDATION
FOR MAJOR BRIDGE AT CH-82+425***

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle : 0 degree 0 Radian

<u>SPAN DETAILS</u>	<u>Left span</u>		<u>Right span</u>		<u>Unit</u>
	<u>Right</u>	<u>Skew</u>	<u>Right</u>	<u>Skew</u>	
C/C Expansion joint	= 40.000	40.000	40.000	40.00	m
C/C Expansion joint to C.L. brg	= 0.600	0.600	0.600	0.60	m
Expansion gap	= 50	50	50	50	mm
C/C bearing	= 38.800	38.800	38.800	38.800	m

SUPERSTRUCTURE DETAILS

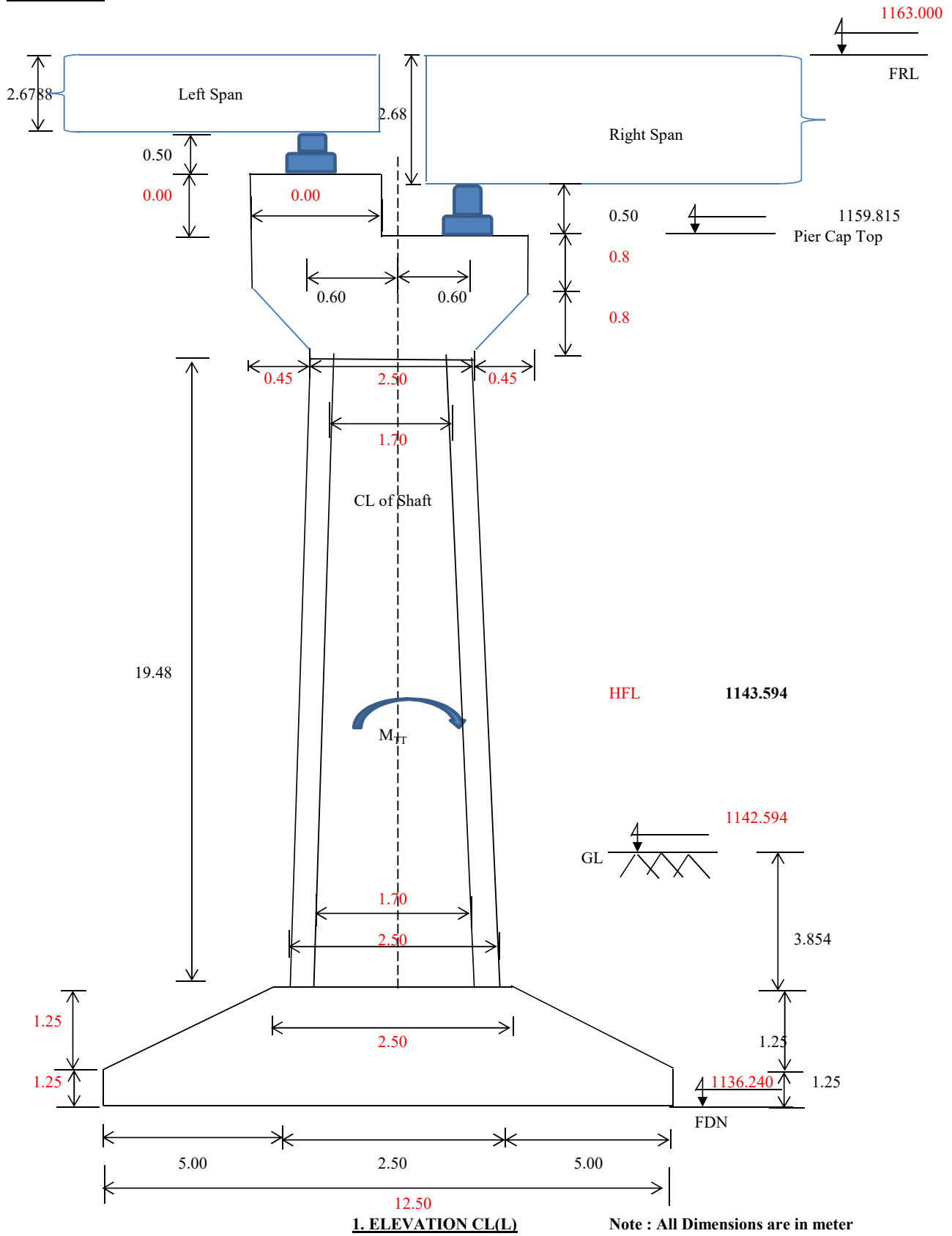
	Left Span	Right Span
Overall deck width of bridge	= 12.50 m	12.50 m
Carriage way width	= 11.50 m	11.50 m
Crash barrier width	= 0.45 m	0.45 m
Height of crash barrier	= 1.00 m	1.00 m
C.g of Crash barrier from bottom	= 0.40 m	0.40 m
Cross-slope	= 2.50 %	2.50 %
Wearing coat thickness	= 65 mm	65 mm
Nos. of Bearing	= 4	4
Spacing of Bearing	= 7.50 m	7.50 m
Depth of Girder	= 2.300 m	2.300 m
Depth of slab	= 0.22 m	0.22 m
Depth of superstructure	= 2.520 m	2.520 m
Bearing + Pedestal height	= 0.50 m	0.50 m
Width of main girder at top	= 0.50 m	0.50 m
Width of cross girder	= 0.30 m	0.30 m
Nos. of cross-girders	= 2	2
FRL to Soffit	= 2.68 m	2.68 m
Type of Bearing	OR SPHERICAL BRG	

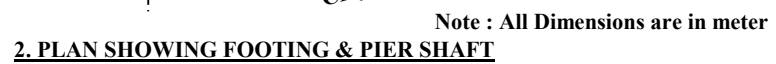
LEVEL DETAILS

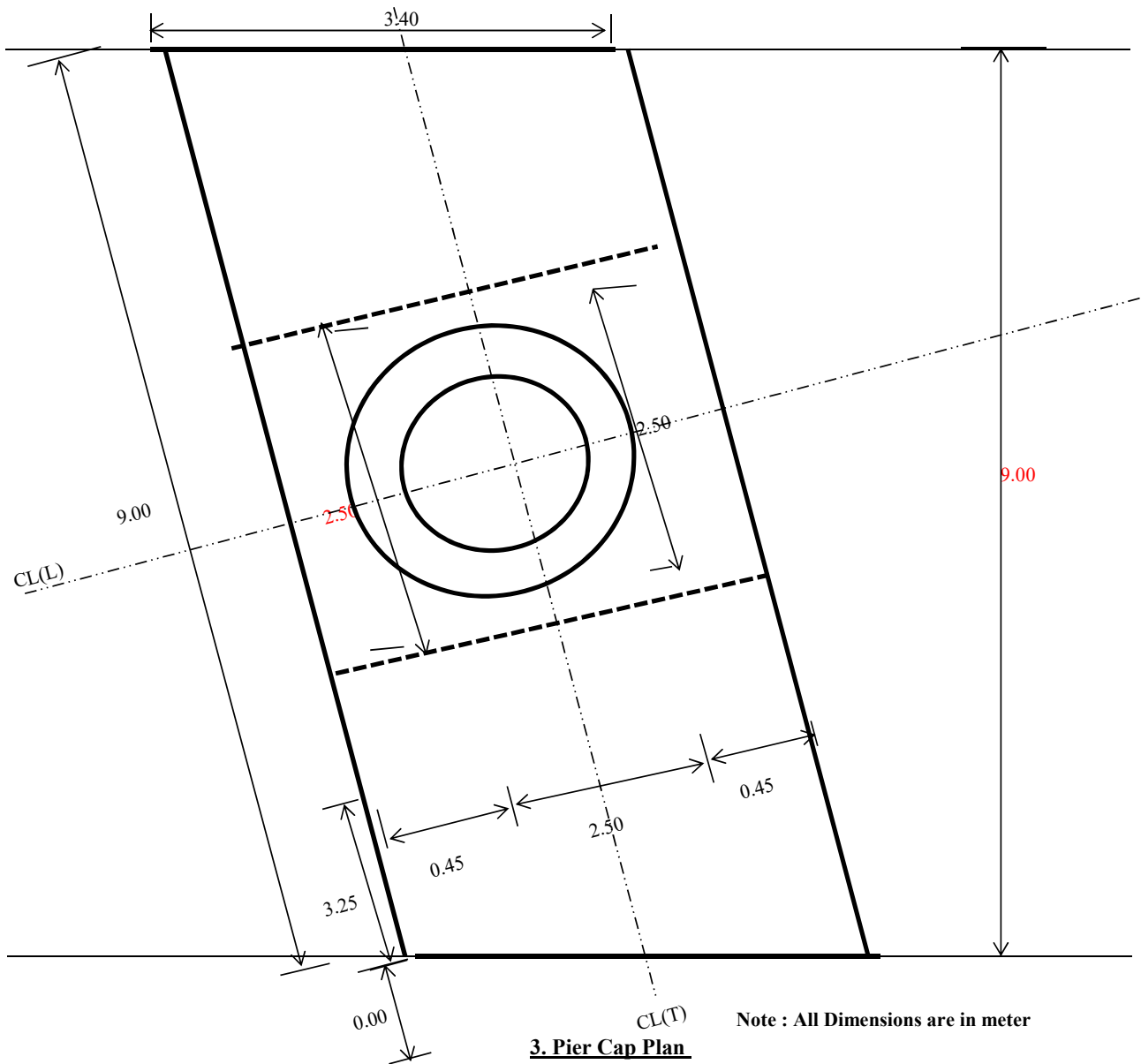
Formation level	= 1163.000 m
Pier cap top level	= 1159.815 m
HFL	= 1142.594 m
Ground level	= 1142.594 m
MSL (Normal)/Rock Level	= 1142.594 m
MSL (Seismic)/Rock Level	= 1142.594 m
Pier shaft bottom/Footing top level	= 1138.734 m
Founding level	= 1136.240 m

DIMENSION DETAILS

<u>Pier cap:</u>	Right	Skew
Width of pier cap at top	= 3.40 m	3.40 m
Width of pier cap at bottom	= 3.40 m	3.40 m
Length of pier cap at top	= 9.00 m	9.00 m
Length of pier cap at bottom	= 2.50 m	2.50 m
Thickness of uniform portion	= 0.80 m	0.80 m
Thickness of tapered portion	= 0.80 m	0.80 m
<u>Pier shaft:</u>		
Width of pier at top	= 2.50 m	2.50 m
Width of pier at bottom	= 2.50 m	2.50 m
Length of pier (rectangle portion)	= 0.00 m	0.00 m
Length of pier(end circular portion Top)	= 1.25 m	1.25 m
Length of pier (end circular portion Bottom)	= 1.25 m	1.25 m
Total length of pier shaft at top	= 2.50 m	2.50 m
Total length of pier shaft at bottom	= 2.50 m	2.50 m
<u>Footing:</u>		
Width of footing at top	= 2.50 m	2.50 m
Width of footing at bottom	= 12.50 m	12.50 m
Length of footing	= 10.50 m	10.50 m
Thickness at tip	= 1.25 m	1.25 m
Maximum thickness	= 2.50 m	2.50 m

DIAGRAMS:





2. MATERIALS DETAILS**CONCRETE:**

Grade of concrete	fck	=	M 35	
Mean value of concrete compressive strength, fcm		=	M 45 (28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447 x fck	(Basic and Seismic combination)
		=	15.633 Mpa	
Secant modulus of elasticity, Ecm		=	32000 Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8 Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5 t/m ³	

SOIL :

Density dry		=	2 t/m ³	
Density Saturated		=	2.3 t/m ³	
Soil density (submerged)		=	2 t/m ³	
Angle of Internal friction ϕ		=	35	
Cohesion c		=	0	
Gross bearing capacity		=	35.00 t/m ²	(Normal case)
		=	43.75 t/m ²	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	11.159 m ²	
Perimeter in contact with atmosphere, u		=	12.854 m	
Notional size, ho = 2Ac/u		=	1736 mm	
Age of concrete at the time of loading to		=	90 days	
	ta	=	25550 days	
	f(α 90)	=	1.2 (Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32 (increased by 10%)	
Creep co-efficient for foundation		=	1.0 (as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793 Mpa	Ecm ' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500 Mpa	
Modulus of elasticity	Es	=	200000 Mpa	

3. PERMISSIBLE STRESSES**MAXIMUM PERMISSIBLE STRESS IN CONCRETE:**

Rare combination		=	0.48 x fck	
		=	16.8 Mpa	
Quasi permanent combination		=	0.36 x fck	
		=	12.6 Mpa	

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300 Mpa	
Permissible crack width	Wk,max	=	0.3 mm	

4. SEISMIC PARAMETERS

Seismic zone		=	V	
Type of soil		=	Type2(Medium)	
Zone factor	Z	=	0.36	
Importance factor	I	=	1.20	
Response Reduction Factor(Long)	R	=	3	
Response Reduction Factor(Trans)	R	=	3	

5. ENVIRONMENTAL PARAMETERS

Relative humidity		=	80%	
Condition of exposure		=	Moderate	

6.OTHER PARAMETERS

Mean velocity of water current flow		=	4.00 m/s	
Design Speed V		=	40 Kmph	
Radius of Curvature R		=	200 m	

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew = **0 °** = **0.000 Radian**
No. of Bearing = 4.00
Right **Skew**
c/c of bearing in Transverse Direction = 7.500 m 7.500 m
c/c bearing on Longitudinal Direction = 1.200 m 1.200 m
Impact Factor for Design of Pier Cap = 1.10

Left Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
		1735.10	320.00							
Total Load	2055.10		440.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000	0.300	0.300

Right Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
		1735.10	320.00							
Total Load	2055.10		440.00	0.00	1175.71	222.89	0.00	0.00	2331.19	1268.81
Resultant Transverse Ecc.	0.000		0.000	0.000	1.510	2.390	1.000	1.000	0.300	0.300

8. VOLUME OF SUBSTRUCTURE

PIER CAP

Uniform portion

No.		L(m)	B(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	9.000	0.000	0.000	0.000	1.700	0.000	21.08125	23.58
2	1	9.000	3.400	0.800	24.480	0.000	0.000	20.68125	23.18

Tapered portion

2a	Rectangle	2.500	3.400	0.800	6.800	0.000	0.000	19.881	22.381
	Triangle	3.250	3.400	0.800	8.840	0.000	0.000	20.015	22.515
Total Inc. 10%					44.132	0.000	0.000	18.544	20.817

PIER SHAFT

Above HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	15.627	41.239	0.000	0.000	11.668	14.168
2	0	2.500	0.000	15.627	0.000	-1.250	0.000	9.063	11.563
3	0	2.500	0.000	15.627	0.000	1.250	0.000	9.063	11.563

Cylinder/Conical Frustum portion

4	0.000	0.850	1.25	15.627	0.000	0.000	0.000	11.668	14.168
Total					41.239	0.000	0.000	11.668	14.168

Below HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	3.854	10.170	0.000	0.000	1.927	4.427
2	0	2.500	0.000	3.854	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	3.854	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.250	0.850	3.854	0.000	0.000	0.000	1.927	4.427
Total					10.171	0.000	0.000	1.927	4.427

Above LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	15.627	41.239	0.000	0.000	11.668	14.168
2	0.0	2.500	0.000	15.627	0.000	-0.850	0.000	9.063	11.563
3	0.0	2.500	0.000	15.627	0.000	0.850	0.000	9.063	11.563

Cylinder/Conical Frustum portion

4	0.000	0.850	0.850	15.627	0.000	0.000	0.000	11.234	13.734
Total					41.239	0.000	0.000	11.668	14.168

Below LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	3.854	10.170	0.000	0.000	1.927	4.427
2	0	2.500	0.000	3.854	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	3.854	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.25	0.850	3.854	0.000	0.000	0.000	1.623	4.123
Total					10.170	0.000	0.000	1.927	4.427

FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	2.500	2.50	65.625	0.000	0.000	-1.250	1.250
2	1	10.500	5	1.875	98.438	-3.472	0.000	-1.528	0.972
3	1	10.500	5.000	1.875	98.438	3.472	0.000	-1.528	0.972
Total					262.5	0.000	0.000	-1.458	1.042

EARTH ABOVE FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	12.500	6.354	833.963	0.000	0.000	0.677	3.177
2	-1	Shaft Below LBL			-10.170	0.000	0.000	1.927	4.427
3	-1	Footing			-262.500	0.000	0.000	-1.458	1.042
Total					561.292	0.000	0.000	1.653	4.153

9. CALCULATION OF SEISMIC FORCE

$$\text{Time Period } C \cdot T = 2 \sqrt{\frac{D}{1000 F}}$$

$$\begin{aligned} D &= \text{Approximate DL of super-structure \& LL in Tonne (DL+20\% LL)} \\ &= 4990.20 \text{ KN} + 235.142 \text{ KN} \\ &= 5225 \text{ KN} \end{aligned}$$

$$F =$$

Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction; and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

$$F = \frac{6 E I}{x^2(3L-x)} \quad \text{for 1 mm deflection at } x$$

$$E = 32000 \text{ N/mm}^2$$

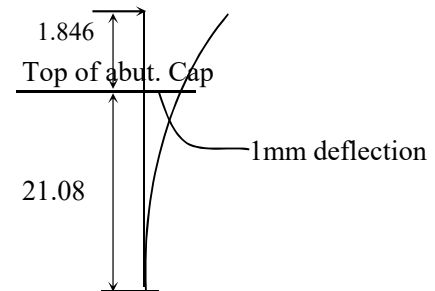
Column Cross-Section

$$D1 = 2.50 \text{ m (Average Outer Dia)}$$

$$D2 = 1.70 \text{ m (Average Inner Dia)}$$

$$I_{TT} = 1.13E+12 \text{ mm}^4 \quad 1.5E+12$$

$$I_{LL} = 1.13E+12 \text{ mm}^4$$



$$\text{Force required in Long. Dir. } F_L = 12 \text{ KN}$$

$$\text{Force required in Trans. Dir. } F_T = 10 \text{ KN}$$

$$\text{Time Period -Longitudinal Seismic Case} = 1.343 \text{ seconds}$$

$$\text{Time Period -Transverse Seismic Case} = 1.429 \text{ seconds}$$

$$S_a/g \text{ -Longitudinal Seismic Case} = 1.013$$

$$S_a/g \text{ -Transverse Seismic Case} = 0.952$$

$$\text{Seismic Zone} = V$$

$$\text{Zone Factor } Z = 0.36$$

$$\text{Importance Factor } I = 1.20$$

$$\begin{aligned} \text{Response reduction Factor } R &= 3.00 \quad \text{Longitudinal} \\ R &= 3.00 \quad \text{Transverse} \end{aligned}$$

$$\text{Avg response acceleration } S_a/g = 1.013 \quad \text{Longitudinal}$$

$$\text{Avg response acceleration } S_a/g = 0.952 \quad \text{Transverse}$$

$$\text{Elastic Seismic Coefficient} = Z/2 \times (S_a/g) \times (I/R)$$

$$\text{In longitudinal direction} = 0.219 / R$$

$$\text{In Transverse direction} = 0.206 / R$$

			Substructure	Foundation
Enhancement factor				1.35
Design Seismic coefficient	Long. Ah		0.073	0.098
	Trans. At		0.069	0.093
	Vert. Av		0.049	0.066

CALCULATION OF SEISMIC FORCES

SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPLL :

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVF	W	eVS	eVF
	Tonnes	(m)	(m)		(m)	(m)
Total Super-Structure DL	347.02	23.37	25.87	347.02	23.37	25.87
Total Super-Structure SIDL	64.00	24.66	27.16	64.00	24.66	27.16
Total Super-Structure WC	88.00	24.29	26.79	88.00	24.29	26.79
Total Super-Structure FPLL	0.00	24.29	26.79	0.00	24.29	26.79
Total	499.02	23.70	26.20	499.02	20.53	22.71

* Bearing level	21.58	24.08		21.58	24.08

SEISMIC COMPONENT OF SUB-STRUCTURE :

Description	W	eVS	eVF
	Tonnes	(m)	(m)
Total weight of shaft and pier cap	238.85	13.81	16.20
Total weight of foundation	656.25	-1.46	1.04

SEISMIC COMPONENT OF LIVE LOAD(70R+Class A) :

Description	W	W	eVS	eVF
	Tonnes	Tonnes	(m)	(m)
	70R + Class A	70R + Class A		
Maximum Live Load	117.57	0.00	25.46	27.96
Minimum Live Load	22.29	0.00	25.46	27.96

Summary of Seismic force at shaft and foundation

Super structure

Dead load - Super structure about shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		36.38		785.105	
Seismic Transverse direction			34.20		756.38
Seismic Vertical Direction	24.25				

Dead load - Super structure about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		49.11		1182.67	
Seismic Transverse direction			46.173		1129.14
Seismic Vertical Direction	32.74				

Dead load Left span Dislodged- about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		24.56		591.336	
Seismic Transverse direction			23.09		524.36
Seismic Vertical Direction	16.37				

Sub structure

Dead load - Sub structure about Shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		17.41		240.42	
Seismic Transverse direction			16.37		226.04
Seismic Vertical Direction	11.61				

Dead load - Sub structure about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		23.5072		380.87	
Seismic Transverse direction			22.10		358.08
Seismic Vertical Direction	15.67				

Live Load - Max**70R + Class A**

Live load - Max shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.61		41.03
Seismic Vertical Direction	1.14				

Live load - Max foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.18		60.83
Seismic Vertical Direction	1.54				

70R

Live load - Max shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.61		41.03
Seismic Vertical Direction	1.14				

Live load - Max foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.18		60.83
Seismic Vertical Direction	1.54				

Live Load - Min**70R + Class A**

Live load - Min about shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.31		7.78
Seismic Vertical Direction	0.22				

Live load - Min about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.41		11.53
Seismic Vertical Direction	0.29				

70R

Live load - Min about shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.31		7.78
Seismic Vertical Direction	0.22				

Live load - Min about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.41		11.53
Seismic Vertical Direction	0.29				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)**1. Normal Max Reaction on Fix End****Left Span**

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ &+ 0.1 \times 0 + 0.05 \times 0 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 22.29) \\ &= 13.59 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q)) \\ &= 24.94 \text{ Ton} \\ F_{hr} &= 24.94 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 24.94 - 12.48 \\ &= 12.46 \text{ Ton} \end{aligned}$$

2. Normal Min Reaction on Fix End**Left Span**

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 + 76.00 + 117.57) \\ &= 18.35 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q)) \\ &= 29.70 \text{ Ton} \\ F_{hr} &= 29.70 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 29.70 - 12.48 \\
 &= 17.23 \text{ Ton}
 \end{aligned}$$

3. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= 0.2 \times \text{Class 70R on First two Lane} + 0.05 \times \text{Class A on third Lane} \\
 &= 0.2 \times 20 + 0.05 \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 18.190 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 24.556 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 22.730 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 29.096 \text{ Ton} \\
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 4.46) \\
 &= 12.69838 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned}
 F_{hr} \text{ for shaft} &= 26.33 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 29.52 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 26.33 - 12.48 \\
 &= 13.86 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 29.52 - 12.48 \\
 &= 17.04 \text{ Ton}
 \end{aligned}$$

4. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= 0.2 \times \text{Class 70R on First two Lane} + 0.05 \times \text{Class A on third Lane} \\
 &= 0.2 \times 20 + 0.05 \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 18.190 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 24.556 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \%})
 \end{aligned}$$

Total Horizontal force for Shaft(Fh) = 22.730 Ton inc.)
 Total Horizontal force for foundation(Fh) = 29.096 Ton

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{23.51} \right)$$

$$= 13.651204 \text{ Ton}$$

Max of (Fh/2 + $\mu (Rg + Rq)$) and Fh - $\mu (Rg + Rq)$)

Fhr for shaft = 27.29 Ton
 Fhr for foundation = 30.47 Ton

Horizontal force for shaft
 = Fhr - Fhl
 = 27.29 - 12.48
 = 14.81 Ton

Horizontal force for foundation
 = Fhr - Fhl
 = 30.47 - 12.48
 = 17.99 Ton

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right)$$

$$= 12.48 \text{ Ton}$$

Fhl = 12.48 Ton

Right Span

Beaking Force = Class 70R on First two Lane $\times$ 100 + Class A on third Lane $\times$ 0.05 $\times$ 0.00)

Fh = 20 Ton

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{22.29} \right)$$

$$= 13.59 \text{ Ton}$$

Max of (Fh/2 + $\mu (Rg + Rq)$) and Fh - $\mu (Rg + Rq)$)

Fhr = 23.59 Ton
Fhr = 23.59 Ton

Horizontal force
 = Fhr - Fhl
 = 23.59 - 12.48
 = 11.11 Ton

6. Normal Min Reaction on Fix End

Left Span

$$\mu (Rg + Rq) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right)$$

$$= 12.48 \text{ Ton}$$

$$F_{hl} = 12.48 \text{ Ton}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 20 \text{ Ton}$$

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{117.57} \right) = 18.35 \text{ Ton}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$= 28.35 \text{ Ton}$$

$$F_{hr} = 28.35 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 28.35 - 12.48 \\ &= 15.88 \text{ Ton} \end{aligned}$$

7. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 4 \text{ Ton}$$

$$\text{Seismic Horizontal force (Shaft)} = 18.190 \text{ Ton}$$

$$\text{Seismic Horizontal force (foundation)} = 24.556 \text{ Ton}$$

$$\text{Total Horizontal force for Shaft (Fh)} = 22.190 \text{ Ton}$$

$$\text{Total Horizontal force for foundation (Fh)} = 28.556 \text{ Ton}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{4.46} \right) \\ &= 12.69838 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 25.79 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 28.98 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 25.79 - 12.48 \\ &= 13.32 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 28.98 - 12.48 \\ &= 16.50 \text{ Ton} \end{aligned}$$

8. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= 0.2 \times 20 \text{ Ton} + 0.05 \times 0 \\ F_h &= 4 \text{ Ton} \\ \text{Seismic Horizontal force(Shaft)} &= 18.190 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\ \text{Seismic Horizontal force(foundation)} &= 24.556 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\ \text{Total Horizontal force for Shaft}(F_h) &= 22.190 \text{ Ton} \\ \text{Total Horizontal force for foundation}(F_h) &= 28.556 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 23.51) \\ &= 13.651204 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned} F_{hr} \text{ for shaft} &= 26.75 \text{ Ton} \\ F_{hr} \text{ for foundation} &= 29.93 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 26.75 - 12.48 \\ &= 14.27 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 29.93 - 12.48 \\ &= 17.45 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 126.88) \\ &= 18.82 \text{ Ton} \\ F_{hr} &= 18.82 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 18.82 - 12.48 \\ &= 6.34 \text{ Ton} \end{aligned}$$

10. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 24.13 \text{ Ton} \\ F_{hr} &= 24.13 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 24.13 - 12.48 \\ &= 11.66 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hr} &= 12.48 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 12.48 - 12.48 \\ &= 0.00 \text{ Ton} \end{aligned}$$

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.475492 \text{ Ton} \\ F_{hr} &= 12.47549 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 12.47549 - 0.000 \\
 &= 12.47549 \text{ Ton}
 \end{aligned}$$

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 0 + 0.05 \times 0
 \end{aligned}$$

$$F_h = 0 \text{ Ton}$$

$$\begin{aligned}
 \text{Seismic Horizontal force(Shaft)} &= 18.190 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 24.556 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\
 \text{Total Horizontal force for Shaft}(F_h) &= 18.190 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 24.556 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.475492 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 21.57 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 24.75 \text{ Ton}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 21.57 - 0.00 \\
 &= 21.57 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 24.75 - 0.00 \\
 &= 24.75 \text{ Ton}
 \end{aligned}$$

Summary of forces			
Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	12.46	12.46
	2. Normal Min Reaction on Fix End	17.23	17.23
	3. Seismic Max Reaction on Fix End	13.86	17.04
	4. Seismic Min Reaction on Fix End	14.81	17.99
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.11	11.11
	6. Normal Min Reaction on Fix End	15.88	15.88
	7. Seismic Max Reaction on Fix End	13.32	16.50
	8. Seismic Min Reaction on Fix End	14.27	17.45
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	6.34	6.34
	10. Normal Min Reaction on Fix End	11.66	11.66
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	12.48	12.48
	13. Seismic Span Dislodge Condition	21.57	24.75

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$C = \frac{WV^2}{127R}$$

70R + Class A

Maxium Reaction				
Live Load	W	=	117.57	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	7.41	t	

C (t)	e _{VS} (m)	e _{VF} (m)
7.41	25.46	27.96

Minimum Reaction				
Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0	25.46	27.96

70R

Maxium Reaction				
Live Load	W	=	117.57	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	7.4060597	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
7.40606	25.46	27.96

Minimum Reaction				
Live Load	W	=	22.29	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	1.404019	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
1.404019	25.46	27.96

Special Vehicle

Maxium Reaction				
Live Load	W	=	233.12	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	200	m

$$C = 0.2294474 \text{ KN}$$

C (t)	e_{VS}(m)	e_{VF}(m)
0.229447	25.46	27.96

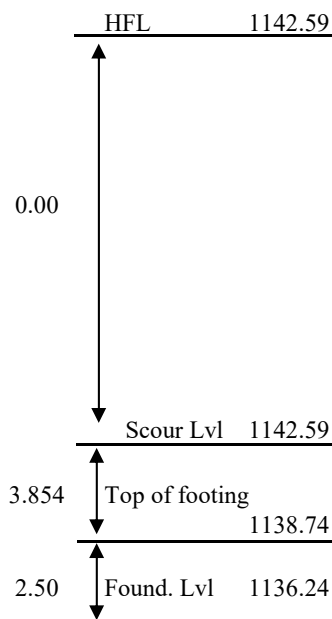
Minimum Reaction				
Live Load	W	=	126.88	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	200	m

$$C = 0.1248833 \text{ KN}$$

C (t)	e_{VS}(m)	e_{VF}(m)
0.124883	25.46	27.96

12. WATER CURRENT FORCES**NORMAL CASE****Water current forces**

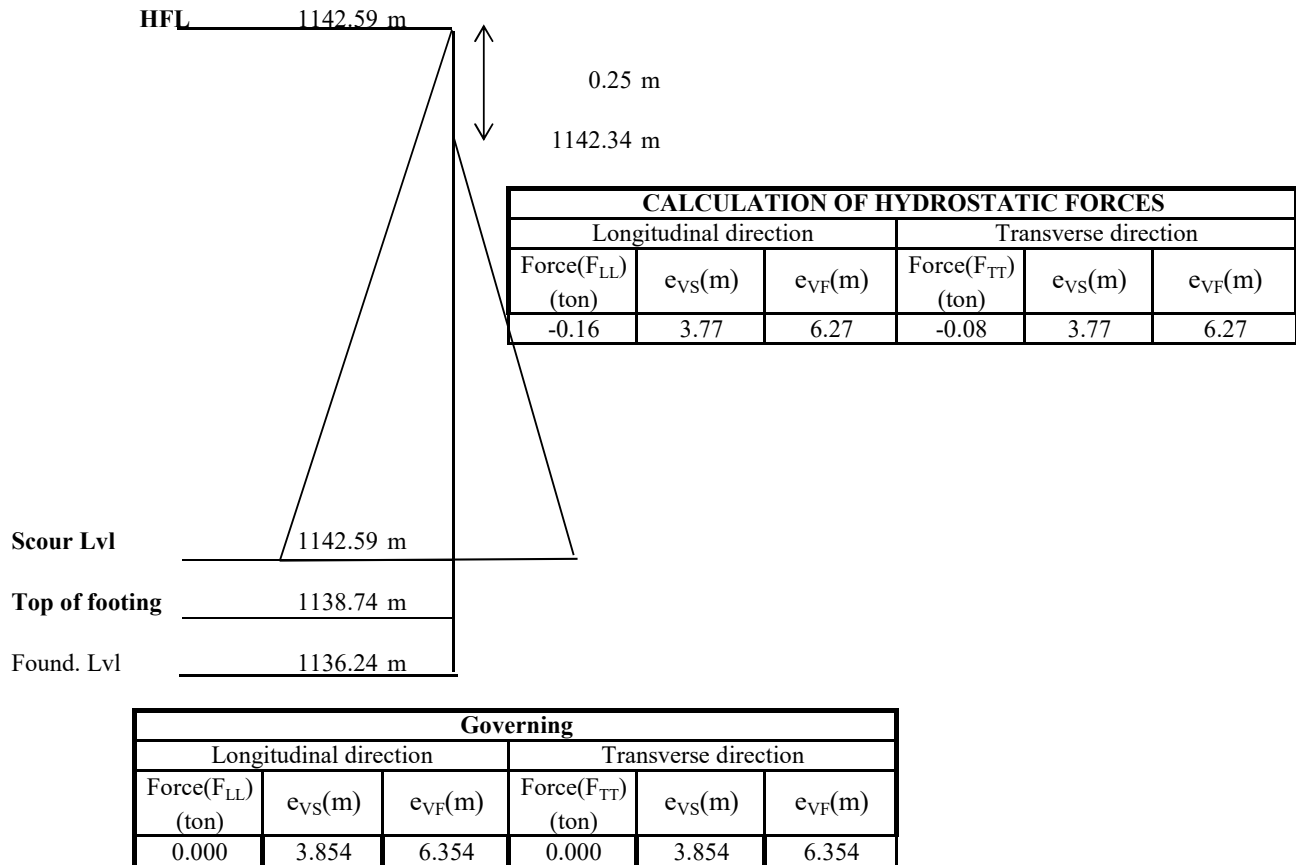
HFL	=	1142.594 m	
MSL (NORMAL)	=	1142.594 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL (Trans direction)		=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ² 53 K (vsinq) ²



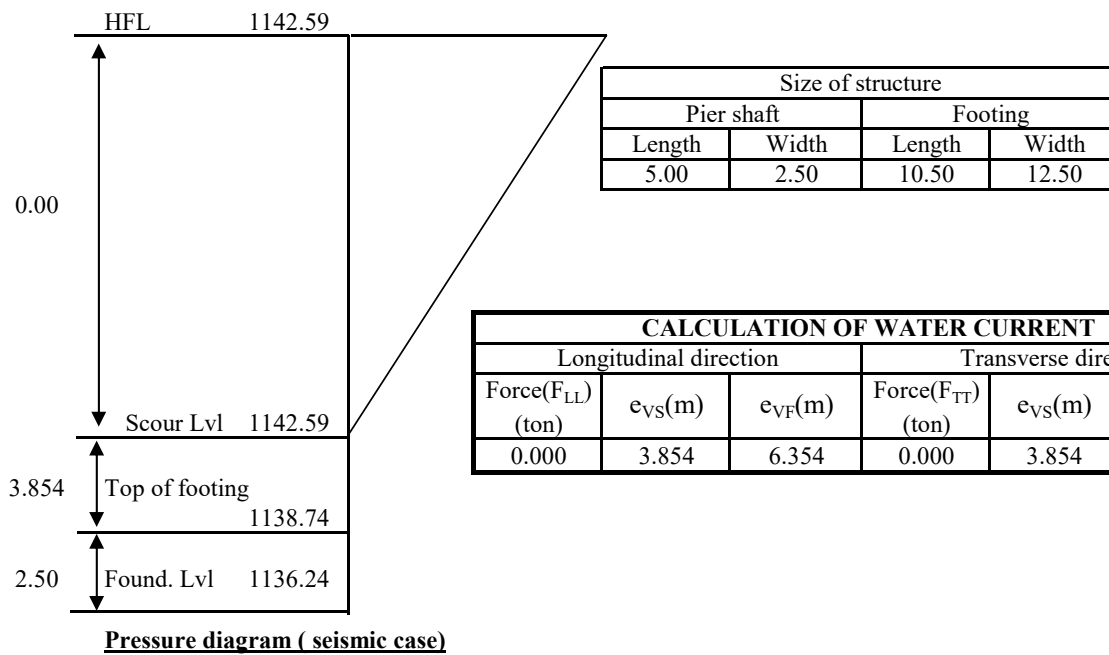
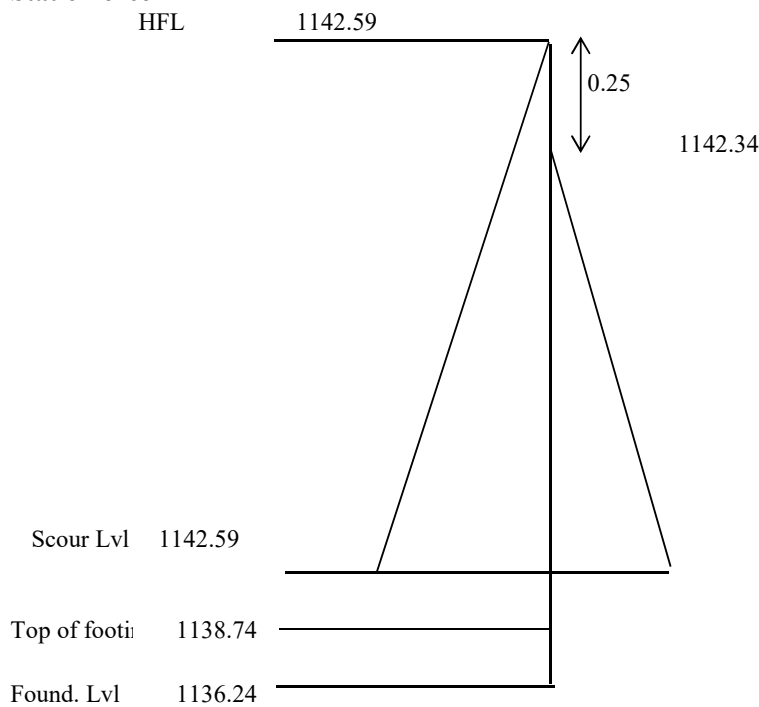
Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
5.00	2.50	10.50	12.50

CALCULATION OF WATER CURRENT FORCES					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.000	3.854	6.354	0.000	3.854	6.354

Pressure diagram (Normal case)

Static Force**SEISMIC CASE**

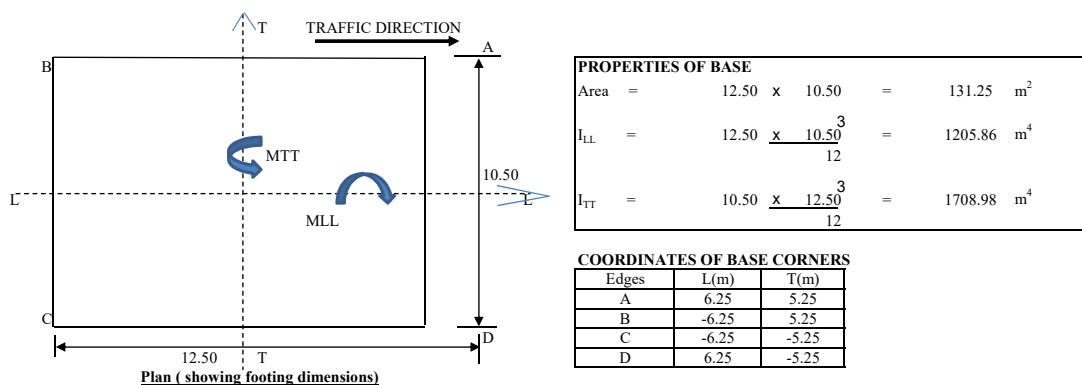
HFL	=	1142.594 m	
MSL (SEISMIC)	=	1142.59 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2} \times 4.00$
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL (Trans direction)		=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ² 53 K (vsinq) ²

**Static Force**

CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
-0.16	3.77	6.27	-0.08	3.77	6.27

Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
0.000	3.854	6.354	0.000	3.854	6.354

20. CHECK FOR BASE PRESSURE



SUMMARY OF FORCES

$$\text{Base pressure} = \frac{P}{A} + \frac{M_{LL} \cdot x}{I_{LL}} + \frac{M_{TT} \cdot z}{I_{TT}}$$

Sr. No.	Description	Forces at founding levels			Base pressure at footing corners in T/m ²			
		V(Tonne)	M _{TT} (Tm)	M _{LL} (Tm)	A	B	C	D
LC -1	NORMAL MAX REACTION(70R+Class A)	2622.52	363.65	366.85	22.91	20.25	17.05	19.71
LC -2	NORMAL SPAN DISLOGED	2267.20	450.13	0.00	18.92	15.63	15.63	18.92
LC -6	SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z	2275.54	1594.70	223.95	24.14	12.48	10.53	22.19
LC -7	SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R + class A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LC -8	SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z	2275.54	736.75	746.50	23.28	17.89	11.39	16.78
LC -13	SEISMIC NORMAL MAX REACTION(70R)	2622.52	331.14	366.85	22.79	20.37	17.17	19.59
LC -15	SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)	2555.25	2016.42	501.48	29.03	14.28	9.91	24.66
LC -16	SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)	2555.25	921.95	1600.86	29.81	23.07	9.13	15.87
LC -18	NORMAL SV MAX REACTION	2749.83	292.64	76.35	22.35	20.21	19.55	21.69

Sr. No.	Average pressure along BC	Average pressure along AD	Average pressure along AB	Average pressure along CD	Effective Length along TT	Effective Width along LL	Effective Area	I _{LL}	I _{TT}
	T/m ²	T/m ²	T/m ²	T/m ²	m	m	m ²	m ⁴	m ⁴
LC -1	18.65	21.31	21.58	18.38	10.50	12.50	131.25	1205.86	1708.98
LC -2	15.63	18.92	17.27	17.27	10.50	12.50	131.25	1205.86	1708.98
LC -6	11.51	23.17	18.31	16.36	10.50	12.50	131.25	1205.86	1708.98
LC -8	14.64	20.03	20.59	14.09	10.50	12.50	131.25	1205.86	1708.98
LC -13	18.77	21.19	21.58	18.38	10.50	12.50	131.25	1205.86	1708.98
LC -15	12.09	26.84	21.65	17.29	10.50	12.50	131.25	1205.86	1708.98
LC -16	16.10	22.84	26.44	12.50	10.50	12.50	131.25	1205.86	1708.98
LC -18	19.88	22.02	21.28	20.62	10.50	12.50	131.25	1205.86	1708.98

Sr. No.	M _{TT}	M _{LL}	A'		B'		C'		D'		Base Pressure(T/m ²)			
	T _m	T _m	L(m)	T(m)	L(m)	T(m)	L(m)	T(m)	L(m)	T(m)	T/m ²	T/m ²	T/m ²	T/m ²
LC -1	363.65	366.85	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	22.91	20.25	17.05	19.71
LC -2	450.13	0.00	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	18.92	15.63	15.63	18.92
LC -6	1594.70	223.95	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	24.14	12.48	10.53	22.19
LC -8	736.75	746.50	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	23.28	17.89	11.39	16.78
LC -13	331.14	366.85	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	22.79	20.37	17.17	19.59
LC -15	2016.42	501.48	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	29.03	14.28	9.91	24.66
LC -16	921.95	1600.86	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	29.81	23.07	9.13	15.87
LC -18	292.64	76.35	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	22.35	20.21	19.55	21.69

Minimum Effective Area Allowed Normal case

=

0.8 x 131

105.00

m²

Minimum Effective Area Allowed Seismic case

=

0.67 x 131

=

87.938

m²

Minimum Effective Area Normal Case

=

131.25

>

105.00

m²

Ok

Minimum Effective Area Seismic Case

=

131.25

>

87.94

m²

Ok

SUMMARY OF BASE PRESSURES**NORMAL CASE**

Maximum base pressure

=

22.91 t/m²

<

35 t/m²

Ok

Minimum base pressure

=

15.63 t/m²

>

0 t/m²

Ok

SEISMIC CASE

Maximum base pressure

=

29.81 t/m²

<

43.75 t/m²

Ok

Minimum base pressure

=

9.13 t/m²

>

0 t/m²

Ok

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

LC -1 ULS NORMAL LWL MAX REACTION
 LC -2 ULS NORMAL LWL SPAN DISLOGED

LC - 5 ULS MAX REACTION $1X + 0.3Y + 0.3Z$
 LC - 6 ULS MAX REACTION $0.3X + 1Y + 0.3Z$

LC - 9 ULS NORMAL SV MAX REACTION

SLS

LC -1 RARE NORMAL MAX REACTION
 LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

LC - 1 ULS NORMAL MAX REACTION($70R + \text{Class A}$)
 LC - 2 ULS NORMAL SPAN DISLOGED

LC - 5 ULS NORMAL MAX REACTION($70R$)

LC - 7 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R + \text{Class A})$
 LC - 8 ULS SPAN DISLODGED $1X + 0.3Y + 0.3Z$
 LC - 9 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{Class A})$
 LC - 10 ULS SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 15 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC - 16 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION(70R+Class A)

LC - 2 NORMAL SPAN DISLOGED

LC - 5 0

LC - 6 SEISMIC SPAN DISLODGED $1X + 0.3Y + 0.3Z$ LC - 7 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{class A})$ LC - 8 SEISMIC LWL SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 13 SEISMIC NORMAL MAX REACTION(70R)

LC - 15 SEISMIC MAX REACTION $1X + 0.3Y + 0.3Z(70R)$ LC - 16 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 13 NORMAL LWL SV MAX REACTION

14.A DESIGN FORCES FOR PIER SHAFT(ULS CASES)**LC -1 ULS NORMAL LWL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				7.406			25.460	0.0	188.558	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				12.464			21.581	268.998		1.5	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1207.69	498.73	522.51

LC -2 ULS NORMAL LWL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			25.460	0.000	0.000	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				12.475			21.581	269.237		1.5	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
676.89	616.52	0.00

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.60	0.000		-123.306	0.000	1.35	
2	Surfacing			44.000		-0.60	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.60	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.60	0.950		0.000	0.000	0.2	1
5	LL (Class-A)			0.000		-0.60	1.000		0.000	0.000	0.2	1
Right Span												
6	DL (superstructure)			205.510		0.60	0.000		123.306	0.000	1.35	
7	Surfacing			44.000		0.60	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.60	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.60	1.510		70.543	177.5	0.2	1
10	LL (Class-A)			0.000		0.60	1.000		0.000	0.0	0.2	1
11	Centrifugal force				7.406			25.460	0.0	188.6	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				13.858			21.581	299.065		1.000	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				36.379				785.11		1.5	
	Transverse				34.203					756.38026	0.45	
	Vertical			24.253							0.45	
Sub structure												
	Longitudinal				17.413				240.42		1.5	
	Transverse				16.371					226.03673	0.45	
	Vertical			11.609							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.612					41.032666	0.45	
	Vertical			1.143							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1071.496	1851.46	533.77

LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.60	0.00		-123.31	0.00	1.35	
2	Surfacing			44.000		-0.60	0.00		-26.40	0.00	1.75	
3	FLL			0.000		-0.60	0.00		0.00	0.00	0.2	
4	LL (70R)			0.000		-0.60	0.95		0.00	0.00	0.2	1
5	LL (Class-A)			0.000		-0.60	1.00		0.00	0.00	0.2	1
Right Span												
6	DL (superstructure)			205.510		0.60	0.00		123.31	0.00	1.35	
7	Surfacing			44.000		0.60	0.00		26.40	0.00	1.75	
8	FLL			0.000		0.60	0.00		0.00	0.00	0.2	
9	LL (70R)			117.571		0.60	1.51		70.54	177.53	0.2	1
10	LL (Class-A)			0.000		0.60	1.00		0.00	0.00	0.2	1
11	Centrifugal force				7.406			25.460	0.0	188.558	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.500	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.500	25.426		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				13.858			21.581	299.065		1.000	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				36.379				785.11		0.45	
	Transverse				34.203					756.380	1.5	
	Vertical			24.253							0.45	
Sub structure												
	Longitudinal				17.413				240.42		0.45	
	Transverse				16.371					226.037	1.5	
	Vertical			11.609							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.612					41.033	1.5	
	Vertical			1.143							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1071.496	774.66	1608.39

LC - 9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1.35	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
7	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			25.460	5.842		1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
15	Horizontal Force(F _{LL})				6.344			21.581	136.913		1.5	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1.5	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1264.45	351.08	69.94

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)**LC -1 RARE NORMAL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				7.406			25.460	0.000	188.558	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			3.854	0.000		1	
	Water Current Force(F _{TT})				0.000			3.854		0.000	1	
17	Horizontal Force(F _{LL})				12.464			21.581	268.998		1	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
873.05	332.49	348.34

LC-2 RARE NORMAL SPAN DISLOADED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force(F _{LL})				0.000			25.460	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			3.854	0.000		1	
	Water Current Force(F _{TT})				0.000			3.854		0.000	1	
17	Horizontal Force(F _{LL})				12.475			21.581	269.237		1	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
497.16	424.22	0.00

LC -5 QP NORMAL

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	0	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			25.460	0.000	188.558	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			3.854	0.000		0	
	Water Current Force(F _{TT})				0.000			3.854		0.000	0	
17	Horizontal Force(F _{LL})				0.000			21.581	0.000		0	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
755.47	0.00	188.56

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			25.460	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F _{LL})				0.000			3.854	0.000		0	
	Water Current Force(F _{TT})				0.000			3.854		0.000	0	
17	Horizontal Force(F _{LL})				12.475			21.581	269.237		1	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
497.16	424.22	0.00

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
7	FLL			0.000		0.600	0.000		0.000	0.000	1	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			25.460	5.842		1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			3.854	0.000		1	
	Water Current Force(F _{TT})				0.000			3.854		0.000	1	
15	Horizontal Force(F _{LL})				6.344			21.581	136.913		1	
	Horizontal Force(F _{TT})				0.000			21.581		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
988.59	282.63	69.94

15. DESIGN FORCES FOR FOUNDATION**LC -I ULS NORMAL MAX REACTION(70R +Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				7.406				27.960	0.0	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				12.464			24.081	300.16		1.5	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
3591.48	545.47	550.28

LC -2 ULS NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			27.960	0.000	0.000	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				12.475			24.081	300.425		1.5	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
3078.32	663.30	0.00

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			27.960	0.0	207.073	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				11.114			24.081	267.65		1.5	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2075.989	496.71	550.28

LC - 7 ULS MAX REACTION IX + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				7.406			27.960	0.0	207.073	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.500	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.500	25.426		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				17.041			24.081	410.36		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				49.112				1182.7		1.5	
	Transverse				46.173					1129.1	0.45	
	Vertical			32.741							0.45	
Sub structure												
	Longitudinal				23.507				380.9		1.5	
	Transverse				22.101					358.08145	0.45	
	Vertical			15.67							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				2.176					60.833426	0.45	
	Vertical			1.543							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3478.790	2769.78	775.10

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			27.960	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				24.753			24.081	596.09		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				24.556				591.34		1.5	
	Transverse				23.087					524.36324	0.45	
	Vertical			16.371							0.45	
	Sub structure											
	Longitudinal				23.507				380.9		1.5	
	Transverse				22.101					358.08145	0.45	
	Vertical			15.671							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3092.737	2100.60	397.10

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				7.406			27.960	0.0	207.073	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				17.041			24.081	410.36		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				49.112				1182.7		0.45	
	Transverse				46.173					1129.145	1.5	
	Vertical			32.741							0.45	
	Sub structure											

	Longitudinal				23.507				380.9		0.45	
	Transverse				22.101					358.081	1.5	
	Vertical			15.671							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				2.176					60.833	1.5	
	Vertical			1.543							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3478.790	1128.07	2416.31

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			27.960	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				24.753			24.081	596.09		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				24.556				591.34		0.45	
	Transverse				23.087					524.36324	1.5	
	Vertical			16.371							0.45	
	Sub structure											
	Longitudinal				23.507				380.9		0.45	
	Transverse				22.101					358.08145	1.5	
	Vertical			15.671							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3092.737	1079.79	1323.67

LC -15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			27.960	207.1	0.000	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	41.239	2.500	103.098		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.170	2.500	25.426		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				16.501			24.081	397.36		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				49.112				1182.7		1.5	
	Transverse				46.173					1129.1	0.45	
	Vertical			32.741							0.45	
Sub structure												
	Longitudinal				23.507				380.9		1.5	
	Transverse				22.101					358.08145	0.45	
	Vertical			15.67							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				2.176					60.83	0.45	
	Vertical			1.543							0.45	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.412					11.532622	0.45	0.3
	Vertical			0.292							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3478.790	2798.19	733.69

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			27.960	207.1	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				16.501			24.081	397.36		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				49.112			1182.7			0.45	
	Transverse				46.173					1129.145	1.5	
	Vertical			32.741							0.45	
	Sub structure											
	Longitudinal				23.507			380.9			0.45	
	Transverse				22.101					358.081	1.5	
	Vertical			15.671							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				2.176					60.833	1.5	
	Vertical			1.543							0.45	
b)	Min Live Load											
	Longitudinal										0.45	0.3

Transverse				0.412					11.532622	1.5	1
Vertical				0.292						0.45	0.3
SUMMARY OF FACTORED FORCES											
V(ton)			MTT (tm)		MLL(tm)						
3478.790			1156.48		2374.89						

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
7	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			27.960	0.0	6.415	1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
15	Horizontal Force(F _{LL})				6.344			24.081	152.77		1.5	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1.5	
16	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
3665.87	369.03	76.35

16. DESIGN FORCES FOR BASE PRESSURE**LC -1 NORMAL MAX REACTION(70R+Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				7.406			27.960	0.0	207.073	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})							6.354	0.000		1	
	Water Current Force(F _{TT})							6.354		0.000	1	
17	Horizontal Force(F _{LL})				12.464			24.081	300.16		1	
	Horizontal Force(F _{TT})							24.081		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2622.52	363.65	366.85

LC -2 NORMAL SPAN DISLODGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			27.960	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				12.475			24.081	300.425		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2267.20	450.13	0.00

450.131 0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centifugal force				0.000			27.960	0.00	0.000	0	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				24.753			24.081	596.09		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				24.556			591.34			1	
	Transverse				17.101					388.41721	0.3	
	Vertical			12.126							0.3	
	Sub structure											
	Longitudinal				23.507			380.9			1	
	Transverse				22.101					358.08	0.3	
	Vertical			15.671							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2275.538	1594.70	223.95

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			27.960	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				24.753			24.081	596.09		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				0.000			0.00			0.3	
	Transverse				17.101					388.41721	1	
	Vertical			12.126							0.3	
	Sub structure											
	Longitudinal				23.507			380.9			0.3	
	Transverse				22.101					358.08145	1	
	Vertical			15.671							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2275.538	736.75	746.50

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VT} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			27.960	0.0	207.073	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				11.114			24.081	267.65		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2622.52	331.14	366.85

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VT} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			27.960	207.1	0.000	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	41.239	2.500	103.098		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.170	2.500	25.426		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				16.501			24.081	397.36		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1	
20	Seismic											
Super structure												
	Longitudinal				49.112				1182.7		1	
	Transverse				46.173					1129.1	0.3	
	Vertical			32.741							0.3	
Sub structure												
	Longitudinal				23.507				380.9		1	
	Transverse				22.101					358.08	0.3	
	Vertical			15.67							0.3	
a)	Max Live Load											
	Longitudinal										1	
	Transverse				2.176					60.83	0.3	
	Vertical			1.543							0.3	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.412					11.532622	0.45	0.3
	Vertical			0.292							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2555.249	2016.42	501.48

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			27.960	207.1	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	41.24	2.50	103.10		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.17	2.50	25.43		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			6.354	0.00		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
17	Horizontal Force(F _{LL})				16.501			24.081	397.36		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	561.29	2.00	1122.58		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				49.112				1182.7		0.3	
	Transverse				46.173					1129.1	1	
	Vertical			32.741							0.3	
	Sub structure											
	Longitudinal				23.507				380.9		0.3	
	Transverse				22.101					358.08	1	
	Vertical			15.671							0.3	
a)	Max Live Load											
	Longitudinal										0.3	
	Transverse				2.176					60.83	1	
	Vertical			1.543							0.3	
b)	Min Live Load											
	Longitudinal										0.45	0.3
	Transverse				0.412					11.5	1.5	1
	Vertical			0.292							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2555.249	921.95	1600.86

LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
7	FLL			0.000		0.600	0.000		0.000	0.000	1	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			27.960	0.0	6.415	1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	41.239	2.5	103.098		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	10.170	2.5	25.426		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F _{LL})				0.000			6.354	0.000		1	
	Water Current Force(F _{TT})				0.000			6.354		0.000	1	
15	Horizontal Force(F _{LL})				6.344			24.081	152.77		1	
	Horizontal Force(F _{TT})				0.000			24.081		0.000	1	
16	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	561.29	2	1122.584		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2749.83	292.64	76.35

***DESIGN OF PIER P7 AND
ITS FOUNDATION
FOR MAJOR BRIDGE AT CH-82+425***

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle : 0 degree 0 Radian

<u>SPAN DETAILS</u>	<u>Left span</u>		<u>Right span</u>		<u>Unit</u>
	<u>Right</u>	<u>Skew</u>	<u>Right</u>	<u>Skew</u>	
C/C Expansion joint	= 40.000	40.000	40.000	40.00	m
C/C Expansion joint to C.L. brg	= 0.600	0.600	0.600	0.60	m
Expansion gap	= 50	50	50	50	mm
C/C bearing	= 38.800	38.800	38.800	38.800	m

SUPERSTRUCTURE DETAILS

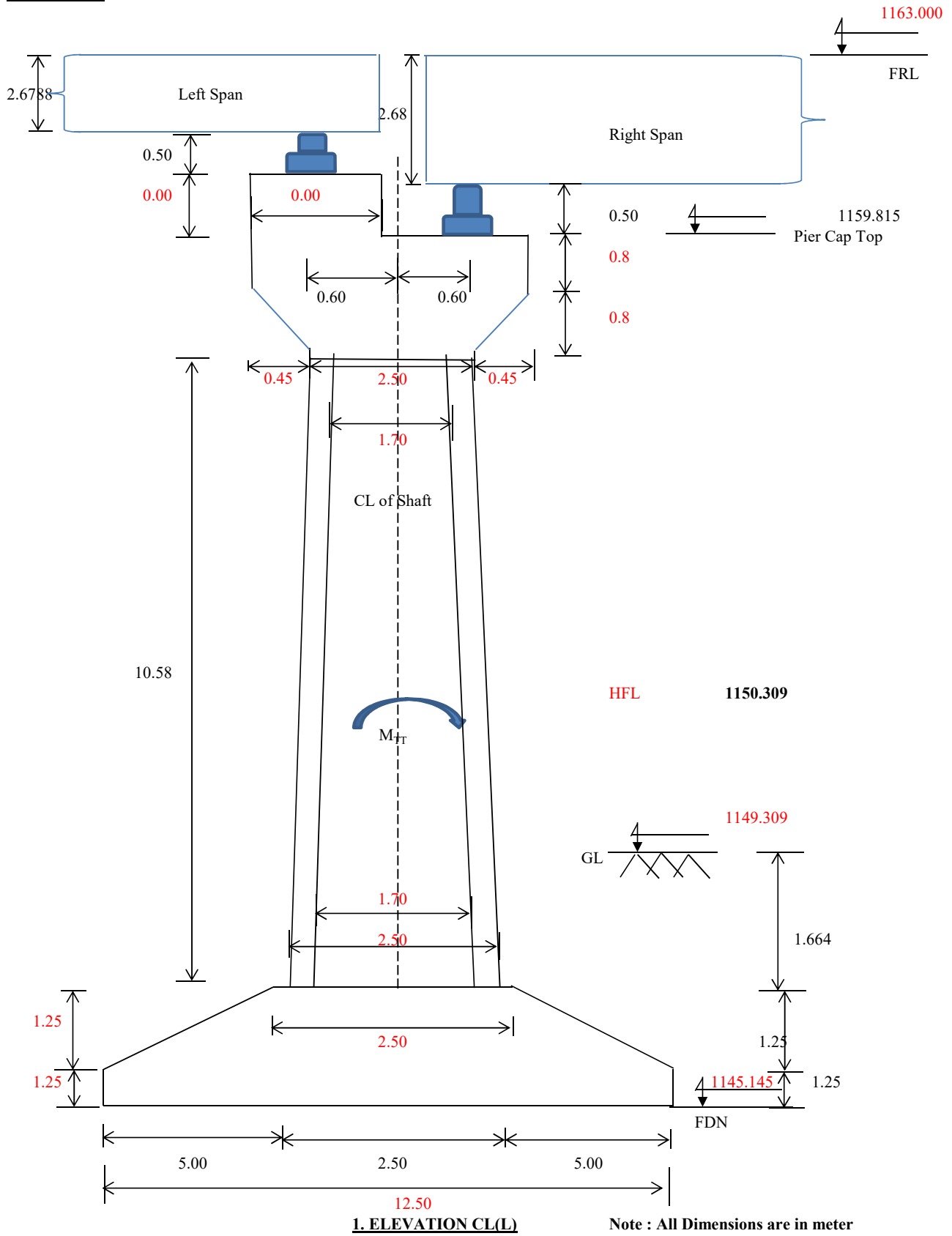
	Left Span	Right Span
Overall deck width of bridge	= 12.50 m	12.50 m
Carriage way width	= 11.50 m	11.50 m
Crash barrier width	= 0.45 m	0.45 m
Height of crash barrier	= 1.00 m	1.00 m
C.g of Crash barrier from bottom	= 0.40 m	0.40 m
Cross-slope	= 2.50 %	2.50 %
Wearing coat thickness	= 65 mm	65 mm
Nos. of Bearing	= 4	4
Spacing of Bearing	= 7.50 m	7.50 m
Depth of Girder	= 2.300 m	2.300 m
Depth of slab	= 0.22 m	0.22 m
Depth of superstructure	= 2.520 m	2.520 m
Bearing + Pedestal height	= 0.50 m	0.50 m
Width of main girder at top	= 0.50 m	0.50 m
Width of cross girder	= 0.30 m	0.30 m
Nos. of cross-girders	= 2	2
FRL to Soffit	= 2.68 m	2.68 m
Type of Bearing	OR SPHERICAL BRG	

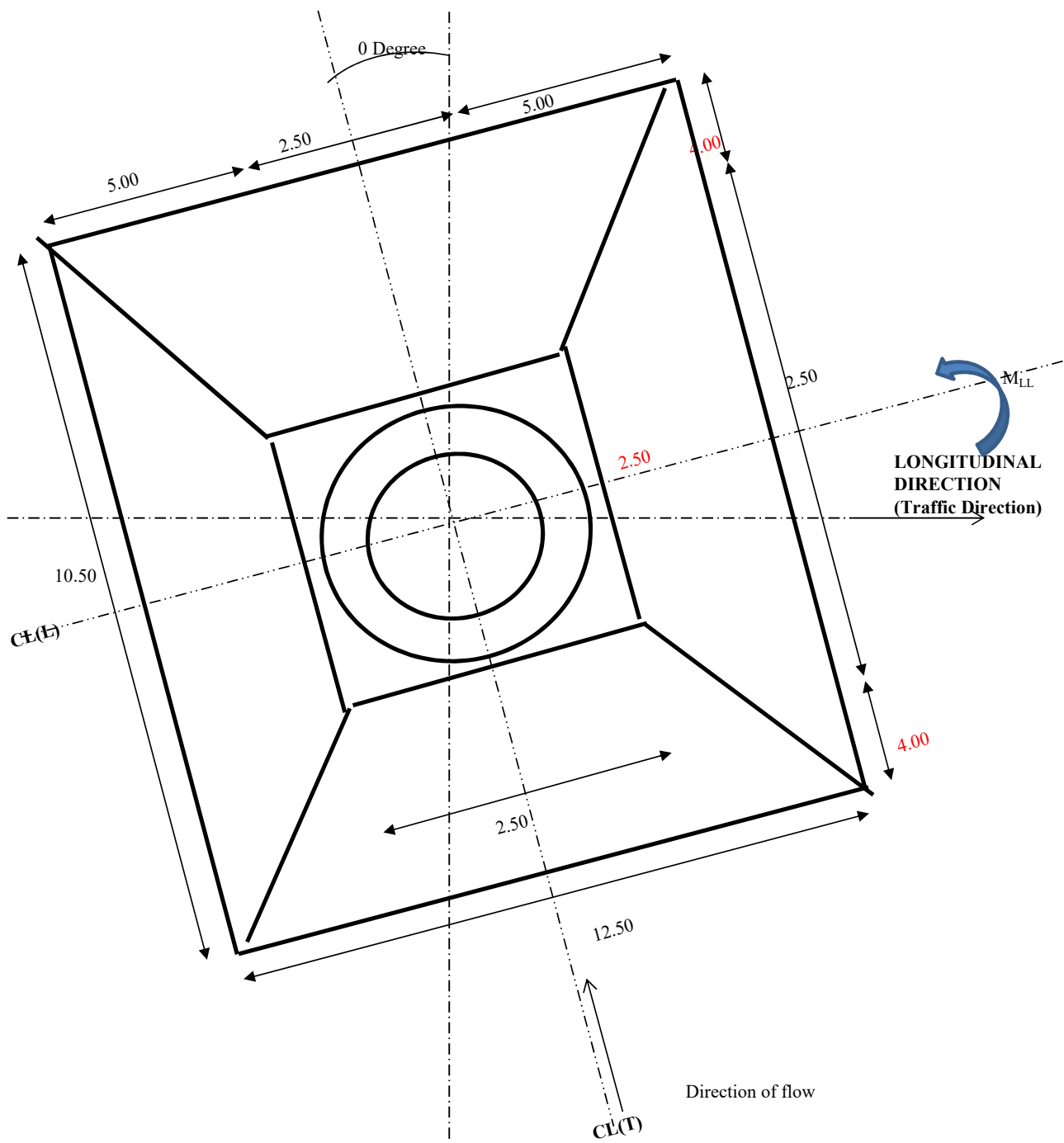
LEVEL DETAILS

Formation level	= 1163.000 m
Pier cap top level	= 1159.815 m
HFL	= 1149.309 m
Ground level	= 1149.309 m
MSL (Normal)/Rock Level	= 1149.309 m
MSL (Seismic)/Rock Level	= 1149.309 m
Pier shaft bottom/Footing top level	= 1147.639 m
Founding level	= 1145.145 m

DIMENSION DETAILS

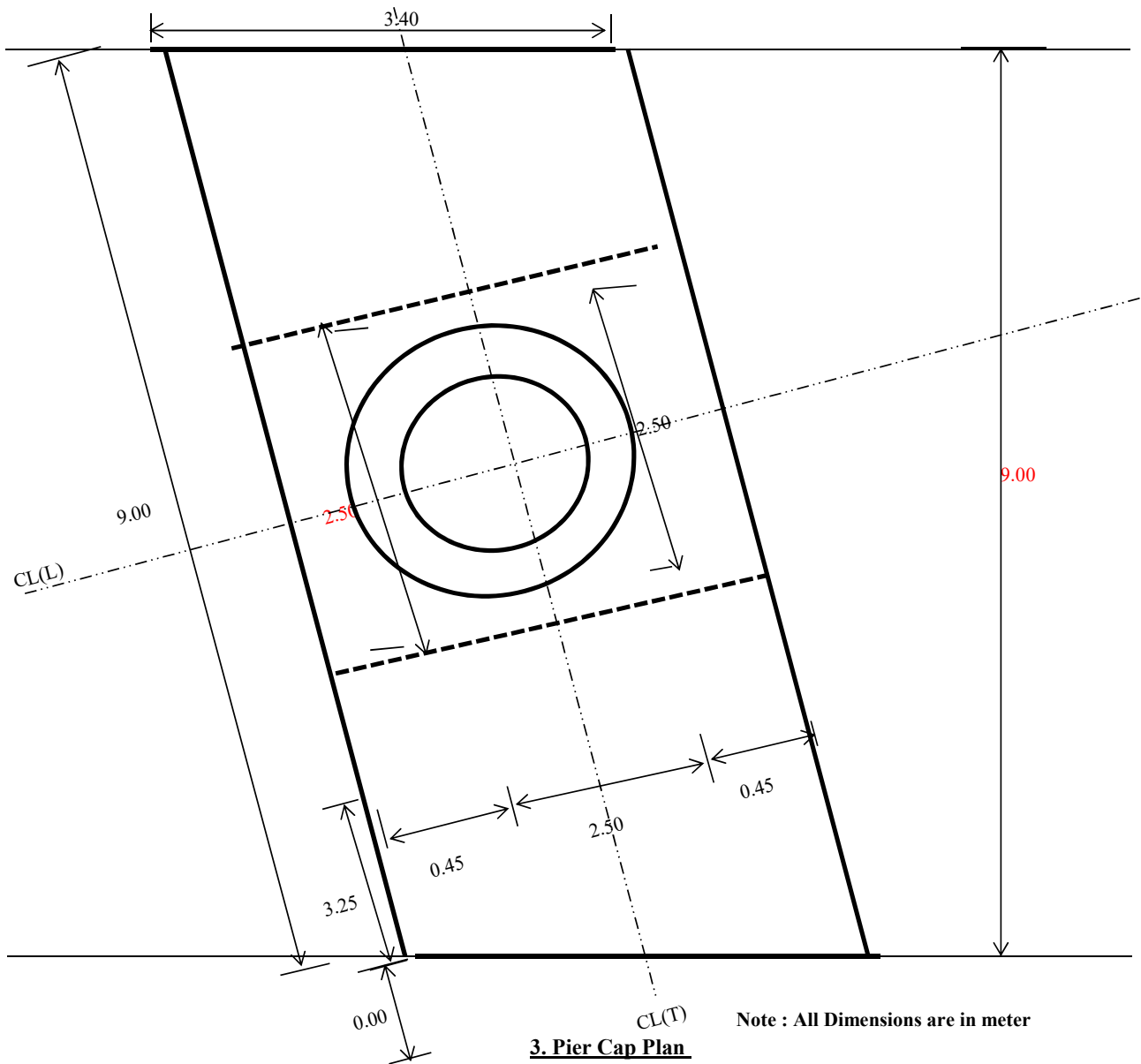
<u>Pier cap:</u>	Right	Skew
Width of pier cap at top	= 3.40 m	3.40 m
Width of pier cap at bottom	= 3.40 m	3.40 m
Length of pier cap at top	= 9.00 m	9.00 m
Length of pier cap at bottom	= 2.50 m	2.50 m
Thickness of uniform portion	= 0.80 m	0.80 m
Thickness of tapered portion	= 0.80 m	0.80 m
<u>Pier shaft:</u>		
Width of pier at top	= 2.50 m	2.50 m
Width of pier at bottom	= 2.50 m	2.50 m
Length of pier (rectangle portion)	= 0.00 m	0.00 m
Length of pier(end circular portion Top)	= 1.25 m	1.25 m
Length of pier (end circular portion Bottom)	= 1.25 m	1.25 m
Total length of pier shaft at top	= 2.50 m	2.50 m
Total length of pier shaft at bottom	= 2.50 m	2.50 m
<u>Footing:</u>		
Width of footing at top	= 2.50 m	2.50 m
Width of footing at bottom	= 12.50 m	12.50 m
Length of footing	= 10.50 m	10.50 m
Thickness at tip	= 1.25 m	1.25 m
Maximum thickness	= 2.50 m	2.50 m

DIAGRAMS:



Note : All Dimensions are in meter

2. PLAN SHOWING FOOTING & PIER SHAFT



2. MATERIALS DETAILS**CONCRETE:**

Grade of concrete	fck	=	M 35	
Mean value of concrete compressive strength, fcm		=	M 45 (28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447 x fck	(Basic and Seismic combination)
		=	15.633 Mpa	
Secant modulus of elasticity, Ecm		=	32000 Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8 Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5 t/m ³	

SOIL :

Density dry		=	2 t/m ³	
Density Saturated		=	2.3 t/m ³	
Soil density (submerged)		=	2 t/m ³	
Angle of Internal friction ϕ		=	35	
Cohesion c		=	0	
Gross bearing capacity		=	35.00 t/m ²	(Normal case)
		=	43.75 t/m ²	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	11.159 m ²	
Perimeter in contact with atmosphere, u		=	12.854 m	
Notional size, ho = 2Ac/u		=	1736 mm	
Age of concrete at the time of loading to		=	90 days	
	ta	=	25550 days	
	f(α 90)	=	1.2 (Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32 (increased by 10%)	
Creep co-efficient for foundation		=	1.0 (as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793 Mpa	Ecm ' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500 Mpa	
Modulus of elasticity	Es	=	200000 Mpa	

3. PERMISSIBLE STRESSES**MAXIMUM PERMISSIBLE STRESS IN CONCRETE:**

Rare combination		=	0.48 x fck	
		=	16.8 Mpa	
Quasi permanent combination		=	0.36 x fck	
		=	12.6 Mpa	

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300 Mpa	
Permissible crack width	Wk,max	=	0.3 mm	

4. SEISMIC PARAMETERS

Seismic zone		=	V	
Type of soil		=	Type2(Medium)	
Zone factor	Z	=	0.36	
Importance factor	I	=	1.20	
Response Reduction Factor(Long)	R	=	3	
Response Reduction Factor(Trans)	R	=	3	

5. ENVIRONMENTAL PARAMETERS

Relative humidity		=	80%	
Condition of exposure		=	Moderate	

6.OTHER PARAMETERS

Mean velocity of water current flow		=	4.00 m/s	
Design Speed V		=	40 Kmph	
Radius of Curvature R		=	200 m	

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew = **0 °** = **0.000 Radian**
No. of Bearing = 4.00
Right **Skew**
c/c of bearing in Transverse Direction = 7.500 m 7.500 m
c/c bearing on Longitudinal Direction = 1.200 m 1.200 m
Impact Factor for Design of Pier Cap = 1.10

Left Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
		1735.10	320.00							
Total Load	2055.10		440.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000	0.300	0.300

Right Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
		1735.10	320.00							
Total Load	2055.10		440.00	0.00	1175.71	222.89	0.00	0.00	2331.19	1268.81
Resultant Transverse Ecc.	0.000		0.000	0.000	1.510	2.390	1.000	1.000	0.300	0.300

8. VOLUME OF SUBSTRUCTURE

PIER CAP

Uniform portion

No.		L(m)	B(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	9.000	0.000	0.000	0.000	1.700	0.000	12.17625	14.68
2	1	9.000	3.400	0.800	24.480	0.000	0.000	11.77625	14.28

Tapered portion

2a	Rectangle	2.500	3.400	0.800	6.800	0.000	0.000	10.976	13.476
	Triangle	3.250	3.400	0.800	8.840	0.000	0.000	11.110	13.610
Total Inc. 10%					44.132	0.000	0.000	10.449	12.722

PIER SHAFT

Above HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	8.912	23.519	0.000	0.000	6.120	8.620
2	0	2.500	0.000	8.912	0.000	-1.250	0.000	4.635	7.135
3	0	2.500	0.000	8.912	0.000	1.250	0.000	4.635	7.135

Cylinder/Conical Frustum portion

4	0.000	0.850	1.25	8.912	0.000	0.000	0.000	6.120	8.620
Total					23.519	0.000	0.000	6.120	8.620

Below HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	1.664	4.391	0.000	0.000	0.832	3.332
2	0	2.500	0.000	1.664	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	1.664	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.250	0.850	1.664	0.000	0.000	0.000	0.832	3.332
Total					4.391	0.000	0.000	0.832	3.332

Above LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	8.912	23.519	0.000	0.000	6.120	8.620
2	0.0	2.500	0.000	8.912	0.000	-0.850	0.000	4.635	7.135
3	0.0	2.500	0.000	8.912	0.000	0.850	0.000	4.635	7.135

Cylinder/Conical Frustum portion

4	0.000	0.850	0.850	8.912	0.000	0.000	0.000	5.873	8.373
Total					23.519	0.000	0.000	6.120	8.620

Below LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	1.664	4.391	0.000	0.000	0.832	3.332
2	0	2.500	0.000	1.664	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	1.664	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.25	0.850	1.664	0.000	0.000	0.000	0.701	3.201
Total					4.391	0.000	0.000	0.832	3.332

FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	2.500	2.50	65.625	0.000	0.000	-1.250	1.250
2	1	10.500	5	1.875	98.438	-3.472	0.000	-1.528	0.972
3	1	10.500	5.000	1.875	98.438	3.472	0.000	-1.528	0.972
Total					262.5	0.000	0.000	-1.458	1.042

EARTH ABOVE FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.500	12.500	4.164	546.525	0.000	0.000	-0.418	2.082
2	-1	Shaft Below LBL			-4.391	0.000	0.000	0.832	3.332
3	-1	Footing			-262.500	0.000	0.000	-1.458	1.042
Total					279.634	0.000	0.000	0.539	3.039

9. CALCULATION OF SEISMIC FORCE

$$\text{Time Period } T = 2 \sqrt{\frac{D}{1000 F}}$$

$$\begin{aligned} D &= \text{Approximate DL of super-structure \& LL in Tonne (DL+20\% LL)} \\ &= 4990.20 \text{ KN} + 235.142 \text{ KN} \\ &= 5225 \text{ KN} \end{aligned}$$

F = Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction; and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

$$F = \frac{6 E I}{x^2(3L-x)} \quad \text{for 1 mm deflection at } x$$

$$E = 32000 \text{ N/mm}^2$$

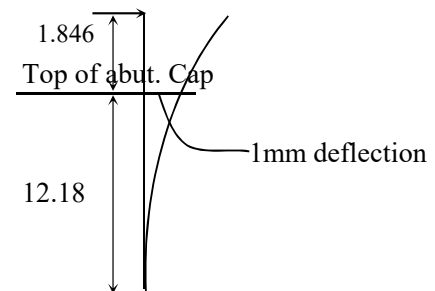
Column Cross-Section

$$D1 = 2.50 \text{ m (Average Outer Dia)}$$

$$D2 = 1.70 \text{ m (Average Inner Dia)}$$

$$I_{TT} = 1.13E+12 \text{ mm}^4 \quad 1.5E+12$$

$$I_{LL} = 1.13E+12 \text{ mm}^4$$



$$\text{Force required in Long. Dir. } F_L = 60 \text{ KN}$$

$$\text{Force required in Trans. Dir. } F_T = 49 \text{ KN}$$

$$\text{Time Period -Longitudinal Seismic Case} = 0.590 \text{ seconds}$$

$$\text{Time Period -Transverse Seismic Case} = 0.653 \text{ seconds}$$

$$S_a/g \text{ -Longitudinal Seismic Case} = 2.307$$

$$S_a/g \text{ -Transverse Seismic Case} = 2.082$$

$$\text{Seismic Zone} = V$$

$$\text{Zone Factor } Z = 0.36$$

$$\text{Importance Factor } I = 1.20$$

$$\begin{aligned} \text{Response reduction Factor } R &= 3.00 && \text{Longitudinal} \\ R &= 3.00 && \text{Transverse} \end{aligned}$$

$$\text{Avg response acceleration } S_a/g = 2.307 \quad \text{Longitudinal}$$

$$\text{Avg response acceleration } S_a/g = 2.082 \quad \text{Transverse}$$

$$\text{Elastic Seismic Coefficient} = \frac{Z}{2} \times (S_a/g) \times (I/R)$$

$$\text{In longitudinal direction} = 0.498 / R$$

$$\text{In Transverse direction} = 0.450 / R$$

			Substructure	Foundation
Enhancement factor				1.35
Design Seismic coefficient	Long. Ah		0.166	0.224
	Trans. At		0.150	0.202
	Vert. Av		0.111	0.149

CALCULATION OF SEISMIC FORCES

SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPLL :

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVF	W	eVS	eVF
	Tonnes	(m)	(m)		(m)	(m)
Total Super-Structure DL	347.02	14.46	16.96	347.02	14.46	16.96
Total Super-Structure SIDL	64.00	15.76	18.26	64.00	15.76	18.26
Total Super-Structure WC	88.00	15.39	17.89	88.00	15.39	17.89
Total Super-Structure FPLL	0.00	15.39	17.89	0.00	15.39	17.89
Total	499.02	14.79	17.29	499.02	12.77	14.95

* Bearing level	12.68	15.18		12.68	15.18

SEISMIC COMPONENT OF SUB-STRUCTURE :

Description	W	eVS	eVF
	Tonnes	(m)	(m)
Total weight of shaft and pier cap	180.11	8.45	10.81
Total weight of foundation	656.25	-1.46	1.04

SEISMIC COMPONENT OF LIVE LOAD(70R+Class A) :

Description	W	W	eVS	eVF
	Tonnes	Tonnes	(m)	(m)
	70R + Class A	70R + Class A		
Maximum Live Load	117.57	0.00	16.56	19.055
Minimum Live Load	22.29	0.00	16.56	19.055

Summary of Seismic force at shaft and foundation

Super structure

Dead load - Super structure about shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		82.88		1050.549	
Seismic Transverse direction			74.81		1030.89
Seismic Vertical Direction	55.25				

Dead load - Super structure about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		111.88		1697.95	
Seismic Transverse direction			100.989		1627.99
Seismic Vertical Direction	74.59				

Dead load Left span Dislodged- about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		55.94		848.973	
Seismic Transverse direction			50.49		754.88
Seismic Vertical Direction	37.29				

Sub structure

Dead load - Sub structure about Shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		29.91		252.74	
Seismic Transverse direction			27.00		228.13
Seismic Vertical Direction	19.94				

Dead load - Sub structure about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		40.3802		436.52	
Seismic Transverse direction			36.45		394.02
Seismic Vertical Direction	26.92				

Live Load - Max**70R + Class A**

Live load - Max shaft about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			3.52		58.36
Seismic Vertical Direction	2.60				

Live load - Max foundation about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			4.76		90.68
Seismic Vertical Direction	3.51				

70R

Live load - Max shaft about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			3.52		58.36
Seismic Vertical Direction	2.60				

Live load - Max foundation about	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			4.76		90.68
Seismic Vertical Direction	3.51				

Live Load - Min**70R + Class A**

Live load - Min about shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.67		11.06
Seismic Vertical Direction	0.49				

Live load - Min about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.90		17.19
Seismic Vertical Direction	0.67				

70R

Live load - Min about shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.67		11.06
Seismic Vertical Direction	0.49				

Live load - Min about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.90		17.19
Seismic Vertical Direction	0.67				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)**1. Normal Max Reaction on Fix End****Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ &+ 0.1 \times 0 + 0.05 \times 0 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 22.29) \\ &= 13.59 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 24.94 \text{ Ton} \\ F_{hr} &= 24.94 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 24.94 - 12.48 \\ &= 12.46 \text{ Ton} \end{aligned}$$

2. Normal Min Reaction on Fix End**Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (173.510 + 76.00 + 117.57) \\ &= 18.35 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 29.70 \text{ Ton} \\ F_{hr} &= 29.70 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 29.70 - 12.48 \\
 &= 17.23 \text{ Ton}
 \end{aligned}$$

3. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= 0.2 \times \text{Class 70R on First two Lane} + 0.05 \times \text{Class A on third Lane} \\
 &= 0.2 \times 20 + 0.05 \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 41.438 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 55.941 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 45.978 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 60.481 \text{ Ton} \\
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 4.46) \\
 &= 12.69838 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned}
 F_{hr} \text{ for shaft} &= 37.96 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 52.32 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 37.96 - 12.48 \\
 &= 25.48 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 52.32 - 12.48 \\
 &= 39.85 \text{ Ton}
 \end{aligned}$$

4. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= 0.2 \times \text{Class 70R on First two Lane} + 0.05 \times \text{Class A on third Lane} \\
 &= 0.2 \times 20 + 0.05 \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 41.438 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 55.941 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \%})
 \end{aligned}$$

$$\begin{aligned}
 \text{Total Horizontal force for Shaft}(F_h) &= 45.978 \text{ Ton} \quad \text{inc.)} \\
 \text{Total Horizontal force for foundation}(F_h) &= 60.481 \text{ Ton} \\
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{23.51} \right) \\
 &= 13.651204 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned}
 F_{hr} \text{ for shaft} &= 38.91 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 51.37 \text{ Ton} \\
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 38.91 - 12.48 \\
 &= 26.43 \text{ Ton} \\
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 51.37 - 12.48 \\
 &= 38.89 \text{ Ton}
 \end{aligned}$$

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\
 &= 12.48 \text{ Ton} \\
 F_{hl} &= 12.48 \text{ Ton}
 \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0.00$$

$$F_h = 20 \text{ Ton}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{22.29} \right) \\
 &= 13.59 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned}
 F_{hr} &= 23.59 \text{ Ton} \\
 F_{hr} &= 23.59 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 23.59 - 12.48 \\
 &= 11.11 \text{ Ton}
 \end{aligned}$$

6. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\
 &= 12.48 \text{ Ton}
 \end{aligned}$$

$$F_{hl} = 12.48 \text{ Ton}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 20 \text{ Ton}$$

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{117.57} \right) = 18.35 \text{ Ton}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$= 28.35 \text{ Ton}$$

$$F_{hr} = 28.35 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 28.35 - 12.48 \\ &= 15.88 \text{ Ton} \end{aligned}$$

7. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{0.00} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 4 \text{ Ton}$$

$$\text{Seismic Horizontal force (Shaft)} = 41.438 \text{ Ton}$$

$$\text{Seismic Horizontal force (foundation)} = 55.941 \text{ Ton}$$

$$\text{Total Horizontal force for Shaft (Fh)} = 45.438 \text{ Ton}$$

$$\text{Total Horizontal force for foundation (Fh)} = 59.941 \text{ Ton}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \frac{\text{CWLL}}{4.46} \right) \\ &= 12.69838 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 37.42 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 51.24 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 37.42 - 12.48 \\ &= 24.94 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 51.24 - 12.48 \\ &= 38.77 \text{ Ton} \end{aligned}$$

8. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= 0.2 \times 20 \text{ Ton} + 0.05 \times 0 \\ F_h &= 4 \text{ Ton} \\ \text{Seismic Horizontal force(Shaft)} &= 41.438 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\ \text{Seismic Horizontal force(foundation)} &= 55.941 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\ \text{Total Horizontal force for Shaft}(F_h) &= 45.438 \text{ Ton} \\ \text{Total Horizontal force for foundation}(F_h) &= 59.941 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 23.51) \\ &= 13.651204 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned} F_{hr} \text{ for shaft} &= 38.37 \text{ Ton} \\ F_{hr} \text{ for foundation} &= 50.29 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 38.37 - 12.48 \\ &= 25.89 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 50.29 - 12.48 \\ &= 37.81 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 0.00) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times (173.510 \text{ Ton} + 76.00 \text{ Ton} + 126.88) \\ &= 18.82 \text{ Ton} \\ F_{hr} &= 18.82 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 18.82 - 12.48 \\ &= 6.34 \text{ Ton} \end{aligned}$$

10. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 24.13 \text{ Ton} \\ F_{hr} &= 24.13 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 24.13 - 12.48 \\ &= 11.66 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hl} &= 12.48 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.48 \text{ Ton} \\ F_{hr} &= 12.48 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 12.48 - 12.48 \\ &= 0.00 \text{ Ton} \end{aligned}$$

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{173.510} + \frac{\text{Total SIDL load}}{76.00} + \text{CWLL} \right) \\ &= 12.475492 \text{ Ton} \\ F_{hr} &= 12.47549 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 12.47549 - 0.000 \\
 &= 12.47549 \text{ Ton}
 \end{aligned}$$

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 0 + 0.05 \times 0
 \end{aligned}$$

$$F_h = 0 \text{ Ton}$$

$$\begin{aligned}
 \text{Seismic Horizontal force(Shaft)} &= 41.438 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 55.941 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\
 \text{Total Horizontal force for Shaft}(F_h) &= 41.438 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 55.941 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (173.510 + 76.00 + 0.00) \\
 &= 12.475492 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$\begin{aligned}
 F_{hr} \text{ for shaft} &= 33.19 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 43.47 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 33.19 - 0.00 \\
 &= 33.19 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 43.47 - 0.00 \\
 &= 43.47 \text{ Ton}
 \end{aligned}$$

Summary of forces			
Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	12.46	12.46
	2. Normal Min Reaction on Fix End	17.23	17.23
	3. Seismic Max Reaction on Fix End	25.48	39.85
	4. Seismic Min Reaction on Fix End	26.43	38.89
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.11	11.11
	6. Normal Min Reaction on Fix End	15.88	15.88
	7. Seismic Max Reaction on Fix End	24.94	38.77
	8. Seismic Min Reaction on Fix End	25.89	37.81
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	6.34	6.34
	10. Normal Min Reaction on Fix End	11.66	11.66
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	12.48	12.48
	13. Seismic Span Dislodge Condition	33.19	43.47

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$C = \frac{WV^2}{127R}$$

70R + Class A

Maxium Reaction				
Live Load	W	=	117.57	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	7.41	t	

C (t)	e _{VS} (m)	e _{VF} (m)
7.41	16.56	19.06

Minimum Reaction				
Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0	16.56	19.06

70R

Maxium Reaction				
Live Load	W	=	117.57	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	7.4060597	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
7.40606	16.56	19.06

Minimum Reaction				
Live Load	W	=	22.29	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	200	m
C	=	1.404019	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
1.404019	16.56	19.06

Special Vehicle

Maxium Reaction				
Live Load	W	=	233.12	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	200	m

$$C = 0.2294474 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0.229447	16.56	19.06

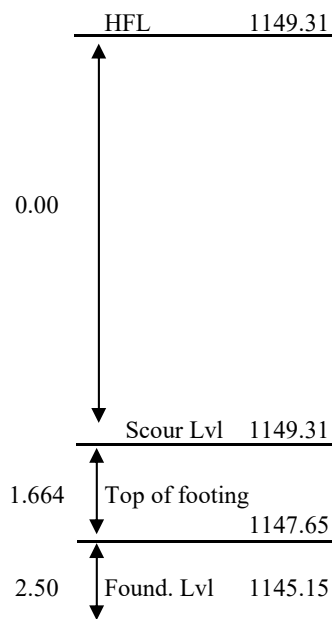
Minimum Reaction				
Live Load	W	=	126.88	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	200	m

$$C = 0.1248833 \text{ KN}$$

C (t)	e _{VS} (m)	e _{VF} (m)
0.124883	16.56	19.06

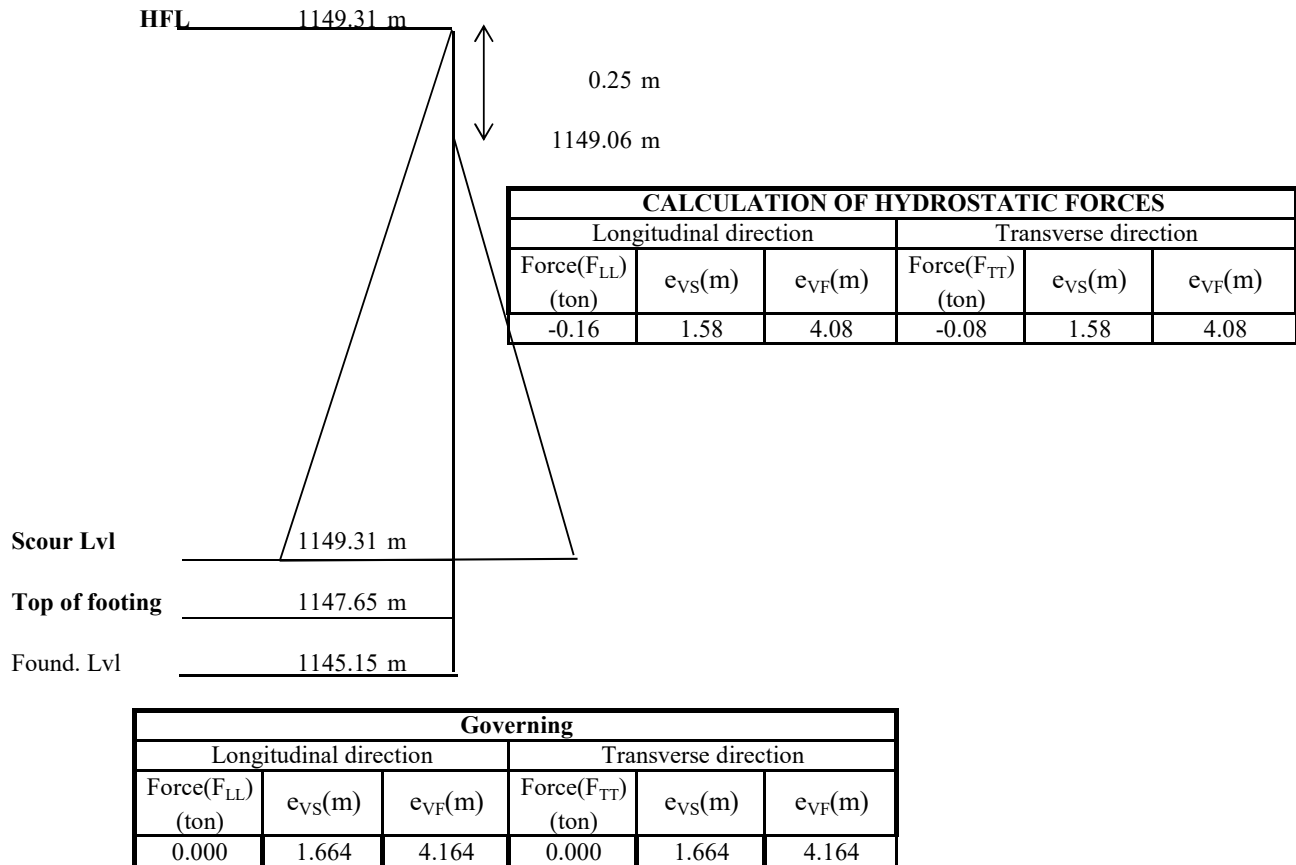
12. WATER CURRENT FORCES**NORMAL CASE****Water current forces**

HFL	=	1149.309 m		
MSL (NORMAL)	=	1149.309 m		
Water current pressure	P	=	52 KV ² Kg/m ²	
For piers with square ends	K	=	1.5	
For piers with semicircular ends	K	=	0.66	
Mean velocity of water current	V _{mean}	=	4.00 m/s	
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00	
		=	5.66 m/s	
Angle of variation		=	20 degree	
Water current pressure at HFL	(Trans direction)	=	0.97 t/m ²	52 K (vcosq) ²
Water current pressure at HFL	(Long direction)	=	0.29 t/m ²	53 K (vsinq) ²

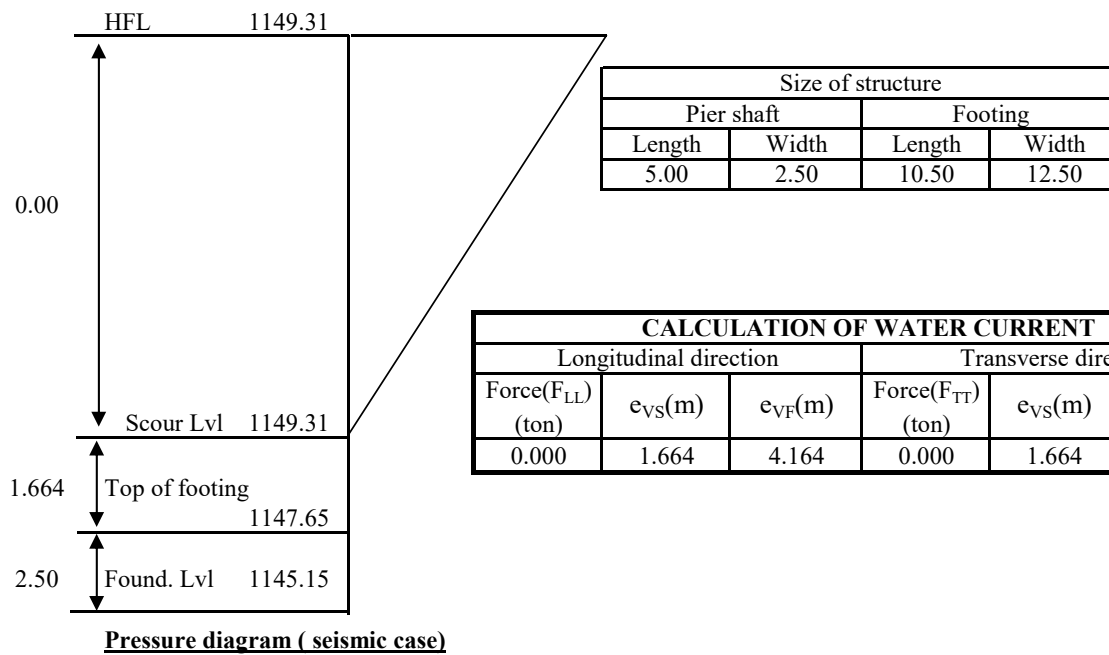
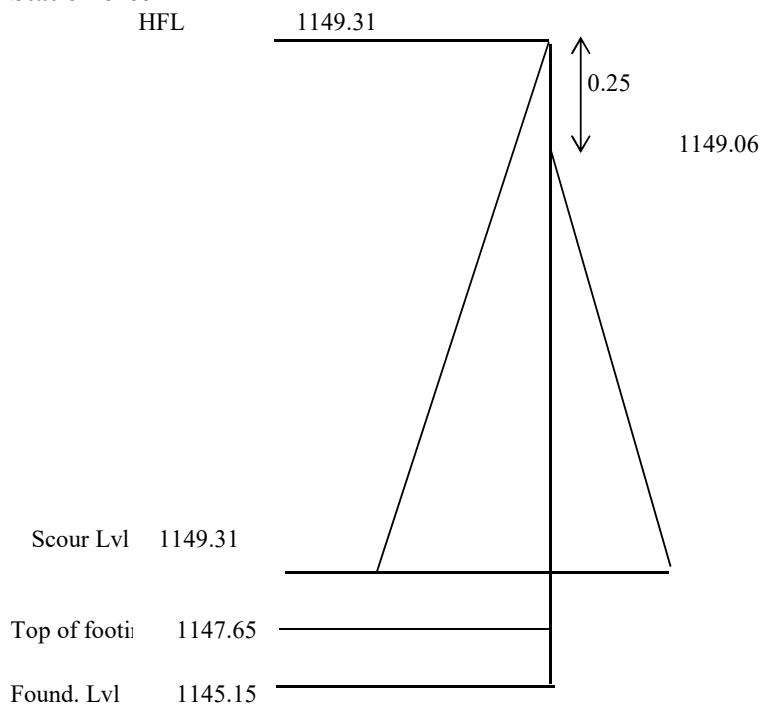
**Pressure diagram (Normal case)**

Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
5.00	2.50	10.50	12.50

CALCULATION OF WATER CURRENT FORCES					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.000	1.664	4.164	0.000	1.664	4.164

Static Force**SEISMIC CASE**

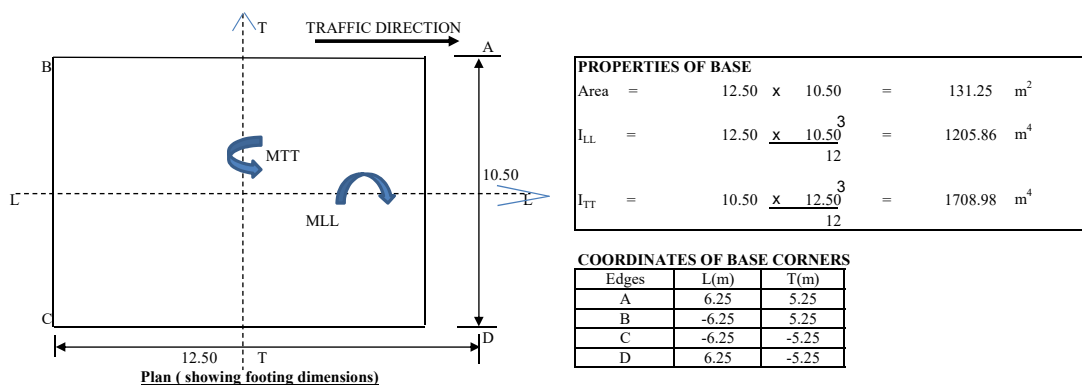
HFL	=	1149.309 m	
MSL (SEISMIC)	=	1149.31 m	
Water current pressure	P	52 KV ²	Kg/m ²
For piers with square ends	K	1.5	
For piers with semicircular ends	K	0.66	
Mean velocity of water current	V _{mean}	4.00 m/s	
Max. velocity of water current	V	$\sqrt{2} \times 4.00$	
		5.66 m/s	
Angle of variation		20 degree	
Water current pressure at HFL (Trans direction)	=	0.97 t/m ²	52 K (vcosq) ²
Water current pressure at HFL (Long direction)	=	0.29 t/m ²	53 K (vsinq) ²

**Static Force**

CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
-0.16	1.58	4.08	-0.08	1.58	4.08

Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
0.000	1.664	4.164	0.000	1.664	4.164

20. CHECK FOR BASE PRESSURE



SUMMARY OF FORCES

$$\text{Base pressure} = \frac{P}{A} + \frac{M_{LL} \cdot x}{I_{LL}} + \frac{M_{TT} \cdot z}{I_{TT}}$$

Sr. No.	Description	Forces at founding levels			Base pressure at footing corners in T/m ²			
		V(Tonne)	M _{TT} (Tm)	M _{LL} (Tm)	A	B	C	D
LC -1	NORMAL MAX REACTION(70R+Class A)	2000.46	252.65	300.90	17.48	15.63	13.01	14.86
LC -2	NORMAL SPAN DISLOGED	1645.13	339.04	0.00	13.77	11.29	11.29	13.77
LC -6	SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z	1661.50	1971.54	285.96	21.11	6.69	4.20	18.62
LC -7	SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R + class A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LC -8	SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z	1661.50	817.00	953.19	19.80	13.82	5.52	11.50
LC -13	SEISMIC NORMAL MAX REACTION(70R)	2000.46	232.16	300.90	17.40	15.70	13.08	14.78
LC -15	SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)	1949.75	2765.14	671.63	27.89	7.67	1.82	22.04
LC -16	SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)	1949.75	1271.01	2173.98	28.97	19.67	0.74	10.04
LC -18	NORMAL SV MAX REACTION	2127.76	236.15	74.31	17.40	15.67	15.02	16.75

Sr. No.	Average pressure along BC	Average pressure along AD	Average pressure along AB	Average pressure along CD	Effective Length along TT	Effective Width along LL	Effective Area	I _{LL}	I _{TT}
	T/m ²	T/m ²	T/m ²	T/m ²	m	m	m ²	m ⁴	m ⁴
LC -1	14.32	16.17	16.55	13.93	10.50	12.50	131.25	1205.86	1708.98
LC -2	11.29	13.77	12.53	12.53	10.50	12.50	131.25	1205.86	1708.98
LC -6	5.45	19.87	13.90	11.41	10.50	12.50	131.25	1205.86	1708.98
LC -8	9.67	15.65	16.81	8.51	10.50	12.50	131.25	1205.86	1708.98
LC -13	14.39	16.09	16.55	13.93	10.50	12.50	131.25	1205.86	1708.98
LC -15	4.74	24.97	17.78	11.93	10.50	12.50	131.25	1205.86	1708.98
LC -16	10.21	19.50	24.32	5.39	10.50	12.50	131.25	1205.86	1708.98
LC -18	15.35	17.08	16.54	15.89	10.50	12.50	131.25	1205.86	1708.98

Sr. No.											Base Pressure(T/m ²)			
	M _{TT}	M _{LL}	A'		B'		C'		D'		A'	B'	C'	D'
	T _m	T _m	L(m)	T(m)	L(m)	T(m)	L(m)	T(m)	L(m)	T(m)	T/m ²	T/m ²	T/m ²	T/m ²
LC -1	252.65	300.90	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	17.48	15.63	13.01	14.86
LC -2	339.04	0.00	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	13.77	11.29	11.29	13.77
LC -6	1971.54	285.96	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	21.11	6.69	4.20	18.62
LC -8	817.00	953.19	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	19.80	13.82	5.52	11.50
LC -13	232.16	300.90	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	17.40	15.70	13.08	14.78
LC -15	2765.14	671.63	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	27.89	7.67	1.82	22.04
LC -16	1271.01	2173.98	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	28.97	19.67	0.74	10.04
LC -18	236.15	74.31	6.25	5.25	-6.25	5.25	-6.25	-5.25	6.25	-5.25	17.40	15.67	15.02	16.75

Minimum Effective Area Allowed Normal case

=

0.8 x 131

=

105.00

m²

Minimum Effective Area Allowed Seismic case

=

0.67 x 131

=

87.938

m²

Minimum Effective Area Normal Case

=

131.25

>

105.00

m²

Ok

Minimum Effective Area Seismic Case

=

131.25

>

87.94

m²

Ok

SUMMARY OF BASE PRESSURES**NORMAL CASE**

Maximum base pressure

=

17.48 t/m²

<

35 t/m²

Ok

Minimum base pressure

=

11.29 t/m²

>

0 t/m²

Ok

SEISMIC CASE

Maximum base pressure

=

28.97 t/m²

<

43.75 t/m²

Ok

Minimum base pressure

=

0.74 t/m²

>

0 t/m²

Ok

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

LC -1 ULS NORMAL LWL MAX REACTION
 LC -2 ULS NORMAL LWL SPAN DISLOGED

LC -5 ULS MAX REACTION $1X + 0.3Y + 0.3Z$
 LC -6 ULS MAX REACTION $0.3X + 1Y + 0.3Z$

LC -9 ULS NORMAL SV MAX REACTION

SLS

LC -1 RARE NORMAL MAX REACTION
 LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

LC -1 ULS NORMAL MAX REACTION($70R + \text{Class A}$)
 LC -2 ULS NORMAL SPAN DISLOGED

LC -5 ULS NORMAL MAX REACTION($70R$)

LC -7 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R + \text{Class A})$
 LC -8 ULS SPAN DISLODGED $1X + 0.3Y + 0.3Z$
 LC -9 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{Class A})$
 LC -10 ULS SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC -15 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC -16 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC -19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION(70R+Class A)

LC - 2 NORMAL SPAN DISLOGED

LC - 5 0

LC - 6 SEISMIC SPAN DISLODGED $1X + 0.3Y + 0.3Z$ LC - 7 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{class A})$ LC - 8 SEISMIC LWL SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 13 SEISMIC NORMAL MAX REACTION(70R)

LC - 15 SEISMIC MAX REACTION $1X + 0.3Y + 0.3Z(70R)$ LC - 16 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 13 NORMAL LWL SV MAX REACTION

14.A DESIGN FORCES FOR PIER SHAFT(ULS CASES)**LC -1 ULS NORMAL LWL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				7.406			16.555	0.0	122.607	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				12.464			12.676	158.002		1.5	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1128.38	332.24	423.58

LC -2 ULS NORMAL LWL SPAN DISLODGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			16.555	0.000	0.000	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				12.475			12.676	158.142		1.5	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
597.58	449.88	0.00

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.60	0.000		-123.306	0.000	1.35	
2	Surfacing			44.000		-0.60	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.60	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.60	0.950		0.000	0.000	0.2	1
5	LL (Class-A)			0.000		-0.60	1.000		0.000	0.000	0.2	1
Right Span												
6	DL (superstructure)			205.510		0.60	0.000		123.306	0.000	1.35	
7	Surfacing			44.000		0.60	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.60	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.60	1.510		70.543	177.5	0.2	1
10	LL (Class-A)			0.000		0.60	1.000		0.000	0.0	0.2	1
11	Centrifugal force				7.406			16.555	0.0	122.6	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				25.482			12.676	323.013		1.000	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				82.875				1050.55		1.5	
	Transverse				74.806					1030.8917	0.45	
	Vertical			55.250							0.45	
Sub structure												
	Longitudinal				29.911				252.74		1.5	
	Transverse				26.999					228.12903	0.45	
	Vertical			19.941							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				3.525					58.355428	0.45	
	Vertical			2.603							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1010.540	2292.05	652.85

LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.60	0.00		-123.31	0.00	1.35	
2	Surfacing			44.000		-0.60	0.00		-26.40	0.00	1.75	
3	FLL			0.000		-0.60	0.00		0.00	0.00	0.2	
4	LL (70R)			0.000		-0.60	0.95		0.00	0.00	0.2	1
5	LL (Class-A)			0.000		-0.60	1.00		0.00	0.00	0.2	1
Right Span												
6	DL (superstructure)			205.510		0.60	0.00		123.31	0.00	1.35	
7	Surfacing			44.000		0.60	0.00		26.40	0.00	1.75	
8	FLL			0.000		0.60	0.00		0.00	0.00	0.2	
9	LL (70R)			117.571		0.60	1.51		70.54	177.53	0.2	1
10	LL (Class-A)			0.000		0.60	1.00		0.00	0.00	0.2	1
11	Centrifugal force				7.406			16.555	0.0	122.607	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.500	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.500	10.978		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				25.482			12.676	323.013		1.000	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				82.875				1050.55		0.45	
	Transverse				74.806					1030.892	1.5	
	Vertical			55.250							0.45	
Sub structure												
	Longitudinal				29.911				252.74		0.45	
	Transverse				26.999					228.129	1.5	
	Vertical			19.941							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				3.525					58.355	1.5	
	Vertical			2.603							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1010.540	923.60	2036.09

LC - 9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1.35	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
7	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			16.555	3.799		1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
15	Horizontal Force(F _{LL})				6.344			12.676	80.419		1.5	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1.5	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1185.14	264.30	69.94

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)**LC -1 RARE NORMAL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				7.406			16.555	0.000	122.607	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			1.664	0.000		1	
	Water Current Force(F _{TT})				0.000			1.664		0.000	1	
17	Horizontal Force(F _{LL})				12.464			12.676	158.002		1	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
814.30	221.49	282.39

LC-2 RARE NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force(F _{LL})				0.000			16.555	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			1.664	0.000		1	
	Water Current Force(F _{TT})				0.000			1.664		0.000	1	
17	Horizontal Force(F _{LL})				12.475			12.676	158.142		1	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
438.41	313.13	0.00

LC -5 QP NORMAL

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	0	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			16.555	0.000	122.607	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			1.664	0.000		0	
	Water Current Force(F _{TT})				0.000			1.664		0.000	0	
17	Horizontal Force(F _{LL})				0.000			12.676	0.000		0	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
696.72	0.00	122.61

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
8	FLL			0.000		0.600	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			16.555	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F _{LL})				0.000			1.664	0.000		0	
	Water Current Force(F _{TT})				0.000			1.664		0.000	0	
17	Horizontal Force(F _{LL})				12.475			12.676	158.142		1	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
438.41	313.13	0.00

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.306	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.2	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.306	0.000	1	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.2	
7	FLL			0.000		0.600	0.000		0.000	0.000	1	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			16.555	3.799		1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			1.664	0.000		1	
	Water Current Force(F _{TT})				0.000			1.664		0.000	1	
15	Horizontal Force(F _{LL})				6.344				80.419		1	
	Horizontal Force(F _{TT})				0.000			12.676		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
929.84	224.09	69.94

15. DESIGN FORCES FOR FOUNDATION**LC -I ULS NORMAL MAX REACTION(70R +Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				7.406				19.055	0.0	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				12.464			15.176	189.16		1.5	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2751.69	378.98	451.35

LC -2 ULS NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			19.055	0.000	0.000	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				12.475			15.176	189.331		1.5	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2238.53	496.66	0.00

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1.5	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centrifugal force				7.406			19.055	0.0	141.122	1.5	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				11.114			15.176	168.68		1.5	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1.5	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1996.677	348.25	451.35

LC - 7 ULS MAX REACTION IX + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				7.406			19.055	0.0	141.122	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.500	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.500	10.978		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				39.847			15.176	604.73		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				111.882				1697.9		1.5	
	Transverse				100.989					1628.0	0.45	
	Vertical			74.588							0.45	
Sub structure												
	Longitudinal				40.380				436.5		1.5	
	Transverse				36.449					394.02132	0.45	
	Vertical			26.92							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				4.759					90.676509	0.45	
	Vertical			3.515							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2663.832	3820.54	1016.76

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			19.055	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				43.465			15.176	659.64		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				55.941				848.97		1.5	
	Transverse				50.494					754.88332	0.45	
	Vertical			37.294							0.45	
Sub structure												
	Longitudinal				40.380				436.5		1.5	
	Transverse				36.449					394.02132	0.45	
	Vertical			26.920							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2267.425	2634.08	517.01

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				7.406			19.055	0.0	141.122	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				39.847			15.176	604.73		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				111.882				1697.9		0.45	
	Transverse				100.989					1627.985	1.5	
	Vertical			74.588							0.45	
Sub structure												

	Longitudinal				40.380				436.5		0.45	
	Transverse				36.449					394.021	1.5	
	Vertical			26.920							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				4.759					90.677	1.5	
	Vertical			3.515							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2663.832	1579.35	3258.54

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			19.055	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				43.465			15.176	659.64		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				55.941			848.97			0.45	
	Transverse				50.494					754.88332	1.5	
	Vertical			37.294							0.45	
	Sub structure											
	Longitudinal				40.380				436.5		0.45	
	Transverse				36.449					394.02132	1.5	
	Vertical			26.920							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2267.425	1284.31	1723.36

LC -15 ULS MAX REACTION IX + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			19.055	141.1	0.000	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	23.519	2.500	58.797		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	4.391	2.500	10.978		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				38.767			15.176	588.34		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				111.882				1697.9		1.5	
	Transverse				100.989					1628.0	0.45	
	Vertical			74.588							0.45	
Sub structure												
	Longitudinal				40.380				436.5		1.5	
	Transverse				36.449					394.02132	0.45	
	Vertical			26.92							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				4.759					90.68	0.45	
	Vertical			3.515							0.45	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.902					17.190186	0.45	0.3
	Vertical			0.666							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2663.832	3832.37	988.53

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
8	FLL			0.000		0.600	0.000		0.000	0.000	0.2	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			19.055	141.1	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				38.767			15.176	588.34		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				111.882			1697.9			0.45	
	Transverse				100.989					1627.985	1.5	
	Vertical			74.588							0.45	
Sub structure												
	Longitudinal				40.380			436.5			0.45	
	Transverse				36.449					394.021	1.5	
	Vertical			26.920							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				4.759					90.677	1.5	
	Vertical			3.515							0.45	
b)	Min Live Load											
	Longitudinal										0.45	0.3

Transverse				0.902					17.190186	1.5	1
Vertical				0.666						0.45	0.3
SUMMARY OF FACTORED FORCES											
V(ton)		MTT (tm)		MLL(tm)							
2663.832		1591.18		3230.32							

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1.35	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1.75	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1.35	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1.75	
7	FLL			0.000		0.600	0.000		0.000	0.000	1.5	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			19.055	0.0	4.372	1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
15	Horizontal Force(F _{LL})				6.344			15.176	96.28		1.5	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1.5	
16	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
2826.09	284.29	74.31

16. DESIGN FORCES FOR BASE PRESSURE**LC -1 NORMAL MAX REACTION(70R+Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				7.406			19.055	0.0	141.122	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})							4.164	0.000		1	
	Water Current Force(F _{TT})							4.164		0.000	1	
17	Horizontal Force(F _{LL})				12.464			15.176	189.16		1	
	Horizontal Force(F _{TT})							15.176		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2000.46	252.65	300.90

LC -2 NORMAL SPAN DISLOD

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			19.055	0.000	0.000	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				12.475			15.176	189.331		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1645.13	339.04	0.00

339.037 0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			19.055	0.00	0.000	0	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				43.465			15.176	659.64		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				55.941				848.97		1	
	Transverse				37.403					559.17283	0.3	
	Vertical			27.625							0.3	
	Sub structure											
	Longitudinal				40.380				436.5		1	
	Transverse				36.449					394.02	0.3	
	Vertical			26.920							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1661.496	1971.54	285.96

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.600	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.600	0.000		0.000	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.600	1.510		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			19.055	0.00	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				43.465			15.176	659.64		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				0.000				0.00		0.3	
	Transverse				37.403					559.17283	1	
	Vertical			27.625							0.3	
	Sub structure											
	Longitudinal				40.380				436.5		0.3	
	Transverse				36.449					394.02132	1	
	Vertical			26.920							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1661.496	817.00	953.19

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VT} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	1	0.9
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	0.9
11	Centifugal force				7.406			19.055	0.0	141.122	1	
12	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				11.114			15.176	168.68		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2000.46	232.16	300.90

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VT} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.543	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centifugal force				7.406			19.055	141.1	0.000	0.2	
12	Pier cap	44.132	2.500	110.330		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	23.519	2.500	58.797		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	4.391	2.500	10.978		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				38.767			15.176	588.34		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.00	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1	
20	Seismic											
Super structure												
	Longitudinal				111.882				1697.9		1	
	Transverse				100.989					1628.0	0.3	
	Vertical			74.588							0.3	
Sub structure												
	Longitudinal				40.380				436.5		1	
	Transverse				36.449					394.02	0.3	
	Vertical			26.92							0.3	
a)	Max Live Load											
	Longitudinal										1	
	Transverse				4.759					90.68	0.3	
	Vertical			3.515							0.3	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.902					17.190186	0.45	0.3
	Vertical			0.666							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1949.753	2765.14	671.63

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.600	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.600	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
7	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
8	FLL			0.000		0.600	0.000		0.000	0.000	1	
9	LL (70R)			117.571		0.600	1.510		70.5427	177.533	0.2	
10	LL (Class-A)			0.000		0.600	1.000		0.000	0.000	0	
11	Centrifugal force				7.406			19.055	141.1	0.000	0.2	
12	Pier cap	44.13	2.50	110.33		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	23.52	2.50	58.80		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	4.39	2.50	10.98		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			4.164	0.00		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
17	Horizontal Force(F _{LL})				38.767			15.176	588.34		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
18	Footing	262.50	2.50	656.25		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	279.63	2.00	559.27		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				111.882				1697.9		0.3	
	Transverse				100.989					1628.0	1	
	Vertical			74.588							0.3	
	Sub structure											
	Longitudinal				40.380				436.5		0.3	
	Transverse				36.449					394.02	1	
	Vertical			26.920							0.3	
a)	Max Live Load											
	Longitudinal										0.3	
	Transverse				4.759					90.68	1	
	Vertical			3.515							0.3	
b)	Min Live Load											
	Longitudinal										0.45	0.3
	Transverse				0.902					17.2	1.5	1
	Vertical			0.666							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1949.753	1271.01	2173.98

LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			205.510		-0.600	0.000		-123.31	0.000	1	
2	Surfacing			44.000		-0.600	0.000		-26.400	0.000	1	
3	FLL			0.000		-0.600	0.000		0.000	0.000	1	
4	LL			0.000		-0.600	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			205.510		0.600	0.000		123.31	0.000	1	
6	Surfacing			44.000		0.600	0.000		26.400	0.000	1	
7	FLL			0.000		0.600	0.000		0.000	0.000	1	
8	LL			233.119		0.600	0.300		139.871	69.936	1	1
9	Centrifugal force				0.229			19.055	0.0	4.372	1	
10	Pier cap	44.132	2.5	110.330		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	23.519	2.5	58.797		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	4.391	2.5	10.978		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F _{LL})				0.000			4.164	0.000		1	
	Water Current Force(F _{TT})				0.000			4.164		0.000	1	
15	Horizontal Force(F _{LL})				6.344			15.176	96.28		1	
	Horizontal Force(F _{TT})				0.000			15.176		0.000	1	
16	Footing	262.50	2.5	656.250		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	279.63	2	559.268		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2127.76	236.15	74.31

DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
86+106

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	13.750m	13.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	15.000m	15.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m²
SBC of soil-Normal Case = 410 kN/m² Assumed
SBC of soil-Seismic Case = 513 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	0.914m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion = 1.850m 1.850m
Width of Abutmentcap at bottom of Tapering Portion = 1.000m 1.000m
Projection of Abutment Cap (Span Side) = 0.400m 0.400m

Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.089m	1.089m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.400m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.600m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	9.900m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	1.200m	
Width of Toe Slab	=	3.300m	
Width of Heel Slab	=	5.400m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.200m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.200m	
Width of backfill on heel slab	=	5.400m	
Thickness of heel slab at back fill edge	=	1.200m	
Height of back fill at bottom edge of heel slab	=	10.048m	
Height of back fill at back fill edge of heel slab	=	9.348m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1198.133m	Cross Slope (Bi-directional)	=	2.500%	
Deck level at Outer Edge =	1197.991m	Height of Superstructure	=	1.420m	
Deck level at center line =	1198.133m	Min. Height of Footpath Side Pedestal (1)	=	0.300m	
Soffit Level at center of bridge =	1196.648m	Height of Pedestal (2)	=	0.375m	
Abutment cap top level =	1196.148m	Height of Pedestal (3)	=	0.450m	
Abutment cap bottom lvl (uniform portion ends	1195.848m	Height of Pedestal (4)	=	0.525m	
Abutment cap bottom lvl (corbel portion ends)	1195.548m	Height of Pedestal (5)	=	0.000m	
Abutment shaft top level =	1195.548m	Height of Pedestal (6)	=	0.000m	
Ground level/LBL =	1190.514m	Distance of nearest girder to c.l. of deck	=	1.500m	
Abutment shaft bottom level =	1188.714m	Height (Avg.) of Dirt Wall	=	1.914m	
Foundation level =	1187.514m	Abutment shaft Above G.L	=	5.034m	
HFL	=	1192.514m	Abutment Shaft below G.L	=	1.800m
			Height of abutment shaft	=	6.834m
			MSL	=	1189.514m
			Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z =Zone factor	=	0.36	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	267.12 4.50
DL Reaction on Bearing No.-2	=	280.83 1.50
DL Reaction on Bearing No.-3	=	280.83 -1.50
DL Reaction on Bearing No.-4	=	267.12 -4.50
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		1095.90 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	60.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	60.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		120.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	41.113 4.50
SIDL Reaction on Bearing No.-2	=	49.335 1.50
SIDL Reaction on Bearing No.-3	=	49.335 -1.50
SIDL Reaction on Bearing No.-4	=	41.113 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		180.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	934.20	KN	Corr. Transv	=	1533.259 kNm	ecc.	1.64
min	=	464.40	KN	Corr. Transv	=	780.011 kNm	ecc.	1.68

SV Loading

max	=	1801.96	KN	Corr. Transv	=	540.589 kNm	ecc.	0.30
min	=	1618.04	KN	Corr. Transv	=	485.411 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	671.00	KN	Corr. Transv	=	2116.994 kNm	ecc.	3.16
min	=	329.00	KN	Corr. Transv	=	1038.006 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.114
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.114
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.300 x	0.800 x	0.800 =	0.1920 m ³	4.500
Pedestal 2	=	0.375 x	0.800 x	0.800 =	0.2400 m ³	1.500
Pedestal 3	=	0.450 x	0.800 x	0.800 =	0.2880 m ³	-1.500
Pedestal 4	=	0.525 x	0.800 x	0.800 =	0.3360 m ³	-4.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.0560 m ³	-0.682

VOLUME CALCULATION

C.G. Of Footing = 4.950 m
 C.G. Of shaft from toe tip = 3.900 m
 Distance between c.g. of shaft and footing = 1.050 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.250	-4.700	0.000
-Trapering portion	1	12.50	0.300	0.914	3.427	-0.800	0.250	-4.700	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	-0.050	-5.000	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.000	-4.950	0.000
Cap (uniform portion)	1	12.50	1.850	0.300	6.938	-0.025	1.025	-3.925	0.000
Cap (Corbel Portion)	1	12.50	1.850	0.300	5.263	-0.025	1.025	-3.925	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.044	3.034	39.609	0.077	1.127	-3.823	0.000
Shaft below HFL	1	12.50	1.144	3.300	47.206	0.027	1.077	-3.873	0.000
Solid Return Wall	1	5.40	0.550	9.769	29.014	-3.300	-2.250	-7.200	5.975
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.600	0.450	-4.500	5.975
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.600	0.450	-4.500	5.975
Footing									
Heel Slab	1	12.50	5.400	0.850	57.375		-1.879	-6.829	0.000
Toe Slab	1	12.50	3.300	0.850	35.063		3.074	-1.876	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		1.050	-3.900	0.000
Back filling above HFL over Heel Slab	1	12.50	5.400	5.619	379.283		-2.250	-7.200	0.000
Back filling below HFL over Heel Slab	1	12.50	5.400	4.150	280.125		-2.326	-7.276	0.000
Backfill above Heel slab	1	12.50	5.400	9.698	654.598		-2.282	-7.232	0.000
Front Filling over Toe Slab	1	12.50	3.300	2.150	88.688		3.210	-1.740	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.300	1.150	47.438		2.083	-2.867	0.000
Side filling between heel and toe	1	0.00	1.200	2.150	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	-0.050	-5.000	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.089	5.619	6.236		0.530	-4.420	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.111	4.150	5.769		0.487	-4.463	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.250	-4.700

SECTIONAL PROPERTIES

Width of Footing (B) = 9.900 m
 Length of Footing (L) = 12.500 m

A = 9.900 x 12.500 = 123.750 m²
 ZL = 12.500 x 16.335 = 204.188 m³
 ZT = IT1 + IT2

distance of extreme point from centre

IT1 = 9.900 x 162.760 = 1611.33 m⁴
 IT2 (moment of inertia of triangle) = 9.900 x 0.000 + 0.500 x 9.900 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1611.33 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 257.813 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 8.934 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction

= 10.257 m

Abutment Cap Top Level - Foundation Level

= 8.634 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.10 m

Moment of Inertia , $I_{longitudinal}$ = 1.040 m^4

Moment of Inertia , $I_{transverse}$ = 179.036 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force	=	148.834	KN
D	=	1396.80	KN
T	=	0.1938	sec

Transverse Direction

Force	=	21030.214	KN
D	=	1676.518	KN
T	=	0.0179	sec

For Hard or Rocky Strata, with $N > 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.268$$

For Medium Strata, with $N > 10 \& N < 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.268$$

For Soft Soil Strata, with $N < 10$

$$\frac{S_a}{g} = 2.5$$

$$\frac{S_a}{g} = 1.268$$

Medium Soil Strata

$$S_a/g = 2.5$$

$$S_a/g = 1.268$$

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.274

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.274	In Transverse direction
Av	=	0.183	In Vertical direction

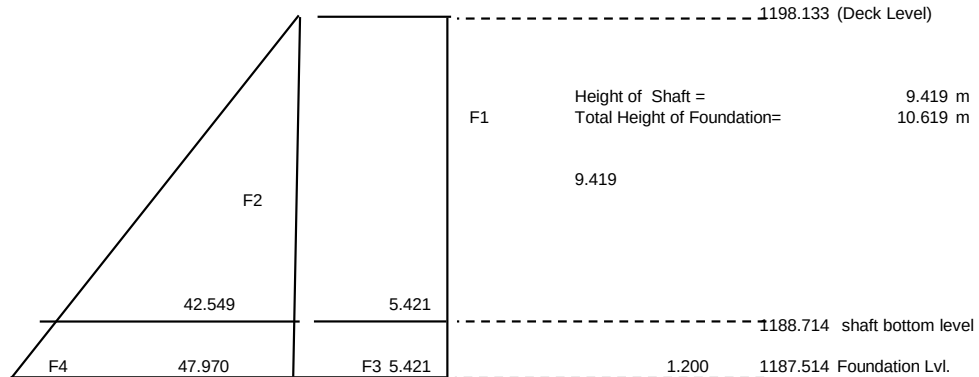
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.274	In Transverse direction
Av	=	0.183	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1188.714 m (at Shaft Base)			
@ RL					1187.514 m (at Foundation Level)			
Due to Live Load Surcharge								
Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421 kN/m ²
F1	=	5.421	x	9.419	x	12.500	=	638.232 kN
M1	=	638.23	x	4.71	=	3005.755	kN.m	at Shaft Bottom
F3	=	5.421	x	10.619	x	12.500	=	719.544 kN
M3	=	719.544	x	5.310	=	3820.421	kN.m	at Foundation
Due to Active Earth Pressure								
Intensity for triangular portion (At Shaft bottom level)								
	=	0.226	x	20	x	9.419	=	42.549 kN/m ²
F2	=	0.5	x	42.55	x	9.419	x	12.50
	=	2504.796 kN						
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)								
M2	=	2504.80	x	3.96	=	9908.922	kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)								
	=	0.226	x	20	x	10.619	=	47.970 kN/m ²
F4	=	0.5	x	47.97	x	10.619	x	12.50
	=	3183.684 kN						
M4	=	3183.68	x	4.46	=	14199.167	kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
 = 4.800 x 9.419 = 45.211 kN/m²

F = 0.5 x 45.211 x 12.500
 = 2661.527 kN

M = 2661.53 x 3.140 = 8356.307 kN.m at Shaft Bottom

Intensity for triangular portion (At Foundation level)
 = 4.800 x 10.619 = 50.97 kN/m²

F = 0.5 x 50.971 x 12.500
 = 3382.895 kN

M = 3382.89 x 3.540 = 11974.320 kN.m at Foundation

Intensity of Passive pressure
 = 5.249 x 20 x 0.000 = 0.000 kN/m²

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 12.500
 = 0.000 kN

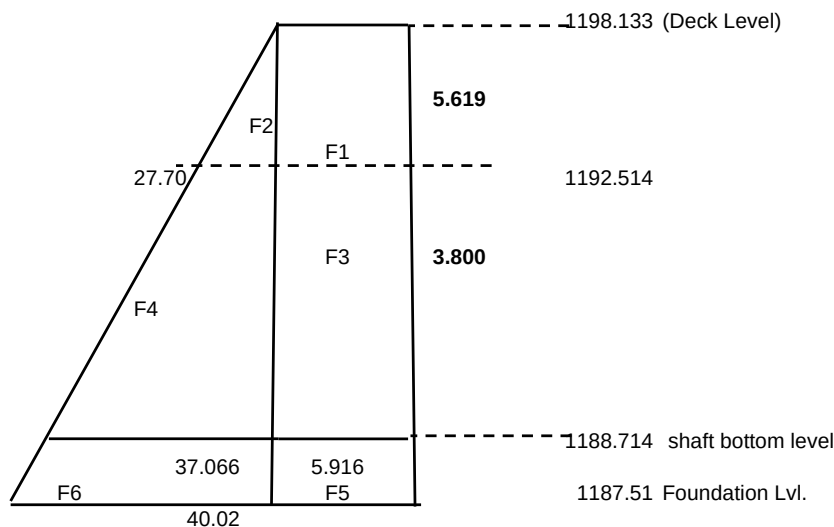
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = 0.000 kN.m at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	9908.922	14199.167	2504.796	3183.684
Due to Minimum Fluid Pressure	8356.307	11974.320	2661.527	3382.895
Governing of Two	9908.922	14199.167	2661.527	3382.895
Due to Live Load Surcharge	3005.755	3820.421	638.232	719.544
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246	active component
	Kp'	=	5.249	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1188.7 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	9.419	x	12.500	=	696.479 kN
M1	=	696.48	x	4.71	=	3280.069 kN.m		at Shaft Bottom
F3	=	5.916	x	10.619	x	12.500	=	785.212 kN
M3	=	785.21	x	5.31	=	4169.084 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	5.619	=	27.699 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.800	=	9.366 kN/m ²
F2	=	0.5	x	27.70	x	5.619	x	12.50
	=	972.770 kN						
F4	=	$\left(\frac{27.70 + 37.07}{2} \right)$	x	3.80	x	12.50		
	=	1538.172 kN						
Total Force	=	2510.942 kN						
M2	=	972.77	x	6.16	=	5992.244 kN.m		
M4	=	1538.17	x	1.81	=	2781.643 kN.m		

Total Moment = 8773.89 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 5.619 = 27.699 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.000 = 12.324 \text{ kN/m}^2$$

$$\text{F2} = 0.5 \times 27.70 \times 5.619 \times 12.50 = 972.770 \text{ kN}$$

$$\text{F6} = \left(\frac{27.70 + 40.02}{2} \right) \times 5.00 \times 12.50 = 2116.341 \text{ kN}$$

Total Force = 3089.111 kN

$$\text{M2} = 972.77 \times 7.36 = 7159.569 \text{ kN.m}$$

$$\text{M6} = 2116.34 \times 2.35 = 4969.915 \text{ kN.m}$$

Total Moment = 12129.48 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	8773.888	12129.483	2510.942	3089.111
Due to Minimum Fluid Pressure	8356.307	11974.320	2661.527	3382.895
Governing of Two	8773.888	12129.483	2661.527	3382.895
Due to Live Load Surcharge	3280.069	4169.084	696.479	785.212
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.180	
αv	=	0.183	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.151 \\ 0.217 \end{matrix}$$

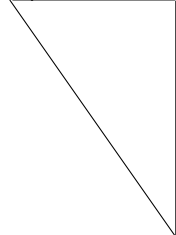
C_a	=	$\frac{1}{0.376}$	$\frac{2}{0.303}$	
Ca	=	0.376	0.303	
Ka	=	0.226		
Dynamic Increment	=	0.376	-0.226	0.150

3 Earth Pressure : DRY CASE (Seismic case)

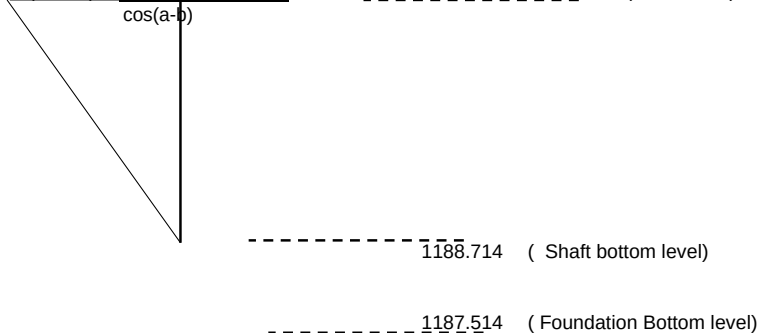
Equivalent Live Load Surcharge height	=	1.2 m
Assuming	γ_{dry}	= 20 kN/m ³
	γ_{water}	= 10.00 kN/m ³

Active Earth Pressure

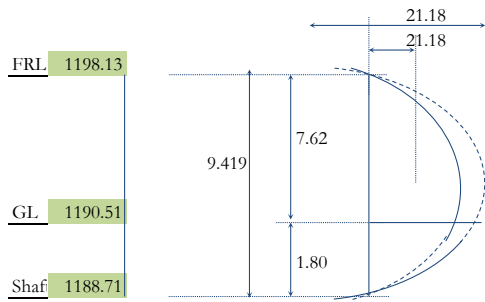
$$3 (C_a - K_a) = 0.450$$

**Surcharge Earth Pressure**

$$2 (C_a - K_a) \frac{\cos \alpha}{\cos(\alpha - \beta)} = 0.30$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.300	x	20.00	x	1.2	=	7.194 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.194	x	9.419	x	12.500
	=	423.505	kN					
M1	=	423.505	x	6.311			=	2672.626 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.194	x	9.419	x	12.500
	=	423.505	kN					
M2	=	423.505	x	7.511			=	3180.832 kN.m

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height	=	21.18 t/m ²
h	=	9.419 m
y	=	2.9095 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	21.18 t/m ²
h	=	9.419 m
y	=	-2.9095 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	1503.2	5.1
Parabola below Water Level	158.9	1.2
Total Dynamic Earth Pressure	1662.1	4.7

$$E3 = 1662.081 \text{ kN}$$

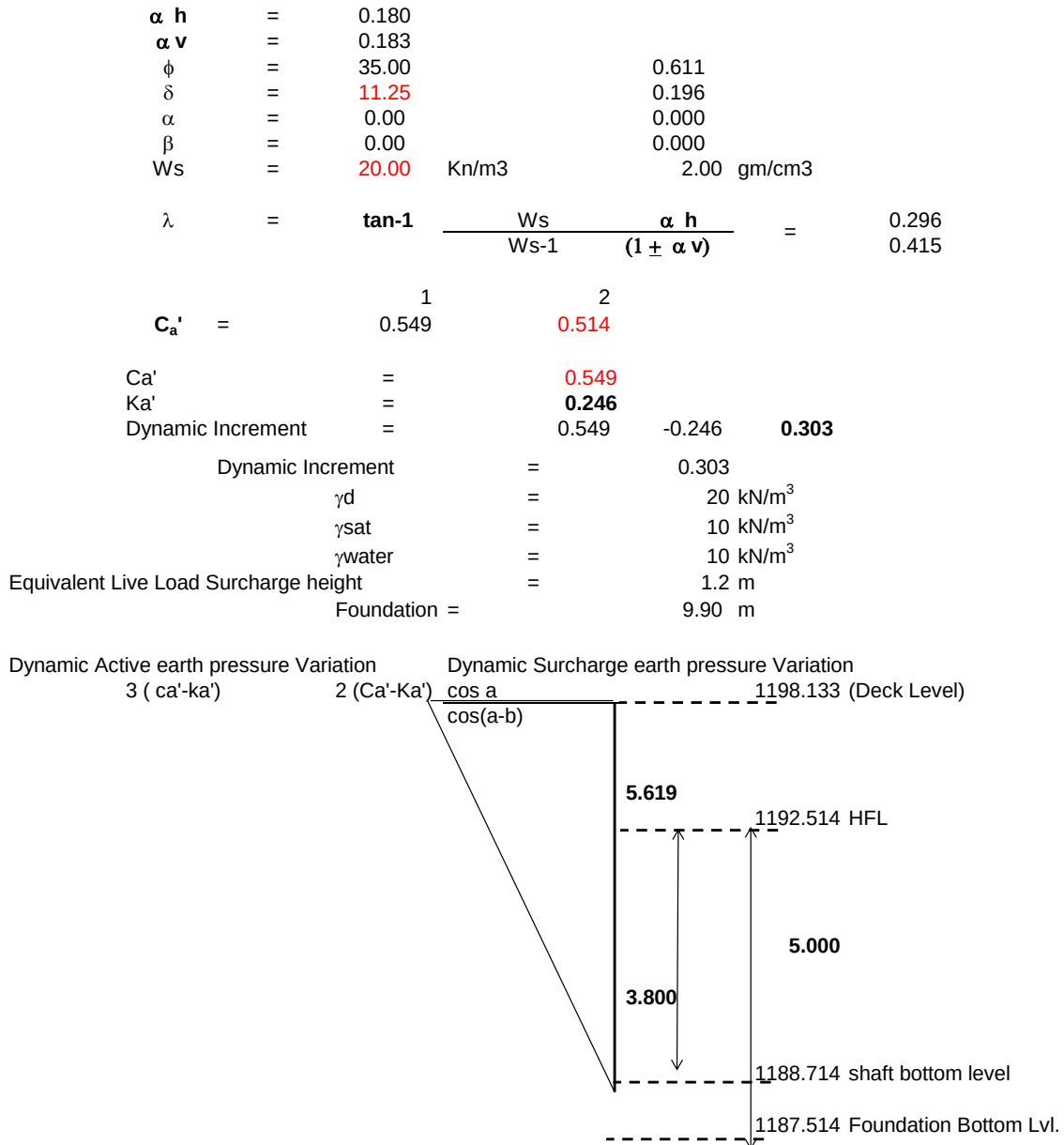
$$E4 = 1662.081 \text{ kN}$$

$$M3 = 1662.08 \times 4.71 = 7827.571 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 1662.08 \times 5.91 = 9822.068 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	9908.922	14199.167	2504.796	3183.684
Due to active Earth Pressure (dynamic Increment)	7827.571	9822.068	1662.081	1662.081
Total Earth Pressure	17736.492	24021.235	4166.877	4845.765
Due to Minimum Fluid Pressure	8356.307	11974.320	2661.527	3382.895
Governing of Two	9908.922	24021.235	4166.877	4845.765
Due to Live Load Surcharge (Static)	3005.755	3820.421	638.232	719.544
Due to Live Load Surcharge(Dynamic)	2672.626	3180.832	423.505	423.505
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case**Earth Pressure Diagram**

h'	=	3.800
h	=	9.419

Dynamic active earth pressure

$3 (ca'-ka')$	=	0.450 at deck level
$3 (ca'-ka')$	=	0.909 at deck level
$3 (ca'-ka')h'/h$	=	0.367 at HFL level

Dynamic Surcharge earth pressure

$2 (Ca'-Ka') \frac{\cos a}{\cos(a-b)}$	=	0.606 at deck level	Pressure =	14.54 kN/m ²
	=	0.244 at HFL level	Pressure =	5.87 kN/m ²

Due to Live Load Surcharge

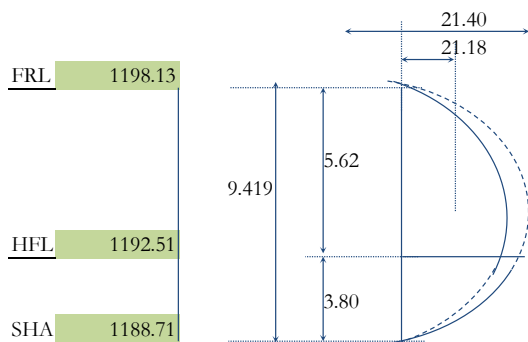
Dynamic surcharge pressure in dry condition at deck level = 7.194 kN/m²
 Dynamic surcharge pressure in Submerge condition at HFL level = 5.87 kN/m²

at Shaft Bottom Level

F1 = 6.531 x 5.619 x 12.500 = **458.692 kN**
 M1 = 458.69 x 6.61 = **3031.727 kN.m**
 F2 = 0.50 x 5.867 x 3.800 x 12.500
 = **139.344 kN**
 M2 = 139.34 x 2.55 = **354.770 kN.m**
 Total Force at Abutment shaft level = 598.037 **kN**
 Total Moment at Abutment shaft level = 3386.498 **kN.m**

at Foundation Bottom Level

F3 = 6.531 x 5.619 x 12.500 = **458.692 kN**
 M3 = 458.69 x 7.81 = **3582.158 kN.m**
 F4 = 0.500 x 5.867 x 3.800 x 12.500
 = **139.344 kN**
 M4 = 139.34 x 3.75 = **521.984 kN.m**
 Total Force at Founding level = 598.037 **kN**
 Total Moment at Founding level = 4104.142 **kN.m**

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height = 21.18 t/m²
 h = 9.419 m
 y = 0.9095 m
 L = 12.500 m

Parabola below Water Level

p_mid_height = 21.40 t/m²
 h = 9.419 m
 y = -0.9095 m
 L = 12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1068.8	6.0
Parabola below Water Level	599.7	2.4
Total Dynamic Earth Pressure	1668.5	4.7

Total Force (F1 + F2)	=	1668.458 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	1668.458 kN	at Foundation Bottom Level

$$M1 = 1668.46 \times 4.70 = 7842.982 \text{ kN.m}$$

Total Mome = 7842.982 kN.m at Shaft Bottom

$$M1 = 1668.46 \times 5.90 = 9845.131 \text{ kN.m}$$

Total Mome = 9845.131 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	8773.888	12129.483	2510.942	3089.111
Due to active Earth Pressure (Dynamic Increment)	7842.982	9845.131	1668.458	1668.458
Total Earth Pressure	16616.870	21974.614	4179.400	4757.569
Due to Minimum Fluid Pressure	8356.307	11974.320	2661.527	3382.895
Governing of Two	16616.870	21974.614	4179.400	4757.569
Due to Live Load Surcharge(Static)	3280.069	4169.084	696.479	785.212
Due to Live Load Surcharge (Dynamic Increment)	3386.498	4104.142	598.037	598.037
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1095.90	1.35	1.35	1479.47	1479.47	
SIDL except wc	=	120.00	1.35	1.35	162.00	162.00	
WC	=	180.90	1.75	1.75	316.57	316.57	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	934.20	1.5	0.20	1401.30	186.84	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1801.96	1	0.20	1801.96	360.39	SV Loading
CWLLmin	=	464.40	1.5	0.20	696.60	92.88	(1-70RW + 1-CLASS A)
CWLLmin	=	1618.04	1	0.20	1618.04	323.61	SV Loading
CWLLmax-Transv. Moment Case		671.00	1.5	0.20	1006.49	134.20	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 500 = 225 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1958.04	0	97.902	97.902	-97.902	97.902	
DL+SIDL+LL-Max Reaction case	2654.64	337.5	132.732	301.482	204.768	301.482	(1-70RW + 1-CLASS A)
	4272.67	0	213.634	213.634	-213.634	213.634	SV Loading
DL+SIDL+LL-Min Reaction case	3359.34	337.5	167.967	336.717	169.533	336.717	(1-70RW + 1-CLASS A)
	3760.00	0	188.000	188.000	-188.000	188.000	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2964.53	337.5	148.227	316.977	189.273	316.977	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1396.80	1958.04	754.27	97.902	475.037	656.369	754.271	
DL+SIDL+LL-Max Reaction case		2050.92	799.27	102.546	502.181	696.725	799.271	Dry Case
DL+SIDL+LL-Min Reaction case		2144.88	799.27	107.244	506.879	692.027	799.271	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2092.23	799.27	104.612	504.247	694.659	799.271	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1396.80	1958.04	226.281	97.902	211.042	128.380	226.281	
DL+SIDL+LL-Max Reaction case		2050.92	271.281	102.546	238.186	168.736	271.281	Dry Case
DL+SIDL+LL-Min Reaction case		2144.88	271.281	107.244	242.884	164.038	271.281	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2092.23	271.281	104.612	240.252	166.670	271.281	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1095.90	1.35	1.35	1479.47	1479.47
SIDL except wc	=	120.00	1.35	1.35	162.00	162.00
WC	=	180.90	1.75	1.75	316.57	316.57
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	934.20	1.5	0.75	1401.30	700.65
CWLLmax- Transv. Moment Case	=	671.00	1.5	0.75	1006.49	503.25
CWLLmin	=	464.40	1.5	0.75	696.60	348.30

Braking Force = 225 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1958.04	0.000	97.902	97.902	-97.902	97.902	
DL+SIDL+LL-Max Reaction case	2654.64	337.500	132.732	301.482	204.768	301.482	(1-70RW + 1-CLASS A)
	4272.67	0.000	213.634	213.634	-213.634	213.634	SV Loading
DL+SIDL+LL-Min Reaction case	3359.34	337.500	167.967	336.717	169.533	336.717	(1-70RW + 1-CLASS A)
	3760.00	0.000	188.000	188.000	-188.000	188.000	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2964.53	337.500	148.227	316.977	189.273	316.977	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1958.04	1018.27	97.902	607.035	920.364	1018.266	
DL+SIDL+LL-Max Reaction case		2306.34	1063.27	115.317	646.950	947.949	1063.266	Dry Case
DL+SIDL+LL-Min Reaction case		2658.69	1063.27	132.934	664.567	930.332	1063.266	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2461.28	1063.27	123.064	654.697	940.202	1063.266	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1958.04	305.480	97.902	250.642	207.578	305.480	
DL+SIDL+LL-Max Reaction case		2306.34	350.480	115.317	290.557	235.163	350.480	Dry Case
DL+SIDL+LL-Min Reaction case		2658.69	350.480	132.934	308.174	217.545	350.480	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2461.28	350.480	123.064	298.304	227.416	350.480	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1095.90	1	1.00	1095.90	1095.90
SIDL except wc	=	120.00	1	1.00	120.00	120.00
WC	=	180.90	1	1.00	180.90	180.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	934.20	1	0.20	934.20	186.84
CWLLmax- Transv. Moment Case		671.00	1	0.20	671.00	134.20
CWLLmin	=	464.40	1	0.20	464.40	92.88

Braking Force = 225 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	0.000	69.840	69.840	-69.840	69.840	
DL+SIDL+LL-Max Reaction case	1861.20	225.000	93.060	205.560	131.940	205.560	(1-70RW + 1-CLASS A)
	3014.83	0.000	150.742	150.742	-150.742	150.742	SV Loading
DL+SIDL+LL-Min Reaction case	2331.00	225.000	116.550	229.050	108.450	229.050	(1-70RW + 1-CLASS A)
	3198.76	0.000	159.938	159.938	-159.938	159.938	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2067.79	225.000	103.390	215.890	121.610	215.890	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	678.844	69.840	409.262	609.004	678.844	
DL+SIDL+LL-Max Reaction case	1489.68	723.844	74.484	436.406	649.360	723.844	Dry Case
DL+SIDL+LL-Min Reaction case	1583.64	723.844	79.182	441.104	644.662	723.844	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1531.00	723.844	76.550	438.472	647.294	723.844	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	203.653	69.840	171.666	133.813	203.653	
DL+SIDL+LL-Max Reaction case	1489.68	248.653	74.484	198.810	174.169	248.653	Dry Case
DL+SIDL+LL-Min Reaction case	1583.64	248.653	79.182	203.508	169.471	248.653	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1531.00	248.653	76.550	200.876	172.103	248.653	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1095.90	1.1	1.10	1205.49	1205.49
SIDL except wc	=	120.00	1.1	1.10	132.00	132.00
WC	=	180.90	1.35	1.35	244.21	244.21
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	934.20	1.5	0.00	1401.30	0.00
CWLLmax- Transv. Moment Case		671.00	1.5	0.00	1006.49	0.00
CWLLmin	=	464.40	1.5	0.00	696.60	0.00

Braking Force = 225 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	1581.70	0.000	79.085	79.085	-79.085	79.085	
DL+SIDL+LL-Max Reaction case	2278.30	337.500	113.915	282.665	223.585	282.665	(1-70RW + 1-CLASS A)
	3199.74	0.000	159.987	159.987	-159.987	159.987	SV Loading
DL+SIDL+LL-Min Reaction case	2983.00	337.500	149.150	317.900	188.350	317.900	(1-70RW + 1-CLASS A)
	3383.67	0.000	169.183	169.183	-169.183	169.183	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2588.20	337.500	129.410	298.160	208.090	298.160	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1581.70	1018.27	79.085	588.218	939.181	1018.266	
DL+SIDL+LL-Max Reaction case		1581.70	1018.27	79.085	588.218	939.181	1018.266	Dry Case
DL+SIDL+LL-Min Reaction case		1581.70	1018.27	79.085	588.218	939.181	1018.266	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1581.70	1018.27	79.085	588.218	939.181	1018.266	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1581.70	305.480	79.085	231.825	226.395	305.480	
DL+SIDL+LL-Max Reaction case		1581.70	305.480	79.085	231.825	226.395	305.480	Dry Case
DL+SIDL+LL-Min Reaction case		1581.70	305.480	79.085	231.825	226.395	305.480	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1581.70	305.480	79.085	231.825	226.395	305.480	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1095.90	1	1	1	1095.90	1095.90	1095.90
SIDL except wc	=	120.00	1	1	1	120.00	120.00	120.00
WC	=	180.90	1.20	1.20	1.20	217.07	217.07	217.07
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	934.20	1	0.75	0	934.20	700.65	0.00
CWLLmax-Transv. Moment Case	=	671.00	1	0.75	0	671.00	503.25	0.00
CWLLmin	=	464.40	1	0.75	0	464.40	348.30	0.00

Braking Force = 225 kN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1432.98	0.000	71.649	71.649	-71.649	71.649	
DL+SIDL+LL-Max Reaction case	1897.38	225.000	94.869	207.369	130.131	207.369	(1-70RW + 1-CLASS A) Dry Case
	3051.01	0.000	152.551	152.551	-152.551	152.551	SV Loading
DL+SIDL+LL-Min Reaction case	2367.18	225.000	118.359	230.859	106.641	230.859	(1-70RW + 1-CLASS A) HFL Case
	3234.94	0.000	161.747	161.747	-161.747	161.747	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2103.97	225.000	105.199	217.699	119.801	217.699	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1432.98	0.000	71.649	71.649	-71.649	71.649	
DL+SIDL+LL-Max Reaction case	1781.28	168.750	89.064	173.439	79.686	173.439	Dry Case
DL+SIDL+LL-Min Reaction case	2133.63	168.750	106.681	191.056	62.069	191.056	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1936.22	168.750	96.811	181.186	71.939	181.186	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1432.98	0.000	71.649	71.649	-71.649	71.649	
DL+SIDL+LL-Max Reaction case	1432.98	0.000	71.649	71.649	-71.649	71.649	Dry Case
DL+SIDL+LL-Min Reaction case	1432.98	0.000	71.649	71.649	-71.649	71.649	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1432.98	0.000	71.649	71.649	-71.649	71.649	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	934.20	kN	934.20	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

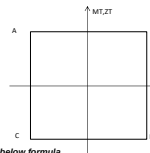
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1187.514 m

Properties of Footing Base:

A	=	123.750	m ²
ZL	=	204.188	m ³
ZT	=	257.813	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1423.198		1494.358		-18.000
Dead Load	1			1095.903	1.050	1150.698	0.000	0.000
SIDL, except Wearing Course	1			120.000	1.050	126.000	0.000	0.000
Wearing Course	1			180.895	1.050	189.940	0.000	0.000
Bearing Pedestal	1	25	1.056	26.400	1.050	27.720	-0.682	-18.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.250	23.438	0.000	0.000
Dirt Wall-Tapered portion	1	25	3.427	85.664	0.250	21.416	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.050	-1.406	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.000	0.000	0.000	0.000
Cap - (uniform portion)	1	25	6.938	173.438	1.025	177.773	0.000	0.000
Cap - (corbel portion)	1	25	5.263	131.567	1.025	134.856	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.450	0.000	5.975	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.450	0.000	5.975	0.000
RCC Railing or Crash Barrier	1	25	0.000	0.000	0.250	0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.050	-8.203	0.000	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	29.014	725.348	-2.250	-1632.034	5.975	4333.956
Abutment Slab	1	25	86.815	2170.376	1.077	2338.298	0.000	0.000
Back filling over heel slab	1	20	654.598	13091.963	-2.282	-29882.166	0.000	0.000
Front Filling over toe slab	1	20	88.688	1773.750	3.210	5694.563	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	57.375	1434.375	-1.879	-2695.781	0.000	0.000
Toe slab	1	25	35.063	876.563	3.074	2694.141	0.000	0.000
Portion between heel & toe	1	25	18.000	450.000	1.050	472.500	0.000	0.000
Vertical Components of active earth pressure	1			1401.241	-4.950	-6936.143	0.000	0.000
Total				22163.723		-29624.568		4333.956
				24305.590		-27975.336		4315.956

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@Toe = PxeL2 (kNm)
0.900	986.313	-3.900	-3846.620
0.900	108.000	-3.900	-421.200
0.900	180.895	-3.900	-705.491
0.900	23.760	-3.900	-92.564
1298.968			-5065.975
0.900	84.375	-4.700	-396.563
0.900	77.098	-4.700	-362.359
0.900	25.313	-5.000	-126.563
0.900	12.656	-4.950	-62.648
0.900	156.094	-3.925	-612.668
0.900	118.410	-3.925	-464.761
0.900	0.000	-4.500	0.000
0.900	0.000	-4.500	0.000
0.900	25.200	-4.700	-118.440
0.900	147.655	-5.000	-738.281
646.802			-2882.282
0.900	652.813	-7.200	-4700.257
0.900	1953.338	-3.873	-7564.591
0.900	11782.766	-7.232	-85218.642
0.900	1596.375	-1.740	-2776.950
0.900	0.000	0.000	0.000
0.900	1290.938	-6.829	-8816.344
0.900	788.906	-1.876	-1480.359
0.900	405.000	-3.900	-1579.500
0.900	1261.117	-9.900	-12485.057
19947.351			-125576.870
21893.121			-133525.127

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	69.840	1196.648	637.919
due to Earth pressure	1	3382.895		14199.167

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
69.84	637.92
3382.89	14199.17
3452.735	14837.085
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		79.085	1196.648	722.363
due to Earth pressure	1.5	5074.342		21298.750
		5153.427		22021.113

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
79.09	722.36
5074.34	21298.75
5153.427	22021.113
0.000	0.000

Summary of Forces For SBC		
P	24305.590	KN
ML	-13138.252	kNm
MT	4315.956	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		24305.590		-27975.336		4315.956
CWLL-Max. Reaction case	1	934.200	1.050	980.910	1.641	1533.259
Vertical Components of LL Surcharge	1	298.045	-4.950	-1475.323	0.000	0.000
Total		25537.835		-28469.749		5849.215

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@Toe = PxeL2 (kNm)
0.000	21893.12078	-3.900	0.00
0.900	0.000	-9.900	-2655.58
21893.121			-136180.71

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	205.560	1196.648	1877.584
due to Earth pressure	1	3382.895		14199.167
due to Live load surcharge	1	719.544		3820.421

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
205.56	1877.58
3382.89	14199.17
719.544	3820.421
4308.00	19897.17
0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		282.665	1196.648	2581.863
due to Earth pressure	1.5	5074.342		21298.750
due to Live load surcharge	1.2	863.453		4584.505
		6220.461		28465.118

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
282.67	2581.86
5074.34	21298.75
863.45	4584.50
6220.461	28465.118
0.000	0.000

Summary of Forces For SBC		
P	25537.835	kN
ML	-8572.578	kNm
MT	5849.215	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1423.198		1494.358		-18.000
Substructure & Foundation -Portion 1				718.669		354.874		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	29.014	725.348	-2.250	-1632.034	5.975	4333.956
Slab above HFL	1	25	39.609	990.218	1.127	1116.458	0.000	0.000
Slab below HFL	1	15	47.206	708.095	1.077	762.867	0.000	0.000
Back filling above HFL over heel slab	1	20	379.283	7585.650	-2.250	-17067.713	0.000	0.000
Back filling below HFL over heel slab	1	10	280.125	2801.250	-2.326	-6515.438	0.000	0.000
Front Filling over toe slab	1	10	88.688	886.875	2.083	1847.014	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	57.375	860.625	-1.879	-1617.469	0.000	0.000
Toe slab	1	15	35.063	525.938	3.074	1616.484	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	1.050	283.500	0.000	0.000
Vertical Components of active earth pressure	1			1401.241	-4.950	-6936.143	0.000	0.000
Total				16937.658		-28048.277		4333.956
				19079.525		-26199.045		4315.956

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@Toe = PxeL2 (kNm)
0.900	1298.968	-3.900	-5065.975
0.900	108.000	-3.900	-421.200
0.900	180.895	-3.900	-705.491
0.900	23.760	-3.900	-92.564
1298.968			-5065.975
0.900	84.375	-4.700	-396.563
0.900	77.098	-4.700	-362.359
0.900	25.313	-5.000	-126.563
0.900	12.656	-4.950	-62.648
0.900	156.094	-3.925	-612.668
0.900	118.410	-3.925	-464.761
0.900	0.000	-4.500	0.000
0.900	0.000	-4.500	0.000
0.900	25.200	-4.700	-118.440
0.900	147.655	-5.000	-738.281
646.802			-2882.282
0.900	652.813	-7.200	-4700.257
0.900	1953.338	-3.873	-7564.591
0.900	11782.766	-7.232	-85218.642
0.900	1596.375	-1.740	-2776.950
0.900	0.000	0.000	0.000
0.900	1290.938	-6.829	-8816.344
0.900	788.906	-1.876	-1480.359
0.900	405.000	-3.900	-1579.500
0.900	1261.117	-9.900	-12485.057
15243.892			-100700.717
17189.662			-108648.974

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	69.840	1196.648	637.919
due to Earth pressure	1	3382.895		12129.483

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
69.84	637.92
3382.89	12129.48
3452.73	12767.40
0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		79.085	1196.648	722.363
due to Earth pressure	1.5	5074.342		18194.225
		5153.427		18916.588

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
79.09	722.36
5074.34	18194.23
5153.43	18916.59
0.00	0.00

Summary of Forces For SBC		
P	19079.525	KN
ML	-13431.644	kNm
MT	4315.956	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation						
Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		19079.525		-26199.045		4315.956
CWLL-Min. Reaction case	1	464.400	1.050	487.620	1.680	780.011
Vertical Components of LL Surcharge	1	325.246	-4.950	-1609.965	0.000	0.000
Total		19869.171		-27321.390		5095.967

Vertical Forces For Restoring or Resisting Effect			
Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	17189.662	0.000	-108648.974
0.900	292.721	-9.900	-2897.938
	17482.383		-111546.911

Horizontal Forces For SBC Calculation				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	273.050	1196.648	2092.142
due to Earth pressure	1	3382.895		12129.483
due to live load surcharge	1	785.212		4169.084

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
273.05	2092.14	0.00	0.00
3382.89	12129.48	0.00	0.00
785.212	4169.084	0.000	0.000
4397.16	18390.71	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		317.900	1196.648	2903.699
due to Earth pressure	1.5	5074.342		18194.225
due to live load surcharge	1.2	634.487		26106.825

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
317.90	2903.70	0.00	0.00
5074.34	18194.23	0.00	0.00
634.49	26106.83	0.00	0.00

Summary of Forces For SBC	
P	19869.171 KN
ML	-8950.681 kNm
MT	5095.967 kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah= 0.243	In Longitudinal direction	Weight of shaft below Ground level	=	616.779 KN
		av= 0.183	In Transverse direction	Weight of back fill below Ground level	=	2430.000 KN
			In Vertical direction			

Vertical Forces For SBC Calculation												
Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL
Superstructure												
Dead Load	1			1095.903	90.036	60.024	1.050	1150.698	63.025	1197.595		0.000
SIDL except Wearing Course	1			120.000	9.859	6.573	1.050	126.000	6.901	1198.582		0.000
Wearing Course	1			180.895	14.862	9.908	1.050	189.940	10.403	1198.133		0.000
Bearing Pedestal	1	25	1.056	26.400	2.169	1.446	1.050	27.720	1.518			-0.682
				1423.198	116.926	77.951		1494.358	81.848			-18.000
Substructure & Foundation -Portion 1												
Dirt Wall-Uniform portion	1	25	3.750	93.750	22.781	7.702	5.135	0.250	23.438	1.284	1197.633	230.523
Dirt Wall-Tapered portion	1	25	3.427	85.684	20.816	7.038	4.692	0.250	21.416	1.173	1196.676	190.722
Bracket - Uniform portion	1	25	1.125	28.125				-0.050	0.000			
Bracket - Tapered portion	1	25	0.563	14.063				0.000	0.000			
Cap - (uniform portion)	1	25	6.938	173.438	42.145	14.249	9.499	1.025	177.773	9.737	1195.998	357.561
Cap - (corbel portion)	1	25	5.263	131.567	31.971	10.809	7.206	1.025	134.856	7.386	1195.698	261.649
Cantilever Return Wall-Rectangle of	1	25	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000	1198.133	0.000
Cantilever Return Wall-Triangle port	1	25	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000	1198.133	0.000
RCC Railing or Crash Barrier	1			28.000				0.250	7.000			
Approach Slab	1	25	6.563	164.063				-0.950	-8.203			
				718.669	117.714	39.798	26.532		354.874	19.580		1040.456
Substructure & Foundation -Portion 2												
Solid Return wall	1	25	29.014	725.348	176.260	59.593	39.728	-2.250	-1632.034	-89.389	1193.284	1017.040
Abutment Shaft	1	25	86.815	2170.376	377.524	127.639	85.093	1.077	2338.258	91.675	1193.031	2082.800
Back filling over heel slab	1	20	654.598	13091.963	0.000	0.000	0.000	-2.282	-29882.166	0.000	1193.284	0.000
Front Filling over toe	1	20	88.688	1773.750				3.210	5694.563			
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000			
Heel slab	1	25	57.375	1434.375				-1.879	-2695.781			
Toe slab	1	25	35.063	876.563				3.074	2694.141			
portion between heel & toe	1	25	18.000	450.000				1.050	472.500			
Vertical component of active earth pressure	1							-4.950	-6527.689			
Vertical component of dynamic increment of earth pressure	1							-4.950	-3407.860			
				22769.664	553.784	187.232	124.821		-32823.975	2.286		3099.840
Total =				24911.531	671.497	343.956	229.304		-30974.743	103.714		4140.296

Vertical Forces For Restoring or Resisting Effect									
Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv	
Superstructure									
Dead Load	0.9			986.313	54.022	-3.900	-3846.620	-210.688	
SIDL except Wearing Course	0.9			108.000	5.915	-3.900	-421.200	-23.070	
Wearing Course	1.00			180.895	9.908	-3.900	-705.491	-38.641	
Bearing Pedestal	0.9	25	1.056	23.760	-3.900		-27.664		
				1298.968	69.845		-5065.975	-272.395	
Substructure & Foundation -Portion 1									
Dirt Wall-Uniform portion	0.9	25	3.750	84.375	4.621	-4.700	-396.563	-21.720	1.0
Dirt Wall-Tapered portion	0.9	25	3.427	77.098	4.223	-4.700	-362.359	-19.847	1.0
Bracket - Uniform portion	0.9	25	1.125	25.313					
Bracket - Tapered portion	0.9	25	0.563	12.656					
Cap - (uniform portion)	0.9	25	6.938	156.094	8.549	-3.925	-612.668	-33.557	1.0
Cap - (corbel portion)	0.9	25	5.263	118.410	6.486	-3.925	-464.761	-25.456	1.0
Cantilever Return Wall-Rectangle of	0.9	25	0.000	0.000	0.000	-4.500	0.000	0.000	1.0
Cantilever Return Wall-Triangle port	0.9	25	0.000	0.000	0.000	-4.500	0.000	0.000	1.0
RCC Railing or Crash Barrier	0.9			25.200		-4.700	-118.440		
Approach Slab	0.9	25	6.563	147.656		-5.000	-738.281		
				646.892	23.879		-2693.071	-100.580	
Substructure & Foundation -Portion 2									
Abutment Shaft	0.9	25	86.815	1953.338	73.205	-3.873	-7564.591	-283.498	1.0
Solid Return wall	0.9	25	29.014	652.813	35.756	-7.200	-4700.257	-257.440	1.0
Back filling over heel slab	0.9	20	654.598	11782.766	0.000	-7.232	-85218.6	0.000	1.0
Front Filling over toe	0.9	20	88.688	1596.375		-1.740	-2776.950		
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000		
Heel slab	0.9	25	57.375	1290.938		-6.829	-8816.344		
Toe slab	0.9	25	35.063	788.906		-1.876	-1480.359		
portion between heel & toe	0.9	25	18.000	450.000		-3.900	-1579.500		
Vertical component of active earth pressure	0.9					-9.900	-12485.057		
Vertical component of dynamic increment of earth pressure	0.9					-9.900	-6134.147		
				20566.962	108.961		-131711.02	-540.938	
Total =				22512.732	202.685		-139470.06	-913.913	

For Overturning or Sliding Effect			
Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	22.781	1197.633	230.523
1.0	20.816	1196.676	190.722
1.0	42.145	1195.998	357.561
1.0	31.971	1195.698	261.649
1.0	0.000	1198.133	0.000
1.0	0.000	1198.133	0.000
	117.714		1040.456
1.0	360.871	1193.031	1990.926
1.0	176.260	1193.284	1017.040
1.0	0.000	1193.284	0.000
	537.131		3007.966
	654.844		4048.421

Horizontal Forces For SBC Calculation					
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	678.844	116.926	1196.648	6200.560
due to Substructure	1	671.497	227.030	4140.296	1399.815
due to Earth pressure	1	4845.765		24021.235	

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FT Sin θ	ML Sin θ
678.84	6200.56	0.00	0.00
671.50	4140.30	0.00	0.00
4845.76	24021.23	0.00	0.00
6196.11	34362.09	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.648	9300.84
due to Substructure	1.5	962.267		6072.63
due to Active Earth pressure	1	3183.884		14199.167
due to dynamic Earth pressure	1.5	2493.122		14733.10
		7677.338		44305.741

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1018.27	9300.84	0.00	0.00
962.27	6072.63	0.00	0.00
3183.884	14199.167	0.000	0.000
2493.122	14733.102	0.000	0.000
7677.34	44305.74	0.00	0.00

Summary of Forces For SBC	
Downward	Upward
P	25140.835
ML	3491.062
MT	6890.331

Summary of Restoring Forces	
Vertical Load	22310.047 KN
Moment	-140383.977 kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1423.198	116.926	77.951		1494.358	81.848					-18.000	1174.560
Forces from Substructure				23488.333	671.497	227.030	151.353		-32469.101	21.866		4140.298		4333.956	1399.815
CWLL-Max. Reaction case	0.20			186.84		15.350	10.233	1.050	196.182	10.745	1199.333		1.341	306.652	181.425
Vertical component of LL Surcharge	0.20			59.61				-4.950	-295.065				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			35.08				-4.950	-173.667				0.000	0.000	
Total =				25193.064	671.497	359.306	239.538		-31247.293	114.459		4140.298		4622.608	2755.800
								-239.538		-114.459					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1298.968	69.845	0.000	-5065.97	-272.395
Forces from Substructure				21213.764	132.840	0.000	-134404.09	-641.518
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.900	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-9.900	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.900	0.00	
Total =				22512.732	202.685		-139470.06	-913.913
								913.913

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	723.844	132.276	1196.648	6611.590	1355.995
due to Substructure	1	671.497	227.030		4140.296	1399.815
due to Earth pressure	1	4845.765			24021.235	
due to Live load surcharge	0.20	228.610			1400.251	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
723.84	6611.59	0.00	0.00	0.00	0.00	132.28	1355.99
671.50	4140.30	0.00	0.00	0.00	0.00	227.03	1399.81
4845.76	24021.23						
6469.72	36173.37	0.00	0.00	0.00	0.00	359.31	2755.80

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.648	9300.841
due to Substructure	1.5	982.267		6072.632
due to Active Earth pressure	1	3183.684		14199.167
due to dynamic Earth pressure	1.5	2493.122		14733.102
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		7677.338		44305.741

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.27	9300.84	0.00	0.00
982.27	6072.63	0.00	0.00
3183.684	14199.167		
2493.122	14733.102		
0.000	0.000		
0.000	0.000		
7677.34	44305.74	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	25432.602	24953.527 kN
ML	5040.538	4811.620 kNm
MT	7378.407	7378.407 kNm

Summary of Restoring Forces

Vertical Load	22310.947 kN
Moment	-140383.977 kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1423.198		116.926	77.951		1494.358	81.848				-18.000	1174.560
Substructure & Foundation -Portion 1				718.669	117.714	39.798	26.532		354.874	19.580		1040.456		0.000	351.773
Substructure & Foundation -Portion 2															
Solid Return wall	1		29.01	725.35	176.260	59.593	39.728	-2.25	-1632.034	-89.389	1193.28	1017.040	5.98	4333.956	343.856
Shall above HFL	1	25	39.609	990.218	240.623	81.353	54.236	1.127	1116.458	61.150	1194.031	1568.139	0.000	0.000	530.181
Shall below HFL	1	15	47.206	708.095	136.901	46.286	30.857	1.077	762.867	33.244	1191.514	547.605	0.000	0.000	185.143
Back filling above HFL over heel slab	1	20	379.283	7585.650	0.000	0.000	0.000	-2.250	-17067.713	0.000	1195.324	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	280.125	2801.250	0.000	0.000	0.000	-2.326	-6515.438	0.000	1190.314	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	88.688	886.875	0.000	0.000	0.000	2.083	1847.014	0.000	0.000	0.000	0.000	0.000	0.00
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Heel slab	1	15	57.375	860.625	0.000	-7.200	-1.879	-1.879	-1617.469	0.000	0.000	0.000	0.000	0.000	0.00
Toe slab	1	15	35.063	525.938	0.000	-3.074	-3.074	3.074	1616.484	0.000	0.000	0.000	0.000	0.000	0.00
portion between heel & toe	1	15	18.000	270.000	0.000	-1.050	-1.050	1.050	283.500	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of active earth pressure	1			1279.552				-4.950	-6333.781	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of dynamic increment of earth pressure	1			691.098				-4.950	-3420.934	0.000	0.000	0.000	0.000	0.000	0.00
				17507.067	598.112	202.219	134.812		-30961.044	5.005		3369.562		4333.956	1139.233
Total =				19648.934	715.825	358.843	239.295		-29111.812	106.433		4410.017		4315.956	2665.567
							-239.295			-106.433					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1298.968	69.845		-5065.975	-272.395
Substructure & Foundation -Portion 1				646.802	23.879		-2693.071	-100.580
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	29.01393	652.813	35.756	-7.20	-4700.257	-257.440
Shall above HFL	0.9	25	39.609	891.196	48.812	-3.823	-3406.607	-186.585
Shall below HFL	0.9	15	47.206	637.285	24.393	-3.873	-2467.982	-94.466
Back filling above HFL over heel slab	0.9	20	379.283	6627.065	0.000	0.000	-49155.012	0.000
Back filling below HFL over heel slab	0.9	10	280.125	2521.125	0.000	-7.276	-18343.463	0.000
Front Filling over toe	0.9	10	88.688	798.188	0.000	-2.867	-2288.716	0.000
Side filling between heel and toe	0.9	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.9	15	57.375	774.563	0.000	-6.829	-5289.806	0.000
Toe slab	0.9	15	35.063	473.344	0.000	-1.876	-888.216	0.000
portion between heel & toe	0.9	15	18.000	243.000	0.000	-3.900	-947.700	0.000
Vertical component of active earth pressure	0.9			1151.597		-9.900	-11400.806	0.000
Vertical component of dynamic increment of earth pressure	0.9			621.988		-9.900	-6157.681	0.000
				15756.360	117.953		-105774.15	-578.359
Total =				17702.130	211.677		-113533.19	-951.334
								951.334

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	117.714		1040.456
1.0	176.260	1193.284	1017.040
1.0	240.623	1194.031	1568.139
1.0	120.248	1191.514	480.993
1.0	0.000	1195.324	0.000
1.0	0.000	1190.314	0.000
	537.131		3066.172
	654.844		4106.628

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	678.844	116.926	1196.648	6200.560	1174.560
due to Substructure	1	715.825	242.017		4410.017	1491.006
due to Earth pressure	1	4757.569			21974.614	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
678.84	6200.56	0.00	0.00	0.00	0.00	116.93	1174.56
715.83	4410.02	0.00	0.00	0.00	0.00	242.02	1491.01
4757.57	21974.61						
6132.24	32985.19	0.00	0.00	0.00	0.00	358.94	2665.57

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.648	9300.841
due to Substructure	1.5	982.267		6159.941
due to Active Earth pressure	1	3089.113		12129.483
due to dynamic Earth pressure	1.5	2502.686		14767.696
		7592.330		42357.962

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.27	9300.84	0.00	0.00
982.27	6159.94	0.00	0.00
3089.113	12129.483		
2502.686	14767.696		
7592.33	42357.96	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	19886.229	19409.638 kN
ML	3579.813	3356.947 kNm
MT	6981.522	6981.522 kNm

Summary of Restoring Forces

Vertical Load	17490.453 kN
Moment	-114484.528 kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1423.198		116.926	77.951		1494.358	81.848				-18.000	1174.560
Forces from Substructure				18225.736	715.825	242.017	161.345		-30606.170	24.585		4410.017		4333.956	1491.006
CWLL-Max. Reaction case	0.20			92.88		7.631	5.087	1.050	97.524	5.342	1199.333		1.680	156.002	90.189
Vertical component of LL Surcharge	0.20			65.05				-4.950	-321.993				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			49.54				-4.950	-245.238				0.000	0.000	
Total =				19856.406	715.825	366.574	244.383		-29881.519	111.775		4410.017		4471.958	2755.754
							-244.383			-111.775					

Vertical Forces For Restoring or Resisting Effect

Vertical Forces For Restoring or Resisting Effect								
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1298.968	69.845		-5065.975	-272.395
Forces from Substructure				16403.162	141.832		-108467.22	-678.939
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.90	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.900	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.900	0.000	0.000
Total =				17702.130	211.677		-113537.09	-951.334
					211.677			951.334

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	723.844	124.557	1196.648	6611.590	1264.748
due to Substructure	1	715.825	242.017		4410.917	1491.006
due to Earth pressure	1	4757.569			21974.614	
due to Live load surcharge	0.20	276.650			1654.645	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.648	9300.841
due to Substructure	1.5	962.267		6159.9414
due to Active Earth pressure	1	3089.111		12129.483
due to dynamic Earth pressure	1.5	2502.686		14767.696
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
Total		7592.330		42357.962

Summary of Forces For SBC

	Downward	Upward
P	20100.788	19612.023 kN
ML	5181.123	4957.573 kNm
MT	7227.713	7227.713 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) (kN)	FL = 0.3 x ah x P (kN)	FT = 0.3 x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1423.198		389.753	77.951		1494.358	81.848				-18.000	3915.202
Substructure & Foundation -Portion 1				718.669	35.314	132.662	26.532		354.874	19.580		312.137		0.000	1172.577
Substructure & Foundation -Portion 2				22769.664	166.135	624.106	124.821		-32823.975	2.286		929.952		4333.956	3493.471
Total =				24911.531	201.449	1146.520	229.304	-229.304	-30974.743	103.714	-103.714	1242.089		4315.956	8581.250

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1298.968	69.845		-5065.97	-272.395
Substructure & Foundation -Portion 1				646.802	23.879		-2693.07	-100.580
Substructure & Foundation -Portion 2				20566.962	108.961		-131711.02	-540.938
Total =				22512.732	202.685		-139470.06	-913.913

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	117.714		1040.456
	537.131		3007.966
Total	654.844		4048.421

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	203.653	389.753	1196.648	1860.168	3915.202
due to Substructure	1	201.449	756.767		1242.089	4666.048
due to Earth pressure	1	4845.765			24021.235	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		305.480	1196.648	2790.252
due to Substructure	1.5	962.267		6072.6317
due to Active Earth pressure	1	3183.684		14199.167
due to dynamic Earth pressure	1.5	747.94		4419.930
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
Total		5219.367		27481.881

Summary of Forces For SBC

	Downward	Upward
P	25140.835	24682.227 kN
ML	-3747.537	-3954.965 kNm
MT	12897.206	12897.206 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	25193.064	239.538	-31247.29	114.459	4622.608

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	248.653	440.921	1196.648	2271.198	4519.950
due to Substructure	1	201.449	756.767		1242.089	4666.048
due to Earth pressure	1	4845.765			24021.235	
due to Live load surcharge	0.2	228.610			1400.251	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		305.48	1196.648	2790.252
due to Substructure	1.5	962.267		1821.790
due to Active Earth pressure	1	3183.68		14199.167
due to dynamic Earth pressure	1.5	747.94		4419.930
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
Total		4531.78		23231.139

Summary of Forces For SBC

	Downward	Upward
P	25432.602	24953.527 kN
ML	-2198.061	-2426.080 kNm
MT	13808.606	13808.606 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	1423.198	77.951	1494.358	81.848	-18.000
Substructure & Foundation -Portion 1	718.669	26.532	354.874	19.580	0.000
Substructure & Foundation -Portion 2	17607.067	134.812	-30961.044	5.005	4333.956
Total =	19648.934	239.295	-29111.812	106.433	4315.956

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	203.65	389.75	1196.65	1860.17	3915.20
due to Substructure	1	214.75	806.72		1323.01	4970.02
due to Earth pressure	1	4757.57			21974.61	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		305.480	1196.648	2790.25
due to Substructure	1.5	294.680		1847.98
due to Active Earth pressure	1	3089.111		12129.48
due to dynamic Earth pressure	1.5	750.806		4430.31
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
Total		4440.077		21198.03

Summary of Forces For SBC

	Downward	Upward
P	19888.229	19409.638 kN
ML	-3847.591	-4060.458 kNm
MT	13201.178	13201.178 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
723.84	6611.59	0.00	0.00	0.00	0.00	124.56	1264.75
715.83	4410.02	0.00	0.00	0.00	0.00	242.02	1491.01
4757.57	21974.61						
276.65	1654.65						
6473.89	34650.87	0.00	0.00	0.00	0.00	366.57	2755.75

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1018.27	9300.84	0.00	0.00
962.27	6159.94	0.00	0.00
3089.11	12129.48		
2502.68	14767.69		
0.00	0.00		
0.00	0.00		
7592.33	42357.96	0.00	0.00

Summary of Restoring Forces

Vertical Load	17490.453 kN
Moment	-114488.428 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
203.65	1860.17	0.00	0.00	0.00	0.00	389.75	3915.20
201.45	1242.09	0.00	0.00	0.00	0.00	756.77	4666.05
4845.76	24021.23						
5250.87	27123.49	0.00	0.00	0.00	0.00	1146.52	8581.25

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
305.48	2790.25	0.00	0.00
962.27	6072.63	0.00	0.00
3183.68	14199.167		
747.936	4419.930		
5219.37	27481.98	0.00	0.00

Summary of Restoring Forces

Vertical Load	22310.047 kN
Moment	-140383.977 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	22512.732	202.685	-139470.06	-913.913

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
248.65	2271.20	0.00	0.00	0.00	0.00	440.92	4519.95
201.45	1242.09	0.00	0.00	0.00	0.00	756.77	4666.05
4845.76	24021.23						
228.61	1400.25						
5524.48	28934.77	0.00	0.00	0.00	0.00	1197.69	9186.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
305.48	2790.25	0.00	0.00
294.68	1821.79	0.00	0.00
3183.68	14199.167		
747.936	4419.930		
0.00	0.00		
0.00	0.00		
4531.78	23231.14	0.00	0.00

Summary of Restoring Forces

Vertical Load	22310.047 kN
Moment	-140383.977 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	1298.968	69.845		-5065.975	-272.395
Substructure & Foundation	646.802	23.879		-2693.071	-100.580
Substructure & Foundation	15756.360	117.953		-105774.147	-578.359
Total =	17702.130	211.677		-113553.194	-951.334

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
203.65	1860.17	0.00	0.00	0.00	0.00	389.75	3915.20
214.75	1323.01	0.00	0.00	0.00	0.00	806.72	4970.02
4757.57	21974.61						
5175.97	25157.78	0.00	0.00	0.00	0.00	1196.48	8885.22

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
305.48	2790.25	0.00	0.00
294.68	1847.98	0.00	0.00
3089.11	12129.48		
750.806	4430.309		
4440.08	21198.03	0.00	0.00

Summary of Restoring Forces

Vertical Load	17490.453 kN
Moment	-114484.528 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	19856.406	244.383	-29581.52	111.775	4471.958
		-244.383		-111.775	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	248.653	415.1889	1196.648	2271.198	4215.828
due to Substructure	1	214.748	806.72384	1353.905	4970.0203	
due to Earth pressure	1	4757.569		21974.614		
due to Live load surcharge	0.2	276.650			1654.645	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		305.48	1196.648	2790.25
due to Substructure	1.5	294.68		1847.98
due to Active Earth pressure	1	3089.11		12129.48
due to dynamic Earth pressure	1.5	750.81		4430.31
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		4440.08		21198.03

Summary of Forces For SBC

	Downward	Upward
P	20100.788	19612.023 kN
ML	-2246.282	-2469.831 kNm
MT	13657.806	13657.806 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00
Transverse Moment due to C.F.	=	0.000	x (	1199.333 - 1187.514)

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00
Transverse Moment due to C.F.	=	0.000	x (	1199.333 - 1187.514)

Base pressure on corner A	=	σ_a	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_b	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_c	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_d	=	$P/A + ML/ZL - MT/ZT$

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	17702.130	211.677		-113537.09	-951.334
		-211.677			951.334

Forces along Long. Axis

FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
248.65	2271.20	0.00	0.00	0.00	0.00	415.19	4215.83
214.75	1323.01	0.00	0.00	0.00	0.00	806.72	4970.02
4757.57	21974.61						
276.65	1654.65						
5497.62	27223.46	0.00	0.00	0.00	0.00	1221.91	9185.85

Forces along Long. Axis

FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
305.48	2790.25	0.00	0.00
294.68	1847.98	0.00	0.00
3089.11	12129.48		
750.806	4430.309		
0.000	0.000		
4440.08	21198.03	0.00	0.00

Summary of Restoring Forces

Vertical Load	17490.453 kN
Moment	-114488.428 kNm

Forces along Long. Axis	Forces along Trans. Axis
FT Cos θ	MT Sin θ
0.00	0.00

Forces along Long. Axis	Forces along Trans. Axis
FT Sin θ	MT Cos θ
0.00	0.00

	SAFE BEARING CAPACITY CHECK								SLIDING CHECK		OVERTURNING CHECK				
LOAD CASES	P	ML	MT	σ_a	σ_b	σ_c	σ_d	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + cA + F_p$	FOS	Overturning moment	Restoring Moment = $\sum P e_{Toe} + M_B$	FOS
Normal Dry Case	kN	kNm	kNm	kNm ²	kNm ²	kNm ²	kNm ²	kNm ²	kNm ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	24305.590	-13138.252	4315.956	277.494	148.805	244.012	115.324	277.494	115.324	5153.427	15325.185	2.97	22021.113	133525.13	6.06
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	25537.835	-8572.578	5849.215	271.038	187.070	225.662	141.695	271.038	141.695	6220.461	15325.185	2.46	28465.118	136180.71	4.78
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	19079.525	-13431.644	4315.956	236.700	105.138	203.218	71.656	236.700	71.656	5153.427	12032.763	2.33	18916.588	108648.97	5.74
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	19869.171	-8930.681	5095.967	224.063	136.587	184.530	97.055	224.063	97.055	6334.497	12237.668	1.93	26100.825	111546.91	4.27
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	25140.835	3491.062	6890.331	212.787	246.982	159.335	193.529	246.982	159.335	7677.338	15617.033	2.03	44305.741	140383.98	3.17
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	25432.602	5040.538	7378.407	209.449	258.821	152.211	201.583	258.821	152.211	7677.338	15617.033	2.03	44305.741	140383.98	3.17
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	19888.229	3579.813	6981.522	170.261	205.325	116.101	151.165	205.325	116.101	7592.330	12243.317	1.61	42357.962	114484.53	2.70
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	20100.788	5181.123	7227.713	165.091	215.840	109.022	159.770	215.840	109.022	7592.330	12243.317	1.61	42357.962	114488.43	2.70
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	25140.835	-3747.537	12897.206	271.537	234.830	171.486	134.779	271.537	134.779	5219.367	15617.033	2.99	27481.981	140383.98	5.11
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	25432.602	-2198.061	13808.606	269.842	248.312	162.720	141.190	269.842	141.190	4531.780	15617.033	3.45	23231.139	140383.98	6.04
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	19888.229	-3847.591	13201.178	230.761	193.074	128.352	90.665	230.761	90.665	4440.077	12243.317	2.76	21198.027	114484.53	5.40
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	20100.788	-2246.282	13657.806	226.407	204.405	120.456	98.454	226.407	98.454	4440.077	12243.317	2.76	21198.027	114488.43	5.40
								SAFE	SAFE			SAFE			SAFE

DESIGN OF ABUTMENT(A2) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
86+106

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	13.750m	13.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	15.000m	15.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m²
SBC of soil-Normal Case = 416 kN/m² Assumed
SBC of soil-Seismic Case = 521 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	0.914m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion = 1.850m 1.850m
Width of Abutmentcap at bottom of Tapering Portion = 1.000m 1.000m
Projection of Abutment Cap (Span Side) = 0.400m 0.400m

Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.080m	1.080m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.400m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.600m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	9.900m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	1.200m	
Width of Toe Slab	=	3.300m	
Width of Heel Slab	=	5.400m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.200m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.200m	
Width of backfill on heel slab	=	5.400m	
Thickness of heel slab at back fill edge	=	1.200m	
Height of back fill at bottom edge of heel slab	=	10.097m	
Height of back fill at back fill edge of heel slab	=	9.397m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1198.182m	Cross Slope (Bi-directional)	=	2.500%	
Deck level at Outer Edge =	1198.040m	Height of Superstructure	=	1.420m	
Deck level at center line =	1198.182m	Min. Height of Footpath Side Pedestal (1)	=	0.300m	
Soffit Level at center of bridge =	1196.697m	Height of Pedestal (2)	=	0.375m	
Abutment cap top level =	1196.197m	Height of Pedestal (3)	=	0.450m	
Abutment cap bottom lvl (uniform portion ends	1195.897m	Height of Pedestal (4)	=	0.525m	
Abutment cap bottom lvl (corbel portion ends)	1195.597m	Height of Pedestal (5)	=	0.000m	
Abutment shaft top level =	1195.597m	Height of Pedestal (6)	=	0.000m	
Ground level/LBL =	1190.834m	Distance of nearest girder to c.l. of deck	=	1.500m	
Abutment shaft bottom level =	1188.714m	Height (Avg.) of Dirt Wall	=	1.914m	
Foundation level =	1187.514m	Abutment shaft Above G.L	=	4.763m	
HFL	=	1192.834m	Abutment Shaft below G.L	=	2.120m
			Height of abutment shaft	=	6.883m
			MSL	=	1189.514m
			Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade		=	M 35	
Characteristic compressive strength of concrete, f_{ck}		=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}		=	15.63 Mpa at 28 (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}		=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}		=	0.02	
Ultimate Strain, ϵ_{cu2}		=	0.035	
E_{cm}		=	32308.250 N/mm ²	
Steel Grade		=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}		=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}		=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)		=	200000.00 Mpa	
Dry weight of Concrete		=	25 kN/m ³	
Dry unit weight of soil		=	20 kN/m ³	
Permissible Crack Width		=	0.3 mm	- For Moderate Exposure Condition
Maximum compressive stress in concrete under rare combination		=	0.48 f_{ck}	
		=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination		=	300	N/mm ²
<u>Creep Coefficient</u>				
For Abutment Shaft		=	2	for 90 days
For Footing		=	2	for 90 days
<u>Clear Cover to Reinforcement</u>				
Earth Face		=	75	mm
Non-Earth Face		=	50	mm
<u>Seismic Data:</u>				
Seismic Zone		=	5	
Z =Zone factor		=	0.36	
I =Importance factor		=	1.2	
R =Response Reduction factor		=	3	in Longitudinal direction
		=	1	In Transverse direction
<u>Properties of backfill material :</u>				
	c	=	0	
	ϕ	=	35	
	θ	=	90	
	β	=	0	
	δ	=	22.5	

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	267.12 4.50
DL Reaction on Bearing No.-2	=	280.83 1.50
DL Reaction on Bearing No.-3	=	280.83 -1.50
DL Reaction on Bearing No.-4	=	267.12 -4.50
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		1095.90 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	60.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	60.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		120.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	41.113 4.50
SIDL Reaction on Bearing No.-2	=	49.335 1.50
SIDL Reaction on Bearing No.-3	=	49.335 -1.50
SIDL Reaction on Bearing No.-4	=	41.113 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		180.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

		Max CWLL			Min CWLL	
CWLL Reaction on Bearing No.-1	=	23.48	4.50	CWLL Reaction on Bearing No.-8	=	5.015 4.50
CWLL Reaction on Bearing No.-2	=	692.01	1.50	CWLL Reaction on Bearing No.-9	=	26.750 1.50
CWLL Reaction on Bearing No.-3	=	379.41	-1.50	CWLL Reaction on Bearing No.-10	=	111.449 -1.50
CWLL Reaction on Bearing No.-4	=	83.76	-4.50	CWLL Reaction on Bearing No.-11	=	76.684 -4.50
CWLL Reaction on Bearing No.-5	=	0.00	0.00	CWLL Reaction on Bearing No.-12	=	0.00 0.00
CWLL Reaction on Bearing No.-6	=	0.00	0.00	CWLL Reaction on Bearing No.-13	=	0.00 0.00
CWLL Reaction on Bearing No.-7	=	0.00	0.00	CWLL Reaction on Bearing No.-14	=	0.00 0.00

max	=	934.20 KN	Corr. Transv	=	1533.259 kNm	ecc.	1.64
min	=	464.40 KN	Corr. Transv	=	780.011 kNm	ecc.	1.68

SV Loading

max	=	1801.96 KN	Corr. Transv	=	540.589 kNm	ecc.	0.30
min	=	1618.04 KN	Corr. Transv	=	485.411 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	671.00 KN	Corr. Transv	=	2116.994 kNm	ecc.	3.16
min	=	329.00 KN	Corr. Transv	=	1038.006 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.114
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.114
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.300 x 0.800 x 0.800	=	0.1920 m ³	4.500
Pedestal 2	=	0.375 x 0.800 x 0.800	=	0.2400 m ³	1.500
Pedestal 3	=	0.450 x 0.800 x 0.800	=	0.2880 m ³	-1.500
Pedestal 4	=	0.525 x 0.800 x 0.800	=	0.3360 m ³	-4.500
Pedestal 5	=	0.000 x 0.800 x 0.800	=	0.0000 m ³	0.000
Pedestal 6	=	0.000 x 0.800 x 0.800	=	0.0000 m ³	0.000
				1.0560 m ³	-0.682

VOLUME CALCULATION

C.G. Of Footing = 4.950 m
 C.G. Of shaft from toe tip = 3.900 m
 Distance between c.g. of shaft and footing = 1.050 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.250	-4.700	0.000
-Trapering portion	1	12.50	0.300	0.914	3.427	-0.800	0.250	-4.700	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	-0.050	-5.000	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.000	-4.950	0.000
Cap (uniform portion)	1	12.50	1.850	0.300	6.938	-0.025	1.025	-3.925	0.000
Cap (Corbel Portion)	1	12.50	1.850	0.300	5.263	-0.025	1.025	-3.925	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.040	2.763	35.924	0.080	1.130	-3.820	0.000
Shaft below HFL	1	12.50	1.140	3.620	51.591	0.029	1.079	-3.871	0.000
Solid Return Wall	1	5.40	0.550	9.818	29.159	-3.300	-2.250	-7.200	5.975
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.600	0.450	-4.500	5.975
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.600	0.450	-4.500	5.975
Footing									
Heel Slab	1	12.50	5.400	0.850	57.375		-1.879	-6.829	0.000
Toe Slab	1	12.50	3.300	0.850	35.063		3.074	-1.876	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		1.050	-3.900	0.000
Back filling above HFL over Heel Slab	1	12.50	5.400	5.348	360.990		-2.250	-7.200	0.000
Back filling below HFL over Heel Slab	1	12.50	5.400	4.470	301.725		-2.320	-7.270	0.000
Backfill above Heel slab	1	12.50	5.400	9.747	657.906		-2.282	-7.232	0.000
Front Filling over Toe Slab	1	12.50	3.300	2.470	101.888		3.222	-1.728	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.300	1.150	47.438		2.083	-2.867	0.000
Side filling between heel and toe	1	0.00	1.200	2.470	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	-0.050	-5.000	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.080	5.348	5.367		0.532	-4.418	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.120	4.470	6.689		0.490	-4.460	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.250	-4.700

SECTIONAL PROPERTIES

Width of Footing (B) = 9.900 m
 Length of Footing (L) = 12.500 m

A = 9.900 x 12.500 = 123.750 m²
 ZL = 12.500 x 16.335 = 204.188 m³
 ZT = IT1 + IT2

distance of extreme point from centre

IT1 = 9.900 x 162.760 = 1611.33 m⁴
 IT2 (moment of inertia of triangle) = 9.900 x 0.000 + 0.500 x 9.900 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1611.33 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 257.813 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 8.983 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 10.306 m

Abutment Cap Top Level - Foundation Level

= 8.683 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.10 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.040 m^4

Moment of Inertia , $I_{\text{transverse}}$ = 179.036 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 146.369 KN
 D = 1396.80 KN
 T = 0.1954 sec

Transverse Direction

Force = 20701.885 KN
 D = 1676.518 KN
 T = 0.0180 sec

For Hard or Rocky Strata, with $N > 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.270$$

For Medium Strata, with $N > 10 \& N < 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.270$$

For Soft Soil Strata, with $N < 10$

$$\frac{S_a}{g} = 2.5$$

$$\frac{S_a}{g} = 1.270$$

Medium Soil Strata

$$S_a/g = 2.5$$

$$S_a/g = 1.270$$

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.274

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.274	In Transverse direction
Av	=	0.183	In Vertical direction

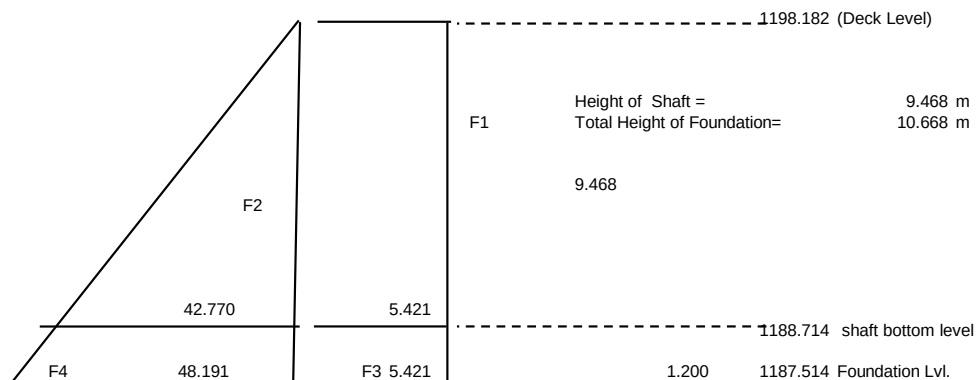
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.274	In Transverse direction
Av	=	0.183	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1188.714 m (at Shaft Base)			
@ RL					1187.514 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421 kN/m^2
F1	=	5.421	x	9.468	x	12.500	=	641.552 kN
M1	=	641.55	x	4.73	=	3037.110	kN.m	at Shaft Bottom
F3	=	5.421	x	10.668	x	12.500	=	722.865 kN
M3	=	722.865	x	5.334	=	3855.760	kN.m	at Foundation
<u>Due to Active Earth Pressure</u>								
Intensity for triangular portion (At Shaft bottom level)								
	=	0.226	x	20	x	9.468	=	42.770 kN/m^2
F2	=	0.5	x	42.77	x	9.468	x	12.50
	=	2530.925 kN						
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)								
M2	=	2530.92	x	3.98	=	10064.374	kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)								
	=	0.226	x	20	x	10.668	=	48.191 kN/m^2
F4	=	0.5	x	48.19	x	10.668	x	12.50
	=	3213.133 kN						
M4	=	3213.13	x	4.48	=	14396.636	kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
 = 4.800 x 9.468 = 45.446 kN/m²

F = 0.5 x 45.446 x 9.468 x 12.500
 = 2689.291 kN

M = 2689.29 x 3.156 = 8487.402 kN.m at Shaft Bottom

Intensity for triangular portion (At Foundation level)
 = 4.800 x 10.668 = 51.21 kN/m²

F = 0.5 x 51.206 x 10.67 x 12.500
 = 3414.187 kN

M = 3414.19 x 3.556 = 12140.848 kN.m at Foundation

Intensity of Passive pressure
 = 5.249 x 20 x 0.000 = 0.000 kN/m²

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 12.500
 = 0.000 kN

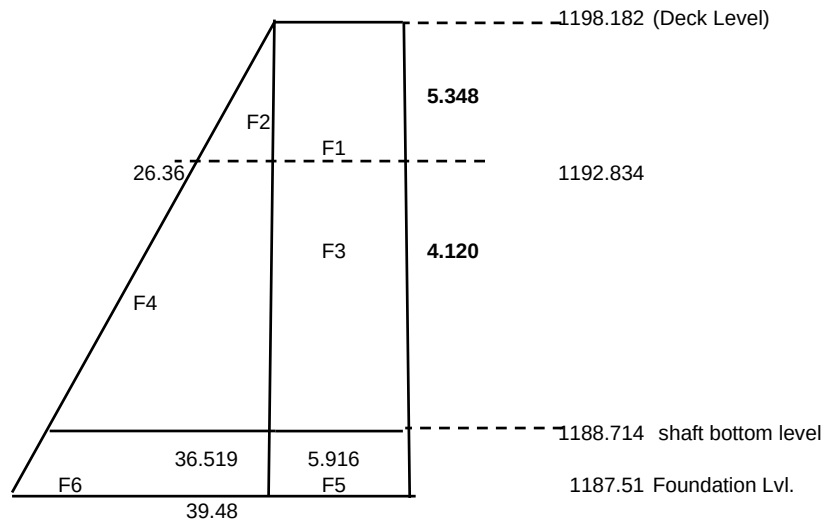
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = 0.000 kN.m at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	10064.374	14396.636	2530.925	3213.133
Due to Minimum Fluid Pressure	8487.402	12140.848	2689.291	3414.187
Governing of Two	10064.374	14396.636	2689.291	3414.187
Due to Live Load Surcharge	3037.110	3855.760	641.552	722.865
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Horizontal Forces and Moments @ RL****1188.7 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	9.468	x	12.500	=	700.103 kN
M1	=	700.10	x	4.73	=	3314.285 kN.m	at Shaft Bottom	
F3	=	5.916	x	10.668	x	12.500	=	788.835 kN
M3	=	788.84	x	5.33	=	4207.648 kN.m	at Foundation Level	

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	5.348	=	26.364 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	4.120	=	10.155 kN/m ²
F2	=	0.5	x	26.36	x	5.348	x	12.50
	=	881.201 kN						
F4	=	$\frac{(26.36 + 36.52)}{2}$				x	4.12	x 12.50
	=	1619.213 kN						
Total Force	=	2500.414 kN						
M2	=	881.20	x	6.37	=	5609.866 kN.m		
M4	=	1619.21	x	1.95	=	3156.021 kN.m		
Total Moment	=	8765.89 kN.m	at Shaft Bottom					

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 5.348 = 26.364 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.320 = 13.113 \text{ kN/m}^2$$

$$F2 = 0.5 \times 26.36 \times 5.348 \times 12.50 = 881.201 \text{ kN}$$

$$F6 = \left(\frac{26.36 + 39.48}{2} \right) \times 5.32 \times 12.50 = 2189.174 \text{ kN}$$

$$\text{Total Force} = 3070.374 \text{ kN}$$

$$M2 = 881.20 \times 7.57 = 6667.307 \text{ kN.m}$$

$$M6 = 2189.17 \times 2.48 = 5436.616 \text{ kN.m}$$

$$\text{Total Moment} = 12103.92 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	8765.887	12103.923	2500.414	3070.374
Due to Minimum Fluid Pressure	8487.402	12140.848	2689.291	3414.187
Governing of Two	8765.887	12140.848	2689.291	3414.187
Due to Live Load Surcharge	3314.285	4207.648	700.103	788.835
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.180	
αv	=	0.183	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.151 \\ 0.217 \end{matrix}$$

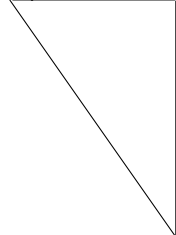
C_a	=	$\frac{1}{0.376}$	$\frac{2}{0.303}$	
Ca	=	0.376	0.303	
Ka	=	0.226		
Dynamic Increment	=	0.376	-0.226	0.150

3 Earth Pressure : DRY CASE (Seismic case)

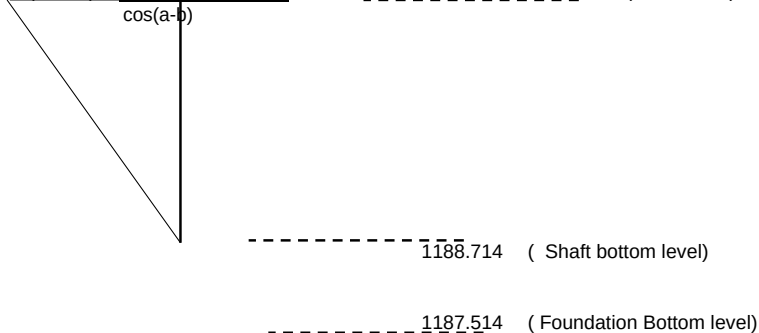
Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

Active Earth Pressure

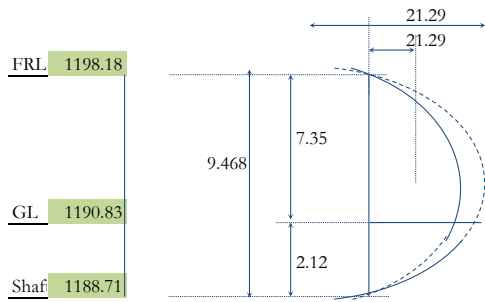
$$3 (Ca - Ka) = 0.450$$

**Surcharge Earth Pressure**

$$2 (Ca - Ka) \frac{\cos \alpha}{\cos(\alpha - \beta)} = 0.30$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.300	x	20.00	x	1.2	=	7.197 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.197	x	9.468	x	12.500
	=	425.889	kN					
M1	=	425.889	x	6.344			=	2701.651 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.197	x	9.468	x	12.500
	=	425.889	kN					
M2	=	425.889	x	7.544			=	3212.717 kN.m

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height	=	21.29 t/m ²
h	=	9.468 m
y	=	2.614 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	21.29 t/m ²
h	=	9.468 m
y	=	-2.614 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	1465.1	5.2
Parabola below Water Level	215.0	1.4
Total Dynamic Earth Pressure	1680.1	4.7

$$E3 = 1680.131 \text{ kN}$$

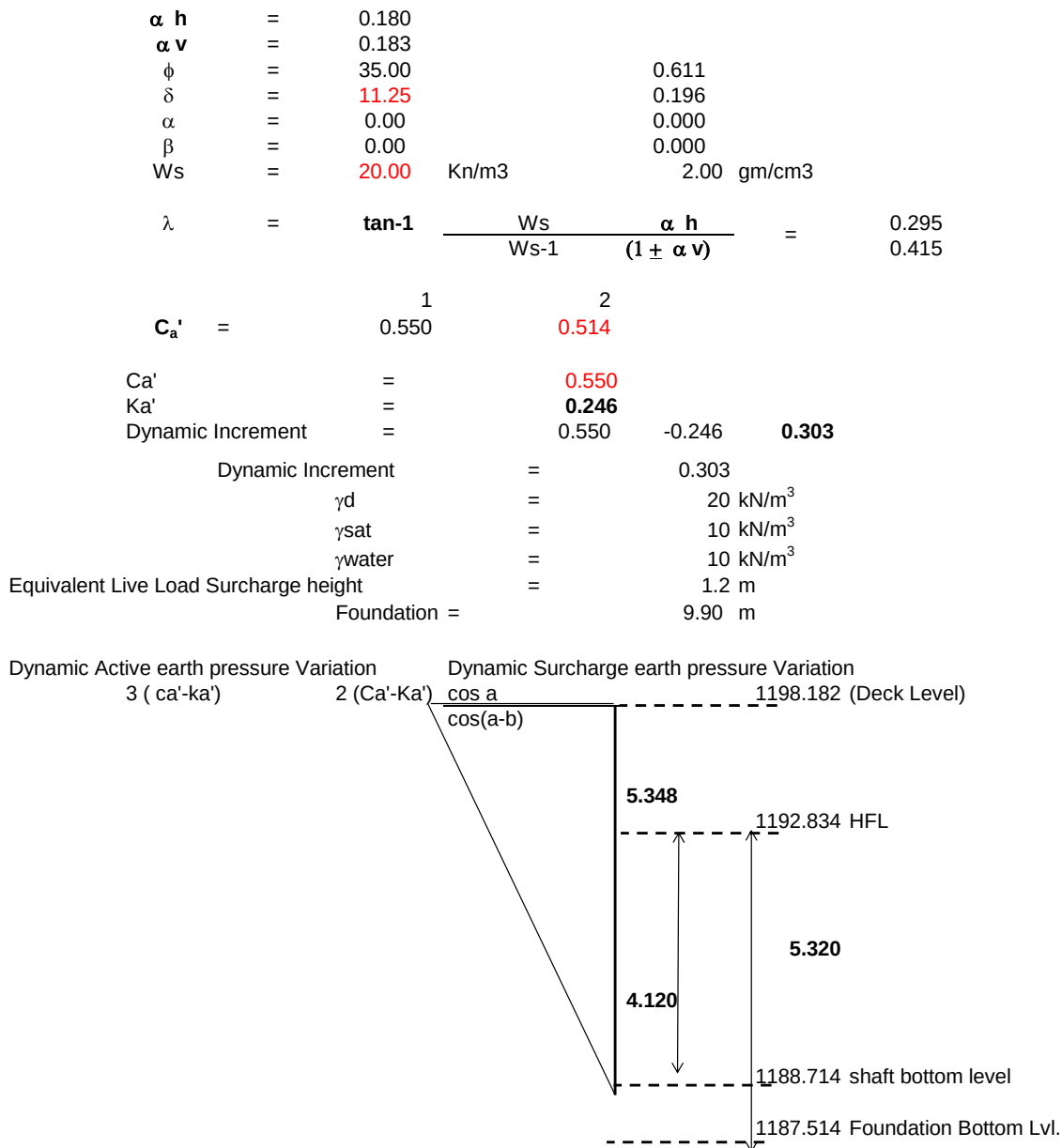
$$E4 = 1680.131 \text{ kN}$$

$$M3 = 1680.13 \times 4.73 = 7953.740 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 1680.13 \times 5.93 = 9969.898 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	10064.374	14396.636	2530.925	3213.133
Due to active Earth Pressure (dynamic Increment)	7953.740	9969.898	1680.131	1680.131
Total Earth Pressure	18018.114	24366.533	4211.056	4893.264
Due to Minimum Fluid Pressure	8487.402	12140.848	2689.291	3414.187
Governing of Two	10064.374	24366.533	4211.056	4893.264
Due to Live Load Surcharge (Static)	3037.110	3855.760	641.552	722.865
Due to Live Load Surcharge(Dynamic)	2701.651	3212.717	425.889	425.889
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case**Earth Pressure Diagram**

h'	=	4.120
h	=	9.468

Dynamic active earth pressure		
3 (ca'-ka')	=	0.450 at deck level
3 (ca'-ka')	=	0.909 at deck level
3 (ca'-ka')h'/h	=	0.396 at HFL level

Dynamic Surcharge earth pressure			
2 (Ca'-Ka') $\frac{\cos a}{\cos(a-b)}$	=	0.606 at deck level	Pressure = 14.55 kN/m ²
	=	0.264 at HFL level	Pressure = 6.33 kN/m ²

Due to Live Load Surcharge

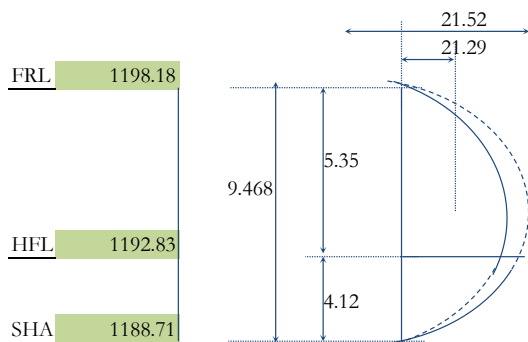
Dynamic surcharge pressure in dry condition at deck level = 7.197 kN/m²
 Dynamic surcharge pressure in Submerge condition at HFL level = 6.33 kN/m²

at Shaft Bottom Level

F1 = 6.763 x 5.348 x 12.500 = **452.120 kN**
 M1 = 452.12 x 6.79 = **3071.706 kN.m**
 F2 = 0.50 x 6.329 x 4.120 x 12.500
 = **162.980 kN**
 M2 = 162.98 x 2.76 = **449.889 kN.m**
 Total Force at Abutment shaft level = 615.100 **kN**
 Total Moment at Abutment shaft level = 3521.595 **kN.m**

at Foundation Bottom Level

F3 = 6.763 x 5.348 x 12.500 = **452.120 kN**
 M3 = 452.12 x 7.99 = **3614.250 kN.m**
 F4 = 0.500 x 6.329 x 4.120 x 12.500
 = **162.980 kN**
 M4 = 162.98 x 3.96 = **645.465 kN.m**
 Total Force at Founding level = 615.100 **kN**
 Total Moment at Founding level = 4259.715 **kN.m**

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height = 21.29 t/m²
 h = 9.468 m
 y = 0.614 m
 L = 12.500 m

Parabola below Water Level

p_mid_height = 21.52 t/m²
 h = 9.468 m
 y = -0.614 m
 L = 12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1002.6	6.2
Parabola below Water Level	684.7	2.6
Total Dynamic Earth Pressure	1687.2	4.7

Total Force (F1 + F2)	=	1687.234 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	1687.234 kN	at Foundation Bottom Level

M1 = 1687.23 x 4.73 = **7972.254 kN.m**

Total Mome = 7972.254 kN.m at Shaft Bottom

M1 = 1687.23 x 5.93 = 9996.935 kN.m

Total Mome = 9996.935 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundation Bottom Lvl kN
Due to active Earth Pressure(Static)	8765.887	12103.923	2500.414	3070.374
Due to active Earth Pressure (Dynamic Increment)	7972.254	9996.935	1687.234	1687.234
Total Earth Pressure	16738.141	22100.858	4187.648	4757.609
Due to Minimum Fluid Pressure	8487.402	12140.848	2689.291	3414.187
Governing of Two	16738.141	22100.858	4187.648	4757.609
Due to Live Load Surcharge(Static)	3314.285	4207.648	700.103	788.835
Due to Live Load Surcharge (Dynamic Increment)	3521.595	4259.715	615.100	615.100
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1095.90	1.35	1.35	1479.47	1479.47	
SIDL except wc	=	120.00	1.35	1.35	162.00	162.00	
WC	=	180.90	1.75	1.75	316.57	316.57	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	934.20	1.5	0.20	1401.30	186.84	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1801.96	1	0.20	1801.96	360.39	SV Loading
CWLLmin	=	464.40	1.5	0.20	696.60	92.88	(1-70RW + 1-CLASS A)
CWLLmin	=	1618.04	1	0.20	1618.04	323.61	SV Loading
CWLLmax-Transv. Moment Case		671.00	1.5	0.20	1006.49	134.20	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 500 = 225 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1958.04	0	97.902	97.902	-97.902	97.902	
DL+SIDL+LL-Max Reaction case	2654.64	337.5	132.732	301.482	204.768	301.482	(1-70RW + 1-CLASS A)
	4272.67	0	213.634	213.634	-213.634	213.634	SV Loading
DL+SIDL+LL-Min Reaction case	3359.34	337.5	167.967	336.717	169.533	336.717	(1-70RW + 1-CLASS A)
	3760.00	0	188.000	188.000	-188.000	188.000	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2964.53	337.5	148.227	316.977	189.273	316.977	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	1396.80	1958.04	754.27	97.902	475.037	656.369	754.271	
DL+SIDL+LL-Max Reaction case		2050.92	799.27	102.546	502.181	696.725	799.271	Dry Case
DL+SIDL+LL-Min Reaction case		2144.88	799.27	107.244	506.879	692.027	799.271	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2092.23	799.27	104.612	504.247	694.659	799.271	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μ R	Fh/2 + μ R	Fh- μ R	Governing Long. Force (kN)
DL+SIDL	1396.80	1958.04	226.281	97.902	211.042	128.380	226.281
DL+SIDL+LL-Max Reaction case		2050.92	271.281	102.546	238.186	168.736	271.281
DL+SIDL+LL-Min Reaction case		2144.88	271.281	107.244	242.884	164.038	271.281
DL+SIDL+LL-Max Transv. Moment case		2092.23	271.281	104.612	240.252	166.670	271.281

Dry Case

HFL Case

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1095.90	1.35	1.35	1479.47	1479.47
SIDL except wc	=	120.00	1.35	1.35	162.00	162.00
WC	=	180.90	1.75	1.75	316.57	316.57
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	934.20	1.5	0.75	1401.30	700.65
CWLLmax- Transv. Moment Case	=	671.00	1.5	0.75	1006.49	503.25
CWLLmin	=	464.40	1.5	0.75	696.60	348.30

Braking Force = 225 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Fh/2 + μ R	Fh- μ R	Governing Long. Force (kN)
DL+SIDL	1958.04	0.000	97.902	97.902	-97.902	97.902
DL+SIDL+LL-Max Reaction case	2654.64	337.500	132.732	301.482	204.768	301.482
	4272.67	0.000	213.634	213.634	-213.634	213.634
DL+SIDL+LL-Min Reaction case	3359.34	337.500	167.967	336.717	169.533	336.717
	3760.00	0.000	188.000	188.000	-188.000	188.000
DL+SIDL+LL-Max Transv. Moment case	2964.53	337.500	148.227	316.977	189.273	316.977

(1-70RW + 1-CLASS A)

Dry Case

SV Loading

(1-70RW + 1-CLASS A)

HFL Case

SV Loading

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μ R	Fh/2 + μ R	Fh- μ R	Governing Long. Force (kN)
DL+SIDL	1396.80	1958.04	1018.27	97.902	607.035	920.364	1018.266
DL+SIDL+LL-Max Reaction case		2306.34	1063.27	115.317	646.950	947.949	1063.266
DL+SIDL+LL-Min Reaction case		2658.69	1063.27	132.934	664.567	930.332	1063.266
DL+SIDL+LL-Max Transv. Moment case		2461.28	1063.27	123.064	654.697	940.202	1063.266

Dry Case

HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1958.04	305.480	97.902	250.642	207.578	305.480	
DL+SIDL+LL-Max Reaction case		2306.34	350.480	115.317	290.557	235.163	350.480	Dry Case
DL+SIDL+LL-Min Reaction case		2658.69	350.480	132.934	308.174	217.545	350.480	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2461.28	350.480	123.064	298.304	227.416	350.480	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1095.90	1	1.00	1095.90	1095.90
SIDL except wc	=	120.00	1	1.00	120.00	120.00
WC	=	180.90	1	1.00	180.90	180.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	934.20	1	0.20	934.20	186.84
CWLLmax-Transv. Moment Case		671.00	1	0.20	671.00	134.20
CWLLmin	=	464.40	1	0.20	464.40	92.88

Braking Force = 225 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	0.000	69.840	69.840	-69.840	69.840	
DL+SIDL+LL-Max Reaction case	1861.20	225.000	93.060	205.560	131.940	205.560	(1-70RW + 1-CLASS A)
	3014.83	0.000	150.742	150.742	-150.742	150.742	SV Loading
DL+SIDL+LL-Min Reaction case	2331.00	225.000	116.550	229.050	108.450	229.050	(1-70RW + 1-CLASS A)
	3198.76	0.000	159.938	159.938	-159.938	159.938	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2067.79	225.000	103.390	215.890	121.610	215.890	

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	678.844	69.840	409.262	609.004	678.844	
DL+SIDL+LL-Max Reaction case	1489.68	723.844	74.484	436.406	649.360	723.844	Dry Case
DL+SIDL+LL-Min Reaction case	1583.64	723.844	79.182	441.104	644.662	723.844	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1531.00	723.844	76.550	438.472	647.294	723.844	

Transverse Seismic Case:

	Vertical Force (R)	F _h	μR	F _h /2 + μR	F _h - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	203.653	69.840	171.666	133.813	203.653	
DL+SIDL+LL-Max Reaction case	1489.68	248.653	74.484	198.810	174.169	248.653	Dry Case
DL+SIDL+LL-Min Reaction case	1583.64	248.653	79.182	203.508	169.471	248.653	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1531.00	248.653	76.550	200.876	172.103	248.653	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1095.90	1.1	1.10	1205.49	1205.49
SIDL except wc	=	120.00	1.1	1.10	132.00	132.00
WC	=	180.90	1.35	1.35	244.21	244.21
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	934.20	1.5	0.00	1401.30	0.00
CWLLmax- Transv. Moment Case		671.00	1.5	0.00	1006.49	0.00
CWLLmin	=	464.40	1.5	0.00	696.60	0.00

Braking Force = 225 KN

Normal Case:

	Vertical Force (R)	F _h	μR	F _h /2 + μR	F _h - μR	Governing Long. Force (kN)	
DL+SIDL	1581.70	0.000	79.085	79.085	-79.085	79.085	
DL+SIDL+LL-Max Reaction case	2278.30	337.500	113.915	282.665	223.585	282.665	(1-70RW + 1-CLASS A)
	3199.74	0.000	159.987	159.987	-159.987	159.987	SV Loading
DL+SIDL+LL-Min Reaction case	2983.00	337.500	149.150	317.900	188.350	317.900	(1-70RW + 1-CLASS A)
	3383.67	0.000	169.183	169.183	-169.183	169.183	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2588.20	337.500	129.410	298.160	208.090	298.160	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	F _h	μR	F _h /2 + μR	F _h - μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1581.70	1018.27	79.085	588.218	939.181	1018.266	
DL+SIDL+LL-Max Reaction case		1581.70	1018.27	79.085	588.218	939.181	1018.266	Dry Case
DL+SIDL+LL-Min Reaction case		1581.70	1018.27	79.085	588.218	939.181	1018.266	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1581.70	1018.27	79.085	588.218	939.181	1018.266	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	1396.80	1581.70	305.480	79.085	231.825	226.395	305.480	
DL+SIDL+LL-Max Reaction case		1581.70	305.480	79.085	231.825	226.395	305.480	Dry Case
DL+SIDL+LL-Min Reaction case		1581.70	305.480	79.085	231.825	226.395	305.480	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1581.70	305.480	79.085	231.825	226.395	305.480	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1095.90	1	1	1	1095.90	1095.90	1095.90
SIDL except wc	=	120.00	1	1	1	120.00	120.00	120.00
WC	=	180.90	1.20	1.20	1.20	217.07	217.07	217.07
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	934.20	1	0.75	0	934.20	700.65	0.00
CWLLmax-Transv. Moment Case	=	671.00	1	0.75	0	671.00	503.25	0.00
CWLLmin	=	464.40	1	0.75	0	464.40	348.30	0.00

Braking Force = 225 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	1432.98	0.000	71.649	71.649	-71.649	71.649	
DL+SIDL+LL-Max Reaction case	1897.38	225.000	94.869	207.369	130.131	207.369	(1-70RW + 1-CLASS A) Dry Case
	3051.01	0.000	152.551	152.551	-152.551	152.551	SV Loading
DL+SIDL+LL-Min Reaction case	2367.18	225.000	118.359	230.859	106.641	230.859	(1-70RW + 1-CLASS A) HFL Case
	3234.94	0.000	161.747	161.747	-161.747	161.747	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2103.97	225.000	105.199	217.699	119.801	217.699	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	1432.98	0.000	71.649	71.649	-71.649	71.649	
DL+SIDL+LL-Max Reaction case	1781.28	168.750	89.064	173.439	79.686	173.439	Dry Case
DL+SIDL+LL-Min Reaction case	2133.63	168.750	106.681	191.056	62.069	191.056	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1936.22	168.750	96.811	181.186	71.939	181.186	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	F _h	μ R	F _h /2 + μ R	F _h - μ R	Governing Long. Force (kN)	
DL+SIDL	1432.98	0.000	71.649	71.649	-71.649	71.649	
DL+SIDL+LL-Max Reaction case	1432.98	0.000	71.649	71.649	-71.649	71.649	Dry Case
DL+SIDL+LL-Min Reaction case	1432.98	0.000	71.649	71.649	-71.649	71.649	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1432.98	0.000	71.649	71.649	-71.649	71.649	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	934.20	kN	934.20	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

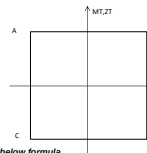
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1187.514 m

Properties of Footing Base:

A	=	123.750	m ²
ZL	=	204.188	m ³
ZT	=	257.813	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1095.903	1.050	1150.698	0.000	0.000
SIDL except Wearing Course	1			120.000	1.050	126.000	0.000	0.000
Wearing Course	1			180.895	1.050	189.940	0.000	0.000
Bearing Pedestal	1	25	1.056	26.400	1.050	27.720	-0.682	-18.000
				1423.198		1494.358		-18.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.250	23.438	0.000	0.000
Dirt Wall-Tapered portion	1	25	3.427	85.664	0.250	21.416	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.050	-1.406	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.000	0.000	0.000	0.000
Cap - (uniform portion)	1	25	6.938	173.438	1.025	177.773	0.000	0.000
Cap - (corbel portion)	25	5.263	131.567	1.025	134.856	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.450	0.000	5.975	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.450	0.000	5.975	0.000
RCC Railing or Crash Barrier	1	25	0.000	28.000	0.250	7.000	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.050	-8.203	0.000	0.000
				718.669		354.874		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	29.159	728.986	-2.250	-1640.220	5.975	4355.694
Abutment Slab	1	25	87.515	2187.884	1.079	2361.613	0.000	0.000
Back filling over heel slab	1	20	657.906	13158.113	-2.282	-30031.003	0.000	0.000
Front Filling over toe slab	1	20	101.888	2037.750	3.222	6565.763	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	57.375	1434.375	-1.879	-2695.781	0.000	0.000
Toe slab	1	25	35.063	876.563	3.074	2694.141	0.000	0.000
Portion between heel & toe	1	25	18.000	450.000	1.050	472.500	0.000	0.000
Vertical Components of active earth pressure	1			1414.202	-4.950	-7000.302	0.000	0.000
				22528.995		-29150.135		4355.694
Total				24670.862		-27300.903		4337.694

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	986.313	-3.900	-3846.620
0.900	108.000	-3.900	-421.200
0.900	180.895	-3.900	-705.491
0.900	23.760	-3.900	-92.564
	1298.968		-5065.975
0.900	84.375	-4.700	-396.563
0.900	77.998	-4.700	-362.359
0.900	25.313	-5.000	-126.563
0.900	12.656	-4.950	-62.648
0.900	156.094	-3.925	-612.668
0.900	118.410	-3.925	-464.761
0.900	0.000	-4.500	0.000
0.900	0.000	-4.500	0.000
0.900	25.200	-4.700	-118.440
0.900	147.655	-5.000	-738.281
	646.802		-2882.282
0.900	656.088	-7.200	-4723.833
0.900	1969.096	-3.871	-7621.571
0.900	11842.301	-7.232	-85647.294
0.900	1833.975	-1.728	-3168.990
0.900	0.000	0.000	0.000
0.900	1290.938	-6.829	-8816.344
0.900	788.906	-1.876	-1480.359
0.900	405.000	-3.900	-1579.500
0.900	1272.782	-9.900	-12600.544
	20276.096		-126597.271
	22221.866		-134545.526

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	69.840	1196.697	841.340
due to Earth pressure	1	3414.187		14396.636

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
69.84	641.34	0.00	0.00
3414.19	14396.64	0.00	0.00
3484.027	15037.976	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		79.085	1196.697	726.238
due to Earth pressure	1.5	5121.280		21594.954
		5200.365		22321.192

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
79.09	726.24	0.00	0.00
5121.28	21594.95	0.00	0.00
5200.365	22321.192	0.000	0.000

Summary of Forces For SBC

P	24670.862	kN
ML	-12262.927	kNm
MT	4337.694	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		24670.862		-27300.903		4337.694
CWLL-Max. Reaction case	1	934.200	1.050	980.910	1.641	1533.259
Vertical Components of LL Surcharge	1	299.420	-4.950	-1482.131	0.000	0.000
Total		25904.483		-27802.124		5870.953

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	22221.86557		-134545.53
0.900			0.00
		-3.900	-134545.53
		-9.900	-2667.84
	22221.866		-137213.36

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	205.560	1196.697	1887.657
due to Earth pressure	1	3414.187		14396.636
due to Live load surcharge	1	722.865		3855.760

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
205.56	1887.66	0.00	0.00
3414.19	14396.64	0.00	0.00
722.865	3855.760	0.00	0.00
4342.61	20140.05	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		282.665	1196.697	2595.714
due to Earth pressure	1.5	5121.280		21594.954
due to Live load surcharge	1.2	867.438		4626.912
		6271.383		28817.579

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
282.67	2595.71	0.00	0.00
5121.28	21594.95	0.00	0.00
867.44	4626.91	0.00	0.00
6271.383	28817.579	0.000	0.000

Summary of Forces For SBC

P	25904.483	kN
ML	-1662.071	kNm
MT	5870.953	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
				1423.198		1494.358		-18.000
Substructure & Foundation -Portion 1								
				718.669		354.874		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	29.159	728.986	-2.250	-1640.220	5.975	4355.694
Slab above HFL	1	25	35.924	898.098	1.130	1014.555	0.000	0.000
Slab below HFL	1	15	51.591	773.872	1.079	835.321	0.000	0.000
Back filling above HFL over heel slab	1	20	360.990	7219.800	-2.250	-16244.550	0.000	0.000
Back filling below HFL over heel slab	1	10	301.725	3017.250	-2.320	-7001.498	0.000	0.000
Front Filling over toe slab	1	10	101.888	1018.875	2.083	2121.918	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	57.375	860.625	-1.879	-1617.469	0.000	0.000
Toe slab	1	15	35.063	525.938	3.074	1616.484	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	1.050	283.500	0.000	0.000
Vertical Components of active earth pressure	1			1414.202	-4.950	-7000.302	0.000	0.000
				16901.878		-27542.366		4355.694
Total				19043.744		-25693.134		4337.694

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	656.088	-7.200	-4723.833
0.900	808.288	-3.820	-3087.927
0.900	696.484	-3.871	-2695.809
0.900	6497.820	-7.200	-46784.304
0.900	2715.525	-7.270	-19743.143
0.900	916.988	-2.867	-2629.362
0.900	0.000	0.000	0.000
0.900	774.563	-6.829	-5289.806
0.900	473.344	-1.876	-888.216
0.900	243.000	-3.900	-947.700
0.900	1272.782	-9.900	-12600.544
	15211.690		-100085.995
	17157.460		-108034.252

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	69.840	1196.697	841.340
due to Earth pressure	1	3414.187		12140.848

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
69.84	641.34	0.00	0.00
3414.19	12140.85	0.00	0.00
3484.03	12782.19	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		79.085	1196.697	726.238
due to Earth pressure	1.5	5121.280		18211.272
		5200.365		18937.510

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
79.09	726.24	0.00	0.00
5121.28	18211.27	0.00	0.00
5200.37	18937.51	0.00	0.00

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation						
Loads	Load Factor	Vertical Load(P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		19043.744		-25693.134		4337.694
CWLL-Min. Reaction case	1	464.400	1.050	487.620	1.680	780.011
Vertical Components of LL Surcharge	1	326.746	-4.950	-1617.394	0.000	0.000
Total		19834.891		-26822.909		5117.706

Vertical Forces For Restoring or Resisting Effect			
Load Factor	Vertical Load(P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	17157.460	0.000	-108034.252
0.900	294.072	-9.900	-2911.310
	17451.531		-110945.561

Horizontal Forces For SBC Calculation				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	229.050	1196.697	2103.395
due to Earth pressure	1	3414.197		12140.848
due to live load surcharge	1	788.835		4207.648

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
229.05	2103.37	0.00	0.00
3414.19	12140.85	0.00	0.00
788.835	4207.648	0.000	0.000
4432.07	18451.86	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		317.900	1196.697	2919.277
due to Earth pressure	1.5	5121.280		18211.272
due to live load surcharge	1.2			6385.783
				26178.726

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
317.90	2919.28	0.00	0.00
5121.28	18211.27	0.00	0.00
946.502	5249.172	0.000	0.000
6385.78	26179.73	0.00	0.00

Summary of Forces For SBC		
P	19834.891	kN
ML	-8371.047	kNm
MT	5117.706	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah= 0.243	In Longitudinal direction	Weight of shaft below Ground level	=	726.667 kN
		av= 0.183	In Transverse direction	Weight of back fill below Ground level	=	2862.000 kN
			In Vertical direction			

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1095.903		90.187	60.124	1.050	1150.698	63.131	1197.644		0.000	0.000	913.560
SIDL except Wearing Course	1			120.000		9.875	6.584	1.050	126.000	6.913	1198.631		0.000	0.000	109.783
Wearing Course	1			180.895		14.887	9.924	1.050	189.940	10.421	1198.182		0.000	0.000	158.810
Bearing Pedestal	1	25	1.056	26.400		2.173	1.448	1.050	27.720	1.521			-0.682	-18.000	
				1423.198		117.121	78.081		1494.358	81.985				-18.000	1182.153
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	3.750	93.750	22.781	7.715	5.143	0.250	23.438	1.286	1197.682	231.640	0.000	0.000	78.447
Dirt Wall-Tapered portion	1	25	3.427	85.664	20.816	7.050	4.700	0.250	21.416	1.175	1196.725	191.742	0.000	0.000	64.935
Bracket - Uniform portion	1	25	1.125	28.125				0.000	-0.050						
Bracket - Tapered portion	1	25	0.563	14.063				0.000	0.000						
Cap - (uniform portion)	1	25	6.938	173.438	42.145	14.273	9.515	1.025	177.773	9.753	1196.047	359.626	0.000	0.000	121.791
Cap - (corbel portion)	1	25	5.263	131.567	31.971	10.827	7.218	1.025	134.856	7.399	1195.747	263.216	0.000	0.000	89.140
Cantilever Return Wall-Rectangle of	1	25	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000	1198.182	0.000	5.975	0.000	0.000
Cantilever Return Wall-Triangle port	1	25	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000	1198.182	0.000	5.975	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.250	7.000				0.000	0.000	
Approach Slab	1	25	6.563	164.063			-0.950	-8.203					0.000	0.000	
				718.669	117.714	39.865	26.577		354.874	19.613		1046.223		0.000	354.314
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	29.159	728.986	177.144	59.991	39.994	-2.250	-1640.220	-89.987	1193.309	1026.481	5.975	4355.694	347.628
Abutment Shaft	1	25	87.515	2187.884	355.076	120.250	80.167	1.079	2361.613	86.532	1193.216	2024.465	0.000	0.000	685.604
Back filling over heel slab	1	20	657.906	13158.113	0.000	0.000	0.000	-2.282	-30031.003	0.000	1193.309	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	101.888	2037.750				3.222	6565.763				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	57.375	1434.375				-1.879	-2695.781				0.000	0.000	
Toe slab	1	25	35.063	876.563				3.074	2694.141				0.000	0.000	
portion between heel & toe	1	25	18.000	450.000				1.050	472.500				0.000	0.000	
Vertical component of active earth pressure	1						-4.950	-6588.070					0.000	0.000	
Vertical component of dynamic increment of earth pressure	1						-4.950	-3444.869					0.000	0.000	
				995.933									0.000	0.000	
				23141.649	532.220	180.241	120.161		-32182.772	-3.455		3050.946		4355.694	1033.232
Total =				25283.516	649.933	337.227	224.818		-30333.540	98.142		4097.170		4337.694	2569.698
							-224.818			-98.142					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.9			986.313	54.112	-3.900	-3846.620	-211.038
SIDL except Wearing Course	0.9			108.000	5.925	-3.900	-421.200	-23.108
Wearing Course	1.00			180.895	9.924	-3.900	-705.491	-38.705
Bearing Pedestal	0.9	25	1.056	23.760		-3.900	-92.664	
				1298.968	69.962		-5066.975	-272.850
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	3.750	84.375	4.629	-4.700	-396.563	-21.757
Dirt Wall-Tapered portion	0.9	25	3.427	77.098	4.230	-4.700	-362.359	-19.880
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	6.938	156.094	8.564	-3.925	-612.668	-33.613
Cap - (corbel portion)	0.9	25	5.263	118.410	6.496	-3.925	-464.761	-25.498
Cantilever Return Wall-Rectangle of	0.9	25	0.000	0.000	0.000	-4.500	0.000	0.000
Cantilever Return Wall-Triangle port	0.9	25	0.000	0.000	0.000	-4.500	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-4.700	-118.440	
Approach Slab	0.9	25	6.563	147.656		-5.000	-738.281	
				646.892	23.919		-2693.071	-100.747
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	87.515	1969.096	68.163	-3.871	-7621.571	-263.832
Solid Return wall	0.9	25	29.159	656.088	35.995	-7.200	-4723.833	-259.163
Back filling over heel slab	0.9	20	657.906	11842.301	0.000	-7.232	-85647.3	0.000
Front Filling over toe	0.9	20	101.888	1633.975		-1.729	-3169.990	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	57.375	1290.938		-6.829	-8816.344	
Toe slab	0.9	25	35.063	788.906		-1.876	-1480.359	
portion between heel & toe	0.9	25	18.000	450.000		-3.900	-1579.500	
Vertical component of active earth pressure	0.9					-9.900	-12600.544	
Vertical component of dynamic increment of earth pressure	0.9					-9.900	-6200.764	
				20902.436	104.158		-132798.03	-522.995
Total =				22848.205	198.038		-140557.08	-896.592
							-198.038	896.592

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	22.781	1197.682	231.640
1.0	20.816	1196.725	191.742
1.0	42.145	1196.047	359.626
1.0	31.971	1195.747	263.216
1.0	0.000	1198.182	0.000
1.0	0.000	1198.182	0.000
	117.714	1046.223	
1.0	335.455	1193.216	1912.601
1.0	177.144	1193.309	1026.481
1.0	0.000	1193.309	0.000
	512.600	2939.083	
	630.313	3985.306	

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	678.844	117.121	1196.697	6233.824	1182.153
due to Substructure	1	649.933	220.106		4097.170	1387.545
due to Earth pressure	1	4893.264			24366.533	

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ
678.84	6233.82	0.00	0.00
649.93	4097.17	0.00	0.00
4893.26	24366.53		
6222.04	34697.53	0.00	0.00
		0.00	0.00
		0.00	0.00
		337.23	2569.70

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.697	9350.74
due to Substructure	1.5	945.470		5977.36
due to Active Earth pressure	1	3213.133		14396.64
due to dynamic Earth pressure	1.5	2520.197		14954.85
		7697.065		44680.177

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos()	ML Cos()	FL Sin()	ML Sin ()
1018.27	9350.74	0.00	0.00
945.47	5977.96	0.00	0.00
3213.133	14396.636	0.000	0.000
2520.197	14954.846	0.000	0.000
7697.07	44680.18	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1298.968	69.962	0.000	-5065.97	-272.850
Forces from Substructure				21549.237	128.077	0.000	-135491.11	-623.742
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.900	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-9.900	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000	-9.900		0.00	
Total =				22848.205	198.038		-140557.08	-896.592
					-198.038			896.592

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	723.844	132.497	1196.697	6647.059	1364.634
due to Substructure	1	649.933	220.106		4097.170	1387.545
due to Earth pressure	1	4893.264			24366.533	
due to Live load surcharge	0.20	229.751			1413.695	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
723.84	6647.06	0.00	0.00	0.00	0.00	132.50	1364.63
649.93	4097.17	0.00	0.00	0.00	0.00	220.11	1387.55
4893.26	24366.53						
229.75	1413.70						
6496.79	36524.46	0.00	0.00	0.00	0.00	352.60	2752.18

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.697	9350.736
due to Substructure	1.5	945.470		5977.959
due to Active Earth pressure	1	3213.133		14396.636
due to dynamic Earth pressure	1.5	2520.197		14954.846
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		7697.065		44680.177

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.27	9350.74	0.00	0.00
945.47	5977.96	0.00	0.00
3213.133	14396.636		
2520.197	14954.846		
0.000	0.000		
0.000	0.000		
7697.07	44680.18	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	25800.591	25330.453	kN
ML	6024.934	5807.123	kNm
MT	7396.525	7396.525	kNm

Summary of Restoring Forces

Vertical Load	22850.167	kN
Moment	-141453.673	kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1423.198		117.121	78.081		1494.358	81.985				-18.000	1182.153
Substructure & Foundation -Portion 1				718.669	117.714	39.865	26.577		354.874	19.613		1046.223		0.000	354.314
Substructure & Foundation -Portion 2															
Solid Return wall	1		29.16	728.99	177.144	59.991	39.994	-2.25	-1640.220	-89.987	1193.31	1026.481	5.98	4355.694	347.628
Shall above HFL	1	25	35.924	898.098	218.238	73.908	49.272	1.130	1014.555	55.661	1194.216	1462.521	0.000	0.000	495.296
Shall below HFL	1	15	51.591	773.872	136.838	46.341	30.894	1.079	835.321	33.347	1191.834	591.140	0.000	0.000	200.195
Back filling above HFL over heel slab	1	20	360.990	7219.800	0.000	0.000	0.000	-2.250	-16244.550	0.000	1195.508	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	301.725	3017.250	0.000	0.000	0.000	-2.320	-7001.438	0.000	1190.474	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	101.888	1018.875	0.000	0.000	0.000	2.083	2121.918	0.000	0.000	0.000	0.000	0.000	0.00
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Heel slab	1	15	57.375	860.625	0.000	-1.879	-1.879	3.074	1616.484	0.000	0.000	0.000	0.000	0.000	0.00
Toe slab	1	15	35.063	525.938	0.000	-1.876	-1.876	1.050	283.500	0.000	0.000	0.000	0.000	0.000	0.00
portion between heel & toe	1	15	18.000	270.000	0.000	-1.876	-1.876	0.000	-4295.364	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of active earth pressure	1			1271.791				-4.950	-3459.433				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			698.875				-4.950	-3459.433				0.000	0.000	
				17458.341	574.558	194.579	129.720		-30386.695	-0.978		3303.056		4355.694	1118.611
Total =				19600.208	692.272	351.565	234.377		-28537.463	100.619		4349.279		4337.694	2655.078
							-234.377			-100.619					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1298.968	69.962		-5065.975	-272.850
Substructure & Foundation -Portion 1				646.802	23.919		-2693.071	-100.747
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	29.15946	656.088	35.995	-7.20	-4723.833	-259.163
Shall above HFL	0.9	25	35.924	808.288	44.345	-3.820	-3087.927	-169.412
Shall below HFL	0.9	15	51.591	696.484	23.818	-3.871	-2695.809	-92.191
Back filling above HFL over heel slab	0.9	20	360.990	6487.820	0.000	-7.200	-46784.304	0.000
Back filling below HFL over heel slab	0.9	10	301.725	2715.525	0.000	-7.270	-19743.143	0.000
Front Filling over toe	0.9	10	101.888	916.988	0.000	-2.867	-2629.362	0.000
Side filling between heel and toe	0.9	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.9	15	57.375	774.563	0.000	-6.829	-5289.806	0.000
Toe slab	0.9	15	35.063	473.344	0.000	-1.876	-888.216	0.000
portion between heel & toe	0.9	15	18.000	243.000	0.000	-3.900	-947.700	0.000
Vertical component of active earth pressure	0.9			1144.612		-9.900	-11331.656	0.000
Vertical component of dynamic increment of earth pressure	0.9			628.988		-9.900	-6226.979	0.000
				15712.507	112.761		-105044.09	-558.915
Total =				17658.277	206.641		-112803.13	-932.512
					-206.641			932.512

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	117.714		1046.223
1.0	177.144	1193.309	1026.481
1.0	218.238	1194.216	1462.521
1.0	117.218	1191.834	506.382
1.0	0.000	1195.508	0.000
1.0	0.000	1190.474	0.000
	512.600		2995.384
	630.313		4041.607

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	678.844	117.121	1196.697	6233.824	1182.153
due to Substructure	1	692.272	234.444		4349.279	1472.925
due to Earth pressure	1	4757.609			22100.858	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
678.84	6233.82	0.00	0.00	0.00	0.00	117.12	1182.15
692.27	4349.28	0.00	0.00	0.00	0.00	234.44	1472.92
4757.61	22100.86						
6128.72	32683.96	0.00	0.00	0.00	0.00	351.57	2655.08

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.697	9350.736
due to Substructure	1.5	945.470		6062.411
due to Active Earth pressure	1	3070.374		12103.923
due to dynamic Earth pressure	1.5	2530.851		14995.403
		7564.962		42512.472

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.27	9350.74	0.00	0.00
945.47	6062.41	0.00	0.00
3070.374	12103.923		
2530.851	14995.403		
7564.96	42512.47	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	19834.585	19365.831	kN
ML	4247.118	4045.880	kNm
MT	6992.772	6992.772	kNm

Summary of Restoring Forces

Vertical Load	17451.635	kN
Moment	-113735.644	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1423.198					1494.358	81.985				-18.000	1182.153
Forces from Substructure				18177.010					-30031.821	18.634				4355.694	1472.925
CWLL-Max. Reaction case	0.20			92.88				1.050	97.524	5.350	1199.382		1.680	156.002	90.713
Vertical component of LL Surcharge	0.20			65.35				-4.950	-323.479				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			50.96				-4.950	-252.235				0.000	0.000	
Total =				19809.394	692.272	359.209	239.473		-29015.653	105.969		4349.279		4493.697	2745.791

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1298.968	69.962		-5065.975	-272.850
Forces from Substructure				16359.309	136.680		-107737.16	-655.662
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.90	0.00
Vertical component of LL Surcharge	0.00			0.00	0.00	-3.900	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000	0.000	-9.900	0.000	0.000
Total =				17658.277	206.641		-112807.93	-932.512

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	723.844	124.765	1196.697	6647.059	1272.866
due to Substructure	1	692.272	234.444		4349.279	1472.925
due to Earth pressure	1	4757.609			22100.858	
due to Live load surcharge	0.20	280.787			1693.473	

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
723.84	6647.06	0.00	0.00	0.00	0.00	124.76	1272.87
692.27	4349.28	0.00	0.00	0.00	0.00	234.44	1472.92
4757.61	22100.86						
280.79	1693.47						
6454.51	34790.67	0.00	0.00	0.00	0.00	359.21	2745.79

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.266	1196.697	9350.796
due to Substructure		945.470		6062.4108
due to Active Earth pressure	1.5	3070.374		12103.923
due to dynamic Earth pressure	1.5	2530.851		14995.403
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		7564.962		42512.472

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1018.27	9350.74	0.00	0.00
945.47	6062.41	0.00	0.00
3070.374	12103.923		
2530.851	14995.403		
0.000	0.000		
0.000	0.000		
7564.96	42512.47	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	20048.866	19569.921 kN
ML	5880.986	5669.047 kNm
MT	7239.487	7239.487 kNm

Summary of Restoring Forces

Vertical Load	17451.635 kN
Moment	-113739.544 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	FL = 0.3 x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1423.198					1494.358	81.985				-18.000	3940.510
Substructure & Foundation -Portion 1				718.669	35.314	132.883	26.577		354.874	19.613		313.867		0.000	1181.045
Substructure & Foundation -Portion 2				23141.649	159.666	600.804	120.161		-32182.772	-3.455		915.284		4355.694	3444.106
Total =				25283.516	194.980	1124.089	224.818		-30333.540	98.142		1229.151		4337.694	8565.661

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1298.968	69.962		-5065.97	-272.850
Substructure & Foundation -Portion 1				646.802	23.919		-2693.07	-100.747
Substructure & Foundation -Portion 2				20902.436	104.158		-132798.03	-522.995
Total =				22848.205	198.038		-140557.08	-896.592

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	117.714		1046.223
	512.600		2939.083
	630.313		3985.306

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	203.653	390.403	1196.697	1870.147	3940.510
due to Substructure	1	194.980	733.687		1229.151	4625.151
due to Earth pressure	1	4893.264			24366.533	

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
203.65	1870.15	0.00	0.00	0.00	0.00	390.40	3940.51
194.98	1229.15	0.00	0.00	0.00	0.00	733.69	4625.15
4893.26	24366.53						
5291.90	27465.83	0.00	0.00	0.00	0.00	1124.09	8565.66

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		305.480	1196.697	2805.221
due to Substructure	1.5	945.470		5977.9591
due to Active Earth pressure	1	3213.133		14396.636
due to dynamic Earth pressure	1.5	756.059		4486.454
		5220.142		27666.270

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
305.48	2805.22	0.00	0.00
945.47	5977.96	0.00	0.00
3213.133	14396.636		
756.059	4486.454		
5220.14	27666.27	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	25508.334	25058.698 kN
ML	-2769.566	-2965.851 kNm
MT	12903.355	12903.355 kNm

Summary of Restoring Forces

Vertical Load	22850.167 kN
Moment	-141453.673 kNm

Case 10 : DL+SIDL+LL(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	25565.522	235.069	-30608.43	108.905	4644.346
		-235.069		-108.905	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	248.653	441.656	1196.697	2283.382	4548.779
due to Substructure	1	104.980	733.687		1229.151	4625.151
due to Earth pressure	1	4893.264			24366.533	
due to Live load surcharge	0.2	229.751			1413.695	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	22848.205	198.038	-140557.08	-896.592
		-198.038		896.592

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		305.48	1196.697	2805.221
due to Substructure	1.5	283.64		1793.389
due to Active Earth pressure	1	3213.13		14396.636
due to dynamic Earth pressure	1.5	756.06		4486.454
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		4558.31		23481.698

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
305.48	2805.22	0.00	0.00
283.64	1793.39	0.00	0.00
3213.133	14396.636		
756.059	4486.454		
0.000	0.000		
0.000	0.000		
4558.31	23481.70	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	25800.591	25330.453 kN
ML	-1206.762	-1424.573 kNm
MT	13818.276	13818.276 kNm

Summary of Restoring Forces

Vertical Load	22850.167 kN
Moment	-141453.673 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation****Vertical Forces For Restoring or Resisting Effect**

Loads		Vertical Load(P) kN	$F_v = 0.3 \times \text{av} \times P$ (kN)	$M_L = P \times e_L$	M_L due to F_v	$M_T = P \times e_T$
Superstructure		1423.198	78.081	1494.358	81.985	-18.000
Substructure & Foundation -Portion 1		718.669	26.577	354.874	19.613	0.000
Substructure & Foundation -Portion 2		17458.341	129.720	-30386.695	-0.978	4355.694
Total =		19600.208	234.377	-28537.463	100.619	4337.694
			-234.377		-100.619	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	203.65	390.40	1196.70	1870.15	3940.51
due to Substructure	1	207.68	781.48		1304.78	4909.75
due to Earth pressure	1	4757.61			22100.86	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure			305.48	1196.697
due to Substructure	1.5	283.64		2805.22
due to Active Earth pressure	1	3070.374		12103.92
due to dynamic Earth pressure	1.5			4498.62
		4418.75		21226.49

Summary of Forces For SBC

	Downward	Upward
P	19634.585	19365.831 kN
ML	-3161.055	-3362.293 kNm
MT	13187.953	13187.953 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN	$F_v = 0.3 \times \text{av} \times P$ (kN)	$M_L = P \times e_L$	M_L due to F_v	$M_T = P \times e_T$
Total =	19600.394	239.473	-29015.65	105.969	4493.697
		-239.473		-105.969	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	248.653	415.88175	1196.697	2283.382	4242.8865
due to Substructure	1	207.681	781.48105		1304.784	4909.7491
due to Earth pressure	1	4757.609			22100.858	
due to Live load surcharge	0.2	280.787			1693.473	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure			305.48	1196.697
due to Substructure	1.5	283.64		1818.72
due to Active Earth pressure	1	3070.37		12103.92
due to dynamic Earth pressure	1.5	759.26		4498.62
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		4418.75		21226.49

Summary of Forces For SBC

	Downward	Upward
P	20048.866	19569.921 kN
ML	-1527.186	-1739.125 kNm
MT	13646.332	13646.332 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000 kN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1199.382	-	1187.514	)

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000 kN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1199.382	-	1187.514	)

Base pressure on corner A	=	σ_a	=	$P/A - M_L/Z_L + M_T/Z_T$
Base pressure on corner B	=	σ_b	=	$P/A + M_L/Z_L + M_T/Z_T$
Base pressure on corner C	=	σ_c	=	$P/A - M_L/Z_L - M_T/Z_T$
Base pressure on corner D	=	σ_d	=	$P/A + M_L/Z_L - M_T/Z_T$

Loads		Vertical Load(P) kN	$F_v = 0.3 \times \text{av} \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$M_L = P \times e_L$	M_L due to F_v
Superstructure		1298.968	69.962		-5065.975	-272.850
Substructure & Foundation		646.802	23.819		-2693.071	-100.747
Substructure & Foundation		15712.507	112.761		-105044.086	-558.915
Total =		17658.277	206.641		-112807.132	-932.512
			-206.641			932.512

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
203.65	1870.15	0.00	0.00	0.00	0.00	390.40	3940.51
207.68	1304.78	0.00	0.00	0.00	0.00	781.48	4909.75
4757.61	22100.86						
5168.94	25275.79	0.00	0.00	0.00	0.00	1171.88	8850.26

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
305.48	2805.22	0.00	0.00
283.64	1818.72	0.00	0.00
3070.374	12103.923		
759.255	4498.621		
4418.75	21226.49	0.00	0.00

Summary of Restoring Forces

Vertical Load	17451.635 kN
Moment	-113735.644 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN	$F_v = 0.3 \times \text{av} \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$M_L = P \times e_L$	M_L due to F_v
Total =	17658.277	206.641		-112807.03	-932.512
		-206.641			932.512

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
248.65	2283.38	0.00	0.00	0.00	0.00	415.88	4242.89
207.68	1304.78	0.00	0.00	0.00	0.00	781.48	4909.75
4757.61	22100.86						
280.79	1693.47						
5494.73	27382.50	0.00	0.00	0.00	0.00	1197.36	9152.64

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
305.48	2805.22	0.00	0.00
283.64	1818.72	0.00	0.00
3070.374	12103.923		
759.255	4498.621		
0.000	0.000		
0.000	0.000		
4418.75	21226.49	0.00	0.00

Summary of Restoring Forces

Vertical Load	17451.635 kN
Moment	-113739.544 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00

LOAD CASES	SAFE BEARING CAPACITY CHECK							SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_a	σ_b	σ_c	σ_d	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c \cdot A + F_p$	FOS	Restoring Moment = $\sum P \cdot e / \text{Toe} / \text{M}$
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm
Case 1 : DL+SIDL-Normal Dry Case	24670.862	-12262.927	4337.694	276.243	156.128	242.593	122.478	276.243	122.478	5200.365	15555.306	2.99	22321.192
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	25904.483	-7662.071	5870.953	269.626	194.577	224.082	149.032	269.626	149.032	6271.383	15555.306	2.48	28817.579
Normal HFL Case								SAFE	SAFE			SAFE	SAFE
Case 3 : DL+SIDL-Normal HFL Case	19043.744	-12910.947	4337.694	233.945	107.483	200.295	73.833	233.945	73.833	5200.365	12010.222	2.31	18937.510
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	19834.891	-8371.047	5117.708	221.129	139.136	181.428	99.435	221.129	99.435	6385.783	12216.072	1.91	26179.726
Longitudinal Seismic Dry Case								SAFE	SAFE			SAFE	SAFE
Case 5 : DL+SIDL-Long. Seismic Dry Case	25508.334	4462.129	6907.393	211.067	254.773	157.483	201.189	254.773	157.483	7697.065	15855.117	2.06	44680.177
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	25800.591	6024.934	7396.525	207.672	266.686	150.293	209.307	266.686	150.293	7697.065	15855.117	2.06	44680.177
Longitudinal Seismic HFL Case								SAFE	SAFE			SAFE	SAFE
Case 7 : DL+SIDL-Long. Seismic HFL Case	19834.585	4247.118	6992.772	166.603	208.203	112.356	153.956	208.203	112.356	7564.962	12216.145	1.61	42512.472
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	20048.866	5880.986	7239.487	161.290	218.893	105.129	162.732	218.893	105.129	7564.962	12216.145	1.61	42512.472
Transverse Seismic Dry Case								SAFE	SAFE			SAFE	SAFE
Case 9 : DL+SIDL-Trans. Seismic Dry Case	25508.334	-2769.566	12903.355	269.741	242.613	169.642	142.515	269.741	142.515	5220.142	15855.117	3.04	27666.270
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	25800.591	-1206.762	13818.276	267.998	256.178	160.802	148.981	267.998	148.981	4558.313	15855.117	3.48	23481.698
Transverse Seismic HFL Case								SAFE	SAFE			SAFE	SAFE
Case 11 : DL+SIDL-Trans. Seismic HFL Case	19834.585	-3161.055	13187.953	226.914	195.952	124.607	93.645	226.914	93.645	4418.751	12216.145	2.76	21226.488
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	20048.866	-1527.186	13646.332	222.422	207.463	116.559	101.600	222.422	101.600	4418.751	12216.145	2.76	21226.488
								SAFE	SAFE			SAFE	SAFE

DESIGN OF ABUTMENT(A2) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
86+415

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 18.750m	18.750m
Thickness of Expansion Joint	= 0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	= 20.000m	20.00m
Type of Superstructure	= CAST IN SITU RCC GIRDER	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on one side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m²
SBC of soil-Normal Case = 430 kN/m² Assumed
SBC of soil-Seismic Case = 538 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 2.285m	
Height of Trapering portion	= 0.454m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	= 1.850m	1.850m
Width of Abutmentcap at bottom of Tapering Portion	= 1.000m	1.000m
Projection of Abutment Cap (Span Side)	= 0.400m	0.400m

Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.082m	1.082m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	6.500m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.750m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	11.500m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	2.000m	
Width of Toe Slab	=	3.800m	
Width of Heel Slab	=	6.500m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.500m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.500m	
Width of backfill on heel slab	=	6.500m	
Thickness of heel slab at back fill edge	=	1.500m	
Height of back fill at bottom edge of heel slab	=	12.029m	
Height of back fill at back fill edge of heel slab	=	11.029m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1198.870m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1198.728m	Height of Superstructure	=	2.220m
Deck level at center line =	1198.870m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1196.585m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1196.060m	Height of Pedestal (3)	=	0.475m
Abutment cap bottom IV (uniform portion ends)	1195.760m	Height of Pedestal (4)	=	0.550m
Abutment cap bottom IV (corbel portion ends)	1195.460m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1195.460m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1190.292m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1187.770m	Height (Avg.) of Dirt Wall	=	2.739m
Foundation level =	1186.270m	Abutment shaft Above G.L	=	5.168m
HFL =	1192.292m	Abutment Shaft below G.L	=	2.522m
		Height of abutment shaft	=	7.690m
		MSL	=	1188.270m
		Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade		=	M 35	
Characteristic compressive strength of concrete, f_{ck}		=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}		=	15.63 Mpa at 28 , $(0.67/1.5 * f_{ck})$	
Tensile strength of concrete , f_{ctm}		=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}		=	0.02	
Ultimate Strain, ϵ_{cu2}		=	0.035	
E_{cm}		=	32308.250 N/mm ²	
Steel Grade		=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}		=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}		=	434.78 Mpa	$(1/1.15 * f_y)$
Modulus of Elasticity of Steel (E_s)		=	200000.00 Mpa	
Dry weight of Concrete		=	25 kN/m ³	
Dry unit weight of soil		=	20 kN/m ³	
Permissible Crack Width		=	0.3 mm	- For Moderate Exposure Condition
Maximum compressive stress in concrete under rare combination		=	0.48 f_{ck}	
		=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination		=	300	N/mm ²
<u>Creep Coefficient</u>				
For Abutment Shaft		=	2	for 90 days
For Footing		=	2	for 90 days
<u>Clear Cover to Reinforcement</u>				
Earth Face		=	75	mm
Non-Earth Face		=	50	mm
<u>Seismic Data:</u>				
Seismic Zone		=	5	
Z =Zone factor		=	0.36	
I =Importance factor		=	1.2	
R =Response Reduction factor		=	3	in Longitudinal direction
		=	1	In Transverse direction
<u>Properties of backfill material :</u>				
	c	=	0	
	ϕ	=	35	
	θ	=	90	
	β	=	0	
	δ	=	22.5	

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	426.37 4.50
DL Reaction on Bearing No.-2	=	408.04 1.50
DL Reaction on Bearing No.-3	=	408.04 -4.50
DL Reaction on Bearing No.-4	=	426.37 -1.50

DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		1668.82 0.033

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	169.870 4.50
SIDL Reaction on Bearing No.-2	=	-69.896 1.50
SIDL Reaction on Bearing No.-3	=	-69.896 -4.50
SIDL Reaction on Bearing No.-4	=	169.870 -1.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		199.95 3.597

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	60.349 4.50
SIDL Reaction on Bearing No.-2	=	65.835 1.50
SIDL Reaction on Bearing No.-3	=	65.835 -4.50
SIDL Reaction on Bearing No.-4	=	60.349 -1.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		252.37 -0.065

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	981.82	KN	Corr. Transv	=	932.730 kNm	ecc.	0.95
min	=	368.18	KN	Corr. Transv	=	349.770 kNm	ecc.	0.95

SV Loading

max	=	2003.04	KN	Corr. Transv	=	600.912 kNm	ecc.	0.30
min	=	1416.96	KN	Corr. Transv	=	425.088 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	682.86	KN	Corr. Transv	=	2154.416 kNm	ecc.	3.16
min	=	217.14	KN	Corr. Transv	=	685.084 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.091
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.091
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	-4.500
Pedestal 4	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.2160 m ³	-0.237

VOLUME CALCULATION

C.G. Of Footing	=	5.750 m
C.G. Of shaft from toe tip	=	4.400 m
Distance between c.g. of shaft and footing	=	1.350 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	2.285	8.569	-0.800	0.550	-5.200	0.000
-Trapering portion	1	12.50	0.300	0.454	1.702	-0.800	0.550	-5.200	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	0.250	-5.500	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-1.050	0.300	-5.450	0.000
Cap (uniform portion)	1	12.50	1.850	0.300	6.938	-0.025	1.325	-4.425	0.000
Cap (Corbel Portion)	1	12.50	1.850	0.300	5.263	-0.025	1.325	-4.425	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.041	3.168	41.231	0.079	1.429	-4.321	0.000
Shaft below HFL	1	12.50	1.141	4.022	57.374	0.029	1.379	-4.371	0.000
Solid Return Wall	2	6.50	0.625	11.600	94.250	-3.850	-2.500	-8.250	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.750	-5.000	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.750	-5.000	0.000
Footing									
Heel Slab	1	12.50	6.500	1.000	81.250		-1.958	-7.708	0.000
Toe Slab	1	12.50	3.800	1.000	47.500		3.533	-2.217	0.000
Portion between Heel and Toe	1	12.50	1.200	1.500	22.500		1.350	-4.400	0.000
Back filling above HFL over Heel Slab	1	12.50	6.500	6.578	534.462		-2.500	-8.250	0.000
Back filling below HFL over Heel Slab	1	12.50	6.500	5.022	408.037		-2.608	-8.358	0.000
Backfill above Heel slab	1	12.50	6.500	11.529	936.711		-2.547	-8.297	0.000
Front Filling over Toe Slab	1	12.50	3.800	3.022	143.545		3.745	-2.005	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.800	1.000	47.500		2.183	-3.567	0.000
Side filling between heel and toe	1	0.00	1.200	3.022	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	0.250	-5.500	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.082	6.578	6.775		0.831	-4.919	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.118	5.022	7.383		0.789	-4.961	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN		-0.800	0.550	-5.200

SECTIONAL PROPERTIES

Width of Footing (B)	=	11.500 m						
Length of Footing (L)	=	12.500 m						
A	=	11.500	x	12.500	=	143.750	m ²	
ZL	=	12.500	x	22.042	=	275.521	m ³	
ZT	=	IT1	+	IT2				
		distance of extreme point from centre						
IT1	=	11.500	x	162.760	=	1871.74	m ⁴	
IT2 (moment of inertia of triangle)	=	11.500	x	0.000	+	0.500 x 11.500 x		39.063
from centre of footing	=	0.000	m ⁴					
Moment of inertia of two triangle	=	0.000	m ⁴					
Total moment of inertia	=	1871.74	m ⁴					
Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250	m	
Total Section modulus (ZT)	=	299.479	m ³					

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Servicibility Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 10.190 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction

= 12.063 m

Abutment Cap Top Level - Foundation Level

= 9.790 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.10 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.040 m^4

Moment of Inertia , $I_{\text{transverse}}$ = 179.036 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 101.210 KN
 D = 2121.14 KN
 T = 0.2895 sec

Transverse Direction

Force = 13716.296 KN
 D = 2391.139 KN
 T = 0.0264 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.396

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.396

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.396

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.396

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.302

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.302	In Transverse direction
Av	=	0.201	In Vertical direction

For Design of Foundation

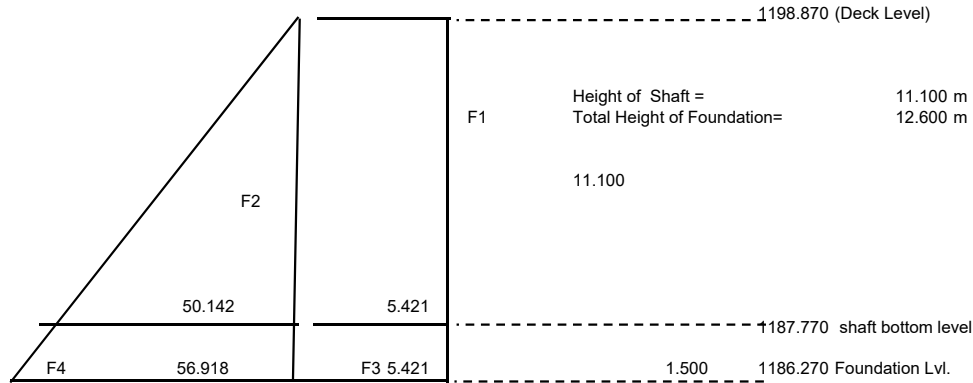
(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.302	In Transverse direction
Av	=	0.201	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1187.770 m (at Shaft Base)			
@ RL				1186.270 m (at Foundation Level)			
Due to Live Load Surcharge							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m^2
F1	=	5.421	x	11.100	x	12.500	= 752.137 kN
M1	=	752.14	x	5.55	=	4174.360	kN.m at Shaft Bottom
F3	=	5.421	x	12.600	x	12.500	= 853.777 kN
M3	=	853.777	x	6.300	=	5378.796	kN.m at Foundation
Due to Active Earth Pressure							
Intensity for triangular portion (At Shaft bottom level)							
=	0.226	x	20	x	11.100	=	50.142 kN/m^2
F2	=	0.5	x	50.14	x	11.100	x 12.50
	=	3478.633	kN				
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)							
M2	=	3478.63	x	4.66	=	16217.389	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
=	0.226	x	20	x	12.600	=	56.918 kN/m^2
F4	=	0.5	x	56.92	x	12.600	x 12.50
	=	4482.330	kN				
M4	=	4482.33	x	5.29	=	23720.489	kN.m at Foundation
Force Due To Fluid Pressure							
As per Cl. 214.1 of IRC :6 -2014			γ fluid	=	4.8	kN/m^3	
Intensity for triangular portion (At Shaft bottom level)							
=	4.800	x	11.100	=	53.280	kN/m^2	
F	=	0.5	x	53.280	x	11.100	x 12.500
	=	3696.300	kN				
M	=	3696.30	x	3.700	=	13676.310	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
=	4.800	x	12.600	=	60.48	kN/m^2	
F	=	0.5	x	60.480	x	12.60	x 12.500
	=	4762.800	kN				
M	=	4762.80	x	4.200	=	20003.760	kN.m at Foundation
Intensity of Passive pressure							
=	5.249	x	20	x	0.000	=	0.000 kN/m^2

Force due to passive @ Foundation, F
 = $0.5 \times$ 0.000 x 0.000 x 12.50
 = **0.000 kN**

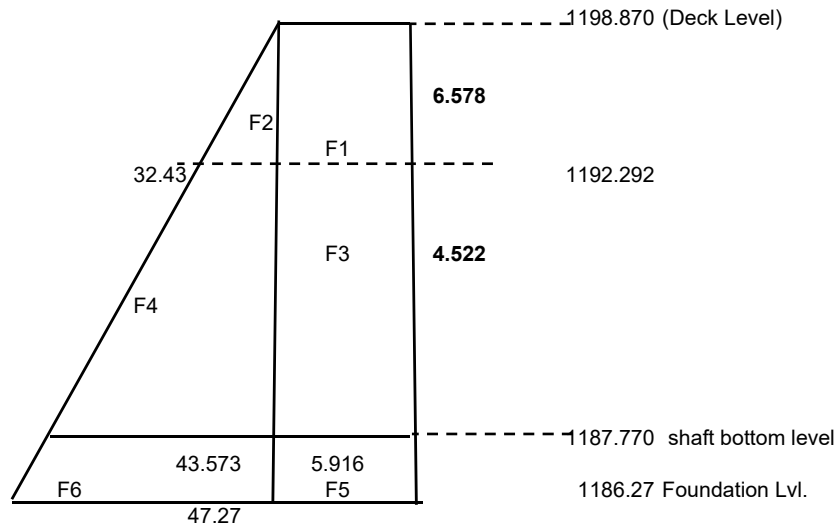
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = **0.000 kN.m** at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	16217.389	23720.489	3478.633	4482.330
Due to Minimum Fluid Pressure	13676.310	20003.760	3696.300	4762.800
Governing of Two	16217.389	23720.489	3696.300	4762.800
Due to Live Load Surcharge	4174.360	5378.796	752.137	853.777
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1187.8 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	11.100	x	12.500	=	820.779 kN
M1	=	820.78	x	5.55	=	4555.325 kN.m		at Shaft Bottom
F3	=	5.916	x	12.600	x	12.500	=	931.695 kN
M3	=	931.70	x	6.30	=	5869.681 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	6.578	=	32.427 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	4.522	=	11.146 kN/m ²
F2	=	0.5	x	32.43	x	6.578	x	12.50
	=	1333.153 kN						
F4	=	$\left(\frac{32.43 + 43.57}{2} \right) \times$				4.52	x	12.50
	=	2147.942 kN						
Total Force	=	3481.095 kN						
M2	=	1333.15	x	7.28	=	9711.697 kN.m		
M4	=	2147.94	x	2.15	=	4619.085 kN.m		

Total Moment = 14330.78 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 6.578 = 32.427 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 6.022 = 14.843 \text{ kN/m}^2$$

$$F2 = 0.5 \times 32.43 \times 6.578 \times 12.50 = 1333.153 \text{ kN}$$

$$F6 = \left(\frac{32.43 + 47.27}{2} \right) \times 6.02 \times 12.50 = 2999.593 \text{ kN}$$

Total Force = 4332.746 kN

$$M2 = 1333.15 \times 8.78 = 11711.426 \text{ kN.m}$$

$$M6 = 2999.59 \times 2.82 = 8471.071 \text{ kN.m}$$

Total Moment = 20182.50 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	14330.783	20182.498	3481.095	4332.746
Due to Minimum Fluid Pressure	13676.310	20003.760	3696.300	4762.800
Governing of Two	14330.783	20182.498	3696.300	4762.800
Due to Live Load Surcharge	4555.325	5869.681	820.779	931.695
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

$$\begin{aligned} \alpha h &= 0.180 \\ \alpha v &= 0.201 \\ \phi &= 35.00 & 0.611 \\ \delta &= 22.50 & 0.393 \\ \alpha &= 0.00 & 0.000 \\ \beta &= 0.00 & 0.000 \end{aligned}$$

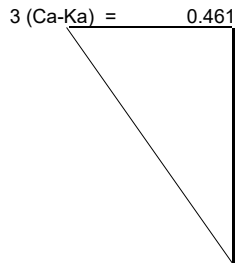
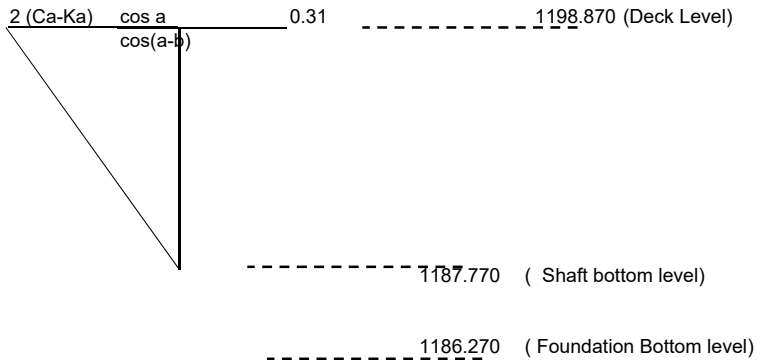
$$\begin{aligned} \alpha h &= \text{HORIZONTAL SEISMIC COEFFICIENT} \\ \alpha v &= \text{VERTICAL SEISMIC COEFFICIENT} \\ \phi &= \text{ANGLE OF INTERNAL FRICTION OF SOIL} \\ \delta &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL} \\ \alpha &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,} \\ \beta &= \text{SLOPE OF EARTH FILL} \end{aligned}$$

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.149 \\ 0.222 \end{matrix}$$

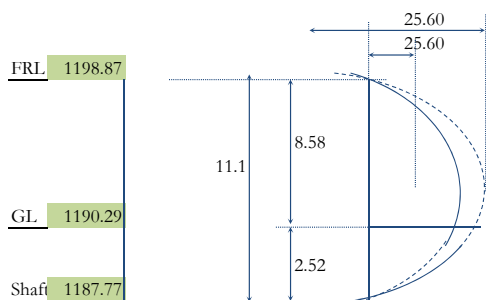
$$\begin{aligned} C_a &= \begin{matrix} 1 & 2 \\ 0.380 & 0.300 \end{matrix} \\ C_a &= 0.380 \\ K_a &= 0.226 \\ \text{Dynamic Increment} &= 0.380 \quad -0.226 \quad \mathbf{0.154} \end{aligned}$$

3 Earth Pressure :**DRY CASE (Seismic case)**

$$\begin{aligned} \text{Equivalent Live Load Surcharge height} &= 1.2 \text{ m} \\ \text{Assuming } \gamma_{\text{dry}} &= 20 \text{ kN/m}^3 \\ \gamma_{\text{water}} &= 10.00 \text{ kN/m}^3 \end{aligned}$$

Active Earth Pressure**Surcharge Earth Pressure****Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

$$\begin{aligned} &= 0.307 \quad \times \quad 20.00 \quad \times \quad 1.2 \quad = \quad 7.379 \text{ kN/m}^2 \\ \text{at Shaft Bottom Level} \\ E1 &= 0.50 \times 7.379 \times 11.100 \times 12.500 \\ &= \mathbf{511.930 \text{ kN}} \\ M1 &= 511.930 \times 7.437 = \mathbf{3807.225 \text{ kN.m}} \\ \text{at Foundation Bottom Level} \\ E2 &= 0.50 \times 7.379 \times 11.100 \times 12.500 \\ &= \mathbf{511.930 \text{ kN}} \\ M2 &= 511.930 \times 8.937 = \mathbf{4575.121 \text{ kN.m}} \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p _{mid_height}	=	25.60 t/m ²
h	=	11.1 m
y	=	3.028 m
L	=	12.500 m

Parabola below Water Level

p _{mid_height}	=	25.60 t/m ²
h	=	11.1 m
y	=	-3.028 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa T	cy m
Parabola above Water Level	2056.5	6.1
Parabola below Water Level	311.1	1.6
Total Dynamic Earth Pressure	2367.7	5.5

$$E3 = 2367.678 \text{ kN}$$

$$E4 = 2367.678 \text{ kN}$$

$$M3 = 2367.68 \times 5.55 = 13140.610 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 2367.68 \times 7.05 = 16692.126 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	16217.389	23720.489	3478.633	4482.330
Due to active Earth Pressure (dynamic Increment)	13140.610	16692.126	2367.678	2367.678
Total Earth Pressure	29357.999	40412.615	5846.311	6850.007
Due to Minimum Fluid Pressure	13676.310	20003.760	3696.300	4762.800
Governing of Two	16217.389	40412.615	5846.311	6850.007
Due to Live Load Surcharge (Static)	4174.360	5378.796	752.137	853.777
Due to Live Load Surcharge(Dynamic)	3807.225	4575.121	511.930	511.930
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

α	h	=	0.180				
α	v	=	0.201				
ϕ		=	35.00		0.611		
δ		=	11.25		0.196		
α		=	0.00		0.000		
β		=	0.00		0.000		
W_s		=	20.00	Kn/m ³	2.00	gm/cm ³	
λ		=	$\tan^{-1}$	$\frac{W_s}{W_s-1}$	$\frac{\alpha h}{(1 \pm \alpha v)}$		=
							0.291
							0.423
C_a'		=	0.552		0.515		
C_a'		=			0.552		
K_a'		=			0.246		
Dynamic Increment		=	0.552	-0.246			0.306
Dynamic Increment		=			0.306		
γ_d		=			20	kN/m ³	
γ_{sat}		=			10	kN/m ³	
γ_{water}		=			10	kN/m ³	
Equivalent Live Load Surcharge height		=			1.2	m	
Foundation		=			11.50	m	
Dynamic Active earth pressure Variation			3 ($ca'-ka'$)				
Dynamic Surcharge earth pressure Variation			2 ($Ca'-Ka'$)				
				$\cos a$			1198.870 (Deck Level)
				$\cos(a-b)$			
					6.578		
						1192.292 HFL	
					4.522		
						1187.770 shaft bottom level	
						1186.27 Foundation Bottom Lvl.	

Earth Pressure Diagram

h'	=	4.522
h	=	11.100

Dynamic active earth pressure

3 ($ca-ka$)	=	0.461	at deck level
3 ($ca'-ka'$)	=	0.918	at deck level
3 ($ca'-ka'$) h'/h	=	0.374	at HFL level

Dynamic Surcharge earth pressure

2 ($Ca'-Ka'$) $\frac{\cos a}{\cos(a-b)}$	=	0.612	at deck level	Pressure	=	14.69	kN/m ²
	=	0.249	at HFL level	Pressure	=	5.98	kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.379	kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	5.98	kN/m ²

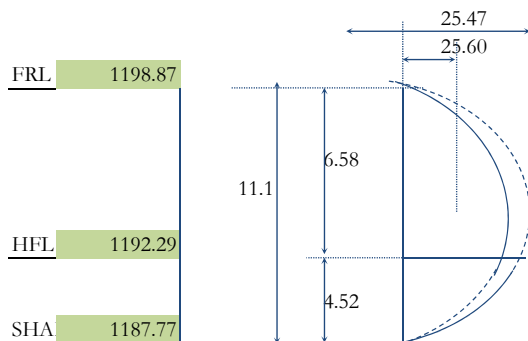
at Shaft Bottom Level

F1	=	6.681	x	6.578	x	12.500	=	549.376	kN
M1	=	549.38	x	7.81	=	4291.173	kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 5.984 \times 4.522 \times 12.500 \\
 &= \mathbf{169.110 \text{ kN}} \\
 M2 &= 169.11 \times 3.03 = \mathbf{512.361 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 718.486 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 4803.534 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 6.681 \times 6.578 \times 12.500 = \mathbf{549.376 \text{ kN}} \\
 M3 &= 549.38 \times 9.31 = \mathbf{5115.236 \text{ kN.m}} \\
 F4 &= 0.500 \times 5.984 \times 4.522 \times 12.500 \\
 &= \mathbf{169.110 \text{ kN}} \\
 M4 &= 169.11 \times 4.53 = \mathbf{766.027 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 718.486 \text{ kN} \\
 \text{Total Moment at Founding level} &= 5881.263 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 25.60 \text{ t/m}^2 \\
 h &= 11.1 \text{ m} \\
 y &= 1.028 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 25.47 \text{ t/m}^2 \\
 h &= 11.1 \text{ m} \\
 y &= -1.028 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1509.0	7.1
Parabola below Water Level	854.6	2.9
Total Dynamic Earth Pressure	2363.6	5.6

Total Force (F1 + F2)	=	2363.564 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	2363.564 kN	at Foundation Bottom Level

$$M1 = 2363.56 \times 5.55 = \mathbf{13128.787 \text{ kN.m}}$$

Total Mome = 13128.787 kN.m at Shaft Bottom

$$M1 = 2363.56 \times 7.05 = \mathbf{16674.134 \text{ kN.m}}$$

Total Mome = 16674.134 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	14330.783	20182.498	3481.095	4332.746
Due to active Earth Pressure (Dynamic Increment)	13128.787	16674.134	2363.564	2363.564
Total Earth Pressure	27459.570	36856.631	5844.659	6696.310
Due to Minimum Fluid Pressure	13676.310	20003.760	3696.300	4762.800
Governing of Two	27459.570	36856.631	5844.659	6696.310
Due to Live Load Surcharge(Static)	4555.325	5869.681	820.779	931.695
Due to Live Load Surcharge (Dynamic Increment)	4803.534	5881.263	718.486	718.486
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1668.82	1.35	1.35	2252.91	2252.91	
SIDL except wc	=	199.95	1.35	1.35	269.93	269.93	
WC	=	252.37	1.75	1.75	441.64	441.64	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	981.82	1.5	0.20	1472.73	196.36	(1-70RW)
CWLLmax-Reaction case	=	2003.04	1	0.20	2003.04	400.61	SV Loading
CWLLmin	=	368.18	1.5	0.20	552.27	73.64	(1-70RW)
CWLLmin	=	1416.96	1	0.20	1416.96	283.39	SV Loading
CWLLmax-Transv. Moment Case		682.86	1.5	0.20	1024.29	136.57	(1-70RW)

Braking Force = 0.2 x 1000 + 0.05 x 554
 = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2964.48	0	148.224	148.224	-148.224	148.224	
DL+SIDL+LL-Max Reaction case	3516.75	341.55	175.838	346.613	165.712	346.613	(1-70RW)
	4933.71	0	246.686	246.686	-246.686	246.686	SV Loading
DL+SIDL+LL-Min Reaction case	4437.22	341.55	221.861	392.636	119.689	392.636	(1-70RW)
	4967.52	0	248.376	248.376	-248.376	248.376	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3988.77	341.55	199.439	370.214	142.111	370.214	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	2964.48	0.00	148.224	148.224	-148.224	148.224	
DL+SIDL+LL-Max Reaction case		3038.12	45.54	151.906	174.676	-106.366	174.676	Dry Case
DL+SIDL+LL-Min Reaction case		3160.85	45.54	158.042	180.812	-112.502	180.812	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3101.06	45.54	155.053	177.823	-109.513	177.823	

Transverse Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	2964.48	0.000	148.224	148.224	-148.224	148.224	
DL+SIDL+LL-Max Reaction case		3038.12	45.540	151.906	174.676	-106.366	174.676	Dry Case

DL+SIDL+LL-Min Reaction case		3160.85	45.540	158.042	180.812	-112.502	180.812	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3101.06	45.540	155.053	177.823	-109.513	177.823	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1668.82	1.35	1.35	2252.91	2252.91
SIDL except wc	=	199.95	1.35	1.35	269.93	269.93
WC	=	252.37	1.75	1.75	441.64	441.64
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	981.82	1.5	0.75	1472.73	736.37
CWLLmax-Transv. Moment Case	=	682.86	1.5	0.75	1024.29	512.14
CWLLmin	=	368.18	1.5	0.75	552.27	276.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2964.48	0.000	148.224	148.224	-148.224	148.224	
DL+SIDL+LL-Max Reaction case	3516.75	341.550	175.838	346.613	165.712	346.613	(1-70RW)
	4933.71	0.000	246.686	246.686	-246.686	246.686	SV Loading
DL+SIDL+LL-Min Reaction case	4437.22	341.550	221.861	392.636	119.689	392.636	(1-70RW)
	4967.52	0.000	248.376	248.376	-248.376	248.376	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3988.77	341.550	199.439	370.214	142.111	370.214	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	2964.48	0.00	148.224	148.224	-148.224	148.224	
DL+SIDL+LL-Max Reaction case		3240.62	45.54	162.031	184.801	-116.491	184.801	Dry Case
DL+SIDL+LL-Min Reaction case		3700.85	45.54	185.043	207.813	-139.503	207.813	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3476.63	45.54	173.831	196.601	-128.291	196.601	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	2964.48	0.000	148.224	148.224	-148.224	148.224	
DL+SIDL+LL-Max Reaction case		3240.62	45.540	162.031	184.801	-116.491	184.801	Dry Case

DL+SIDL+LL-Min Reaction case		3700.85	45.540	185.043	207.813	-139.503	207.813	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3476.63	45.540	173.831	196.601	-128.291	196.601	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1668.82	1	1.00	1668.82	1668.82
SIDL except wc	=	199.95	1	1.00	199.95	199.95
WC	=	252.37	1	1.00	252.37	252.37
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	981.82	1	0.20	981.82	196.36
CWLLmax- Transv. Moment Case		682.86	1	0.20	682.86	136.57
CWLLmin	=	368.18	1	0.20	368.18	73.64

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	0.000	106.057	106.057	-106.057	106.057	
DL+SIDL+LL-Max Reaction case	2489.32	227.700	124.466	238.316	103.234	238.316	(1-70RW)
	3538.10	0.000	176.905	176.905	-176.905	176.905	SV Loading
DL+SIDL+LL-Min Reaction case	3102.96	227.700	155.148	268.998	72.552	268.998	(1-70RW)
	4124.18	0.000	206.209	206.209	-206.209	206.209	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2804.00	227.700	140.200	254.050	87.500	254.050	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	1030.874	106.057	621.494	924.817	1030.874	
DL+SIDL+LL-Max Reaction case	2194.77	1076.414	109.739	647.946	966.675	1076.414	Dry Case
DL+SIDL+LL-Min Reaction case	2317.50	1076.414	115.875	654.082	960.538	1076.414	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2257.71	1076.414	112.886	651.092	963.528	1076.414	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	309.262	106.057	260.688	203.205	309.262	
DL+SIDL+LL-Max Reaction case	2194.77	354.802	109.739	287.140	245.063	354.802	Dry Case
DL+SIDL+LL-Min Reaction case	2317.50	354.802	115.875	293.276	238.927	354.802	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2257.71	354.802	112.886	290.287	241.917	354.802	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1668.82	1.1	1.10	1835.71	1835.71
SIDL except wc	=	199.95	1.1	1.10	219.94	219.94
WC	=	252.37	1.35	1.35	340.70	340.70
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	981.82	1.5	0.00	1472.73	0.00
CWLLmax- Transv. Moment Case		682.86	1.5	0.00	1024.29	0.00
CWLLmin	=	368.18	1.5	0.00	552.27	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2396.34	0.000	119.817	119.817	-119.817	119.817	
DL+SIDL+LL-Max Reaction case	2948.61	341.550	147.431	318.206	194.119	318.206	(1-70RW)
	3813.30	0.000	190.665	190.665	-190.665	190.665	SV Loading
DL+SIDL+LL-Min Reaction case	3869.08	341.550	193.454	364.229	148.096	364.229	(1-70RW)
	4399.38	0.000	219.969	219.969	-219.969	219.969	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3420.63	341.550	171.032	341.807	170.518	341.807	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	2396.34	0.00	119.817	119.817	-119.817	119.817	
DL+SIDL+LL-Max Reaction case		2396.34	0.00	119.817	119.817	-119.817	119.817	Dry Case
DL+SIDL+LL-Min Reaction case		2396.34	0.00	119.817	119.817	-119.817	119.817	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2396.34	0.00	119.817	119.817	-119.817	119.817	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2121.14	2396.34	0.000	119.817	119.817	-119.817	119.817	
DL+SIDL+LL-Max Reaction case		2396.34	0.000	119.817	119.817	-119.817	119.817	Dry Case
DL+SIDL+LL-Min Reaction case		2396.34	0.000	119.817	119.817	-119.817	119.817	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2396.34	0.000	119.817	119.817	-119.817	119.817	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1668.82	1	1	1	1668.82	1668.82	1668.82
SIDL except wc	=	199.95	1	1	1	199.95	199.95	199.95
WC	=	252.37	1.20	1.20	1.20	302.84	302.84	302.84
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	981.82	1	0.75	0	981.82	736.37	0.00
CWLLmax- Transv. Moment Case	=	682.86	1	0.75	0	682.86	512.14	0.00
CWLLmin	=	368.18	1	0.75	0	368.18	276.13	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)		
DL+SIDL	2171.61	0.000	108.581	108.581	-108.581	108.581		
DL+SIDL+LL-Max Reaction case	2539.79	227.700	126.990	240.840	100.710	240.840	(1-70RW)	Dry Case
	3588.57	0.000	179.429	179.429	-179.429	179.429	SV Loading	
DL+SIDL+LL-Min Reaction case	3153.43	227.700	157.672	271.522	70.028	271.522	(1-70RW)	HFL Case
	4174.65	0.000	208.733	208.733	-208.733	208.733	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2854.47	227.700	142.724	256.574	84.976	256.574		

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2171.61	0.000	108.581	108.581	-108.581	108.581	
DL+SIDL+LL-Max Reaction case	2447.75	170.775	122.387	207.775	48.388	207.775	Dry Case
DL+SIDL+LL-Min Reaction case	2907.98	170.775	145.399	230.786	25.376	230.786	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2683.76	170.775	134.188	219.575	36.587	219.575	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2171.61	0.000	108.581	108.581	-108.581	108.581	
DL+SIDL+LL-Max Reaction case	2171.61	0.000	108.581	108.581	-108.581	108.581	Dry Case
DL+SIDL+LL-Min Reaction case	2171.61	0.000	108.581	108.581	-108.581	108.581	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2171.61	0.000	108.581	108.581	-108.581	108.581	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	981.82	kN	981.82	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1186.270 m

Properties of Footing Base:

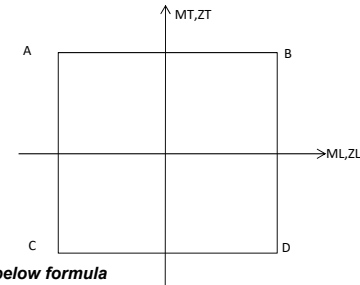
A	=	143.750	m ²
ZL	=	275.521	m ³
ZT	=	299.479	m ³

For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1668.823	1.350	2252.912	0.033	54.979
SIDL except Wearing Course	1			199.948	1.350	269.930	3.597	719.298
Wearing Course	1			252.368	1.350	340.696	-0.065	-16.459
Bearing Pedestal	1	25	1.216	30.400	1.350	41.040	-0.237	-7.200
				2151.539		2904.578		750.618
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	8.569	214.219	0.550	117.820	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.702	42.539	0.550	23.396	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.250	7.031	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.300	4.219	0.000	0.000
Cap - (uniform portion)	1	25	6.938	173.438	1.325	229.805	0.000	0.000
Cap - (corbel portion)	1	25	5.263	131.567	1.325	174.326	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.750	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.750	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.550	15.400	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.250	41.016	0.000	0.000
				796.012		613.014		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	94.250	2356.250	-2.500	-5890.625	0.000	0.000
Abutment Shaft	1	25	98.605	2465.126	1.379	3399.154	0.000	0.000
Back filling over heel slab	1	20	936.711	18734.219	-2.547	-47715.755	0.000	0.000
Front Filling over toe slab	1	20	143.545	2870.900	3.745	10752.132	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	81.250	2031.250	-1.958	-3977.865	0.000	0.000
Toe slab	1	25	47.500	1187.500	3.533	4195.833	0.000	0.000
portion between heel & toe	1	25	22.500	562.500	1.350	759.375	0.000	0.000
Vertical Components of active earth pressure	1			1972.816	-5.750	-11343.694	0.000	0.000
				32463.711		-49592.038		0.000
Total				35411.263		-46074.447		750.618

**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1501.941	-4.400	-6608.541
0.900	179.953	-4.400	-791.794
1.000	252.368	-4.400	-1110.417
0.900	27.360	-4.400	-120.384
	1961.622		-8631.136
0.900	192.797	-5.200	-1002.544
0.900	38.285	-5.200	-199.083
0.900	25.313	-5.500	-139.219
0.900	12.656	-5.450	-68.977
0.900	156.094	-4.425	-690.715
0.900	118.410	-4.425	-523.966
0.900	0.000	-5.000	0.000
0.900	0.000	-5.000	0.000
0.900	25.200	-5.200	-131.040
0.900	147.656	-5.500	-812.109
	716.411		-3567.652
0.900	2120.625	-8.250	-17495.156
0.900	2218.613	-4.371	-9697.786
0.900	16860.797	-8.297	-139893.762
0.900	2583.810	-2.005	-5179.989
0.900	0.000	0.000	0.000
0.900	1828.125	-7.708	-14091.797
0.900	1068.750	-2.217	-2369.063
0.900	506.250	-4.400	-2227.500
0.900	1775.535	-11.500	-20418.649
	29217.340		-212627.192
	31895.373		-224825.980

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	106.057	1196.585	1093.977
due to Earth pressure	1	4762.800		23720.489

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.915
due to Earth pressure	1.5	7144.200		35580.733
		7264.017		36816.648

Summary of Forces For SBC

P	35411.263	kN
ML	-21259.981	kNm
MT	750.618	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		35411.263		-46074.447		750.618
CWLL-Max. Reaction case	1	981.821	1.350	1325.458	0.950	932.730
Vertical Components of LL Surcharge	1	353.646	-5.750	-2033.465	0.000	0.000
Total		36746.730		-46782.454		1683.348

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	238.316	1196.585	2458.229
due to Earth pressure	1	4762.800		23720.489
due to Live load surcharge	1	853.777		5378.796

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		318.206	1196.585	3282.292
due to Earth pressure	1.5	7144.200		35580.733
due to Live load surcharge	1.2	1024.533		6454.555
		8486.938		45317.580

Summary of Forces For SBC

P	36746.730	kN
ML	-15224.941	kNm
MT	1683.348	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
106.06	1093.98	0.00	0.00
4762.80	23720.49	0.00	0.00
4868.857	24814.466	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
7144.20	35580.73	0.00	0.00
7264.017	36816.648	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	31895.37326		-224825.98
0.000		-4.400	0.00
0.900		-11.500	-3660.24
	31895.373		-228486.22

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
238.32	2458.23	0.00	0.00
4762.80	23720.49	0.00	0.00
853.777	5378.796	0.000	0.000
5854.89	31557.51	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
318.21	3282.29	0.00	0.00
7144.20	35580.73	0.00	0.00
1024.53	6454.55	0.00	0.00
8486.938	45317.580	0.000	0.000

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2151.539		2904.578		750.618
Substructure & Foundation -Portion 1				796.012		613.014		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	94.250	2356.250	-2.500	-5890.625	0.000	0.000
Shaft above HFL	1	25	41.231	1030.784	1.429	1473.125	0.000	0.000
Shaft below HFL	1	15	57.374	860.605	1.379	1186.685	0.000	0.000
Back filling above HFL over heel slab	1	20	534.462	10689.250	-2.500	-26723.125	0.000	0.000
Back filling below HFL over heel slab	1	10	408.037	4080.375	-2.608	-10641.042	0.000	0.000
Front Filling over toe slab	1	10	143.545	1435.450	2.183	3134.066	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	81.250	1218.750	-1.958	-2386.719	0.000	0.000
Toe slab	1	15	47.500	712.500	3.533	2517.500	0.000	0.000
Portion between Heel & Toe	1	15	22.500	337.500	1.350	455.625	0.000	0.000
Vertical Components of active earth pressure	1			1972.816	-5.750	-11343.694	0.000	0.000
				24903.603		-48047.317		0.000
Total				27851.155		-44529.726		750.618

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1961.622		-8631.136
	716.411		-3567.652
0.900	2120.625	-8.250	-17495.156
0.900	927.706	-4.321	-4008.497
0.900	774.544	-4.371	-3385.613
0.900	9620.325	-8.250	-79367.681
0.900	3672.337	-8.358	-30692.878
0.900	1291.905	-3.567	-4607.794
0.900	0.000	0.000	0.000
0.900	1096.875	-7.708	-8455.078
0.900	641.250	-2.217	-1421.438
0.900	303.750	-4.400	-1336.500
0.900	1775.535	-11.500	-20418.649
	22413.243		-172118.732
	25091.276		-184317.520

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	106.057	1196.585	1093.977
due to Earth pressure	1	4762.800		20182.498

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
106.06	1093.98	0.00	0.00
4762.80	20182.50	0.00	0.00
4868.86	21276.48	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.915
due to Earth pressure	1.5	7144.200		30273.747
		7264.017		31509.661

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
7144.20	30273.75	0.00	0.00
7264.02	31509.66	0.00	0.00

Summary of Forces For SBC

P	27851.155	kN
ML	-23253.251	kNm
MT	750.618	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		27851.155		-44529.726		750.618
CWLL-Min. Reaction case	1	368.179	1.350	497.042	0.950	349.770
Vertical Components of LL Surcharge	1	385.921	-5.750	-2219.045	0.000	0.000
Total		28605.255		-46251.729		1100.389

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	25091.276		-184317.520
0.000	0.000	-4.400	0
0.900	347.329	-11.500	-3994.281
	25438.605		-188311.801

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	268.998	1196.585	2774.714
due to Earth pressure	1	4762.800		20182.498
due to Live load surcharge	1	931.695		5869.681

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
269.00	2774.71	0.00	0.00
4762.80	20182.50	0.00	0.00
931.695	5869.681	0.000	0.000
5963.49	28826.89	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		364.229	1196.585	3757.020
due to Earth pressure	1.5	7144.200		30273.747
due to live load surcharge	1.2	1118.034		7043.617
		8626.463		41074.384

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
364.23	3757.02	0.00	0.00
7144.20	30273.75	0.00	0.00
1118.034	7043.617	0.000	0.000
8626.46	41074.38	0.00	0.00

Summary of Forces For SBC

P	28605.255	kN
ML	-17424.836	kNm
MT	1100.389	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

ah= 0.243 In Longitudinal direction
ah= 0.302 In Transverse direction
av= 0.201 In Vertical direction

Weight of shaft below Ground level

= 864.680 KN

Weight of back fill below Ground level

= 4098.250 KN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1668.823		150.974	100.649	1.350	2252.912	135.877	1198.065		0.033	54.979	1780.738
SIDL except Wearing Course	1			199.948		18.089	12.059	1.350	269.930	16.280	1199.319		3.597	719.298	236.039
Wearing Course	1			252.368		22.831	15.221	1.350	340.696	20.548	1198.870		-0.065	-16.459	287.671
Bearing Pedestal	1	25	1.216	30.400		2.750	1.833	1.350	41.040	2.475			-0.237	-7.200	
				2151.539		194.644	129.763		2904.578	175.180				750.618	2304.447
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	8.569	214.219	52.055	19.380	12.920	0.550	117.820	7.106	1197.728	596.422	0.000	0.000	222.044
Dirt Wall-Tapered portion	1	25	1.702	42.539	10.337	3.848	2.566	0.550	23.396	1.411	1196.358	104.281	0.000	0.000	38.823
Bracket - Uniform portion	1	25	1.125	28.125				0.250	7.031						
Bracket - Tapered portion	1	25	0.563	14.063				0.300	4.219						
Cap - (uniform portion)	1	25	6.938	173.438	42.145	15.690	10.460	1.325	229.805	13.860	1195.910	406.281	0.000	0.000	151.256
Cap - (corbel portion)	1	25	5.263	131.567	31.971	11.903	7.935	1.325	174.326	10.514	1195.610	298.607	0.000	0.000	111.170
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.750	0.000	0.000	1198.870	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.750	0.000	0.000	1198.870	0.000	0.000	0.000	0.000

RCC Railing or Crash Barrier	1			28.000				0.550	15.400				0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.250	41.016				0.000	0.000	
Substructure & Foundation -Portion 2				796.012	136.508	50.821	33.881		613.014	32.891		1405.591		0.000	523.292
Solid Return wall	1	25	94.250	2356.250	572.569	213.164	142.109	-2.500	-5890.625	-355.273	1193.106	3913.865	0.000	0.000	1457.106
Abutment Shaft	1	25	98.605	2465.126	388.908	144.788	96.525	1.379	3399.154	133.098	1192.876	2569.129	0.000	0.000	956.470
Back filling over heel slab	1	20	936.711	18734.219	0.000	0.000	0.000	-2.547	-47715.755	0.000	1193.106	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	143.545	2870.900				3.745	10752.132				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	81.250	2031.250				-1.958	-3977.865				0.000	0.000	
Toe slab	1	25	47.500	1187.500				3.533	4195.833				0.000	0.000	
portion between heel & toe	1	25	22.500	562.500				1.350	759.375				0.000	0.000	
Vertical component of active earth pressure	1			1856.642				-5.750	-10675.690				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			980.724				-5.750	-5639.164				0.000	0.000	
				33328.261	961.477	357.952	238.634		-54563.198	-222.174		6482.994		0.000	2413.576
Total =				36275.812	1097.985	603.417	402.278		-51045.607	-14.104		7888.585		750.618	5241.315
								-402.278		14.104					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.9			1501.941	90.584	-4.400	-6608.541	-398.571
SIDL except Wearing Course	0.9			179.953	10.853	-4.400	-791.794	-47.754
Wearing Course	1.00			252.368	15.221	-4.400	-1110.417	-66.971
Bearing Pedestal	0.9	25	1.216	27.360		-4.400	-120.384	
				1961.622	116.658		-8631.136	-513.297
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	8.569	192.797	11.628	-5.200	-1002.544	-60.465
Dirt Wall-Tapered portion	0.9	25	1.702	38.285	2.309	-5.200	-199.083	-12.007
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	6.938	156.094	9.414	-4.425	-690.715	-41.658
Cap - (corbel portion)	0.9	25	5.263	118.410	7.142	-4.425	-523.966	-31.601
Cantilever Return Wall-Rectangle portion	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
Cantilever Return Wall-Traingle portion	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.200	-131.040	
Approach Slab	0.9	25	6.563	147.656		-5.500	-812.109	
				716.411	30.493		-3359.457	-145.731
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	98.605	2218.613	81.658	-4.371	-9697.786	-356.935
Solid Return wall	0.9	25	94.250	2120.625	127.898	-8.250	-17495.156	-1055.160
Back filling over heel slab	0.9	20	936.711	16860.797	0.000	-8.297	-139893.8	0.000
Front Filling over toe	0.9	20	143.545	2583.810		-2.005	-5179.989	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	81.250	1828.125		-7.708	-14091.797	
Toe slab	0.9	25	47.500	1068.750		-2.217	-2369.063	
portion between heel & toe	0.9	25	22.500	506.250		-4.400	-2227.500	
Vertical component of active earth pressure	0.9			1775.535		-11.500	-20418.649	
Vertical component of dynamic increment of earth pressure	0.9			882.652		-11.500	-10150.495	
				30099.992	209.556		-222777.69	-1412.094

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	52.055	1197.728	596.422
1.0	10.337	1196.358	104.281
1.0	42.145	1195.910	406.281
1.0	31.971	1195.610	298.607
1.0	0.000	1198.870	0.000
1.0	0.000	1198.870	0.000
	136.508		1405.591
1.0	365.562	1192.876	2414.903
1.0	572.569	1193.106	3913.865
1.0	0.000	1193.106	0.000
	938.131		6328.768

Total =				32778.025	356.707	-234768.28	-2071.122
					-356.707		2071.122

	1074.639		7734.359

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1030.874	194.644	1196.585	10633.460	2304.447
due to Substructure	1	1097.985	408.773		7888.585	2936.868
due to Earth pressure	1	6850.007			40412.615	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1030.87	10633.46	0.00	0.00	0.00	0.00	194.64	2304.45
1097.99	7888.58	0.00	0.00	0.00	0.00	408.77	2936.87
6850.01	40412.62						
8978.87	58934.66	0.00	0.00	0.00	0.00	603.42	5241.32

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.91
due to Substructure	1.5	1611.959		11601.54
due to Active Earth pressure	1	4482.330		23720.49
due to dynamic Earth pressure	1.5	3551.516		25038.19
		9765.622		61596.132

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
1611.96	11601.54	0.00	0.00
4482.330	23720.489	0.000	0.000
3551.516	25038.190	0.000	0.000
9765.62	61596.13	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	36678.090	35873.535	kN
ML	7874.950	7903.157	kNm
MT	5991.934	5991.934	kNm

Summary of Restoring Forces

Vertical Load	32421.318	kN
Moment	-236839.402	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2151.539		194.644	129.763		2904.578	175.180				750.618	2304.447
Forces from Substructure				34124.273	1097.985	408.773	272.515		-53950.185	-189.283		7888.585		0.000	2936.868
CWLL-Max. Reaction case	0.20			196.36		17.765	11.843	1.350	265.092	15.988	1200.070		0.950	186.546	245.151
Vertical component of LL Surcharge	0.20			70.73				-5.750	-406.693				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			42.41				-5.750	-243.856				0.000	0.000	
Total =				36585.315	1097.985	621.181	414.121		-51431.064	1.884		7888.585		937.164	5486.466

-414.121

-1.884

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1961.622	116.658	0.000	-8631.14	-513.297
Forces from Substructure				30816.403	240.049	0.000	-226137.14	-1557.826
CWLL-Max. Reaction case	0.00			0.00	0.000	-4.400	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-11.500	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-11.500	0.00	

Total =				32778.025	356.707		-234768.28	-2071.122
					-356.707			2071.122

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1076.414	212.408	1196.585	11103.205	2549.598
due to Substructure	1	1097.985	408.773		7888.585	2936.868
due to Earth pressure	1	6850.007			40412.615	
due to Live load surcharge	0.20	273.141			1990.783	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1076.41	11103.21	0.00	0.00	0.00	0.00	212.41	2549.60
1097.99	7888.58	0.00	0.00	0.00	0.00	408.77	2936.87
6850.01	40412.62						
273.14	1990.78						
9297.55	61395.19	0.00	0.00	0.00	0.00	621.18	5486.47

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.915
due to Substructure	1.5	1611.959		11601.538
due to Active Earth pressure	1	4482.330		23720.489
due to dynamic Earth pressure	1.5	3551.516		25038.1896
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9765.622		61596.132

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
1611.96	11601.54	0.00	0.00
4482.330	23720.489		
3551.516	25038.190		
0.000	0.000		
0.000	0.000		
9765.62	61596.13	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	36999.436	36171.195	kN
ML	9966.009	9962.240	kNm
MT	6423.630	6423.630	kNm

Summary of Restoring Forces

Vertical Load	32421.318	kN
Moment	-236839.402	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Pxel1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Pxet	MTs due to FT
Superstructure				2151.539		194.644	129.763		2904.578	175.180				750.618	2304.447
Substructure & Foundation -Portion 1				796.012	136.508	50.821	33.881		613.014	32.891		1405.591		0.000	523.292
Substructure & Foundation -Portion 2															
Solid Return wall	1		94.25	2356.25	572.569	213.164	142.109	-2.50	-5890.625	-355.273	1193.11	3913.865	0.00	0.000	1457.106
Shaft above HFL	1	25	41.231	1030.784	250.481	93.252	62.168	1.429	1473.125	88.846	1193.876	1905.156	0.000	0.000	709.277
Shaft below HFL	1	15	57.374	860.605	138.428	51.536	34.357	1.379	1186.685	47.375	1191.292	695.184	0.000	0.000	258.812
Back filling above HFL over heel slab	1	20	534.462	10689.250	0.000	0.000	0.000	-2.500	-26723.125	0.000	1195.581	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	408.037	4080.375	0.000	0.000	0.000	-2.608	-10641.042	0.000	1189.656	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	143.545	1435.450				2.183	3134.066				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	81.250	1218.750				-1.958	-2386.719				0.000	0.000	
Toe slab	1	15	47.500	712.500				3.533	2517.500				0.000	0.000	
portion between heel & toe	1	15	22.500	337.500				1.350	455.625				0.000	0.000	
Vertical component of active earth pressure	1			1794.682				-5.750	-10319.422				0.000	0.000	

Vertical component of dynamic increment of earth pressure	1			979.020				-5.750	-5629.367				0.000	0.000	
				25704.489	1012.343	376.888	251.259		-52823.298	-219.051		6825.380		0.000	2541.044
Total =				28652.041	1148.851	622.354	414.902		-49305.707	-10.981		8230.971		750.618	5368.784
								-414.902		10.981					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1961.622	116.658		-8631.136	-513.297
Substructure & Foundation -Portion 1				716.411	30.493		-3359.457	-145.731
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	94.25	2120.625	127.898	-8.25	-17495.156	-1055.160
Shaft above HFL	0.9	25	41.231	927.706	55.951	-4.321	-4008.497	-241.759
Shaft below HFL	0.9	15	57.374	774.544	25.706	-4.371	-3385.613	-112.365
Back filling above HFL over heel slab	0.9	20	534.462	9620.325	0.000	-8.250	-79367.681	0.000
Back filling below HFL over heel slab	0.9	10	408.037	3672.337	0.000	-8.358	-30692.878	0.000
Front Filling ovetoe	0.9	10	143.545	1291.905		-3.567	-4607.794	
Side filling between heel and toe	0.9	10	0.000	0.000		0.000	0.000	
Heel slab	0.9	15	81.250	1096.875		-7.708	-8455.078	
Toe slab	0.9	15	47.500	641.250		-2.217	-1421.438	
portion between heel & toe	0.9	15	22.500	303.750		-4.400	-1336.500	
Vertical component of active earth pressure	0.9			1615.214		-11.500	-18574.959	
Vertical component of dynamic increment of earth pressure	0.9			881.118		-11.500	-10132.860	
				23134.040	220.918		-180407.90	-1465.340
Total =				25812.073	368.069		-192398.49	-2124.368
						-368.069		2124.368

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	136.508		1405.591
1.0	572.569	1193.106	3913.865
1.0	250.481	1193.876	1905.156
1.0	115.081	1191.292	577.939
1.0	0.000	1195.581	0.000
1.0	0.000	1189.656	0.000
	938.131		6396.960
	1074.639		7802.551

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1030.874	194.644	1196.585	10633.460	2304.447
due to Substructure	1	1148.851	427.710		8230.971	3064.336
due to Earth pressure	1	6696.310			36856.631	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.915
due to Substructure	1.5	1611.959		11703.826
due to Active Earth pressure	1	4332.746		20182.498
due to dynamic Earth pressure	1.5	3545.346		25011.200
		9609.868		58133.439

Summary of Forces For SBC

	Downward	Upward	
P	29066.943	28237.138	kN
ML	6404.375	6426.337	kNm

Summary of Restoring Forces

Vertical Load	25444.004	kN

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1030.87	10633.46	0.00	0.00	0.00	0.00	194.64	2304.45
1148.85	8230.97	0.00	0.00	0.00	0.00	427.71	3064.34
6696.31	36856.63						
8876.03	55721.06	0.00	0.00	0.00	0.00	622.35	5368.78

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
1611.96	11703.83	0.00	0.00
4332.746	20182.498		
3545.346	25011.200		
9609.87	58133.44	0.00	0.00

MT	6119.402	6119.402	kNm

Moment	-194522.863	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = $P \times eL1$	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = $P \times eT$	MTs due to FT
Forces from Superstructure				2151.539		194.644	129.763		2904.578	175.180				750.618	2304.447
Forces from Substructure				26500.502	1148.851	427.710	285.140		-52210.284	-186.160		8230.971		0.000	3064.336
CWLL-Max. Reaction case	0.20			73.64		6.662	4.441	1.350	99.408	5.995	1200.070		0.950	69.954	91.931
Vertical component of LL Surcharge	0.20			77.18				-5.750	-443.809				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			59.52				-5.750	-342.248				0.000	0.000	
Total =				28862.382	1148.851	629.015	419.343		-49992.355	-4.985		8230.971		820.573	5460.714
						-419.343				4.985					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1961.622	116.658		-8631.136	-513.297
Forces from Substructure				23850.451	251.411		-183767.36	-1611.071
CWLL-Max. Reaction case	0.00			0.00	0.00		-4.40	0.00
Vertical component of LL Surcharge	0.00			0.00		-4.400	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-11.500	0.000	0.000
Total =				25812.073	368.069		-192402.89	-2124.368
					-368.069			2124.368

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1076.414	201.306	1196.585	11103.205	2396.378
due to Substructure	1	1148.851	427.710		8230.971	3064.336
due to Earth pressure	1	6696.310			36856.631	
due to Live load surcharge	0.20	330.036			2350.189	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1076.41	11103.21	0.00	0.00	0.00	0.00	201.31	2396.38
1148.85	8230.97	0.00	0.00	0.00	0.00	427.71	3064.34
6696.31	36856.63						
330.04	2350.19						
9251.61	58541.00	0.00	0.00	0.00	0.00	629.02	5460.71

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.915
due to Substructure	1.5	1611.959		11703.8258
due to Active Earth pressure	1	4332.746		20182.498
due to dynamic Earth pressure	1.5	3545.346		25011.2003
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9609.868	58133.439	

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
119.82	1235.91	0.00	0.00
1611.96	11703.83	0.00	0.00
4332.746	20182.498		
3545.346	25011.200		
0.000	0.000		
0.000	0.000		
9609.87	58133.44	0.00	0.00

Vertical Load	25444.004	kN
Moment	-194527.263	kNm

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	136.508		1405.591
	938.131		6328.768
	1074.639		7734.359

Vertical Load	32421.318	kN
Moment	-236839.402	kNm

MT	18221.670	18221.670	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	36585.315	414.121	-51431.06	1.884	937.164
		-414.121		-1.884	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	354.802	708.028	1196.585	3659.783	8498.659
due to Substructure	1	329.396	1362.576		2366.575	9789.561
due to Earth pressure	1	6850.007			40412.615	
due to Live load surcharge	0.2	273.141			1990.783	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.82	1196.585	1235.915
due to Substructure	1.5	483.59		3480.461
due to Active Earth pressure	1	4482.33		23720.489
due to dynamic Earth pressure	1.5	1065.45		7511.457
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		6151.19		35948.322

Summary of Forces For SBC

	Downward	Upward	
P	36999.436	36171.195	kN
ML	-2999.423	-3003.191	kNm
MT	19225.385	19225.385	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure	2151.539	129.763	2904.578	175.180	750.618
Substructure & Foundation -Portion 1	796.012	33.881	613.014	32.891	0.000
Substructure & Foundation -Portion 2	25704.489	251.259	-52823.298	-219.051	0.000
Total =	28652.041	414.902	-49305.707	-10.981	750.618
		-414.902		10.981	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	32778.025	356.707	-234768.28	-2071.122
		-356.707		2071.122

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
354.80	3659.78	0.00	0.00	0.00	0.00	708.03	8498.66
329.40	2366.58	0.00	0.00	0.00	0.00	1362.58	9789.56
6850.01	40412.62						
273.14	1990.78						
7807.35	48429.76	0.00	0.00	0.00	0.00	2070.60	18288.22

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
119.82	1235.91	0.00	0.00
483.59	3480.46	0.00	0.00
4482.330	23720.489		
1065.455	7511.457		
0.000	0.000		
0.000	0.000		
6151.19	35948.32	0.00	0.00

Summary of Restoring Forces

Vertical Load	32421.318	kN
Moment	-236839.402	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure	1961.622	116.658		-8631.136	-513.297
Substructure & Foundation	716.411	30.493		-3359.457	-145.731
Substructure & Foundation	23134.040	220.918		-180407.902	-1465.340
Total =	25812.073	368.069		-192398.495	-2124.368
		-368.069			2124.368

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	309.26	648.81	1196.59	3190.04	7681.49
due to Substructure	1	344.66	1425.70		2469.29	10214.45
due to Earth pressure	1	6696.31			36856.63	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.817	1196.585	1235.91
due to Substructure	1.5	483.588		3511.15
due to Active Earth pressure	1	4332.746		20182.50
due to dynamic Earth pressure	1.5	1063.604		7503.36
		5999.754		32432.92

Summary of Forces For SBC

	Downward	Upward	
P	29066.943	28237.138	kN
ML	-6800.727	-6778.765	kNm
MT	18646.563	18646.563	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	28862.382	419.343	-49992.36	-4.985	820.573
		-419.343		4.985	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	354.802	671.01854	1196.585	3659.783	7987.92582
due to Substructure	1	344.655	1425.6987		2469.291	10214.4544
due to Earth pressure	1	6696.310			36856.631	
due to Live load surcharge	0.2	330.036			2350.189	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		119.82	1196.585	1235.91
due to Substructure	1.5	483.59		3511.15
due to Active Earth pressure	1	4332.75		20182.50
due to dynamic Earth pressure	1.5	1063.60		7503.36
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
309.26	3190.04	0.00	0.00	0.00	0.00	648.81	7681.49
344.66	2469.29	0.00	0.00	0.00	0.00	1425.70	10214.45
6696.31	36856.63						
7350.23	42515.96	0.00	0.00	0.00	0.00	2074.51	17895.95

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
483.59	3511.15	0.00	0.00
4332.746	20182.498		
1063.604	7503.360		
5999.75	32432.92	0.00	0.00

Summary of Restoring Forces

Vertical Load	25444.004	kN
Moment	-194522.863	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Total =	25812.073	368.069		-192402.89	-2124.368
		-368.069			2124.368

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
354.80	3659.78	0.00	0.00	0.00	0.00	671.02	7987.93
344.66	2469.29	0.00	0.00	0.00	0.00	1425.70	10214.45
6696.31	36856.63						
330.04	2350.19						
7725.80	45335.89	0.00	0.00	0.00	0.00	2096.72	18202.38

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
119.82	1235.91	0.00	0.00
483.59	3511.15	0.00	0.00
4332.746	20182.498		
1063.604	7503.360		
0.000	0.000		
0.000	0.000		

5999.75 32432.92 5999.75 32432.92 0.00 0.00

Summary of Forces For SBC			
	Downward	Upward	
P	29281.725	28443.038	KN
ML	-4661.446	-4651.475	kNm
MT	19022.953	19022.953	kNm

Summary of Restoring Forces	
Vertical Load	25444.004 kN
Moment	-194527.263 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00
Transverse Moment due to C.F. = 0.000 x (1200.070 -

1186.270) = 0.000 KN
0.000 kNm

Normal

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00
Transverse Moment due to C.F. = 0.000 x (1200.070 -

1186.270) = 0.000 KN
0.000 kNm

Seismic

0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = $P/A - ML/ZL + MT/ZT$
Base pressure on corner B = σ_B = $P/A + ML/ZL + MT/ZT$
Base pressure on corner C = σ_C = $P/A - ML/ZL - MT/ZT$
Base pressure on corner D = σ_D = $P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force = $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\sum P.e_{Toe+M_p}$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	35411.263	-21259.981	750.618	326.009	171.683	320.996	166.670	326.009	166.670	7264.017	22326.761	3.07	36816.648	224825.98	6.11
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	36746.730	-15224.941	1683.348	316.509	205.992	305.267	194.750	316.509	194.750	8486.938	22326.761	2.63	45317.580	228486.22	5.04
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	27851.155	-23253.251	750.618	280.651	111.856	275.638	106.843	280.651	106.843	7264.017	17563.893	2.42	31509.661	184317.52	5.85
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	28605.255	-17424.836	1100.389	265.911	139.424	258.562	132.075	265.911	132.075	8626.463	17807.023	2.06	41074.384	188311.80	4.58
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	36678.090	7903.157	5991.934	246.475	303.844	206.460	263.829	303.844	206.460	9765.622	22694.923	2.32	61596.132	236839.40	3.85
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	36999.436	9966.009	6423.630	242.665	315.008	199.767	272.110	315.008	199.767	9765.622	22694.923	2.32	61596.132	236839.40	3.85
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	29066.943	6426.337	6119.402	199.314	245.963	158.447	205.096	245.963	158.447	9609.868	17810.803	1.85	58133.439	194522.86	3.35
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	29281.725	8553.627	6281.287	193.628	255.718	151.680	213.770	255.718	151.680	9609.868	17810.803	1.85	58133.439	194527.26	3.35
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	36678.090	-5062.274	18221.670	334.370	297.623	212.681	175.934	334.370	175.934	7279.560	22694.923	3.12	44069.399	236839.40	5.37
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	36999.436	-2999.423	19225.385	332.470	310.697	204.078	182.305	332.470	182.305	6151.189	22694.923	3.69	35948.322	236839.40	6.59
								SAFE	SAFE			SAFE			SAFE

Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	29066.943	-6778.765	18646.563	289.072	239.865	164.545	115.338	289.072	115.338	5999.754	17810.803	2.97	32432.920	194522.86	6.00
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	29281.725	-4651.475	19022.953	284.102	250.337	157.061	123.296	284.102	123.296	5999.754	17810.803	2.97	32432.920	194527.26	6.00
								SAFE	SAFE			SAFE			SAFE

***DESIGN OF PIER P1AND
ITS FOUNDATION
FOR MINOR BRIDGE AT CH- 86+415***

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle	:	0	degree	0	Radian		
		Left span		Right span		Unit	
		Right	Skew	Right	Skew		
C/C Expansion joint	=	25.000	25.000	25.000	25.00	m	
C/C Expansion joint to C.L. brg	=	0.625	0.625	0.625	0.63	m	
Expansion gap	=	50	50	50	50	mm	
C/C bearing	=	23.750	23.750	23.750	23.750	m	

SUPERSTRUCTURE DETAILS

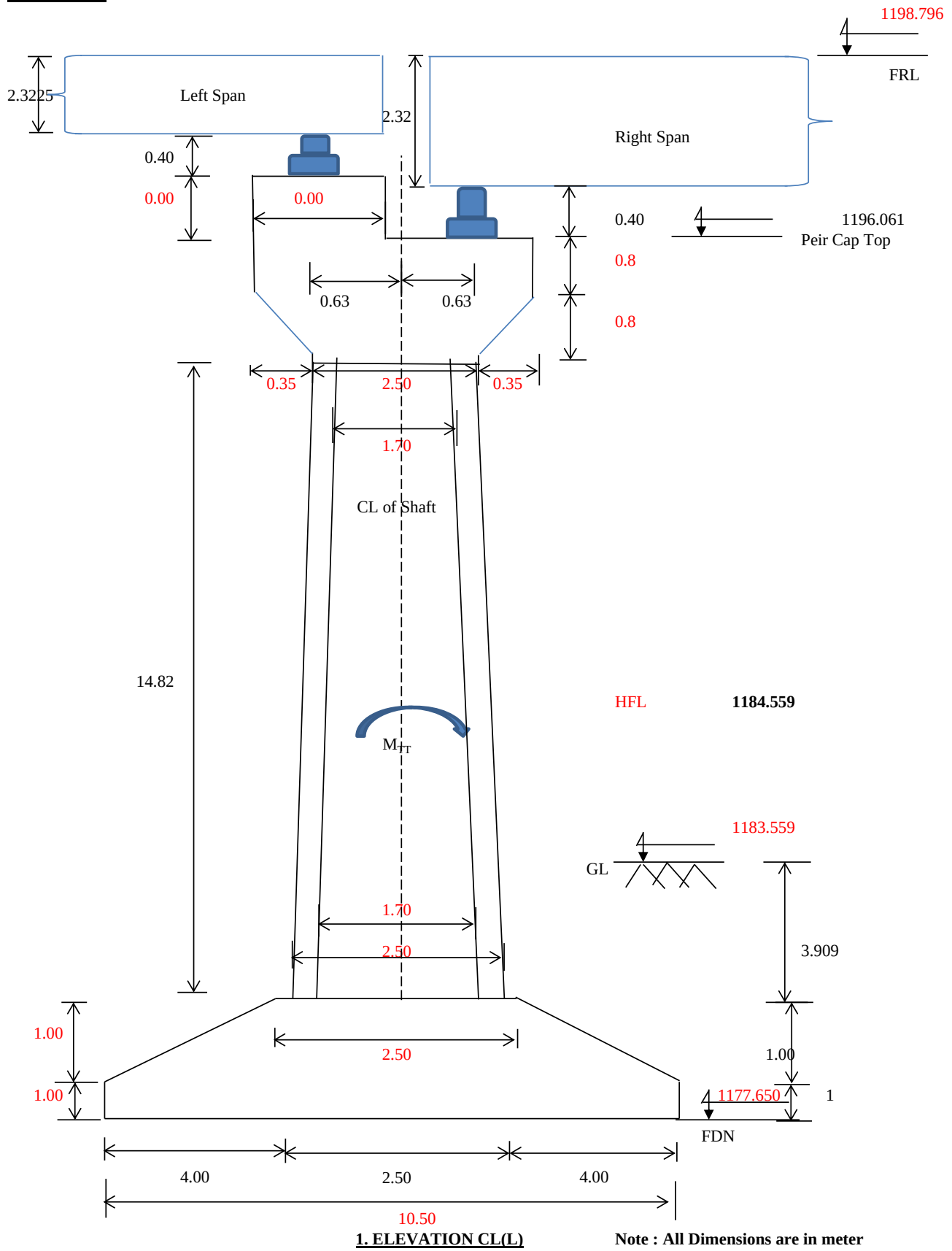
		Left Span	Right Span	
Overall deck width of bridge	=	12.50 m	12.50 m	
Carriage way width	=	11.50 m	11.50 m	
Crash barrier width	=	0.50 m	0.50 m	
Height of crash barrier	=	1.00 m	1.00 m	
C.g of Crash barrier from bottom	=	0.40 m	0.40 m	
Cross-slope	=	2.50 %	2.50 %	
Wearing coat thickness	=	65 mm	65 mm	
Nos. of Bearing	=	4	4	
Spacing of Bearing	=	3.00 m	3.00 m	
Depth of Girder	=	2.000 m	2.000 m	
Depth of slab	=	0.22 m	0.22 m	
Depth of superstructure	=	2.220 m	2.220 m	
Bearing + Pedestal height	=	0.40 m	0.40 m	
Width of main girder at top	=	1.00 m	1.00 m	
Width of cross girder	=	0.40 m	0.40 m	
Nos. of cross-girders	=	2	2	
FRL to Soffit	=	2.32 m	2.32 m	
Type of Bearing				OR SPHERICAL BR

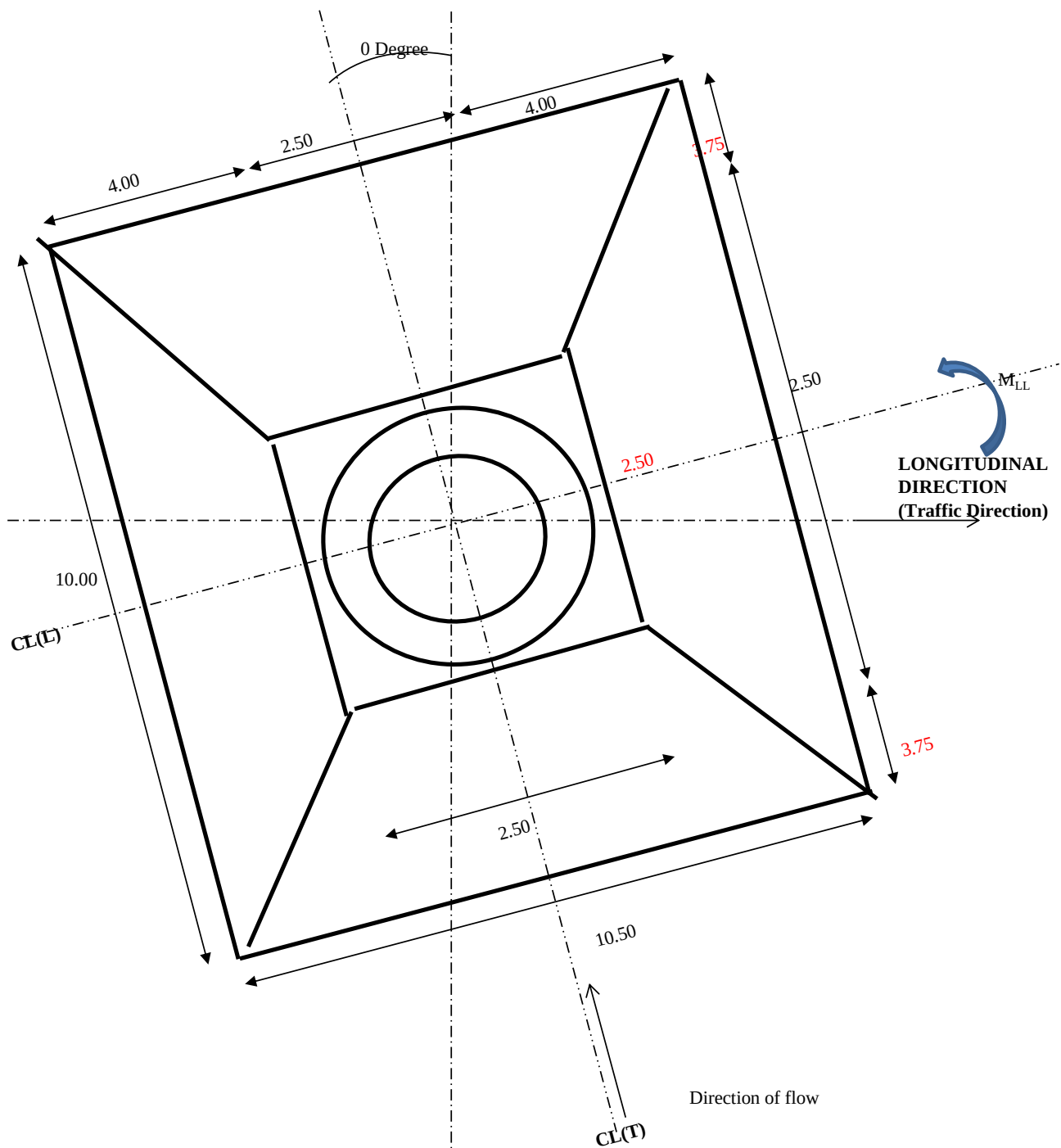
LEVEL DETAILS

Formation level	=	1198.796 m
Pier cap top level	=	1196.061 m
HFL	=	1184.559 m
Ground level	=	1183.559 m
MSL (Normal)/Rock Level	=	1183.559 m
MSL (Seismic)/Rock Level	=	1183.559 m
Pier shaft bottom/Footing top level	=	1179.638 m
Founding level	=	1177.650 m

DIMENSION DETAILS

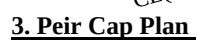
Pier cap:		Right	Skew
Width of pier cap at top	=	3.20 m	3.20 m
Width of pier cap at bottom	=	3.20 m	3.20 m
Length of pier cap at top	=	11.50 m	11.50 m
Length of pier cap at bottom	=	3.00 m	3.00 m
Thickness of uniform portion	=	0.80 m	0.80 m
Thickness of tapered portion	=	0.80 m	0.80 m
Pier shaft:			
Width of pier at top	=	2.50 m	2.50 m
Width of pier at bottom	=	2.50 m	2.50 m
Length of pier (rectangle portion)	=	0.00 m	0.00 m
Length of pier(end circular portion Top)	=	1.25 m	1.25 m
Length of pier (end circular portion Bottom)	=	1.25 m	1.25 m
Total length of pier shaft at top	=	2.50 m	2.50 m
Total length of pier shaft at bottom	=	2.50 m	2.50 m
Footing:			
Width of footing at top	=	2.50 m	2.50 m
Width of footing at bottom	=	10.50 m	10.50 m
Length of footing	=	10.00 m	10.00 m
Thickness at tip	=	1.00 m	1.00 m
Maximum thickness	=	2.00 m	2.00 m

DIAGRAMS:



Note : All Dimensions are in meter

2. PLAN SHOWING FOOTING & PIER SHAFT



Pier P1 AT CH. 86+415.xlsm

2. MATERIALS DETAILS**CONCRETE:**

Grade of concrete	fck	=	M 35	
Mean value of concrete compressive strength, fcm		=	M 45 (28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447 x fck	(Basic and Seismic combination)
		=	15.633 Mpa	
Secant modulus of elasticity, Ecm		=	32000 Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8 Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5 t/m ³	

SOIL :

Density dry		=	2 t/m ³	
Density Saturated		=	2.3 t/m ³	
Soil density (submerged)		=	2 t/m ³	
Angle of Internal friction ϕ		=	35	
Cohesion c		=	0	
Gross bearing capacity		=	35.00 t/m ²	(Normal case)
		=	43.75 t/m ²	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	11.159 m ²	
Perimeter in contact with atmosphere, u		=	12.854 m	
Notional size, ho = 2Ac/u		=	1736 mm	
Age of concrete at the time of loading to		=	90 days	
	t _a	=	25550 days	
	f(α 90)	=	1.2 (Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32 (increased by 10%)	
Creep co-efficient for foundation		=	1.0 (as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793 Mpa	Ecm' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500 Mpa	
Modulus of elasticity	Es	=	200000 Mpa	

3. PERMISSIBLE STRESSES**MAXIMUM PERMISSIBLE STRESS IN CONCRETE:**

Rare combination		=	0.48 x fck	
		=	16.8 Mpa	
Quasi permanent combination		=	0.36 x fck	
		=	12.6 Mpa	

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300 Mpa	
Permissible crack width	W _{k,max}	=	0.3 mm	

4. SEISMIC PARAMETERS

Seismic zone		=	V	
Type of soil		=	Type2(Medium)	
Zone factor	Z	=	0.36	
Importance factor	I	=	1.20	
Response Reduction Factor(Long)	R	=	3	
Response Reduction Factor(Trans)	R	=	3	

5. ENVIRONMENTAL PARAMETERS

Relative humidity		=	80%	
Condition of exposure		=	Moderate	

6.OTHER PARAMETERS

Mean velocity of water current flow		=	4.00 m/s	
Design Speed V		=	40 Kmph	
Radius of Curvature R		=	0 m	

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew = **0 °** = **0.000 Radian**
No. of Bearing = 4.00
Right
c/c of bearing in Transverse Direction = 3.000 m 3.000 m
c/c bearing on Longitudinal Direction = 1.250 m 1.250 m
Impact Factor for Design of Pier Cap = 1.15

Left Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	2261.29	199.95								
Total Load	2461.24		315.62	0.000	1059.33	290.67	0.00	0.00	1926.19	1493.81
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000	0.300	0.300

Right Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	2261.29	199.95								
Total Load	2461.24		315.62	0.00	1059.33	290.67	0.00	0.00	1926.19	1493.81
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	0.950	1.000	1.000	0.300	0.300

8. VOLUME OF SUBSTRUCTURE

PIER CAP

Uniform portion

No.		L(m)	B(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	11.500	0.000	0.000	0.000	1.600	0.000	16.4235	18.42
2	1	11.500	3.200	0.800	29.440	0.000	0.000	16.0235	18.02

Tapered portion

2a	Rectangle	3.000	3.200	0.800	7.680	0.000	0.000	15.224	17.224
	Triangle	4.250	3.200	0.800	10.880	0.000	0.000	15.357	17.357
Total Inc. 10%					52.800	0.000	0.000	14.313	16.131

PIER SHAFT

Above HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	9.915	26.164	0.000	0.000	9.866	11.866
2	0	2.500	0.000	9.915	0.000	-1.250	0.000	8.214	10.214
3	0	2.500	0.000	9.915	0.000	1.250	0.000	8.214	10.214

Cylinder/Conical Frustum portion

4	0.000	0.850	1.25	9.915	0.000	0.000	0.000	9.866	11.866
Total					26.164	0.000	0.000	9.866	11.866

Below HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	4.909	12.955	0.000	0.000	2.454	4.454
2	0	2.500	0.000	4.909	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	4.909	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.250	0.850	4.909	0.000	0.000	0.000	2.454	4.454
Total					12.955	0.000	0.000	2.454	4.454

Above LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	10.915	28.803	0.000	0.000	9.366	11.366
2	0.0	2.500	0.000	10.915	0.000	-0.850	0.000	7.547	9.547
3	0.0	2.500	0.000	10.915	0.000	0.850	0.000	7.547	9.547

Cylinder/Conical Frustum portion

4	0.000	0.850	0.850	10.915	0.000	0.000	0.000	9.063	11.063
Total					28.803	0.000	0.000	9.366	11.366

Below LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	3.909	10.316	0.000	0.000	1.954	3.954
2	0	2.500	0.000	3.909	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	3.909	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.25	0.850	3.909	0.000	0.000	0.000	1.647	3.647
Total					10.316	0.000	0.000	1.954	3.954

FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.000	2.500	2.00	50.000	0.000	0.000	-1.000	1.000
2	1	10.000	4	1.500	60.000	-3.028	0.000	-1.222	0.778
3	1	10.000	4.000	1.500	60.000	3.028	0.000	-1.222	0.778
Total					170	0.000	0.000	-1.157	0.843

EARTH ABOVE FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.000	10.500	5.909	620.445	0.000	0.000	0.954	2.954
2	-1	Shaft Below LBL			-10.316	0.000	0.000	1.954	3.954
3	-1	Footing			-170.000	0.000	0.000	-1.157	0.843
Total					440.129	0.000	0.000	1.747	3.747

9. CALCULATION OF SEISMIC FORCE

$$\text{Time Period } T = 2 \sqrt{\frac{D}{1000 F}}$$

$$\begin{aligned} D &= \text{Approximate DL of super-structure \& LL in Tonne (DL+20\% LL)} \\ &= 5553.72 \text{ KN} + 211.866 \text{ KN} \\ &= 5766 \text{ KN} \end{aligned}$$

$$F =$$

Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction; and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

$$F = \frac{6 E I}{x^2(3L-x)} \quad \text{for 1 mm deflection at } x$$

$$E = 32000 \text{ N/mm}^2$$

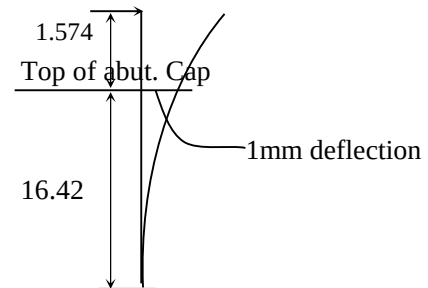
Column Cross-Section

$$D1 = 2.50 \text{ m (Average Outer Dia)}$$

$$D2 = 1.70 \text{ m (Average Inner Dia)}$$

$$I_{TT} = 1.13E+12 \text{ mm}^4 \quad 1.5E+12$$

$$I_{LL} = 1.13E+12 \text{ mm}^4$$



$$\text{Force required in Long. Dir. } F_L = 25 \text{ KN}$$

$$\text{Force required in Trans. Dir. } F_T = 21 \text{ KN}$$

$$\text{Time Period -Longitudinal Seismic Case} = 0.970 \text{ seconds}$$

$$\text{Time Period -Transverse Seismic Case} = 1.038 \text{ seconds}$$

$$S_a/g \text{ -Longitudinal Seismic Case} = 1.402$$

$$S_a/g \text{ -Transverse Seismic Case} = 1.311$$

$$\text{Seismic Zone} = V$$

$$\text{Zone Factor } Z = 0.36$$

$$\text{Importance Factor } I = 1.20$$

$$\begin{aligned} \text{Response reduction Factor } R &= 3.00 \quad \text{Longitudinal} \\ R &= 3.00 \quad \text{Transverse} \end{aligned}$$

$$\text{Avg response acceleration } S_a/g = 1.402 \quad \text{Longitudinal}$$

$$\text{Avg response acceleration } S_a/g = 1.311 \quad \text{Transverse}$$

$$\text{Elastic Seismic Coefficient} = \frac{Z}{2} \times (S_a/g) \times (I/R)$$

$$\text{In longitudinal direction} = 0.303 / R$$

$$\text{In Transverse direction} = 0.283 / R$$

			Substructure	Foundation
Enhancement factor				1.35
Design Seismic coefficient	Long. Ah		0.101	0.136
	Trans. At		0.094	0.127
	Vert. Av		0.067	0.091

CALCULATION OF SEISMIC FORCES

SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPLL :

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVF	W	eVS	eVF
	Tonnes	(m)	(m)		(m)	(m)
Total Super-Structure DL	452.26	18.37	20.37	452.26	18.37	20.37
Total Super-Structure SIDL	39.99	19.55	21.55	39.99	19.55	21.55
Total Super-Structure WC	63.12	19.18	21.18	63.12	19.18	21.18
Total Super-Structure FPLL	0.00	19.18	21.18	0.00	19.18	21.18
Total	555.37	18.55	20.55	555.37	17.14	19.00

* Bearing level	16.82	18.82		16.82	18.82

SEISMIC COMPONENT OF SUB-STRUCTURE :

Description	W	eVS	eVF
	Tonnes	(m)	(m)
Total weight of shaft and pier cap	229.80	11.38	13.27
Total weight of foundation	425.00	-1.16	0.84

SEISMIC COMPONENT OF LIVE LOAD(70R+Class A) :

Description	W	W	eVS	eVF
	Tonnes	Tonnes	(m)	(m)
	70R + Class A	70R + Class A		
Maximum Live Load	105.93	0.00	20.35	22.346
Minimum Live Load	29.07	0.00	20.35	22.346

Summary of Seismic force at shaft and foundation

Super structure

Dead load - Super structure about shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		56.05		943.008	
Seismic Transverse direction			52.41		935.27
Seismic Vertical Direction	37.37				

Dead load - Super structure about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		75.67		1424.40	
Seismic Transverse direction			70.757		1399.03
Seismic Vertical Direction	50.45				

Dead load Left span Dislodged- about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		37.84		712.202	
Seismic Transverse direction			35.38		672.07
Seismic Vertical Direction	25.22				

Sub structure

Dead load - Sub structure Shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		23.19		263.84	
Seismic Transverse direction			21.69		246.71
Seismic Vertical Direction	15.46				

Dead load - Sub structure foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		31.3106		415.54	
Seismic Transverse direction			29.28		388.55
Seismic Vertical Direction	20.87				

Live Load - Max**70R + Class A**

Live load - Max shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.00		40.68
Seismic Vertical Direction	1.43				

Live load - Max foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.70		60.32
Seismic Vertical Direction	1.92				

70R

Live load - Max shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.00		40.68
Seismic Vertical Direction	1.43				

Live load - Max foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.70		60.32
Seismic Vertical Direction	1.92				

Live Load - Min**70R + Class A**

Live load - Min shaft	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.55		11.16
Seismic Vertical Direction		0.39				

Live load - Min foundation	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.74		16.55
Seismic Vertical Direction		0.53				

70R

Live load - Min shaft	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.55		11.16
Seismic Vertical Direction		0.39				

Live load - Min foundation	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.74		16.55
Seismic Vertical Direction		0.53				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)**1. Normal Max Reaction on Fix End****Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \frac{\text{Class 70R on First two Lane}}{0.2 \times 100} + \frac{\text{Class A on third Lane}}{0.05 \times 54} \\ &+ \frac{0.1 \times 0}{0.05 \times 0} \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{29.07} \right) \\ &= 15.34 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 26.69 \text{ Ton} \\ F_{hr} &= 26.69 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 26.69 - 13.88 \\ &= 12.80 \text{ Ton} \end{aligned}$$

2. Normal Min Reaction on Fix End**Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \frac{\text{Class 70R on First two Lane}}{0.2 \times 100} + \frac{\text{Class A on third Lane}}{0.05 \times 54} \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{105.93} \right) \\ &= 19.18 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 30.53 \text{ Ton} \\ F_{hr} &= 30.53 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 30.53 - 13.88 \\
 &= 16.65 \text{ Ton}
 \end{aligned}$$

3. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\
 &= 13.88 \text{ Ton} \\
 F_{hl} &= 13.88 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 28.027 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 37.836 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 32.567 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 42.376 \text{ Ton} \\
 \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{5.81} \right) \\
 &= 14.17497 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Max of } & (F_h/2 + \mu (Rg + Rq) \text{ and } F_h - \mu (Rg + Rq)) \\
 F_{hr} \text{ for shaft} &= 32.73 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 37.63 \text{ Ton} \\
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 32.73 - 13.88 \\
 &= 18.84 \text{ Ton} \\
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 37.63 - 13.88 \\
 &= 23.75 \text{ Ton}
 \end{aligned}$$

4. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (Rg + Rq) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\
 &= 13.88 \text{ Ton} \\
 F_{hl} &= 13.88 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 10.8 \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 28.027 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 37.836 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \%})
 \end{aligned}$$

Total Horizontal force for Shaft(Fh)	=	32.567	Ton	inc.)
Total Horizontal force for foundation(Fh)	=	42.376	Ton	
$\mu (Rg + Rq)$	=	0.05 x (	Total DL 226.129	+ Total SIDL load 51.56 + CWLL 21.19)
	=	14.94363	Ton	
Max of	(Fh/2 + $\mu (Rg + Rq)$	and	Fh - $\mu (Rg + Rq)$	)
	Fhr for shaft	=	33.50	Ton
	Fhr for foundation	=	38.40	Ton
Horizontal force for shaft	=	Fhr	-	Fhl
	=	33.50	-	13.88
	=	19.61	Ton	
Horizontal force for foundation	=	Fhr	-	Fhl
	=	38.40	-	13.88
	=	24.52	Ton	

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

$\mu (Rg + Rq)$	=	0.05 x (	Total DL 226.129	+ Total SIDL load 51.56 + CWLL 0.00)
	=	13.88	Ton	
Fhl	=	13.88	Ton	

Right Span

Beaking Force	=	Class 70R on First two Lane 0.2 x 100	+ Class A on third Lane 0.05 x 0.00)

Fh	=	20 Ton

$\mu (Rg + Rq)$	=	0.05 x (	Total DL 226.129	+ Total SIDL load 51.56 + CWLL 29.07)
	=	15.34	Ton	

Max of	(Fh/2 + $\mu (Rg + Rq)$	and	Fh - $\mu (Rg + Rq)$	)

	=	25.34	Ton
Fhr	=	25.34	Ton

Horizontal force	=	Fhr	-	Fhl
	=	25.34	-	13.88
	=	11.45	Ton	

6. Normal Min Reaction on Fix End

Left Span

$\mu (Rg + Rq)$	=	0.05 x (	Total DL 226.129	+ Total SIDL load 51.56 + CWLL 0.00)
	=	13.88	Ton	

$$F_{hl} = 13.88 \text{ Ton}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 20 \text{ Ton}$$

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{105.93} \right) = 19.18 \text{ Ton}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$= 29.18 \text{ Ton}$$

$$F_{hr} = 29.18 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 29.18 - 13.88 \\ &= 15.30 \text{ Ton} \end{aligned}$$

7. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 4 \text{ Ton}$$

$$\text{Seismic Horizontal force (Shaft)} = 28.027 \text{ Ton}$$

$$\text{Seismic Horizontal force (foundation)} = 37.836 \text{ Ton}$$

$$\text{Total Horizontal force for Shaft (Fh)} = 32.027 \text{ Ton}$$

$$\text{Total Horizontal force for foundation (Fh)} = 41.836 \text{ Ton}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{5.81} \right) \\ &= 14.17497 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 32.19 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 37.09 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 32.19 - 13.88 \\ &= 18.30 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 37.09 - 13.88 \\ &= 23.21 \text{ Ton} \end{aligned}$$

8. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= 0.2 \times \frac{\text{Class 70R on First two Lane}}{20} + 0.05 \times \frac{\text{Class A on third Lane}}{0} \\ F_h &= 4 \text{ Ton} \\ \text{Seismic Horizontal force(Shaft)} &= 28.027 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\ \text{Seismic Horizontal force(foundation)} &= 37.836 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\ \text{Total Horizontal force for Shaft}(F_h) &= 32.027 \text{ Ton} \\ \text{Total Horizontal force for foundation}(F_h) &= 41.836 \text{ Ton} \\ \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{21.19} \right) \\ &= 14.94363 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 32.96 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 37.86 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 32.96 - 13.88 \\ &= 19.07 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 37.86 - 13.88 \\ &= 23.98 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \frac{\text{CWLL}}{149.38} \right) \\ &= 21.35 \text{ Ton} \\ F_{hr} &= 21.35 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 21.35 - 13.88 \\ &= 7.47 \text{ Ton} \end{aligned}$$

10. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \text{CWLL} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \text{CWLL} \right) \\ &= 23.52 \text{ Ton} \\ F_{hr} &= 23.52 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 23.52 - 13.88 \\ &= 9.63 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \text{CWLL} \right) \\ &= 13.88 \text{ Ton} \\ F_{hl} &= 13.88 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \text{CWLL} \right) \\ &= 13.88 \text{ Ton} \\ F_{hr} &= 13.88 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 13.88 - 13.88 \\ &= 0.00 \text{ Ton} \end{aligned}$$

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{226.129} + \frac{\text{Total SIDL load}}{51.56} + \text{CWLL} \right) \\ &= 13.8843 \text{ Ton} \\ F_{hr} &= 13.8843 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 13.8843 - 0.000 \\
 &= 13.8843 \text{ Ton}
 \end{aligned}$$

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 0 + 0.05 \times 0
 \end{aligned}$$

$$F_h = 0 \text{ Ton}$$

$$\begin{aligned}
 \text{Seismic Horizontal force(Shaft)} &= 28.027 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 37.836 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\
 \text{Total Horizontal force for Shaft}(F_h) &= 28.027 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 37.836 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (\text{Total DL} + \text{Total SIDL load} + \text{CWLL}) \\
 &= 0.05 \times (226.129 + 51.56 + 0.00) \\
 &= 13.8843 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 27.90 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 32.80 \text{ Ton}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 27.90 - 0.00 \\
 &= 27.90 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 32.80 - 0.00 \\
 &= 32.80 \text{ Ton}
 \end{aligned}$$

Summary of forces			
Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	12.80	12.80
	2. Normal Min Reaction on Fix End	16.65	16.65
	3. Seismic Max Reaction on Fix End	18.84	23.75
	4. Seismic Min Reaction on Fix End	19.61	24.52
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.45	11.45
	6. Normal Min Reaction on Fix End	15.30	15.30
	7. Seismic Max Reaction on Fix End	18.30	23.21
	8. Seismic Min Reaction on Fix End	19.07	23.98
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	7.47	7.47
	10. Normal Min Reaction on Fix End	9.63	9.63
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	13.88	13.88
	13. Seismic Span Dislodge Condition	27.90	32.80

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$C = \frac{WV^2}{127R}$$

70R + Class A

Maxium Reaction				
Live Load	W	=	105.93	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0.00	20.35	22.35

Minimum Reaction				
Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0	20.35	22.35

70R

Maxium Reaction				
Live Load	W	=	105.93	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
0	20.35	22.35

Minimum Reaction				
Live Load	W	=	29.07	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
0	20.35	22.35

Special Vehicle

Maxium Reaction				
Live Load	W	=	192.62	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e_{VS}(m)	e_{VF}(m)
0	20.35	22.35

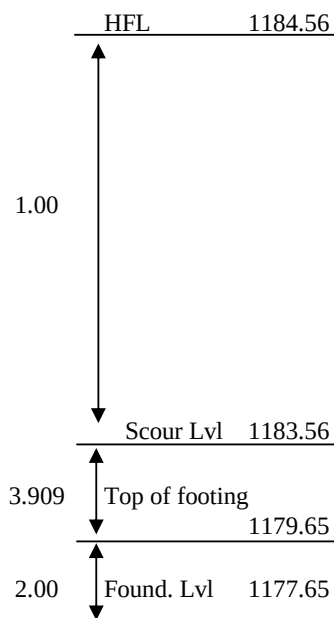
Minimum Reaction				
Live Load	W	=	149.38	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e_{VS}(m)	e_{VF}(m)
0	20.35	22.35

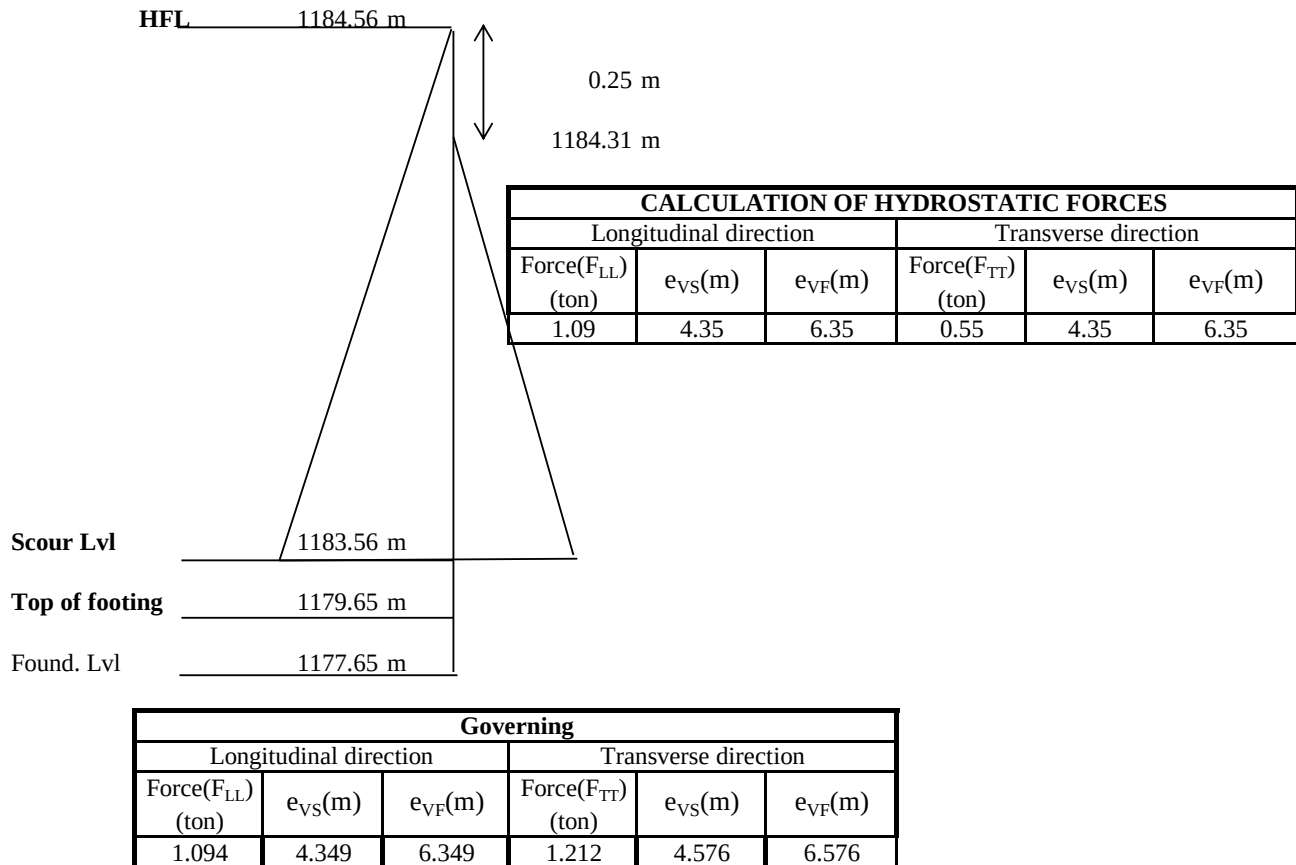
12. WATER CURRENT FORCES**NORMAL CASE****Water current forces**

HFL	=	1184.559 m	
MSL (NORMAL)	=	1183.559 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL (Trans direction)		=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ² 53 K (vsinq) ²

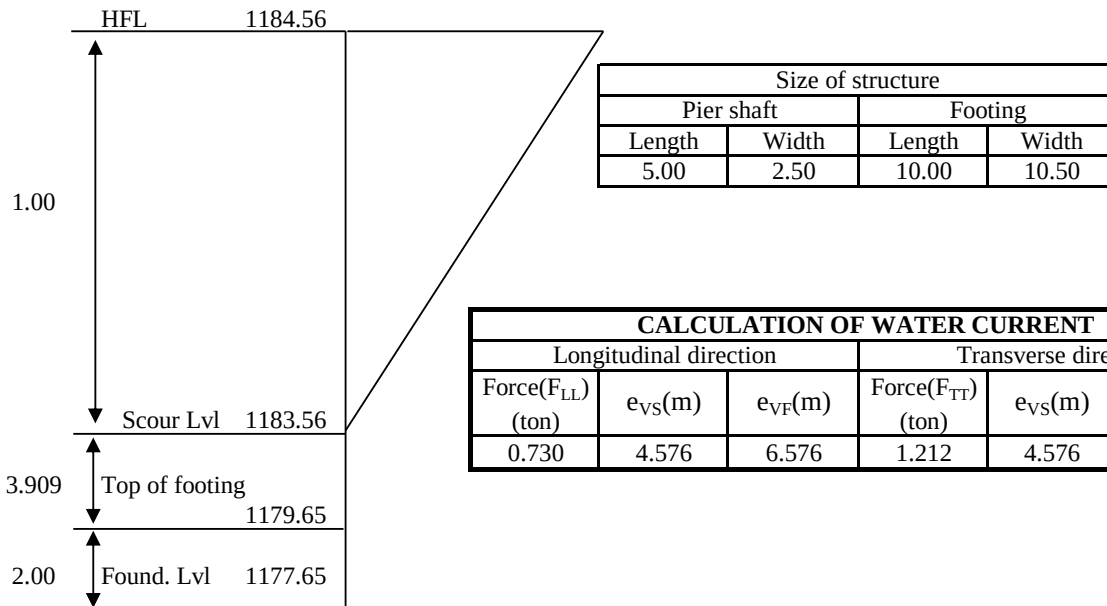
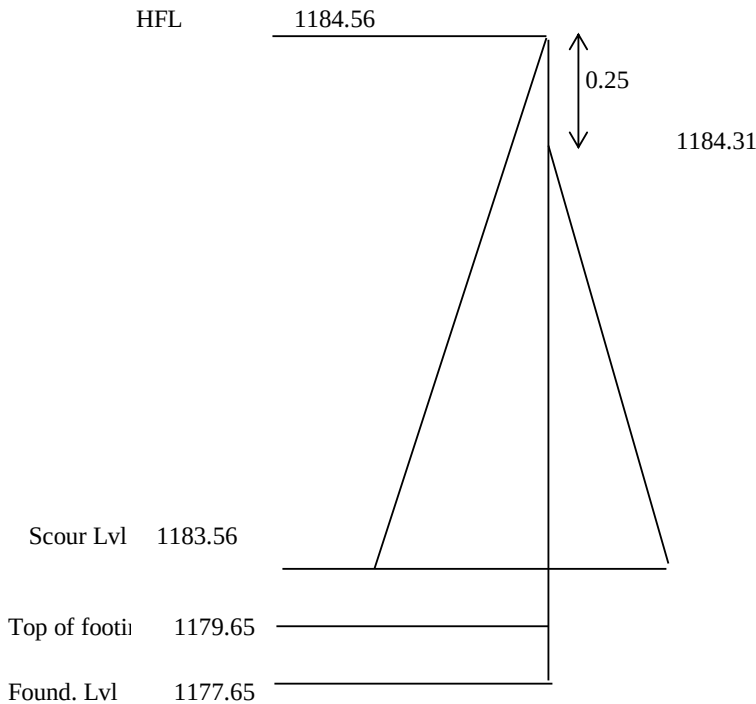


Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
5.00	2.50	10.00	10.50

CALCULATION OF WATER CURRENT FORCES					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.730	4.576	6.576	1.212	4.576	6.576

Static Force**SEISMIC CASE**

HFL	=	1184.559 m		
MSL (SEISMIC)	=	1183.56 m		
Water current pressure	P	=	52 KV ²	Kg/m ²
For piers with square ends	K	=	1.5	
For piers with semicircular ends	K	=	0.66	
Mean velocity of water current	V_{mean}	=	4.00 m/s	
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00	
		=	5.66 m/s	
Angle of variation		=	20 degree	
Water current pressure at HFL (Trans direction)		=	0.97 t/m ²	52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ²	53 K (vsinq) ²

**Pressure diagram (seismic case)****Static Force**

CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
1.09	4.35	6.35	0.55	4.35	6.35

Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
1.094	4.349	6.349	1.212	4.576	6.576

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

- LC -1 ULS NORMAL LWL MAX REACTION
 LC -2 ULS NORMAL LWL SPAN DISLOGED
- LC - 5 ULS MAX REACTION $1X + 0.3Y + 0.3Z$
 LC - 6 ULS MAX REACTION $0.3X + 1Y + 0.3Z$
- LC - 9 ULS NORMAL SV MAX REACTION

SLS

- LC -1 RARE NORMAL MAX REACTION
 LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

- LC - 1 ULS NORMAL MAX REACTION(70R +Class A)
 LC - 2 ULS NORMAL SPAN DISLOGED
- LC - 5 ULS NORMAL MAX REACTION(70R)
- LC - 7 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R + \text{Class A})$
 LC - 8 ULS SPAN DISLODGED $1X + 0.3Y + 0.3Z$
 LC - 9 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{Class A})$
 LC - 10 ULS SPAN DISLODGED $0.3X + 1Y + 0.3Z$
- LC - 15 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC - 16 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R)$
- LC - 19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION(70R+Class A)

LC - 2 NORMAL SPAN DISLOGED

LC - 5 0

LC - 6 SEISMIC SPAN DISLODGED $1X + 0.3Y + 0.3Z$ LC - 7 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{class A})$ LC - 8 SEISMIC LWL SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 13 SEISMIC NORMAL MAX REACTION(70R)

LC - 15 SEISMIC MAX REACTION $1X + 0.3Y + 0.3Z(70R)$ LC - 16 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 13 NORMAL LWL SV MAX REACTION

14.A DESIGN FORCES FOR PIER SHAFT(ULS CASES)**LC -1 ULS NORMAL LWL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			20.346	0.0	0.000	1.5	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				12.803			16.824	215.397		1.5	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1244.13	412.48	135.86

LC -2 ULS NORMAL LWL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			20.346	0.000	0.000	1.5	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				13.884			16.824	233.583		1.5	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
697.73	592.56	0.00

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.63	0.000		-153.828	0.000	1.35	
2	Surfacing			31.562		-0.63	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.63	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.63	0.950		0.000	0.000	0.2	1
5	LL (Class-A)			0.000		-0.63	1.000		0.000	0.000	0.2	1
Right Span												
6	DL (superstructure)			246.124		0.63	0.000		153.828	0.000	1.35	
7	Surfacing			31.562		0.63	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.63	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.63	0.950		66.208	100.6	0.2	1
10	LL (Class-A)			0.000		0.63	1.000		0.000	0.0	0.2	1
11	Centrifugal force				0.000			20.346	0.0	0.0	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				18.844			16.824	317.021		1.000	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				56.053				943.01		1.5	
	Transverse				52.413					935.27047	0.45	
	Vertical			37.369							0.45	
Sub structure												
	Longitudinal				23.193				263.84		1.5	
	Transverse				21.687					246.70943	0.45	
	Vertical			15.462							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.999					40.681103	0.45	
	Vertical			1.426							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1130.828	2140.54	570.32

LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.63	0.00		-153.83	0.00	1.35	
2	Surfacing			31.562		-0.63	0.00		-19.73	0.00	1.75	
3	FLL			0.000		-0.63	0.00		0.00	0.00	0.2	
4	LL (70R)			0.000		-0.63	0.95		0.00	0.00	0.2	1
5	LL (Class-A)			0.000		-0.63	1.00		0.00	0.00	0.2	1
Right Span												
6	DL (superstructure)			246.124		0.63	0.00		153.83	0.00	1.35	
7	Surfacing			31.562		0.63	0.00		19.73	0.00	1.75	
8	FLL			0.000		0.63	0.00		0.00	0.00	0.2	
9	LL (70R)			105.933		0.63	0.95		66.21	100.64	0.2	1
10	LL (Class-A)			0.000		0.63	1.00		0.00	0.00	0.2	1
11	Centrifugal force				0.000			20.346	0.0	0.000	0.2	
12	Pier cap	52.800	2.500	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.500	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.500	25.789		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				18.844			16.824	317.021		1.000	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				56.053				943.01		0.45	
	Transverse				52.413					935.270	1.5	
	Vertical			37.369							0.45	
Sub structure												
	Longitudinal				23.193				263.84		0.45	
	Transverse				21.687					246.709	1.5	
	Vertical			15.462							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.999					40.681	1.5	
	Vertical			1.426							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1130.828	873.35	1854.12

LC - 9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1.35	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
7	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centrifugal force				0.000			20.346	0.000		1	
10	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
15	Horizontal Force(F _{LL})				7.469			16.824	125.656		1.5	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1.5	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1277.85	308.87	57.79

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)**LC -1 RARE NORMAL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			20.346	0.000	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.349	0.000		1	
	Water Current Force(F _{TT})				0.000			4.576		0.000	1	
17	Horizontal Force(F _{LL})				12.803			16.824	215.397		1	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
903.73	274.98	90.57

LC-2 RARE NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centifugal force(F _{LL})				0.000			20.346	0.000	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.349	0.000		1	
	Water Current Force(F _{TT})				0.000			4.576		0.000	1	
17	Horizontal Force(F _{LL})				13.884			16.824	233.583		1	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
513.79	411.08	0.00

LC -5 QP NORMAL

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	0	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			20.346	0.000	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			4.349	0.000		0	
	Water Current Force(F _{TT})				0.000			4.576		0.000	0	
17	Horizontal Force(F _{LL})				0.000			16.824	0.000		0	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
797.79	0.00	0.00

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			20.346	0.000	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F _{LL})				0.000			4.349	0.000		0	
	Water Current Force(F _{TT})				0.000			4.576		0.000	0	
17	Horizontal Force(F _{LL})				13.884			16.824	233.583		1	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
513.79	411.08	0.00

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.828	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			246.124		0.625	0.000		153.828	0.000	1	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1.2	
7	FLL			0.000		0.625	0.000		0.000	0.000	1	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centrifugal force				0.000			20.346	0.000		1	
10	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			4.349	0.000		1	
	Water Current Force(F _{TT})				0.000			4.576		0.000	1	
15	Horizontal Force(F _{LL})				7.469			16.824	125.656		1	
	Horizontal Force(F _{TT})				0.000			16.824		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
990.41	246.04	57.79

15. DESIGN FORCES FOR FOUNDATION**LC -1 ULS NORMAL MAX REACTION(70R +Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			22.346	0.0	0.000	1.5	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				12.803			18.824	241.00		1.5	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1.5	
18	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2990.33	450.89	135.86

LC -2 ULS NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			22.346	0.000	0.000	1.5	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				13.884			18.824	261.351		1.5	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1.5	
18	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2459.82	634.21	0.00

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			22.346	0.0	0.000	1.5	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				11.453			18.824	215.59		1.5	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1.5	
18	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1801.986	412.77	135.86

LC - 7 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			22.346	0.0	0.000	0.2	
12	Pier cap	52.800	2.500	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.500	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.500	25.789		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				23.749			18.824	447.03		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.00	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				75.672				1424.4		1.5	
	Transverse				70.757					1399.0	0.45	
	Vertical			50.448							0.45	
Sub structure												
	Longitudinal				31.311				415.5		1.5	
	Transverse				29.277					388.55429	0.45	
	Vertical			20.87							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				2.699					60.318044	0.45	
	Vertical			1.925							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2901.544	3220.19	853.92

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.00	0.000	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				32.802			18.824	617.45		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				37.836				712.20		1.5	
	Transverse				35.379					672.07343	0.45	
	Vertical			25.224							0.45	
	Sub structure											
	Longitudinal				31.311				415.5		1.5	
	Transverse				29.277					388.55429	0.45	
	Vertical			20.874							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2480.568	2343.59	477.28

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			22.346	0.0	0.000	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				23.749			18.824	447.03		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				75.672				1424.4		0.45	
	Transverse				70.757					1399.034	1.5	
	Vertical			50.448							0.45	
	Sub structure											

	Longitudinal				31.311				415.5		0.45	
	Transverse				29.277					388.554	1.5	
	Vertical			20.874							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				2.699					60.318	1.5	
	Vertical			1.925							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2901.544	1288.25	2816.81

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.00	0.000	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				32.802			18.824	617.45		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				37.836				712.20		0.45	
	Transverse				35.379					672.07343	1.5	
	Vertical			25.224							0.45	
Sub structure												
	Longitudinal				31.311				415.5		0.45	
	Transverse				29.277					388.55429	1.5	
	Vertical			20.874							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2480.568	1159.46	1590.94

LC -15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.0	0.000	0.2	
12	Pier cap	52.800	2.500	132.000		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	28.803	2.500	72.007		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	10.316	2.500	25.789		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				23.209			18.824	436.87		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.00	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				75.672				1424.4		1.5	
	Transverse				70.757					1399.0	0.45	
	Vertical			50.448							0.45	
Sub structure												
	Longitudinal				31.311				415.5		1.5	
	Transverse				29.277					388.55429	0.45	
	Vertical			20.87							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				2.699					60.32	0.45	
	Vertical			1.925							0.45	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.741					16.550693	0.45	0.3
	Vertical			0.528							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2901.544	3210.03	853.92

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.0	0.000	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				23.209			18.824	436.87		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				75.672			1424.4			0.45	
	Transverse				70.757					1399.034	1.5	
	Vertical			50.448							0.45	
Sub structure												
	Longitudinal				31.311			415.5			0.45	
	Transverse				29.277					388.554	1.5	
	Vertical			20.874							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				2.699					60.318	1.5	
	Vertical			1.925							0.45	
b)	Min Live Load											
	Longitudinal										0.45	0.3

	Transverse				0.741					16.550693	1.5	1
	Vertical			0.528							0.45	0.3
SUMMARY OF FACTORED FORCES												
V(ton)		MTT (tm)		MLL(tm)								
2901.544		1278.08		2816.81								

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1.35	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1.35	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1.75	
7	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centrifugal force				0.000			22.346	0.0	0.000	1	
10	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
15	Horizontal Force(F _{LL})				7.469			18.824	140.59		1.5	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1.5	
16	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	MTT (tm)	MLL(tm)
3039.94	331.28	57.79

16. DESIGN FORCES FOR BASE PRESSURE**LC -1 NORMAL MAX REACTION(70R+Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			22.346	0.0	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				12.803			18.824	241.00		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2185.77	300.59	90.57

LC -2 NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			22.346	0.000	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				13.884			18.824	261.351		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1812.74	434.90	0.00

434.905 0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.00	0.000	0	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	

	Water Current Force(F_{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F_{LL})				32.802			18.824	617.45		1	
	Horizontal Force(F_{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				37.836				712.20		1	
	Transverse				26.206					497.83217	0.3	
	Vertical			18.684							0.3	
	Sub structure											
	Longitudinal				31.311				415.5		1	
	Transverse				29.277					388.55	0.3	
	Vertical			20.874							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M_{TT} (tm)	M_{LL} (tm)
1824.608	1764.92	265.92

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			22.346	0.00	0.000	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				32.802			18.824	617.45		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				0.000			0.00			0.3	
	Transverse				26.206					497.83217	1	
	Vertical			18.684							0.3	
	Sub structure											
	Longitudinal				31.311				415.5		0.3	
	Transverse				29.277					388.55429	1	
	Vertical			20.874							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1824.608	761.84	886.39

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000				0.0	0.000	1	
12	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				11.453			18.824	215.59		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2185.77	275.18	90.57

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.208	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.0	0.000	0.2	
12	Pier cap	52.800	2.500	132.000		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	28.803	2.500	72.007		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	10.316	2.500	25.789		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				23.209			18.824	436.87		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.00	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				75.672				1424.4		1	
	Transverse				70.757					1399.0	0.3	
	Vertical			50.448							0.3	
	Sub structure											
	Longitudinal				31.311				415.5		1	
	Transverse				29.277					388.55	0.3	
	Vertical			20.87							0.3	
a)	Max Live Load											
	Longitudinal										1	
	Transverse				2.699					60.32	0.3	
	Vertical			1.925							0.3	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.741					16.550693	0.45	0.3
	Vertical			0.528							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2133.658	2290.05	576.73

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
7	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			105.933		0.625	0.950		66.2081	100.636	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			22.346	0.0	0.000	0.2	
12	Pier cap	52.80	2.50	132.00		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	28.80	2.50	72.01		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	10.32	2.50	25.79		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			6.349	0.00		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
17	Horizontal Force(F _{LL})				23.209			18.824	436.87		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
18	Footing	170.00	2.50	425.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	440.13	2.00	880.26		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				75.672				1424.4		0.3	
	Transverse				70.757					1399.0	1	
	Vertical			50.448							0.3	
	Sub structure											
	Longitudinal				31.311				415.5		0.3	
	Transverse				29.277					388.55	1	
	Vertical			20.874							0.3	
a)	Max Live Load											

	Longitudinal									0.3	
	Transverse			2.699					60.32	1	
	Vertical		1.925							0.3	
b)	Min Live Load										
	Longitudinal									0.45	0.3
	Transverse			0.741					16.6	1.5	1
	Vertical		0.528							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2133.658	1002.09	1892.86

LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			246.124		-0.625	0.000		-153.83	0.000	1	
2	Surfacing			31.562		-0.625	0.000		-19.726	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			246.124		0.625	0.000		153.83	0.000	1	
6	Surfacing			31.562		0.625	0.000		19.726	0.000	1	
7	FLL			0.000		0.625	0.000		0.000	0.000	1	
8	LL			192.619		0.625	0.300		120.387	57.786	1	1
9	Centrifugal force				0.000			22.346	0.0	0.000	1	
10	Pier cap	52.800	2.5	132.000		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	28.803	2.5	72.007		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	10.316	2.5	25.789		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F _{LL})				0.000			6.349	0.000		1	
	Water Current Force(F _{TT})				0.000			6.576		0.000	1	
15	Horizontal Force(F _{LL})				7.469			18.824	140.59		1	
	Horizontal Force(F _{TT})				0.000			18.824		0.000	1	
16	Footing	170.00	2.5	425.000		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	440.13	2	880.259		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2283.05	260.98	57.79

DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
86+825

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	23.750m	23.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	25.000m	25.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 400 kN/m²
SBC of soil-Normal Case = 460 kN/m² Assumed
SBC of soil-Seismic Case = 575 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case
Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	1.414m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.950m	1.950m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m
Projection of Abutment Cap (Span Side)	=	0.500m	0.500m
Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.535m	1.535m
Thickness of Abutment shaft at Bottom	=	1.750m	1.750m

Solid Return Wall

Length of Return wall	=	7.950m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.300m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	14.500m	
abutment pedestal width	=	1.750m	
abutment pedestal Height	=	2.000m	
Width of Toe Slab	=	4.800m	
Width of Heel Slab	=	7.950m	
Thickness of Toe slab at tip	=	0.750m	
Thickness of Toe slab near shaft	=	2.000m	
Thickness of heel slab at tip	=	0.750m	
Thickness of heel slab near shaft	=	2.000m	
Width of backfill on heel slab	=	7.950m	
Thickness of heel slab at back fill edge	=	2.000m	
Height of back fill at bottom edge of heel slab	=	14.732m	
Height of back fill at back fill edge of heel slab	=	13.482m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1199.243m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1199.101m	Height of Superstructure	=	1.820m
Deck level at center line =	1199.243m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1197.358m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1196.758m	Height of Pedestal (3)	=	0.550m
Abutment cap bottom lvl (uniform portion ends)	1196.458m	Height of Pedestal (4)	=	0.625m
Abutment cap bottom lvl (corbel portion ends)	1196.158m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1196.158m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1186.690m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1185.690m	Height (Avg.) of Dirt Wall	=	2.414m
Foundation level =	1183.690m	Abutment shaft Above G.L	=	9.468m
HFL	= 1188.690m	Abutment Shaft below G.L	=	1.000m

Height of abutment shaft	=	10.468m
MSL	=	1185.690m
Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z =Zone factor	=	0.36	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g. of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g. of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	522.61 4.50
DL Reaction on Bearing No.-2	=	544.54 1.50
DL Reaction on Bearing No.-3	=	544.54 -1.50
DL Reaction on Bearing No.-4	=	522.61 -4.50

DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2134.30 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	100.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	100.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		200.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	68.613 4.50
SIDL Reaction on Bearing No.-2	=	82.335 1.50
SIDL Reaction on Bearing No.-3	=	82.335 -1.50
SIDL Reaction on Bearing No.-4	=	68.613 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		301.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 4	=	0.625 x	0.800 x	0.800 =	0.4000 m ³	-4.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.3120 m ³	-0.549

VOLUME CALCULATION

C.G. Of Footing	=	7.250 m
C.G. Of shaft from toe tip	=	5.675 m
Distance between c.g. of shaft and footing	=	1.575 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.775	-6.475	0.000
-Trapering portion	1	12.50	0.300	1.414	5.302	-0.800	0.775	-6.475	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	0.475	-6.775	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.525	-6.725	0.000
Cap (uniform portion)	1	12.50	1.950	0.300	7.313	0.025	1.600	-5.650	0.000
Cap (Corbel Portion)	1	12.50	1.950	0.300	5.433	0.025	1.600	-5.650	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.268	7.468	118.324	0.232	1.807	-5.443	0.000
Shaft below HFL	1	12.50	1.643	2.250	46.196	0.053	1.628	-5.622	0.000
Solid Return Wall	1	7.95	0.900	14.178	101.444	-4.850	-3.275	-10.525	5.800
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.875	0.700	-6.550	5.800
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.875	0.700	-6.550	5.800
Footing									
Heel Slab	1	12.50	7.950	1.375	136.641		-2.673	-9.923	0.000
Toe Slab	1	12.50	4.800	1.375	82.500		4.486	-2.764	0.000
Portion between Heel and Toe	1	12.50	1.750	2.000	43.750		1.575	-5.675	0.000
Back filling above HFL over Heel Slab	1	12.50	7.950	10.553	1048.704		-3.275	-10.525	0.000
Back filling below HFL over Heel Slab	1	12.50	7.950	3.625	360.234		-3.503	-10.753	0.000
Backfill above Heel slab	1	12.50	7.950	14.107	1401.858		-3.334	-10.584	0.000
Front Filling over Toe Slab	1	12.50	4.800	1.625	97.500		4.542	-2.708	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	4.800	0.625	37.500		2.475	-4.775	0.000
Side filling between heel and toe	1	0.00	1.750	1.625	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	0.475	-6.775	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.535	10.553	70.581		0.966	-6.284	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.215	3.625	9.740		0.772	-6.478	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.775	-6.475

SECTIONAL PROPERTIES

Width of Footing (B)	=	14.500 m							
Length of Footing (L)	=	12.500 m							
A	=	14.500	x	12.500	=	181.250	m ²		
ZL	=	12.500	x	35.042	=	438.021	m ³		
ZT	=	IT1	+	IT2					
		distance of extreme point from centre							
IT1	=	14.500	x	162.760	=	2360.03	m ⁴		
IT2 (moment of inertia of triangle)	=	14.500	x	0.000	+	0.500 x	14.500 x	0.000 x	39.063
from centre of footing	=	0.000	m ⁴						
Moment of inertia of two triangle	=	0.000	m ⁴						
Total moment of inertia	=	2360.03	m ⁴						
Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250	m		
Total Section modulus (ZT)	=	377.604	m ³						

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \cdot \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \cdot \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 13.468 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 15.125 m

Abutment Cap Top Level - Foundation Level
= 13.068 m

Dimensions of Abutment Shaft

Length = 12.50 m
Width = 1.38 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 2.031 m^4
Moment of Inertia , $I_{\text{transverse}}$ = 223.796 m^4

Ecm = 3.231E+07 kN/m^2

Longitudinal Direction

Force	=	84.335	KN
D	=	2636.19	KN
T	=	0.3536	sec

For Hard or Rocky Strata, with N>30

$$\frac{S_a}{g} = 2.500$$

For Medium Strata, with N>10&N<30

$$\frac{S_a}{g} = 2.500$$

For Soft Soil Strata, with N<10

$$\frac{S_a}{g} = 2.5$$

Medium Soil Strata

$$S_a/g = 2.5$$

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.341

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.341	In Transverse direction
Av	=	0.227	In Vertical direction

For Design of Foundation

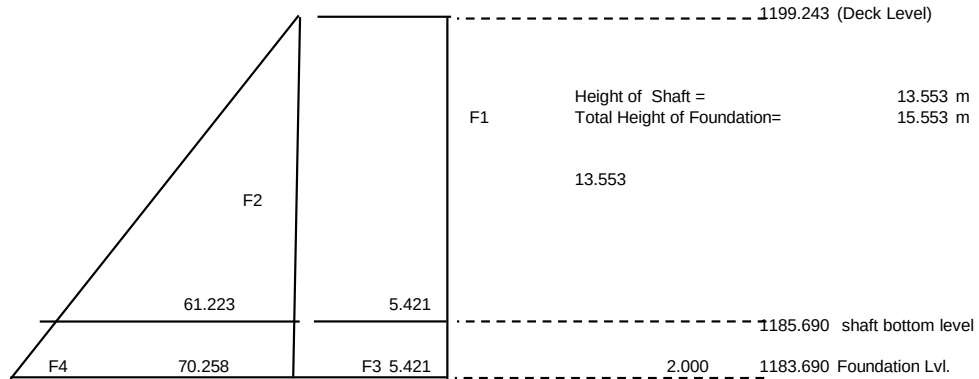
(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.341	In Transverse direction
Av	=	0.227	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1185.690 m (at Shaft Base)			
@ RL					1183.690 m (at Foundation Level)			
Due to Live Load Surcharge								
Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421 kN/m^2
F1	=	5.421	x	13.553	x	12.500	=	918.352 kN
M1	=	918.35	x	6.78	=	6223.215	kN.m	at Shaft Bottom
F3	=	5.421	x	15.553	x	12.500	=	1053.873 kN
M3	=	1053.873	x	7.776	=	8195.440	kN.m	at Foundation
Due to Active Earth Pressure								
Intensity for triangular portion (At Shaft bottom level)								
	=	0.226	x	20	x	13.553	=	61.223 kN/m^2
F2	=	0.5	x	61.22	x	13.553	x	12.50
	=	5186.013 kN						
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)								
M2	=	5186.01	x	5.69	=	29520.133	kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)								
	=	0.226	x	20	x	15.553	=	70.258 kN/m^2
F4	=	0.5	x	70.26	x	15.553	x	12.50
	=	6829.534 kN						
M4	=	6829.53	x	6.53	=	44612.290	kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
 = 4.800 x 13.553 = 65.054 kN/m²

F = 0.5 x 65.054 x 13.553 x 12.500
 = **5510.514 kN**

M = 5510.51 x 4.518 = **24894.667 kN.m at Shaft Bottom**

Intensity for triangular portion (At Foundation level)
 = 4.800 x 15.553 = 74.65 kN/m²

F = 0.5 x 74.654 x 15.55 x 12.500
 = **7256.874 kN**

M = 7256.87 x 5.184 = **37622.055 kN.m at Foundation**

Intensity of Passive pressure
 = 5.249 x 20 x 0.000 = 0.000 kN/m²

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 12.500
 = **0.000 kN**

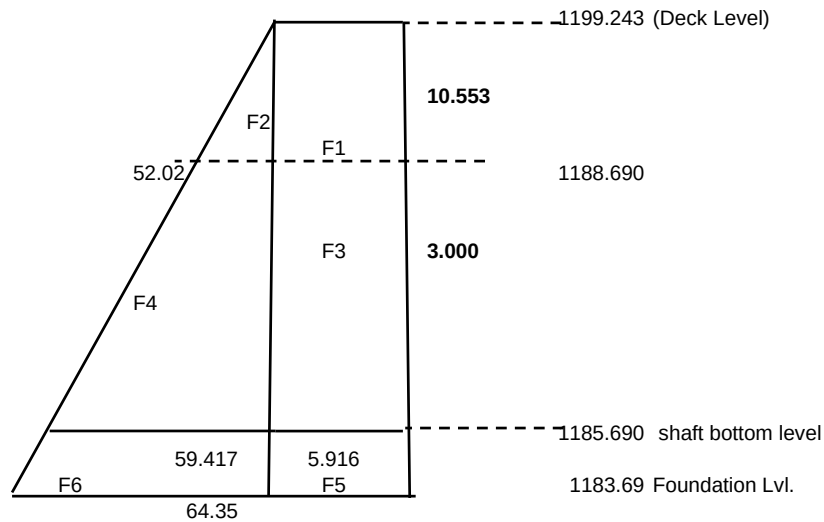
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = **0.000 kN.m at Foundation**

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	29520.133	44612.290	5186.013	6829.534
Due to Minimum Fluid Pressure	24894.667	37622.055	5510.514	7256.874
Governing of Two	29520.133	44612.290	5510.514	7256.874
Due to Live Load Surcharge	6223.215	8195.440	918.352	1053.873
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Horizontal Forces and Moments @ RL****1185.7 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	13.553	x	12.500	=	1002.164 kN
M1	=	1002.16	x	6.78	=	6791.165 kN.m		at Shaft Bottom
F3	=	5.916	x	15.553	x	12.500	=	1150.052 kN
M3	=	1150.05	x	7.78	=	8943.381 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	10.553	=	52.022 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.000	=	7.394 kN/m ²
F2	=	0.5	x	52.02	x	10.553	x	12.50
	=	3431.184 kN						
F4	=	$\frac{(52.02 + 59.42)}{2}$			x	3.00	x	12.50
	=	2089.475 kN						
Total Force	=	5520.659 kN						
M2	=	3431.18	x	7.43	=	25501.453 kN.m		
M4	=	2089.47	x	1.47	=	3064.890 kN.m		
Total Moment	=	28566.34 kN.m		at Shaft Bottom				

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 10.553 = 52.022 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.000 = 12.324 \text{ kN/m}^2$$

$$F2 = 0.5 \times 52.02 \times 10.553 \times 12.50 = 3431.184 \text{ kN}$$

$$F6 = \left(\frac{52.02 + 64.35}{2} \right) \times 5.00 \times 12.50 = 3636.508 \text{ kN}$$

$$\text{Total Force} = 7067.692 \text{ kN}$$

$$M2 = 3431.18 \times 9.43 = 32363.821 \text{ kN.m}$$

$$M6 = 3636.51 \times 2.41 = 8770.332 \text{ kN.m}$$

$$\text{Total Moment} = 41134.15 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 0.00 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	28566.342	41134.154	5520.659	7067.692
Due to Minimum Fluid Pressure	24894.667	37622.055	5510.514	7256.874
Governing of Two	28566.342	41134.154	5520.659	7256.874
Due to Live Load Surcharge	6791.165	8943.381	1002.164	1150.052
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.180	
αv	=	0.227	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \frac{0.146}{0.229}$$

$$C_a = \frac{1}{0.385} \frac{2}{0.295}$$

Ca	=	0.385	0.295	
Ka	=	0.226		
Dynamic Increment	=	0.385	-0.226	0.159

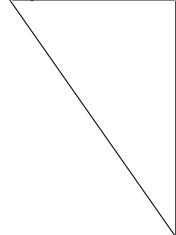
3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height = 1.2 m

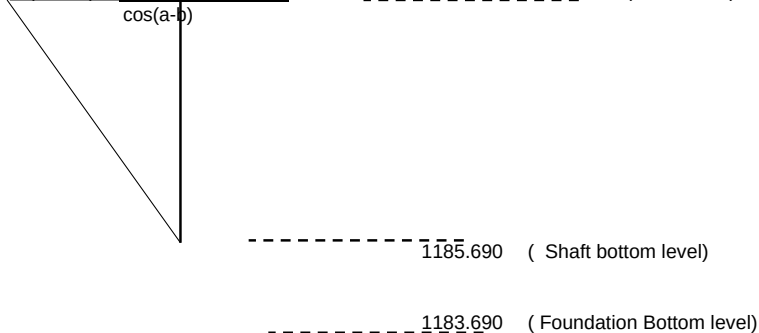
Assuming $\gamma_{dry} = 20 \text{ kN/m}^3$
 $\gamma_{water} = 10.00 \text{ kN/m}^3$

Active Earth Pressure

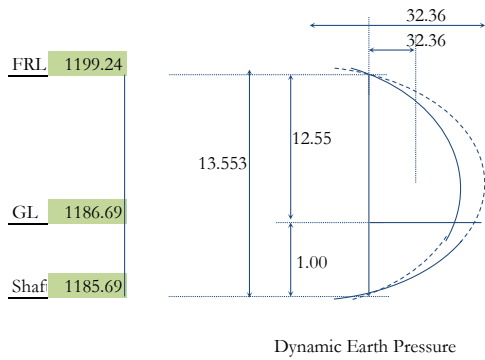
$$3 (Ca - Ka) = 0.478$$

**Surcharge Earth Pressure**

$$2 (Ca - Ka) \frac{\cos \alpha}{\cos(\alpha - \beta)} = 0.32$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.318	x	20.00	x	1.2	=	7.641 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.641	x	13.553	x	12.500
	=	647.225	kN					
M1	=	647.225	x	9.081			=	5877.133 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.641	x	13.553	x	12.500
	=	647.225	kN					
M2	=	647.225	x	11.081			=	7171.583 kN.m

Due to Dynamic Active Earth Pressure**Dyanmic Earth Pressure Calculation****Parabola above Water Level**

p_mid_height	=	32.36 t/m ²
h	=	13.553 m
y	=	5.7765 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	32.36 t/m ²
h	=	13.553 m
y	=	-5.7765 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	3598.2	6.9
Parabola below Water Level	56.8	0.7
Total Dynamic Earth Pressure	3654.9	6.8

$$E3 = 3654.933 \text{ kN}$$

$$E4 = 3654.933 \text{ kN}$$

$$M3 = 3654.93 \times 6.78 = 24767.657 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 3654.93 \times 8.78 = 32077.524 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	29520.133	44612.290	5186.013	6829.534
Due to active Earth Pressure (dynamic Increment)	24767.657	32077.524	3654.933	3654.933
Total Earth Pressure	54287.790	76689.814	8840.946	10484.467
Due to Minimum Fluid Pressure	24894.667	37622.055	5510.514	7256.874
Governing of Two	29520.133	76689.814	8840.946	10484.467
Due to Live Load Surcharge (Static)	6223.215	8195.440	918.352	1053.873
Due to Live Load Surcharge(Dynamic)	5877.133	7171.583	647.225	647.225
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

αh	=	0.180			
αv	=	0.227			
ϕ	=	35.00		0.611	
δ	=	11.25		0.196	
α	=	0.00		0.000	
β	=	0.00		0.000	
Ws	=	20.00	Kn/m3	2.00	gm/cm3
λ	=	$\tan^{-1} \frac{Ws}{Ws-1}$		$\frac{\alpha h}{(1 \pm \alpha v)}$	=
					0.285
					0.436
C_a'	=	1		2	
		0.557		0.517	
Ca'	=			0.557	
Ka'	=			0.246	
Dynamic Increment	=			0.557	-0.246
					0.310
Dynamic Increment	=				0.310
γ_d	=				20 kN/m ³
γ_{sat}	=				10 kN/m ³
γ_{water}	=				10 kN/m ³
Equivalent Live Load Surcharge height	=				1.2 m
Foundation	=				14.50 m
Dynamic Active earth pressure Variation					
$3 (ca'-ka')$					
Dynamic Surcharge earth pressure Variation					
$2 (Ca'-Ka')$					
					$\frac{\cos a}{\cos(a-b)}$
					1199.243 (Deck Level)
					10.553
					1188.690 HFL
					5.000
					3.000
					1185.690 shaft bottom level
					1183.69 Foundation Bottom Lvl.

Earth Pressure Diagram

h'	=	3.000
h	=	13.553

Dynamic active earth pressure		
$3 (ca'-ka')$	=	0.478 at deck level
$3 (ca'-ka')$	=	0.931 at deck level
$3 (ca'-ka')h'/h$	=	0.206 at HFL level

Dynamic Surcharge earth pressure				
$2 (Ca'-Ka')$	$\frac{\cos a}{\cos(a-b)}$	=	0.621 at deck level	Pressure = 14.90 kN/m ²
		=	0.137 at HFL level	Pressure = 3.30 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.641 kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	3.30 kN/m ²

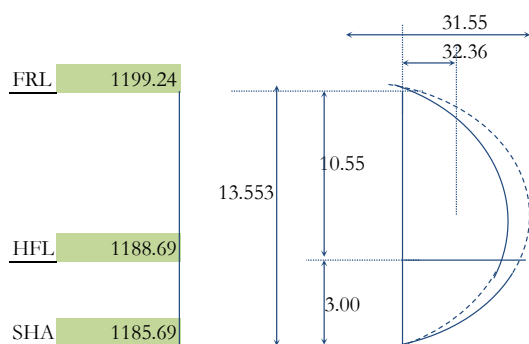
at Shaft Bottom Level

F1	=	5.469	x	10.553	x	12.500	=	721.449 kN
M1	=	721.45	x	8.28	=	5971.072 kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 3.297 \times 3.000 \times 12.500 \\
 &= \mathbf{61.828 \text{ kN}} \\
 M2 &= 61.83 \times 2.01 = \mathbf{124.274 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 783.277 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 6095.346 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 5.469 \times 10.553 \times 12.500 = \mathbf{721.449 \text{ kN}} \\
 M3 &= 721.45 \times 10.28 = \mathbf{7413.970 \text{ kN.m}} \\
 F4 &= 0.500 \times 3.297 \times 3.000 \times 12.500 \\
 &= \mathbf{61.828 \text{ kN}} \\
 M4 &= 61.83 \times 4.01 = \mathbf{247.929 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 783.277 \text{ kN} \\
 \text{Total Moment at Founding level} &= 7661.899 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation**Parabola above Water Level**

$$\begin{aligned}
 p_{\text{mid\_height}} &= 32.36 \text{ t/m}^2 \\
 h &= 13.553 \text{ m} \\
 y &= 3.7765 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 31.55 \text{ t/m}^2 \\
 h &= 13.553 \text{ m} \\
 y &= -3.7765 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	3197.0	7.5
Parabola below Water Level	446.4	2.0
Total Dynamic Earth Pressure	3643.4	6.8

Total Force (F1 + F2)	=	3643.404 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	3643.404 kN	at Foundation Bottom Level

$$M1 = 3643.40 \times 6.79 = 24745.096 \text{ kN.m}$$

Total Mome = 24745.096 kN.m at Shaft Bottom

$$M1 = 3643.40 \times 8.79 = 32031.904 \text{ kN.m}$$

Total Mome = 32031.904 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force**MOMENTS****HORIZONTAL FORCE**

	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundation Bottom Lvl kN
Due to active Earth Pressure(Static)	28566.342	41134.154	5520.659	7067.692
Due to active Earth Pressure (Dynamic Increment)	24745.096	32031.904	3643.404	3643.404
Total Earth Pressure	53311.439	73166.058	9164.063	10711.096
Due to Minimum Fluid Pressure	24894.667	37622.055	5510.514	7256.874
Governing of Two	53311.439	73166.058	9164.063	10711.096
Due to Live Load Surcharge(Static)	6791.165	8943.381	1002.164	1150.052
Due to Live Load Surcharge (Dynamic Increment)	6095.346	7661.899	783.277	783.277
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2134.30	1.35	1.35	2881.30	2881.30	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	301.90	1.75	1.75	528.32	528.32	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW + 1-CLASS A)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax-Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)
Braking Force	=	0.2	x	1000	+	0.05	x 554
	=	227.7	KN				

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.55	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.55	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.55	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1423.55	183.981	895.754	1239.564	1423.545	
DL+SIDL+LL-Max Reaction case		3737.75	1469.09	186.888	921.430	1282.197	1469.085	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	1469.09	194.574	929.117	1274.511	1469.085	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	1469.09	192.076	926.619	1277.009	1469.085	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	427.064	183.981	397.513	243.082	427.064	
DL+SIDL+LL-Max Reaction case		3737.75	472.604	186.888	423.189	285.716	472.604	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	472.604	194.574	430.876	278.029	472.604	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	472.604	192.076	428.378	280.527	472.604	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.35	1.35	2881.30	2881.30
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	301.90	1.75	1.75	528.32	528.32
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax- Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0.000	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.550	205.781	376.556	135.769	376.556	(1-70RW + 1- CLASS A)
	5609.43	0.000	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.550	263.431	434.206	78.119	434.206	(1-70RW + 1- CLASS A)
	5605.81	0.000	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.550	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1921.79	183.981	1144.874	1737.805	1921.786	
DL+SIDL+LL-Max Reaction case		3897.62	1967.33	194.881	1178.544	1772.445	1967.326	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	1967.33	223.706	1207.369	1743.620	1967.326	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	1967.33	214.338	1198.001	1752.988	1967.326	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	576.536	183.981	472.249	392.555	576.536	
DL+SIDL+LL-Max Reaction case		3897.62	622.076	194.881	505.919	427.195	622.076	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	622.076	223.706	534.744	398.370	622.076	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	622.076	214.338	525.376	407.738	622.076	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1	1.00	2134.30	2134.30
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	301.90	1	1.00	301.90	301.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax- Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	0.000	131.810	131.810	-131.810	131.810	
DL+SIDL+LL-Max Reaction case	2926.86	227.700	146.343	260.193	81.357	260.193	(1-70RW + 1-CLASS A)
	4130.01	0.000	206.500	206.500	-206.500	206.500	SV Loading
DL+SIDL+LL-Min Reaction case	3695.53	227.700	184.776	298.626	42.924	298.626	(1-70RW + 1-CLASS A)
	4562.38	0.000	228.119	228.119	-228.119	228.119	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3445.72	227.700	172.286	286.136	55.414	286.136	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	1281.191	131.810	772.405	1149.381	1281.191	
DL+SIDL+LL-Max Reaction case	2694.33	1326.731	134.716	798.082	1192.014	1326.731	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	1326.731	142.403	805.768	1184.328	1326.731	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	1326.731	139.905	803.270	1186.826	1326.731	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	384.357	131.810	323.988	252.547	384.357	
DL+SIDL+LL-Max Reaction case	2694.33	429.897	134.716	349.665	295.181	429.897	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	429.897	142.403	357.352	287.494	429.897	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	429.897	139.905	354.854	289.992	429.897	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.1	1.10	2347.73	2347.73
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	301.90	1.35	1.35	407.56	407.56
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 kN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2975.29	0.000	148.764	148.764	-148.764	148.764	
DL+SIDL+LL-Max Reaction case	3411.29	341.550	170.564	341.339	170.986	341.339	(1-70RW + 1- CLASS A)
	4469.10	0.000	223.455	223.455	-223.455	223.455	SV Loading
DL+SIDL+LL-Min Reaction case	4564.29	341.550	228.214	398.989	113.336	398.989	(1-70RW + 1- CLASS A)
	4901.48	0.000	245.074	245.074	-245.074	245.074	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4189.57	341.550	209.479	380.254	132.071	380.254	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	1921.79	148.764	1109.657	1773.021	1921.786	
DL+SIDL+LL-Max Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	576.536	148.764	437.032	427.771	576.536	
DL+SIDL+LL-Max Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	576.536	148.764	437.032	427.771	576.536	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2134.30	1	1	1	2134.30	2134.30	2134.30
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	301.90	1.20	1.20	1.20	362.27	362.27	362.27
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax- Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2987.24	227.700	149.362	263.212	78.338	263.212	(1-70RW + 1-CLASS A) Dry Case
	4190.38	0.000	209.519	209.519	-209.519	209.519	SV Loading
DL+SIDL+LL-Min Reaction case	3755.91	227.700	187.795	301.645	39.905	301.645	(1-70RW + 1-CLASS A) HFL Case
	4622.76	0.000	231.138	231.138	-231.138	231.138	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3506.10	227.700	175.305	289.155	52.395	289.155	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2914.57	170.775	145.729	231.116	25.046	231.116	Dry Case
DL+SIDL+LL-Min Reaction case	3491.07	170.775	174.554	259.941	-3.779	259.941	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3303.72	170.775	165.186	250.573	5.589	250.573	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	Dry Case
DL+SIDL+LL-Min Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2696.57	0.000	134.829	134.829	-134.829	134.829	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

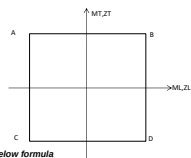
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1183.690 m

Properties of Footing Base:

A	=	181.250	m ²
ZL	=	438.021	m ³
ZT	=	377.604	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			2134.300	1.575	3361.522	0.000	0.000
SIDL, except Wearing Course	1			200.000	1.575	315.000	0.000	0.000
Wearing Course	1			301.895	1.575	475.485	0.000	0.000
Bearing Pedestal	1	25	1.312	32.800	1.575	51.660	-0.549	-18.000
				2668.995		4203.666		-18.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.775	72.656	0.000	0.000
Dirt Wall-Tapered portion	1	25	5.302	132.539	0.775	102.718	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.475	13.359	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.525	7.383	0.000	0.000
Cap - (uniform portion)	1	25	7.313	182.813	1.600	292.500	0.000	0.000
Cap - (corbel portion)	1	25	5.433	135.826	1.600	217.321	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.700	0.000	5.800	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.700	0.000	5.800	0.000
RCC Railing or Crash Barrier	1	25	28.000	700.000	0.775	21.700	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.475	77.930	0.000	0.000
				779.177		805.567		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	101.444	2536.090	-3.275	-8305.694	5.800	14709.321
Abutment Shaft	1	25	164.520	4113.001	1.628	6694.169	0.000	0.000
Back Filling over heel slab	1	20	1401.858	28037.166	-3.334	-93467.616	0.000	0.000
Front Filling over toe slab	1	20	97.500	1950.000	4.542	8857.500	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	136.641	3416.016	-2.673	-9130.078	0.000	0.000
Toe slab	1	25	82.500	2062.500	4.486	9253.125	0.000	0.000
Portion between heel & toe	1	25	43.750	1093.750	1.575	1722.656	0.000	0.000
Vertical Components of active earth pressure	1			3005.896	-7.250	-21792.744	0.000	0.000
				47820.828		-104773.028		14709.321
Total				51269.000		-99763.794		14691.321

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML @ toe = PxeL2 (kNm)
0.900	1920.870	-5.675	-10900.935
0.900	180.000	-5.675	-1021.500
0.900	301.895	-5.675	-1713.254
0.900	29.520	-5.675	-167.526
	2432.285		-13803.215
0.900	84.375	-6.475	-546.328
0.900	119.205	-6.475	-772.371
0.900	25.313	-6.775	-171.492
0.900	12.656	-6.725	-85.113
0.900	164.531	-5.650	-929.602
0.900	122.243	-5.650	-690.674
0.900	0.000	-5.550	0.000
0.900	0.000	-5.550	0.000
0.900	25.200	-6.475	-163.170
0.900	147.656	-6.775	-1000.371
	701.260		-4359.122
0.900	2282.481	-10.525	-24023.110
0.900	3701.701	-5.622	-20912.579
0.900	25233.449	-10.584	-267063.360
0.900	1755.000	-2.708	-4752.000
0.900	0.000	0.000	0.000
0.900	3074.414	-9.923	-30506.572
0.900	1856.250	-2.764	-5130.000
0.900	984.375	-5.675	-5586.328
0.900	2705.306	-14.500	-39226.939
	43038.745		-406186.160
	46172.289		-424348.497

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.358	1801.575
due to Earth pressure	1	7256.874		44612.290

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
131.81	1801.58	0.00	0.00
7256.87	44612.29	0.00	0.00

7388.684 46413.965 0.000 0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	148.764	1197.358	2033.312
due to Earth pressure	1.5	10885.311		66918.435
			11034.076	68951.747

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
148.76	2033.31	0.00	0.00
10885.31	66918.43	0.00	0.00
		11034.076	68951.747

11034.076 68951.747 0.000 0.000

Summary of Forces For SBC

P	51269.000	kN
ML	-53349.929	kNm
MT	14691.321	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		51269.000		-99763.794		14691.321
CWLL-Max. Reaction case	1	1059.332	1.575	1668.448	0.950	1006.366
Vertical Components of LL Surcharge	1	436.528	-7.250	-3164.830	0.000	0.000
Total		52764.860		-101260.176		15697.686

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML @ toe = PxeL2 (kNm)
0.000	46172.28913		-424348.50
0.900			-5.675
			-14.500
			-5696.69
	46172.289		-430045.19

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.193	1197.358	3556.320
due to Earth pressure	1	7256.874		44612.290
due to Live load surcharge	1	1053.873		8195.440

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
260.19	3556.32	0.00	0.00
7256.87	44612.29	0.00	0.00
1053.873	8195.440	0.00	0.00

8570.94 56364.05 0.00 0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	341.339	1197.358	4665.428
due to Earth pressure	1.5	10885.311		66918.435
due to Live load surcharge	1.2	1264.647		8834.529
			12491.298	81418.391

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
341.34	4665.43	0.00	0.00
10885.31	66918.43	0.00	0.00
1264.65	8834.53	0.00	0.00

12491.298 81418.391 0.000 0.000

Summary of Forces For SBC

P	52764.860	kN
ML	-44896.126	kNm
MT	15697.686	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Superstructure								
				2668.995		4203.666		-18.000
Substructure & Foundation -Portion 1								
				779.177		805.567		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	101.444	2536.090	-3.275	-8305.694	5.800	14709.321
Shaft above HFL	1	25	118.324	2958.097	1.807	5344.762	0.000	0.000
Shaft below HFL	1	25	46.196	692.942	1.628	1127.807	0.000	0.000
Back filling above HFL over heel slab	1	20	1048.704	20974.087	-3.275	-68690.137	0.000	0.000
Back filling below HFL over heel slab	1	10	360.234	3602.344	-3.503	-12620.625	0.000	0.000
Front Filling over toe slab	1	10	97.500	1950.000	2.475	2413.125	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	136.641	2049.609	-2.673	-5478.047	0.000	0.000
Toe slab	1	15	82.500	1237.500	4.486	5551.875	0.000	0.000
Portion between Heel & Toe	1	15	43.750	656.250	1.575	1033.594	0.000	0.000
Vertical Components of active earth pressure	1			3005.896	-7.250	-21792.744	0.000	0.000
				40196.831		-99977.362		14709.321
Total				43645.002		-94968.128		14691.321

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML @ toe = PxeL2 (kNm)
	2432.285		-13803.215
	701.260		-4359.122
0.900	2282.481	-10.525	-24023.110
0.900	2652.288	-5.443	-14491.299
0.900	623.648	-5.622	-3506.421
0.900	18876.679	-10.525	-198677.044
0.900	3242.109	-10.753	-34963.855
0.900	877.500	-4.775	-4190.063
0.900	0.000	0.000	0.000
0.900	1844.648	-9.923	-18303.943
0.900	1113.750	-2.764	-3078.000
0.900	590.625	-5.675	-3351.797
0.900	2705.306	-14.500	-39226.939
	36177.148		-352263.945
	39310.692		-370426.282

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.358	1801.575
due to Earth pressure	1	7256.874		41134.154

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
131.81	1801.58	0.00	0.00
7256.87	41134.15	0.00	0.00

7388.68 42935.73 0.00 0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	148.764	1197.358	2033.312
due to Earth pressure	1.5	10885.311		61701.230
			11034.076	63734.542

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
148.76	2033.31	0.00	0.

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Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	163.664	0.000	-13803.22	-928.794
Forces from Substructure				45102.535	412.189	0.000	-430045.37	-3092.081
CWLL-Max. Reaction case	0.00			0.00	0.000	-5.675	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-14.500	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-14.500	0.00	
Total =				47534.820	575.854		-443848.59	-4020.876
					-575.854			4020.876

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	294.345	1197.358	18133.753	4414.500
due to Substructure	1	1645.300	691.787		13951.663	5866.153
due to Earth pressure	1	10484.467			76689.814	
due to Live load surcharge	0.20	340.220			3073.405	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.358	26266.969
due to Substructure	1.5	2450.809		20794.926
due to Active Earth pressure	1	6829.534		44612.290
due to dynamic Earth pressure	1.5	5482.400		48116.28542
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		16684.529		139790.470

Summary of Forces For SBC

	Downward	Upward
P	53616.124	52301.281
ML	1903.261	1505.173
MT	25173.247	25173.247

Summary of Restoring Forces

Vertical Load	46958.966
Moment	-447869.463

Case 7 : DL+SIDL-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		272.698	181.798		4203.666	286.333				-18.000	4051.850
Substructure & Foundation -Portion 1				779.177	132.417	55.677	37.118		805.567	46.672		1779.196			748.085
Substructure & Foundation -Portion 2															
Solid Return wall	1		101.44	2536.09	616.270	259.118	172.745	-3.28	-8305.694	-565.742	1192.19	5238.062	5.80	14709.321	2202.409
Shall above HFL	1	25	118.324	2958.097	718.818	302.236	201.491	1.807	5344.762	364.058	1192.424	6278.153	0.000	0.000	2639.729
Shall below HFL	1	15	46.196	692.942	177.795	74.756	49.838	1.628	1127.807	81.114	1187.690	711.182	0.000	0.000	299.025
Back filling above HFL over heel slab	1	20	1048.704	20974.087	0.000	0.000	0.000	-3.275	-68690.137	0.000	1193.967	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	360.234	3602.344	0.000	0.000	0.000	-3.503	-12620.625	0.000	1186.690	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	97.500	975.000			2.475	2413.125					0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000			0.000	0.000					0.000	0.000	
Heel slab	1	15	136.641	2049.509			-2.673	-5478.047					0.000	0.000	
Toe slab	1	15	82.500	1237.500			4.486	5551.875					0.000	0.000	
portion between heel & toe	1	15	43.750	656.250			1.575	1033.594					0.000	0.000	
Vertical component of active earth pressure	1			2927.534			-7.250	-21224.621					0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			1509.147			-7.250	-10941.318					0.000	0.000	
				41627.616	1879.573	790.290	526.860		-111789.279	-120.570		15294.367		14709.321	6430.710
Total =				45075.788	2011.991	1118.665	745.776		-106780.045	212.435		17073.562		14691.321	11230.645
							-745.776			-212.435					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	163.664		-13803.215	-928.794
Substructure & Foundation -Portion 1				701.260	33.406		-4102.516	-200.188
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	101.44359	2282.481	155.471	-10.53	-24023.110	-1636.333
Shall above HFL	0.9	25	118.324	2662.288	181.342	-5.443	-14491.299	-987.074
Shall below HFL	0.9	15	46.196	623.648	41.971	-5.622	-3506.421	-235.979
Back filling above HFL over heel slab	0.9	20	1048.704	18676.679	0.000	-186677.044	0.000	0.000
Back filling below HFL over heel slab	0.9	10	360.234	3242.109	0.000	-10.753	-34863.855	0.000
Front Filling over toe	0.9	10	97.500	877.500		-4.775	-4190.063	
Side filling between heel and toe	0.9	10	0.000	0.000		0.000	0.000	
Heel slab	0.9	15	136.641	1844.648		-9.923	-18303.943	
Toe slab	0.9	15	82.500	1113.750		-2.764	-3078.000	
portion between heel & toe	0.9	15	43.750	590.625		-5.675	-3351.797	
Vertical component of active earth pressure	0.9			2634.781		-14.500	-38204.319	
Vertical component of dynamic increment of earth pressure	0.9			1358.233		-14.500	-19694.372	
				37464.855	471.291		-370935.70	-3441.869
Total =				40598.399	668.362		-388841.43	-4570.851
					-668.362			4570.851

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	272.698	1197.358	17511.313	4051.850
due to Substructure	1	2011.991	845.967		17073.562	7178.795
due to Earth pressure	1	10711.095			73166.058	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.358	26266.969
due to Substructure	1.5	2450.809		20941.325
due to Active Earth pressure	1	7087.692		41134.154
due to dynamic Earth pressure	1.5	5465.106		48047.856
		16905.393		136390.303

Summary of Forces For SBC

	Downward	Upward
P	45821.564	44330.012
ML	1183.322	758.453
MT	25921.965	25921.965

Summary of Restoring Forces

Vertical Load	39930.037
Moment	-393412.279

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995		272.698	181.798		4203.666	286.333				-18.000	4051.850
Forces from Substructure				42405.793	2011.991	845.967	563.978		-110983.712	-73.898		17073.562		14709.321	7178.795
CWLL-Max. Reaction case	0.20			58.13		5.940	3.960	1.575	91.560	6.237	1200.443		0.950	55.227	99.507
Vertical component of LL Surcharge	0.20			95.27				-7.250	-690.732				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			64.89				-7.250	-470.444				0.000	0.000	
Total =				45294.084	2011.991	1124.604	749.736		-107849.661	218.671		17073.562		14746.547	11330.152
							-749.736			-218.671					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	163.664		-13803.215	-928.794
Forces from Substructure				38166.114	504.697		-375038.21	-3642.057
CWLL-Max. Reaction case	0.00			0.00	0.00		-5.68	0.00
Vertical component of LL Surcharge	0.00			0.00		-5.675	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-14.500	0.000	0.000
Total =				40598.399	668.362		-388847.10	-4570.851
					-668.362			4570.851

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	278.637	1197.358	18133.753	4151.357
due to Substructure	1	2011.991	845.957		17073.562	7178.795
due to Earth pressure	1	10711.096			73166.058	
due to Live load surcharge	0.20	386.666			3321.056	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.358	26266.969
due to Substructure	1.5	2450.809		20941.32476
due to Active Earth pressure	1	7067.692		41134.154
due to dynamic Earth pressure	1.5	5465.106		48047.85618
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
Total		16905.393		136390.303

Summary of Forces For SBC

	Downward	Upward
P	46043.820	44544.348 kN
ML	4063.440	3626.097 kNm
MT	26076.699	26076.699 kNm

Summary of Restoring Forces

Vertical Load	39930.037 kN
Moment	-393417.954 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN	FL = 0.3 x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		908.992	181.788		4203.666	286.333				-18.000	13506.165
Substructure & Foundation -Portion 1				779.177	39.725	185.588	37.118		805.567	46.672		533.759		0.000	2493.618
Substructure & Foundation -Portion 2				49157.740	453.865	2120.369	424.074		-114465.645	-156.689		3651.740		14709.321	17060.226
Total =				52605.912	493.590	3214.950	542.990	-642.990	-109456.412	176.315	-176.315			14691.321	33060.009

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	163.664		-13803.22	-928.794
Substructure & Foundation -Portion 1				701.260	33.406		-4102.52	-200.188
Substructure & Foundation -Portion 2				44401.276	378.784		-425942.86	-2891.893
Total =				47534.820	575.854		-443848.59	-4020.876

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1779.196
	1501.455		12084.088
	1633.873		13863.284

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.357	908.992	1197.358	5253.394	13506.165
due to Substructure	1	493.590	2305.958		4165.499	19553.844
due to Earth pressure	1	10484.467			76689.814	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.358	7880.091
due to Substructure	1.5	2450.809		20794.92574
due to Active Earth pressure	1	6829.534		44612.28992
due to dynamic Earth pressure	1.5	1644.720		14434.886
due to dynamic increment of live load surcharge	0	0		0
Total		11501.599		87722.132

For Overturning or Sliding Effect

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	5253.39	0.00	0.00	0.00	0.00	908.99	13506.17
493.59	4165.50	0.00	0.00	0.00	0.00	2305.96	19553.84
10484.47	76689.81						
11362.41	86128.71	0.00	0.00	0.00	0.00	3214.95	33060.01

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7880.09	0.00	0.00
2450.81	20794.93	0.00	0.00
6829.534	44612.290		
1644.720	14434.886		
11501.60	87722.13	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	53248.902	51952.922 kN
ML	-23151.390	-23504.021 kNm
MT	47751.330	47751.330 kNm

Summary of Restoring Forces

Vertical Load	46958.966 kN
Moment	-447869.463 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	52958.702	657.421	-110144.42	199.044	14892.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	981.148	1197.358	5875.835	14715.001
due to Substructure	1	493.590	2305.958		4165.499	19553.844
due to Earth pressure	1	10484.467			76689.814	
due to Live load surcharge	0.2	340.220			3073.405	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.358	7880.091
due to Substructure	1.5	735.24		6282.478
due to Active Earth pressure	1	6829.53		44612.290
due to dynamic Earth pressure	1.5	1644.72		14434.886
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
Total		9786.03		73165.744

Summary of Forces For SBC

	Downward	Upward
P	53616.124	52301.281 kN
ML	-20120.822	-20518.910 kNm
MT	49161.438	49161.438 kNm

Summary of Restoring Forces

Vertical Load	46958.966 kN
Moment	-447869.463 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	2668.995	181.788	4203.666	286.333	-18.000
Substructure & Foundation -Portion 1	779.177	37.118	805.567	46.672	0.000
Substructure & Foundation -Portion 2	41627.616	526.860	-111789.279	-120.570	14709.321
Total =	45075.788	745.776	-106780.045	212.435	14691.321

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.36	908.99	1197.35	5253.39	13506.17
due to Substructure	1	603.60	2819.89		5122.07	23929.32
due to Earth pressure	1	10711.10			73166.06	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.358	7880.09
due to Substructure	1.5	735.243		6282.40
due to Active Earth pressure	1	7067.692		41134.15
due to dynamic Earth pressure	1.5	1639.533		14414.35
due to dynamic increment of live load surcharge	0	0		0
Total		10019.003		69711.00

Summary of Forces For SBC

	Downward	Upward
P	45821.564	44330.012 kN
ML	-23026.091	-23450.960 kNm
MT	52126.803	52126.803 kNm

Summary of Restoring Forces

Vertical Load	39930.037 kN
Moment	-393417.279 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Forces along Long. Axis**

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1326.73	18133.75	0.00	0.00	0.00	0.00	278.64	4151.36
2011.99	17073.56	0.00	0.00	0.00	0.00	845.97	7178.80
10711.10	73166.06						
386.67	3321.06						
14436.48	111694.43	0.00	0.00	0.00	0.00	1124.60	11330.15

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1921.79	26266.97	0.00	0.00
2450.81	20941.32	0.00	0.00
7067.692	41134.154		
5465.106	48047.856		
0.000	0.000		
0.000	0.000		
16905.39	136390.30	0.00	0.00

Summary of Restoring Forces

Vertical Load	39930.037 kN
Moment	-393417.954 kNm

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN	FL = 0.3 x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		908.992	181.788		4203.666	286.333				-18.000	13506.165
Substructure & Foundation -Portion 1				779.177	39.725	185.588	37.118		805.567	46.672		533.759		0.000	2493.618
Substructure & Foundation -Portion 2				49157.740	453.865	2120.369	424.074		-114465.645	-156.689		3651.740		14709.321	17060.226
Total =				52605.912	493.590	3214.950	542.990	-642.990	-109456.412	176.315	-176.315			14691.321	33060.009

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1779.196
	1501.455		12084.088
	1633.873		13863.284

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	5253.39	0.00	0.00	0.00	0.00	908.99	13506.17
493.59	4165.50	0.00	0.00	0.00	0.00	2305.96	19553.84
10484.47	76689.81						
11362.41	86128.71	0.00	0.00	0.00	0.00	3214.95	33060.01

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7880.09	0.00	0.00
2450.81	20794.93	0.00	0.00
6829.534	44612.290		
1644.720	14434.886		
11501.60	87722.13	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	47534.820	575.854	-443848.59	-4020.876

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
429.90	5875.83	0.00	0.00	0.00	0.00	981.15	14715.00
493.59	4185.50	0.00	0.00	0.00	0.00	2305.96	19553.84
10484.47	76689.81						
340.22	3073.40						
11748.17	89824.55	0.00	0.00	0.00	0.00	3287.11	34268.84

Vertical Forces For SBC Calculation

Loads	Vertical Load (P) kN	$P_v = 0.3 \times w \times P$ (kN)	$M_L = P_{xL1}$	M_L s due to F_v	$M_T = P_{xT}$
Total =	45294.084	749.736	-107849.66	218.671	14746.547
		-749.736		-218.671	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	928.79095	1197.358	2875.635	13837.8515
due to Substructure	1	603.597	2819.8999		5122.059	23929.31884
due to Earth pressure	1	10711.096			73166.058	
due to Live load surcharge	0.2	386.666			3321.056	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.358	7880.09
due to Substructure	1.5	735.24		6282.40
due to Active Earth pressure	1	7067.69		41134.15
due to dynamic Earth pressure	1.5	1639.53		14414.36
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		10019.00		69711.00

Summary of Forces For SBC

	Downward	Upward
P	46043.820	44544.348
ML	-20145.973	-20583.315
MT	52513.719	52513.719

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN
 Transverse Moment due to C.F. = 0.000 x (1200.443 - 1183.690) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 KN
 Transverse Moment due to C.F. = 0.000 x (1200.443 - 1183.690) = 0.000 kNm

Base pressure on corner A = σ_a = $P/A - M_L/ZL + M_T/2T$
 Base pressure on corner B = σ_b = $P/A + M_L/ZL + M_T/2T$
 Base pressure on corner C = σ_c = $P/A - M_L/ZL - M_T/2T$
 Base pressure on corner D = σ_d = $P/A + M_L/ZL - M_T/2T$

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN	$P_v = 0.3 \times w \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$M_L = P_{xL2}$	M_L s due to F_v
Total =	40698.399	668.362		-388847.10	-4570.851
		-668.362			4570.851

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
429.90	5875.83	0.00	0.00	0.00	0.00	928.79	13837.86
603.60	5122.07	0.00	0.00	0.00	0.00	2819.89	23929.32
10711.10	73166.06						
386.67	3321.06						
12131.26	87485.02	0.00	0.00	0.00	0.00	3748.68	37767.17

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	7880.09	0.00	0.00
735.24	6282.40	0.00	0.00
7067.692	41134.154		
1639.532	14414.357		
0.000	0.000		
0.000	0.000		
10019.00	69711.00	0.00	0.00

Summary of Restoring Forces

Vertical Load	39930.037
Moment	-393417.954

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_a	σ_b	σ_c	σ_d	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force: $\mu P + cA + F_p$	FOS	Overturning moment	Restoring Moment = $\sum P_i x_{Toe-M}$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	51269.000	-53349.929	14691.321	443.568	199.972	365.754	122.159	443.568	122.159	11034.076	32320.602	2.93	68951.747	424348.50	6.15
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	52764.860	-44896.126	15697.686	435.186	230.191	352.042	147.047	435.186	147.047	12491.298	32320.602	2.59	81418.391	430045.19	5.28
								SAFE	SAFE			SAFE			SAFE
Normal HFL Case															
Case 3 : DL+SIDL-Normal HFL Case	43645.002	-52032.399	14691.321	398.496	160.917	320.683	83.104	398.496	83.104	11034.076	27517.484	2.49	63734.542	370426.28	5.81
Case 4 : DL+SIDL+LL-(Minimum Reaction Case)-Normal HFL Case	44412.037	-43804.829	14967.455	384.676	184.664	305.400	105.388	384.676	105.388	12664.363	27817.596	2.20	77886.674	376642.87	4.84
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	53248.902	-1127.307	24609.323	361.533	356.386	231.188	226.041	361.533	226.041	16684.529	32871.276	1.97	139790.470	447869.46	3.20
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	53616.124	1903.261	25173.247	358.134	366.824	224.802	233.493	366.824	224.802	16684.529	32871.276	1.97	139790.470	447869.46	3.20
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	45821.564	1183.322	25921.965	318.756	324.159	181.459	186.862	324.159	181.459	16905.393	27951.026	1.65	136390.303	393412.28	2.88
Case 8 : DL+SIDL+LL-(Minimum Reaction Case)-Long. Seismic HFL Case	46043.820	4063.440	26076.699	313.816	332.370	175.700	194.253	332.370	175.700	16905.393	27951.026	1.65	136390.303	393417.95	2.88
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	53248.902	-23151.390	47751.330	473.100	367.391	220.183	114.474	473.100	114.474	11501.599	32871.276	2.86	87722.192	447869.46	5.11
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	53616.124	-20120.822	49161.438	471.942	380.070	211.556	119.684	471.942	119.684	9786.032	32871.276	3.36	73165.744	447869.46	6.12
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	45821.564	-23026.091	52126.803	443.423	338.286	167.331	62.194	443.423	62.194	10019.003	27951.026	2.79	69710.998	393412.28	5.64
Case 12 : DL+SIDL+LL-(Minimum Reaction Case)-Trans. Seismic HFL Case	46043.820	-20145.973	52513.719	439.099	347.113	160.957	68.971	439.099	68.971	10019.003	27951.026	2.79	69710.998	393417.95	5.64
								SAFE	SAFE			SAFE			SAFE

DESIGN OF ABUTMENT(A2) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
86+825

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	23.750m	23.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	25.000m	25.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 400 kN/m² Assumed
SBC of soil-Normal Case = 460 kN/m²
SBC of soil-Seismic Case = 575 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	1.414m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.950m	1.950m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m
Projection of Abutment Cap (Span Side)	=	0.500m	0.500m
Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.204m	1.204m
Thickness of Abutment shaft at Bottom	=	1.400m	1.400m

Solid Return Wall

Length of Return wall	=	5.800m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.600m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	10.800m	
abutment pedestal width	=	1.400m	
abutment pedestal Height	=	1.500m	
Width of Toe Slab	=	3.600m	
Width of Heel Slab	=	5.800m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.500m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.500m	
Width of backfill on heel slab	=	5.800m	
Thickness of heel slab at back fill edge	=	1.500m	
Height of back fill at bottom edge of heel slab	=	11.150m	
Height of back fill at back fill edge of heel slab	=	10.150m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1199.269m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1199.127m	Height of Superstructure	=	1.820m
Deck level at center line =	1199.269m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1197.384m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1196.784m	Height of Pedestal (3)	=	0.550m
Abutment cap bottom lvl (uniform portion ends)	1196.484m	Height of Pedestal (4)	=	0.625m
Abutment cap bottom lvl (corbel portion ends)	1196.184m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1196.184m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1190.548m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1189.048m	Height (Avg.) of Dirt Wall	=	2.414m
Foundation level =	1187.548m	Abutment shaft Above G.L	=	5.636m
HFL =	1192.548m	Abutment Shaft below G.L	=	1.500m

Height of abutment shaft	=	7.136m
MSL	=	1189.548m
Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z =Zone factor	=	0.36	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	522.61 4.50
DL Reaction on Bearing No.-2	=	544.54 1.50
DL Reaction on Bearing No.-3	=	544.54 -1.50
DL Reaction on Bearing No.-4	=	522.61 -4.50

DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2134.30 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	100.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	100.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		200.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	68.613 4.50
SIDL Reaction on Bearing No.-2	=	82.335 1.50
SIDL Reaction on Bearing No.-3	=	82.335 -1.50
SIDL Reaction on Bearing No.-4	=	68.613 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		301.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 4	=	0.625 x	0.800 x	0.800 =	0.4000 m ³	-4.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.3120 m ³	-0.549

VOLUME CALCULATION

C.G. Of Footing = 5.400 m
 C.G. Of shaft from toe tip = 4.300 m
 Distance between c.g. of shaft and footing = 1.100 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.300	-5.100	0.000
-Trapering portion	1	12.50	0.300	1.414	5.302	-0.800	0.300	-5.100	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	0.000	-5.400	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.050	-5.350	0.000
Cap (uniform portion)	1	12.50	1.950	0.300	7.313	0.025	1.125	-4.275	0.000
Cap (Corbel Portion)	1	12.50	1.950	0.300	5.433	0.025	1.125	-4.275	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.102	3.636	50.082	0.147	1.247	-4.153	0.000
Shaft below HFL	1	12.50	1.302	3.000	48.821	0.048	1.148	-4.252	0.000
Solid Return Wall	1	5.80	0.550	10.721	34.200	-3.600	-2.500	-7.900	5.975
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.700	0.400	-5.000	5.975
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.700	0.400	-5.000	5.975
Footing									
Heel Slab	1	12.50	5.800	1.000	72.500		-2.017	-7.417	0.000
Toe Slab	1	12.50	3.600	1.000	45.000		3.300	-2.100	0.000
Portion between Heel and Toe	1	12.50	1.400	1.500	26.250		1.100	-4.300	0.000
Back filling above HFL over Heel Slab	1	12.50	5.800	6.721	487.273		-2.500	-7.900	0.000
Back filling below HFL over Heel Slab	1	12.50	5.800	4.000	290.000		-2.621	-8.021	0.000
Backfill above Heel slab	1	12.50	5.800	10.650	772.107		-2.545	-7.945	0.000
Front Filling over Toe Slab	1	12.50	3.600	2.000	90.000		3.450	-1.950	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.600	1.000	45.000		2.200	-3.200	0.000
Side filling between heel and toe	1	0.00	1.400	2.000	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	0.000	-5.400	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.204	6.721	17.123		0.555	-4.845	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.196	4.000	9.809		0.465	-4.935	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.300	-5.100

SECTIONAL PROPERTIES

Width of Footing (B) = 10.800 m
 Length of Footing (L) = 12.500 m

A = 10.800 x 12.500 = 135.000 m²
 ZL = 12.500 x 19.440 = 243.000 m³
 ZT = IT1 + IT2

distance of extreme point from centre

IT1 = 10.800 x 162.760 = 1757.81 m⁴
 IT2 (moment of inertia of triangle) = 10.800 x 0.000 + 0.500 x 10.800 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1757.81 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 281.250 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20

Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 9.636 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

= 11.293 m

Abutment Cap Top Level - Foundation Level

= 9.236 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.20 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.350 m^4

Moment of Inertia , $I_{\text{transverse}}$ = 195.313 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 155.949 KN
 D = 2636.19 KN
 T = 0.2600 sec

Transverse Direction

Force = 18011.543 KN
 D = 2906.195 KN
 T = 0.0254 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.381

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.381

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.381

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.381

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.298

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.298	In Transverse direction
Av	=	0.199	In Vertical direction

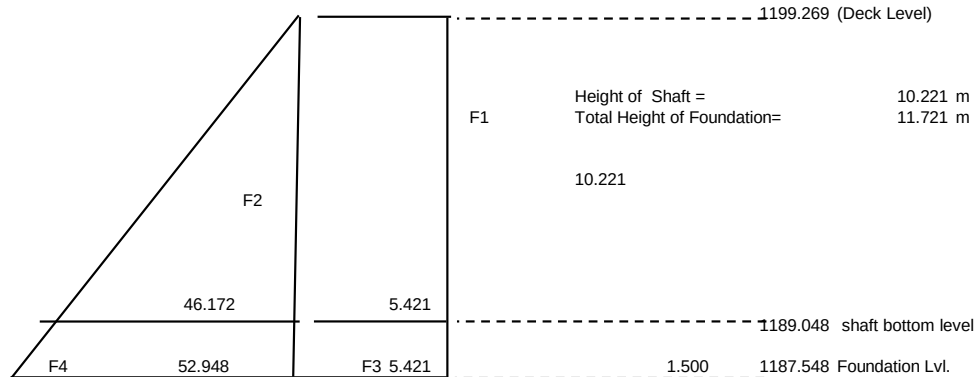
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.298	In Transverse direction
Av	=	0.199	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1189.048 m (at Shaft Base)			
@ RL				1187.548 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m^2
F1	=	5.421	x	10.221	x	12.500	= 692.576 kN
M1	=	692.58	x	5.11	=	3539.409	kN.m at Shaft Bottom
F3	=	5.421	x	11.721	x	12.500	= 794.216 kN
M3	=	794.216	x	5.861	=	4654.503	kN.m at Foundation
<u>Due to Active Earth Pressure</u>							
Intensity for triangular portion (At Shaft bottom level)							
	=	0.226	x	20	x	10.221	= 46.172 kN/m^2
F2	=	0.5	x	46.17	x	10.221	x 12.50
	=	2949.507	kN				
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)							
M2	=	2949.51	x	4.29	=	12661.704	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.226	x	20	x	11.721	= 52.948 kN/m^2
F4	=	0.5	x	52.95	x	11.721	x 12.50
	=	3878.752	kN				
M4	=	3878.75	x	4.92	=	19094.399	kN.m at Foundation
<u>Force Due To Fluid Pressure</u>							
As per Cl. 214.1 of IRC :6 -2014				γ fluid	=	4.8	kN/m^3
Intensity for triangular portion (At Shaft bottom level)							
	=	4.800	x	10.221	=	49.061	kN/m^2
F	=	0.5	x	49.061	x	10.221	x 12.500
	=	3134.065	kN				
M	=	3134.07	x	3.407	=	10677.760	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	4.800	x	11.721	=	56.26	kN/m^2
F	=	0.5	x	56.261	x	11.72	x 12.500
	=	4121.455	kN				
M	=	4121.46	x	3.907	=	16102.526	kN.m at Foundation
<u>Intensity of Passive pressure</u>							
	=	5.249	x	20	x	0.000	= 0.000 kN/m^2

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 0.000 x 12.50
 = **0.000 kN**

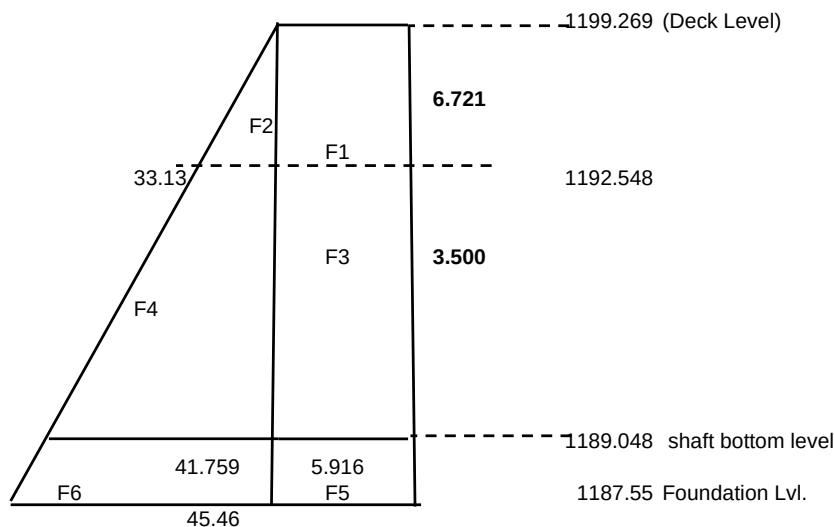
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = **0.000 kN.m** at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	12661.704	19094.399	2949.507	3878.752
Due to Minimum Fluid Pressure	10677.760	16102.526	3134.065	4121.455
Governing of Two	12661.704	19094.399	3134.065	4121.455
Due to Live Load Surcharge	3539.409	4654.503	692.576	794.216
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246	active component
	Kp'	=	5.249	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1189.0 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	10.221	x	12.500	=	755.782 kN
M1	=	755.78	x	5.11	=	3862.426 kN.m		at Shaft Bottom
F3	=	5.916	x	11.721	x	12.500	=	866.699 kN
M3	=	866.70	x	5.86	=	5079.287 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	6.721	=	33.132 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.500	=	8.627 kN/m ²
F2	=	0.5	x	33.13	x	6.721	x	12.50
	=	1391.746 kN						
F4	=	$\left(\frac{33.13 + 41.76}{2} \right) \times 3.50$				x	12.50	
	=	1638.231 kN						
Total Force	=	3029.977 kN						
M2	=	1391.75	x	6.32	=	8799.759 kN.m		
M4	=	1638.23	x	1.68	=	2756.823 kN.m		

Total Moment = 11556.58 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 6.721 = 33.132 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.000 = 12.324 \text{ kN/m}^2$$

$$F2 = 0.5 \times 33.13 \times 6.721 = 12.50$$

$$= 1391.746 \text{ kN}$$

$$F6 = \left(\frac{33.13 + 45.46}{2} \right) \times 5.00 \times 12.50$$

$$= 2455.868 \text{ kN}$$

Total Force = 3847.614 kN

$$M2 = 1391.75 \times 7.82 = 10887.377 \text{ kN.m}$$

$$M6 = 2455.87 \times 2.37 = 5818.731 \text{ kN.m}$$

Total Moment = 16706.11 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	11556.581	16706.109	3029.977	3847.614
Due to Minimum Fluid Pressure	10677.760	16102.526	3134.065	4121.455
Governing of Two	11556.581	16706.109	3134.065	4121.455
Due to Live Load Surcharge	3862.426	5079.287	755.782	866.699
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

αh	=	0.180	
αv	=	0.199	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.149 \\ 0.221 \end{matrix}$$

$$C_a = \frac{1}{0.379} \frac{2}{0.300}$$

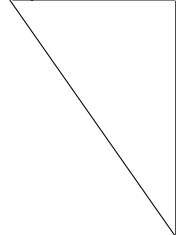
Ca	=	0.379	0.300	
Ka	=	0.226		
Dynamic Increment	=	0.379	-0.226	0.153

3 Earth Pressure : DRY CASE (Seismic case)

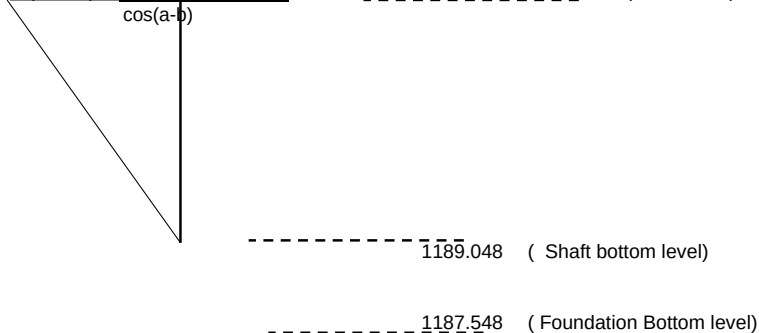
Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

Active Earth Pressure

$$3 (Ca - Ka) = 0.460$$

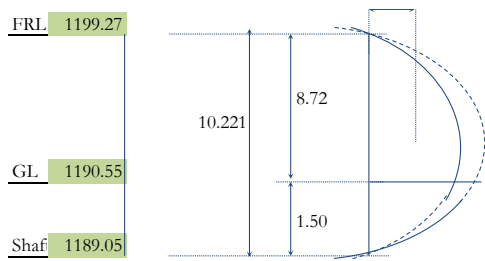
**Surcharge Earth Pressure**

$$2 (Ca - Ka) \frac{\cos a}{\cos(a-b)} = 0.31$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.307	x	20.00	x	1.2	=	7.357 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.357	x	10.221	x	12.500
	=	470.003	kN					
M1	=	470.003	x	6.848			=	3218.616 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.357	x	10.221	x	12.500
	=	470.003	kN					
M2	=	470.003	x	8.348			=	3923.621 kN.m

Due to Dynamic Active Earth Pressure



Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p _{mid_height}	=	23.50 t/m ²
h	=	10.221 m
y	=	3.6105 m
L	=	12.500 m

Parabola below Water Level

p _{mid_height}	=	23.50 t/m ²
h	=	10.221 m
y	=	-3.6105 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	1885.0	5.4
Parabola below Water Level	116.7	1.0
Total Dynamic Earth Pressure	2001.6	5.1

$$E3 = 2001.627 \text{ kN}$$

$$E4 = 2001.627 \text{ kN}$$

$$M3 = 2001.63 \times 5.11 = 10229.315 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 2001.63 \times 6.61 = 13231.756 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force

Dry Seismic Case

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	12661.704	19094.399	2949.507	3878.752
Due to active Earth Pressure (dynamic Increment)	10229.315	13231.756	2001.627	2001.627
Total Earth Pressure	22891.019	32326.155	4951.134	5880.379
Due to Minimum Fluid Pressure	10677.760	16102.526	3134.065	4121.455
Governing of Two	12661.704	32326.155	4951.134	5880.379
Due to Live Load Surcharge (Static)	3539.409	4654.503	692.576	794.216
Due to Live Load Surcharge(Dynamic)	3218.616	3923.621	470.003	470.003
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

αh	=	0.180			
αv	=	0.199			
ϕ	=	35.00		0.611	
δ	=	11.25		0.196	
α	=	0.00		0.000	
β	=	0.00		0.000	
Ws	=	20.00	Kn/m3	2.00	gm/cm3
λ	=	$\tan^{-1} \frac{Ws}{Ws-1}$		$\frac{\alpha h}{(1 \pm \alpha v)}$	=
					0.292
					0.422
C_a'	=	0.552		0.515	
Ca'	=			0.552	
Ka'	=			0.246	
Dynamic Increment	=	0.552		-0.246	0.306
Dynamic Increment	=			0.306	
γ_d	=			20 kN/m ³	
γ_{sat}	=			10 kN/m ³	
γ_{water}	=			10 kN/m ³	
Equivalent Live Load Surcharge height	=			1.2 m	
Foundation	=			10.80 m	
Dynamic Active earth pressure Variation	3 (ca'-ka')				
Dynamic Surcharge earth pressure Variation	2 (Ca'-Ka')				
		$\cos a$			1199.269 (Deck Level)
		$\cos(a-b)$			
				6.721	
					1192.548 HFL
				3.500	
					1189.048 shaft bottom level
					1187.548 Foundation Bottom Lvl.

Earth Pressure Diagram

h'	=	3.500
h	=	10.221

Dynamic active earth pressure		
3 (ca'-ka')	=	0.460 at deck level
3 (ca'-ka')	=	0.917 at deck level
3 (ca'-ka')h'/h	=	0.314 at HFL level

Dynamic Surcharge earth pressure				
2 (Ca'-Ka')	$\frac{\cos a}{\cos(a-b)}$	0.611 at deck level	Pressure	= 14.67 kN/m ²
		0.209 at HFL level	Pressure	= 5.02 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.357 kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	5.02 kN/m ²

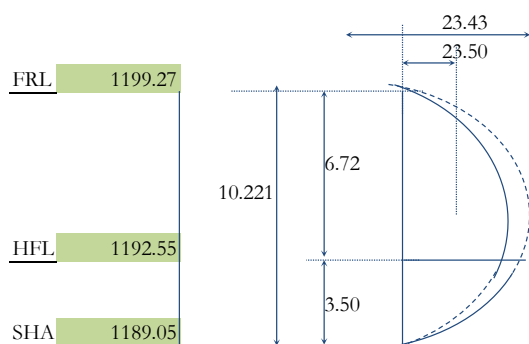
at Shaft Bottom Level

F1	=	6.191	x	6.721	x	12.500	=	520.084 kN
M1	=	520.08	x	6.86	=	3568.036 kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 5.024 \times 3.500 \times 12.500 \\
 &= \mathbf{109.892 \text{ kN}} \\
 M2 &= 109.89 \times 2.35 = \mathbf{257.698 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 629.976 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 3825.734 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 6.191 \times 6.721 \times 12.500 = \mathbf{520.084 \text{ kN}} \\
 M3 &= 520.08 \times 8.36 = \mathbf{4348.163 \text{ kN.m}} \\
 F4 &= 0.500 \times 5.024 \times 3.500 \times 12.500 \\
 &= \mathbf{109.892 \text{ kN}} \\
 M4 &= 109.89 \times 3.85 = \mathbf{422.537 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 629.976 \text{ kN} \\
 \text{Total Moment at Founding level} &= 4770.699 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 23.50 \text{ t/m}^2 \\
 h &= 10.221 \text{ m} \\
 y &= 1.6105 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 23.43 \text{ t/m}^2 \\
 h &= 10.221 \text{ m} \\
 y &= -1.6105 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1458.2	6.2
Parabola below Water Level	541.7	2.2
Total Dynamic Earth Pressure	2000.0	5.1

Total Force (F1 + F2)	=	1999.987 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	1999.987 kN	at Foundation Bottom Level

$$M1 = 1999.99 \times 5.11 = 10225.631 \text{ kN.m}$$

Total Mome = 10225.631 kN.m at Shaft Bottom

$$M1 = 1999.99 \times 6.61 = 13225.612 \text{ kN.m}$$

Total Mome = 13225.612 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force**MOMENTS****HORIZONTAL FORCE**

	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundation Bottom Lvl kN
Due to active Earth Pressure(Static)	11556.581	16706.109	3029.977	3847.614
Due to active Earth Pressure (Dynamic Increment)	10225.631	13225.612	1999.987	1999.987
Total Earth Pressure	21782.212	29931.721	5029.964	5847.601
Due to Minimum Fluid Pressure	10677.760	16102.526	3134.065	4121.455
Governing of Two	21782.212	29931.721	5029.964	5847.601
Due to Live Load Surcharge(Static)	3862.426	5079.287	755.782	866.699
Due to Live Load Surcharge (Dynamic Increment)	3825.734	4770.699	629.976	629.976
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2134.30	1.35	1.35	2881.30	2881.30	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	301.90	1.75	1.75	528.32	528.32	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW + 1-CLASS A)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax-Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.55	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.55	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.55	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1423.55	183.981	895.754	1239.564	1423.545	
DL+SIDL+LL-Max Reaction case		3737.75	1469.09	186.888	921.430	1282.197	1469.085	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	1469.09	194.574	929.117	1274.511	1469.085	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	1469.09	192.076	926.619	1277.009	1469.085	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	427.064	183.981	397.513	243.082	427.064	
DL+SIDL+LL-Max Reaction case		3737.75	472.604	186.888	423.189	285.716	472.604	Dry Case

DL+SIDL+LL-Min Reaction case		3891.49	472.604	194.574	430.876	278.029	472.604	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	472.604	192.076	428.378	280.527	472.604	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.35	1.35	2881.30	2881.30
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	301.90	1.75	1.75	528.32	528.32
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax- Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0.000	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.550	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0.000	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.550	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0.000	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.550	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1921.79	183.981	1144.874	1737.805	1921.786	
DL+SIDL+LL-Max Reaction case		3897.62	1967.33	194.881	1178.544	1772.445	1967.326	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	1967.33	223.706	1207.369	1743.620	1967.326	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	1967.33	214.338	1198.001	1752.988	1967.326	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	576.536	183.981	472.249	392.555	576.536	
DL+SIDL+LL-Max Reaction case		3897.62	622.076	194.881	505.919	427.195	622.076	Dry Case

DL+SIDL+LL-Min Reaction case		4474.12	622.076	223.706	534.744	398.370	622.076	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	622.076	214.338	525.376	407.738	622.076	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1	1.00	2134.30	2134.30
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	301.90	1	1.00	301.90	301.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax- Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	0.000	131.810	131.810	-131.810	131.810	
DL+SIDL+LL-Max Reaction case	2926.86	227.700	146.343	260.193	81.357	260.193	(1-70RW + 1-CLASS A)
	4130.01	0.000	206.500	206.500	-206.500	206.500	SV Loading
DL+SIDL+LL-Min Reaction case	3695.53	227.700	184.776	298.626	42.924	298.626	(1-70RW + 1-CLASS A)
	4562.38	0.000	228.119	228.119	-228.119	228.119	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3445.72	227.700	172.286	286.136	55.414	286.136	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	1281.191	131.810	772.405	1149.381	1281.191	
DL+SIDL+LL-Max Reaction case	2694.33	1326.731	134.716	798.082	1192.014	1326.731	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	1326.731	142.403	805.768	1184.328	1326.731	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	1326.731	139.905	803.270	1186.826	1326.731	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	384.357	131.810	323.988	252.547	384.357	
DL+SIDL+LL-Max Reaction case	2694.33	429.897	134.716	349.665	295.181	429.897	Dry Case

DL+SIDL+LL-Min Reaction case	2848.06	429.897	142.403	357.352	287.494	429.897	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	429.897	139.905	354.854	289.992	429.897	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.1	1.10	2347.73	2347.73
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	301.90	1.35	1.35	407.56	407.56
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2975.29	0.000	148.764	148.764	-148.764	148.764	
DL+SIDL+LL-Max Reaction case	3411.29	341.550	170.564	341.339	170.986	341.339	(1-70RW + 1-CLASS A)
	4469.10	0.000	223.455	223.455	-223.455	223.455	SV Loading
DL+SIDL+LL-Min Reaction case	4564.29	341.550	228.214	398.989	113.336	398.989	(1-70RW + 1-CLASS A)
	4901.48	0.000	245.074	245.074	-245.074	245.074	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4189.57	341.550	209.479	380.254	132.071	380.254	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	1921.79	148.764	1109.657	1773.021	1921.786	
DL+SIDL+LL-Max Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	576.536	148.764	437.032	427.771	576.536	
DL+SIDL+LL-Max Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	Dry Case

DL+SIDL+LL-Min Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	576.536	148.764	437.032	427.771	576.536	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2134.30	1	1	1	2134.30	2134.30	2134.30
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	301.90	1.20	1.20	1.20	362.27	362.27	362.27
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax- Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2987.24	227.700	149.362	263.212	78.338	263.212	(1-70RW + 1-CLASS A)
	4190.38	0.000	209.519	209.519	-209.519	209.519	SV Loading
DL+SIDL+LL-Min Reaction case	3755.91	227.700	187.795	301.645	39.905	301.645	(1-70RW + 1-CLASS A)
	4622.76	0.000	231.138	231.138	-231.138	231.138	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3506.10	227.700	175.305	289.155	52.395	289.155	

Dry Case

HFL Case

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2914.57	170.775	145.729	231.116	25.046	231.116	Dry Case
DL+SIDL+LL-Min Reaction case	3491.07	170.775	174.554	259.941	-3.779	259.941	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3303.72	170.775	165.186	250.573	5.589	250.573	

Normal Case: Quasi Permanant Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	Dry Case
DL+SIDL+LL-Min Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	HFL Case

DL+SIDL+LL-Max Transv. Moment case	2696.57	0.000	134.829	134.829	-134.829	134.829

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

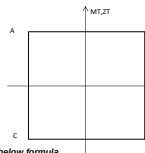
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1187.548 m

Properties of Footing Base:

A	=	135.000	m ²
ZL	=	243.000	m ³
ZT	=	281.250	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis $ML = ML \cos \theta + MT \sin \theta$ Moment along transverse axis $MT = MT \cos \theta - ML \sin \theta$ **Case 1 : DL+SIDL-Normal Dry Case****Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		2935.894		-18.000
Dead Load	1			2134.300	1.100	2347.730	0.000	0.000
SIDL except Wearing Course	1			200.000	1.100	220.000	0.000	0.000
Wearing Course	1			301.895	1.100	332.085	0.000	0.000
Bearing Pedestal	1	25	1.312	32.800	1.100	36.080	-0.549	-18.000
				2668.995		2935.894		-18.000
Substructure & Foundation -Portion 1						435.458		0.000
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.300	28.125	0.000	0.000
Dirt Wall-Tapered portion	1	25	5.302	132.559	0.300	39.762	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.000	0.000	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.050	0.703	0.000	0.000
Cap - (uniform portion)	1	25	7.313	182.813	1.125	205.664	0.000	0.000
Cap - (corbel portion)	25	5.433	135.826	1.125	152.804	0.000	0.000	0.000
Canilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.400	0.000	5.975	0.000
Canilever Return Wall-Triangle portion	1	25	0.000	0.000	0.400	0.000	5.975	0.000
RCC Railing or Crash Barrier	1	25	0.000	0.000	0.300	8.400	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.000	0.000	0.000	0.000
				779.177		435.458		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	34.200	855.000	-2.500	-2137.499	5.975	5108.624
Abutment Shaft	1	25	98.903	2472.577	1.148	2838.062	0.000	0.000
Back filling over heel slab	1	20	772.107	15442.138	-2.545	-39306.177	0.000	0.000
Front Filling over toe slab	1	20	90.000	1800.000	3.450	6210.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	72.500	1812.500	-2.017	-3655.208	0.000	0.000
Toe slab	1	25	45.000	1125.000	3.300	3712.500	0.000	0.000
Portion between heel & toe	1	25	26.250	656.250	1.100	721.875	0.000	0.000
Vertical Components of active earth pressure	1			1707.163	-5.400	-9218.678	0.000	0.000
				26409.270		-40560.351		5108.624
Total				29857.442		-37188.999		5090.624

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1920.870	-4.300	-8259.739
0.900	180.000	-4.300	-774.000
1.000	301.895	-4.300	-1298.149
0.900	29.520	-4.300	-126.936
	2432.285		-10458.824
0.900	84.375	-5.100	-430.313
0.900	119.295	-5.100	-609.354
0.900	25.313	-5.400	-136.688
0.900	12.656	-5.350	-67.711
0.900	164.533	-4.275	-703.371
0.900	122.243	-4.275	-522.590
0.900	0.000	-5.000	0.000
0.900	0.000	-5.000	0.000
0.900	25.200	-5.100	-128.520
0.900	147.656	-5.400	-797.344
	701.260		-3394.890
0.900	769.500	-7.900	-6079.048
0.900	2226.319	-4.252	-9462.470
0.900	13897.924	-7.945	-110424.348
0.900	1620.000	-1.950	-3159.000
0.900	0.000	0.000	0.000
0.900	1631.250	-7.417	-12098.438
0.900	1012.500	-2.100	-2126.250
0.900	590.625	-4.300	-2539.688
0.900	1536.446	-10.800	-16593.621
	23768.343		-164831.685
	26901.887		-178685.396

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.384	1296.480
due to Earth pressure	1	4121.455		19094.399

Forces along Long. Axis	Forces along Trans. Axis
FL Cos θ	ML Cos θ
131.81	1296.48
4121.46	19094.40
4253.265	20390.880
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1197.384	1463.247
due to Earth pressure	1.5	6182.183		28641.599
		6330.947		30104.845

Forces along Long. Axis	Forces along Trans. Axis
FL Cos θ	ML Cos θ
148.76	1463.25
6182.18	28641.60
6330.947	30104.845
0.000	0.000

Summary of Forces For SBC		
P	29857.442	KN
ML	-16798.120	kNm
MT	5090.624	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		29857.442		-37188.999		5090.624
CWLL-Max. Reaction case	1	1059.332	1.100	1165.265	0.950	1006.366
Vertical Components of LL Surcharge	1	328.975	-5.400	-1776.465	0.000	0.000
Total		31245.749		-37800.199		6096.989

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	26901.8872	-4.300	-178685.40
0.900	0.000	-10.800	-3197.64
	26901.887		-181883.04

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.193	1197.384	2559.260
due to Earth pressure	1	4121.455		19094.399
due to Live load surcharge	1	784.216		4654.503

Forces along Long. Axis	Forces along Trans. Axis
FL Cos θ	ML Cos θ
260.19	2559.26
4121.46	19094.40
784.216	4654.503
5175.86	26308.16
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		341.339	1197.384	3357.415
due to Earth pressure	1.5	6182.183		28641.599
due to Live load surcharge	1.2	953.059		5595.403
		7476.581		37584.417

Forces along Long. Axis	Forces along Trans. Axis
FL Cos θ	ML Cos θ
341.34	3357.42
6182.18	28641.60
953.06	5595.40
7476.581	37584.417
0.000	0.000

Summary of Forces For SBC			
P	31245.749	KN	
ML	-11492.038	kNm	
MT	6096.989	kNm	

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		2935.894		-18.000
Substructure & Foundation -Portion 1						435.458		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	34.200	855.000	-2.500	-2137.499	5.975	5108.624
Shaft above HFL	1	25	50.082	1252.040	1.247	1561.891	0.000	0.000
Shaft below HFL	1	15	48.821	732.322	1.148	840.570	0.000	0.000
Back filling above HFL over heel slab	1	20	487.273	9745.450	-2.500	-24363.625	0.000	0.000
Back filling below HFL over heel slab	1	10	290.000	2900.000	-2.621	-7600.417	0.000	0.000
Front Filling over toe slab	1	10	90.000	900.000	2.200	1980.000	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	72.500	1087.500	-2.017	-2193.125	0.000	0.000
Toe slab	1	15	45.000	675.000	3.300	2227.500	0.000	0.000
Portion between Heel & Toe	1	15	26.250	393.750	1.100	433.125	0.000	0.000
Vertical Components of active earth pressure	1			1707.163	-5.400	-9218.678	0.000	0.000
				20688.774		-38234.593		5108.624
Total				24136.946		-34863.241		5090.624

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2432.285		-10458.824
	701.260		-3394.890
0.900	769.500	-7.900	-6079.048
0.900	1126.836	-4.153	-4679.215
0.900	659.090	-4.252	-2802.572
0.900	8770.905	-7.900	-69290.150
0.900	2610.000	-8.021	-20934.375
0.900	810.000	-3.200	-2592.000
0.900	0.000	0.000	0.000
0.900	978.750	-7.417	-7259.063
0.900	607.500	-2.100	-1275.750
0.900	354.375	-4.300	-1523.813
0.900	1536.446	-10.800	-16593.621
	18619.896		-134958.574
	21753.440		-148812.287

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.384	1296.480
due to Earth pressure	1	4121.455		16706.109

Forces along Long. Axis	Forces along Trans. Axis
FL Cos θ	ML Cos θ
131.81	1296.48
4121.46	16706.11
4253.26	18002.59
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1197.384	1463.247
due to Earth pressure	1.5	6182.183		25059.163
		6330.947		26522.410

Forces along Long. Axis	Forces along Trans. Axis
FL Cos θ	ML Cos θ
148.76	1463.25
6182.18	25059.16
6330.95	26522.41
0.000	0.000

Summary of Forces For SBC		
P	24136.946	KN
ML	-16860.652	kNm
MT	5090.624	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation							
Loads	Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)	
Forces from Case : DL+SIDL		24136.946		-34863.241		5090.624	
CWLL-Min. Reaction case	1	290.668	1.100	319.735	0.950	276.134	
Vertical Components of LL Surcharge	1	358.998	-5.400	-1938.591	0.000	0.000	
Total		24786.612		-36482.098		5366.758	

Vertical Forces For Restoring or Resisting Effect				
Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)	
0.000	21753.440	0.000	-4.300	0
0.900	323.098	-10.800	-3489.463	
	22076.539		-152301.751	

Horizontal Forces For SBC Calculation				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	298.626	1197.384	2937.289
due to Earth pressure	1	4121.455		16706.109
due to live load surcharge	1	866.699		5079.287

Forces along Long. Axis			
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
298.63	2937.29	0.00	0.00
4121.46	16706.11	0.00	0.00
866.699	5079.287	0.000	0.000
5286.78	24722.68	0.00	0.00

Forces along Long. Axis			
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
398.99	3924.46	0.00	0.00
6182.18	25059.16	0.00	0.00
1040.038	6095.144	0.000	0.000
7621.21	36078.77	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		398.989	1197.384	3924.458
due to Earth pressure	1.5	6182.183		25059.163
due to live load surcharge	1.2	1040.038		6095.144
		7621.210		36078.766

Summary of Forces For SBC	
P	24786.612 KN
ML	-11759.413 kNm
MT	5366.758 kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah= 0.243	In Longitudinal direction	Weight of shaft below Ground level	=	558.901 KN
		av= 0.298	In Transverse direction	Weight of back fill below Ground level	=	2175.000 KN
		av= 0.199	In Vertical direction			

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			2134.300		191.006	127.337	1.100	2347.730	140.071	1198.597		0.000	0.000	2110.489
SIDL except Wearing Course	1			200.000		17.899	11.932	1.100	220.000	13.126	1199.718		0.000	0.000	217.826
Wearing Course	1			301.895		27.018	18.012	1.100	332.085	19.813	1199.269		0.000	0.000	316.674
Bearing Pedestal	1	25	1.312	32.800		2.935	1.957	1.100	36.080	2.153			-0.549	-18.000	
				2668.995		238.858	159.238		2936.894	175.162				-18.000	2644.989
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	3.750	93.750	22.781	8.390	5.593	0.300	28.125	1.678	1198.769	255.628	0.000	0.000	94.144
Dirt Wall-Tapered portion	1	25	5.302	132.539	32.207	11.861	7.908	0.300	39.762	2.372	1197.562	322.525	0.000	0.000	118.781
Bracket - Uniform portion	1	25	1.125	28.125				0.000	0.000						
Bracket - Tapered portion	1	25	0.563	14.063				0.050	0.703						
Cap - (uniform portion)	1	25	7.313	182.813	44.423	16.361	10.907	1.125	205.664	12.270	1196.634	403.631	0.000	0.000	148.652
Cap - (corbel portion)	1	25	5.433	135.826	33.006	12.156	8.104	1.125	152.804	9.117	1196.334	289.988	0.000	0.000	106.798
Cantilever Return Wall-Rectangle or	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1199.269	0.000	5.975	0.000	0.000
Cantilever Return Wall-Triangle port	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1199.269	0.000	5.975	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.300	8.400				0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.000	0.000				0.000	0.000	
				779.177	132.417	48.767	32.512		435.458	25.437		1271.772		0.000	468.376
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	34.200	855.000	207.765	76.517	51.011	-2.500	-2137.499	-127.528	1193.944	1328.891	5.975	5108.624	489.412
Abutment Shaft	1	25	98.903	2472.577	465.023	171.262	114.174	1.148	2838.062	131.051	1193.366	2705.506	0.000	0.000	996.400
Back filling over heel slab	1	20	172.107	15442.138	0.000	0.000	0.000	-2.545	-39306.177	0.000	1193.944	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	90.000	1800.000	0.000	0.000	0.000	3.450	6210.000	0.000	1193.944	0.000	0.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1193.944	0.000	0.000	0.000	0.000
Heel slab	1	25	72.500	1812.500	0.000	0.000	0.000	-2.017	-3655.208	0.000	1199.269	0.000	0.000	0.000	0.000
Toe slab	1	25	45.000	1125.000	0.000	0.000	0.000	3.300	3712.500	0.000	1199.269	0.000	0.000	0.000	0.000
portion between heel & toe	1	25	26.250	656.250	0.000	0.000	0.000	1.100	721.875	0.000	1199.269	0.000	0.000	0.000	0.000
Vertical component of dynamic earth pressure	1			1606.632				-5.400	-8675.812				0.000	0.000	
Vertical component of active earth pressure	1			829.101				-5.400	-4477.146				0.000	0.000	
				27137.840	672.788	247.779	165.186		-44494.630	3.523		4034.396		5108.624	1485.812
Total =				30586.012	895.206	535.404	356.936		-41123.278	294.123		5306.169		5090.624	4599.177
							-356.936			-204.123					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.9			1920.870	114.604	-4.300	-8259.739	-492.798
SIDL except Wearing Course	0.9			180.000	10.739	-4.300	-774.000	-46.179
Wearing Course	1.00			301.895	18.012	-4.300	-1298.149	-77.451
Bearing Pedestal	0.9	25	1.312	32.800		-4.300	-126.936	-6.817
				2432.565	143.355		-10458.824	-616.425
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	3.750	93.750	5.034	-5.100	-430.313	-25.673
Dirt Wall-Tapered portion	0.9	25	5.302	132.539	7.117	-5.100	-608.354	-36.296
Bracket - Uniform portion	0.9	25	1.125	28.125				
Bracket - Tapered portion	0.9	25	0.563	14.063				
Cap - (uniform portion)	0.9	25	7.313	182.813	9.816	-4.275	-703.371	-41.965
Cap - (corbel portion)	0.9	25	5.433	135.826	7.293	-4.275	-522.590	-31.179
Cantilever Return Wall-Rectangle or	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
Cantilever Return Wall-Triangle port	0.9	25	0.000	0.000	0.000	-5.000	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.100	-128.520	-6.489
Approach Slab	0.9	25	6.563	164.063		-5.400	-787.344	-49.191
				701.260	29.260		-3190.491	-195.113
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	98.903	2225.319	69.422	-4.252	-9452.470	-422.763
Solid Return wall	0.9	25	34.200	769.500	45.910	-7.900	-6079.048	-362.690
Back filling over heel slab	0.9	20	172.107	13897.924	0.000	-7.945	-110424.3	0.000
Front Filling over toe	0.9	20	90.000	1620.000	0.000	-1.950	-3159.000	0.000
Side filling between heel and toe	0.9	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.9	25	72.500	1812.500	0.000	-7.417	-12098.438	0.000
Toe slab	0.9	25	45.000	1125.000	0.000	-2.100	-2126.250	0.000
portion between heel & toe	0.9	25	26.250	656.250	0.000	-4.300	-2538.688	0.000
Vertical component of active earth pressure	0.9			1536.446		-10.800	-16593.621	0.000
Vertical component of dynamic increment of earth pressure	0.9			746.191		-10.800	-8058.862	0.000
				24514.534	145.333		-172890.55	-785.453
Total =				27648.078	317.948		-186539.86	-1536.991

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
0.9			
1.0	22.781	1198.769	255.628
1.0	32.207	1197.562	322.525
1.0	44.423	1196.634	403.631
1.0	33.006	1196.334	289.988
1.0	0.000	1199.269	0.000
1.0	0.000	1199.269	0.000
	132.417		1271.772
1.0	449.933	1193.366	2617.710
1.0	207.765	1193.944	1328.891
1.0	0.000	1193.944	0.000
	657.698		3946.601
	790.115		5218.373

Horizontal Forces For SBC Calculation					
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1281.191	238.858	1197.384	12801.790
due to Substructure	1	805.206	296.546		5306.169
due to Earth pressure	1	5880.379			32326.155

Forces along Long. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sin θ
1281.19	12601.79	0.00	0.00
805.21	5306.17	0.00	0.00
5880.38	32326.15	0.00	0.00
7966.78	50234.11	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.384	18902.69
due to Substructure	1.5	1185.173		7827.56
due to Active Earth pressure	1	3878.752		18094.49
due to dynamic Earth pressure	1.5	3002.441		19847.63
		9988.152		66672.278

Forces along Long. Axis			
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	18902.69	0.00	0.00
1185.17	7827.56	0.00	0.00
3878.752	18094.49	0.000	0.000
3002.441	19847.634	0.000	0.000
9988.15	65672.28	0.00	0.00

Summary of Forces For SBC	
Downward	Upward
P	30942.948
ML	9314.958
MT	9689.800

Summary of Restoring Forces

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	143.355	0.000	-10458.82	-616.425
Forces from Substructure				25215.794	174.593	0.000	-176081.04	-920.566
CWLL-Max. Reaction case	0.00			0.00	0.000	-4.300	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-10.800	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.800	0.00	
Total =				27648.078	317.948		-186539.86	-1536.991
					-317.948			1536.991

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	257.818	1197.384	13049.722	2889.979
due to Substructure	1	805.206	296.546		5306.169	1954.188
due to Earth pressure	1	5880.379			32326.155	
due to Live load surcharge	0.20	252.844			1715.625	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1326.73	13049.72	0.00	0.00	0.00	0.00	257.82	2889.98
805.21	5306.17	0.00	0.00	0.00	0.00	296.55	1954.19
5880.38	32326.15						
252.84	1715.62						
8266.16	52397.67	0.00	0.00	0.00	0.00	554.36	4844.17

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.384	18902.686
due to Substructure	1.5	1185.173		7827.560
due to Active Earth pressure	1	3878.752		19094.399
due to dynamic Earth pressure	1.5	3002.441		18847.634
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9988.152		65672.278

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1921.79	18902.69	0.00	0.00
1185.17	7827.56	0.00	0.00
3878.75	19094.39		
3002.44	18847.63		
0.000	0.000		
0.000	0.000		
9988.15	65672.28	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	31272.186	30533.034 kN
ML	11159.923	10723.868 kNm
MT	10136.064	10136.064 kNm

Summary of Restoring Forces

Vertical Load	27330.130 kN
Moment	-188076.853 kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		238.858	159.238		2935.894	175.162				-18.000	2644.989
Substructure & Foundation -Portion 1				779.177	132.417	48.767	32.512		435.458	25.437		1271.772		0.000	468.376
Substructure & Foundation -Portion 2															
Solid Return wall	1		34.20	855.00	207.765	76.517	51.011	-2.50	-2137.499	-127.528	1193.94	1328.891	5.98	5108.624	489.412
Shaft above HFL	1	25	50.082	1252.040	304.246	112.050	74.700	1.247	1561.891	93.186	1194.366	2074.348	0.000	0.000	763.954
Shaft below HFL	1	15	48.821	732.322	160.778	59.212	39.475	1.148	840.570	45.310	1191.548	643.110	0.000	0.000	236.849
Back filling above HFL over heel slab	1	20	487.273	9745.450	0.000	0.000	0.000	-2.500	-24363.625	0.000	1195.909	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	290.000	2900.000	0.000	0.000	0.000	-2.621	-7600.417	0.000	1190.423	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	90.000	900.000	0.000	0.000	0.000	2.200	1980.000	0.000	0.000	0.000	0.000	0.000	0.00
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Heel slab	1	15	72.500	1087.500	0.000	-7.900	-49290.150	-2.017	-2193.125	0.000	0.000	0.000	0.000	0.000	0.00
Toe slab	1	15	45.000	675.000	0.000	-3.300	-2227.500	3.300	2227.500	0.000	0.000	0.000	0.000	0.000	0.00
portion between heel & toe	1	15	26.250	393.750	0.000	-1.100	-433.125	1.100	433.125	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of active earth pressure	1			1593.734				-5.400	-8606.162	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of dynamic increment of earth pressure	1			828.422				-5.400	-4473.478	0.000	0.000	0.000	0.000	0.000	0.00
				21403.767	779.842	287.205	191.470		-42331.220	10.968		4682.250		5108.624	1724.408
Total =				24851.939	912.259	674.830	383.220		-38959.868	211.567		5954.022		5090.624	4837.772
							-383.220			-211.567					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	143.355		-10458.824	-616.425
Substructure & Foundation -Portion 1				701.260	29.260		-3190.491	-135.113
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	34.19999	769.500	45.910	-7.90	-6079.048	-362.690
Shaft above HFL	0.9	25	50.082	1126.836	67.230	-4.153	-4679.215	-279.173
Shaft below HFL	0.9	15	48.821	659.090	32.193	-4.252	-2802.572	-136.889
Back filling above HFL over heel slab	0.9	20	487.273	9770.905	0.000	0.000	-69290.150	0.000
Back filling below HFL over heel slab	0.9	10	290.000	2610.000	0.000	-8.021	-20934.375	0.000
Front Filling over toe	0.9	10	90.000	810.000	0.000	-3.200	-2592.000	0.000
Side filling between heel and toe	0.9	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.9	15	72.500	978.750	0.000	-7.417	-7259.063	0.000
Toe slab	0.9	15	45.000	607.500	0.000	-2.100	-1275.750	0.000
portion between heel & toe	0.9	15	26.250	354.375	0.000	-4.300	-1523.813	0.000
Vertical component of active earth pressure	0.9			1434.360			-15491.092	0.000
Vertical component of dynamic increment of earth pressure	0.9			745.580			-8052.261	0.000
				19263.390	168.988		-141908.31	-893.840
Total =				22396.934	341.603		-155557.62	-1645.377
					-341.603			1645.377

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1271.772
1.0	207.765	1193.944	1328.891
1.0	304.246	1194.366	2074.348
1.0	145.687	1191.548	582.749
1.0	0.000	1195.909	0.000
1.0	0.000	1190.423	0.000
	657.698		3985.987
	790.115		5257.760

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	238.858	1197.384	12601.790	2644.989
due to Substructure	1	912.259	335.972		5954.022	2192.784
due to Earth pressure	1	5847.601			29931.721	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1281.19	12601.79	0.00	0.00	0.00	0.00	238.86	2644.99
912.26	5954.02	0.00	0.00	0.00	0.00	335.97	2192.78
5847.60	29931.72						
8041.05	48487.83	0.00	0.00	0.00	0.00	574.83	4837.77

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.384	18902.686
due to Substructure	1.5	1185.173		7896.640
due to Active Earth pressure	1	3847.614		19706.109
due to dynamic Earth pressure	1.5	2999.981		19838.418
		9954.554		63333.852

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1921.79	18902.69	0.00	0.00
1185.17	7886.64	0.00	0.00
3847.61	19706.10		
2999.98	19838.41		
9954.55	63333.85	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	25235.159	24468.718 kN
ML	9739.232	9316.098 kNm
MT	9928.396	9928.396 kNm

Summary of Restoring Forces

Vertical Load	22055.331 kN
Moment	-157202.998 kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995		238.858	159.238		2935.894	175.162				-18.000	2644.989
Forces from Substructure				22182.944	912.259	335.972	223.982		-41895.762	36.405		5954.022		5108.624	2192.784
CWLL-Max. Reaction case	0.20			58.13		5.203	3.468	1.100	63.947	3.815	1200.469		0.950	55.227	67.223
Vertical component of LL Surcharge	0.20			71.80				-5.400	-387.718				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			52.19				-5.400	-281.820				0.000	0.000	
Total =				25034.061	912.259	580.033	386.688		-39565.460	215.382		5954.022		5145.850	4904.995
							-386.688			-215.382					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (P) kN/m ³	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	143.355		-10458.824	-616.425
Forces from Substructure				19964.650	198.249		-145098.80	-1028.953
CWLL-Max. Reaction case	0.00			0.00	0.00		-4.30	0.00
Vertical component of LL Surcharge	0.00			0.00		-4.300	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.800	0.000	0.000
Total =				22396.934	341.603		-155561.92	-1645.377
					-341.603			1645.377

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	244.060	1197.384	13049.722	2712.211
due to Substructure	1	912.259	335.972		5954.022	2192.784
due to Earth pressure	1	5847.601			29931.721	
due to Live load surcharge	0.20	299.335			1969.997	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.384	18902.686
due to Substructure	1.5	1185.173		7896.6397
due to Active Earth pressure	1	3847.614		18706.109
due to dynamic Earth pressure	1.5	2999.981		19838.418
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		9954.554		63333.852

Summary of Forces For SBC

	Downward	Upward
P	25420.749	24647.372 kN
ML	11555.384	11124.619 kNm
MT	10050.845	10050.845 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = 0.3 x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		796.192	159.238		2935.894	175.162				-18.000	8816.629
Substructure & Foundation -Portion 1				779.177	39.725	162.558	32.512		435.458	25.437		381.532		0.000	1561.254
Substructure & Foundation -Portion 2				27137.840	201.836	825.929	165.186		-44494.630	3.523		1210.319		5108.624	4952.707
Total =				30586.012	241.562	1784.679	356.936	-356.936	-41123.278	204.123		1591.851		5090.624	15330.590

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	143.355		-10458.82	-616.425
Substructure & Foundation -Portion 1				701.260	29.260		-3190.49	-135.113
Substructure & Foundation -Portion 2				24514.534	145.333		-172890.55	-785.453
Total =				27648.078	317.948		-186539.86	-1536.991

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1271.772
	657.698		3946.601
	790.115		5218.373

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.357	796.192	1197.384	3780.537	8816.629
due to Substructure	1	241.562	988.487		1591.851	6513.961
due to Earth pressure	1	5880.379			32326.155	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.384	6770.806
due to Substructure	1.5	1185.173		7827.5599
due to Active Earth pressure	1	3878.752		19094.399
due to dynamic Earth pressure	1.5	900.732		5954.290
		6541.193		38547.055

Summary of Forces For SBC

	Downward	Upward
P	30942.948	30229.076 kN
ML	-3220.613	-3628.858 kNm
MT	20421.213	20421.213 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	30902.610	369.576	-41455.77	218.027	5291.897

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	859.395	1197.384	4228.469	9633.265
due to Substructure	1	241.562	988.487		1591.851	6513.961
due to Earth pressure	1	5880.379			32326.155	
due to Live load surcharge	0.2	252.844			1715.625	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.384	6770.806
due to Substructure	1.5	355.55		2348.269
due to Active Earth pressure	1	3878.75		19094.399
due to dynamic Earth pressure	1.5	900.73		5954.290
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5711.57		33067.763

Summary of Forces For SBC

	Downward	Upward
P	31272.186	30533.034 kN
ML	-1375.649	-1811.703 kNm
MT	21439.123	21439.123 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	2668.995	159.238	2935.894	175.162	-18.000
Substructure & Foundation -Portion 1	779.177	32.512	435.458	25.437	0.000
Substructure & Foundation -Portion 2	21403.767	191.470	-42331.220	10.968	5108.624
Total =	24851.939	383.220	-38959.868	211.567	5090.624

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.36	796.19	1197.38	3780.54	8816.63
due to Substructure	1	273.68	1119.91		1786.21	7309.28
due to Earth pressure	1	5847.60			29931.72	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.384	6770.81
due to Substructure	1.5	355.552		2365.99
due to Active Earth pressure	1	3847.614		16706.11
due to dynamic Earth pressure	1.5	900.994		5951.333
		5679.696		30694.43

Summary of Forces For SBC

	Downward	Upward
P	25235.159	24468.718 kN
ML	-3249.837	-3672.971 kNm
MT	21216.531	21216.531 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1326.73	13049.72	0.00	0.00	0.00	0.00	244.06	2712.21
912.26	5954.02	0.00	0.00	0.00	0.00	335.97	2192.78
5847.60	29931.72						
299.34	1970.00						
8385.93	50905.46	0.00	0.00	0.00	0.00	580.03	4904.99

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1921.79	18902.69	0.00	0.00
1185.17	7896.64	0.00	0.00
3847.614	16706.109		
2999.981	19838.418		
0.000	0.000		
0.000	0.000		
9954.55	63333.85	0.00	0.00

Summary of Restoring Forces

Vertical Load	22055.331 kN
Moment	-157207.298 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	3780.54	0.00	0.00	0.00	0.00	796.19	8816.63
241.56	1591.85	0.00	0.00	0.00	0.00	988.49	6513.96
5880.38	32326.15						
6506.30	37698.54	0.00	0.00	0.00	0.00	1784.68	15330.59

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	5670.81	0.00	0.00
1185.17	7827.56	0.00	0.00
3878.752	19094.399		
900.732	5954.290		
6541.19	38547.05	0.00	0.00

Summary of Restoring Forces

Vertical Load	27330.130 kN
Moment	-188076.853 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	27648.078	317.948	-186539.86	-1536.991

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
429.90	4228.47	0.00	0.00	0.00	0.00	859.39	9633.26
241.56	1591.85	0.00	0.00	0.00	0.00	988.49	6513.96
5880.38	32326.15						
252.84	1715.62						
6804.68	39862.10	0.00	0.00	0.00	0.00	1847.88	16147.23

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	5670.81	0.00	0.00
355.55	2348.27	0.00	0.00
3878.752	19094.399		
900.732	5954.290		
0.000	0.000		
0.000	0.000		
5711.57	33067.76	0.00	0.00

Summary of Restoring Forces

Vertical Load	27330.130 kN
Moment	-188076.853 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	2432.285	143.355		-10458.824	-616.425
Substructure & Foundation	701.260	29.260		-3190.491	-135.113
Substructure & Foundation	19263.390	168.988		-141908.306	-493.840
Total =	22396.934	341.603		-155557.621	-1645.377

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	3780.54	0.00	0.00	0.00	0.00	796.19	8816.63
273.68	1786.21	0.00	0.00	0.00	0.00	1119.91	7309.28
5847.60	29931.72						
6505.64	35498.46	0.00	0.00	0.00	0.00	1915.10	16125.91

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	5670.81	0.00	0.00
355.55	2365.99	0.00	0.00
3847.614	16706.109		
999.994	5951.333		
5679.70	30694.43	0.00	0.00

Summary of Restoring Forces

Vertical Load	22055.331 kN
Moment	-157202.998 kNm

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN	$P_v = 0.3 \times w \times P$ (kN)	$M_L = P \times e_L$	M_L s due to F_v	$M_T = P \times e_T$
Total =	25034.061	386.688	-39565.46	215.382	5145.850
		-386.688		-215.382	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	813.5344	1197.384	4228.469	9040.7036
due to Substructure	1	273.678	1119.9077		1786.207	7309.2789
due to Earth pressure	1	5847.601			29931.721	
due to Live load surcharge	0.2	299.335			1969.997	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.384	5670.81
due to Substructure	1.5	355.65		2365.99
due to Active Earth pressure	1	3847.61		16706.11
due to dynamic Earth pressure	1.5	899.99		5951.53
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		5679.70		30694.43

Summary of Forces For SBC

	Downward	Upward
P	25420.749	24647.372
ML	-1433.684	-1854.449
MT	21495.833	21495.833

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN	$P_v = 0.3 \times w \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$M_L = P \times e_L$	M_L s due to F_v
Total =	22396.934	341.603		-155561.92	-1645.377
		-341.603			1645.377

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
429.90	4228.47	0.00	0.00	0.00	0.00	813.53	9040.70
273.68	1786.21	0.00	0.00	0.00	0.00	1119.91	7309.28
5847.60	29931.72						
299.34	1970.00						
6850.51	37916.39	0.00	0.00	0.00	0.00	1933.44	16349.98

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	5670.81	0.00	0.00
355.55	2365.99	0.00	0.00
3847.614	16706.109		
899.994	5951.525		
0.000	0.000		
0.000	0.000		
5679.70	30694.43	0.00	0.00

Summary of Restoring Forces

Vertical Load	22055.331
Moment	-157207.298

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00						
Transverse Moment due to C.F.	=	0.000	x (	1200.469	-	1187.548	)			

	=	0.000	kN							
	=	0.000	kNm							

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00						
Transverse Moment due to C.F.	=	0.000	x (	1200.469	-	1187.548	)			

	=	0.000	kN							
	=	0.000	kNm							

	0.00	0.00	0.00	0.00

Base pressure on corner A	=	σ_a	=	$P/A - M_L/Z_L + M_T/Z_T$
Base pressure on corner B	=	σ_b	=	$P/A + M_L/Z_L + M_T/Z_T$
Base pressure on corner C	=	σ_c	=	$P/A - M_L/Z_L - M_T/Z_T$
Base pressure on corner D	=	σ_d	=	$P/A + M_L/Z_L - M_T/Z_T$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK		OVERTURNING CHECK		
	P	ML	MT	σ_a	σ_b	σ_c	σ_d	Max. Base Pressure	Min. Base Pressure	Restoring Force = $\mu P + cA + F_p$	Sliding Force	FOS	Overturning moment	Restoring Moment = $\sum P \times e_{Toe} + M_R$
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm
Case 1 : DL+SIDL-Normal Dry Case	29857.442	-16798.120	5090.624	308.394	170.138	272.194	133.938	308.394	133.938	6330.947	18831.321	2.97	30104.845	178685.40
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	31245.749	-11492.038	6096.989	300.421	205.636	257.064	162.479	300.421	162.479	7476.581	18831.321	2.52	37584.417	181883.04
Normal HFL Case								SAFE	SAFE			SAFE		SAFE
Case 3 : DL+SIDL-Normal HFL Case	24136.946	-16860.652	5090.624	266.278	127.507	230.078	91.307	266.278	91.307	6330.947	15227.408	2.41	26522.410	148812.29
Case 4 : DL+SIDL+LL-(Minimum Reaction Case)-Normal HFL Case	24786.612	-11759.413	5366.758	251.079	154.294	212.915	116.130	251.079	116.130	7621.210	15453.577	2.03	35078.766	152301.75
Longitudinal Seismic Dry Case								SAFE	SAFE			SAFE		SAFE
Case 5 : DL+SIDL-Long. Seismic Dry Case	30942.948	9314.958	9689.800	225.326	301.993	156.421	233.088	301.993	156.421	9988.152	19131.091	1.92	65672.278	188076.85
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	31272.186	11159.923	10136.064	221.760	313.611	149.681	241.532	313.611	149.681	9988.152	19131.091	1.92	65672.278	188076.85
Longitudinal Seismic HFL Case								SAFE	SAFE			SAFE		SAFE
Case 7 : DL+SIDL-Long. Seismic HFL Case	25235.159	9739.232	9928.396	182.149	262.307	111.547	191.705	262.307	111.547	9954.554	15438.732	1.55	63333.852	157203.00
Case 8 : DL+SIDL+LL-(Minimum Reaction Case)-Long. Seismic HFL Case	25420.749	11555.384	10050.845	176.485	271.591	105.012	200.119	271.591	105.012	9954.554	15438.732	1.55	63333.852	157207.30
Transverse Seismic Dry Case								SAFE	SAFE			SAFE		SAFE
Case 9 : DL+SIDL-Trans. Seismic Dry Case	30942.948	3220.613	20421.213	315.069	288.562	169.852	143.345	315.069	143.345	6541.193	19131.091	2.92	38547.055	188076.85
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	31272.186	-1375.649	21439.123	313.535	302.213	161.079	149.757	313.535	149.757	5711.572	19131.091	3.35	33067.763	188076.85
Transverse Seismic HFL Case								SAFE	SAFE			SAFE		SAFE
Case 11 : DL+SIDL-Trans. Seismic HFL Case	25235.159	-3249.837	21216.531	275.737	248.990	124.864	98.117	275.737	98.117	5679.696	15438.732	2.72	30694.432	157203.00
Case 12 : DL+SIDL+LL-(Minimum Reaction Case)-Trans. Seismic HFL Case	25420.749	-1433.684	21495.833	270.631	258.832	117.772	105.972	270.631	105.972	5679.696	15438.732	2.72	30694.432	157207.30
								SAFE	SAFE			SAFE		SAFE

DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
87+006

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	23.750m	23.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	25.000m	25.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m²
SBC of soil-Normal Case = 410 kN/m²
SBC of soil-Seismic Case = 513 kN/m² Assumed

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	1.414m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion = 1.950m 1.950m
Width of Abutmentcap at bottom of Tapering Portion = 1.000m 1.000m
Projection of Abutment Cap (Span Side) = 0.500m 0.500m

Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.389m	1.389m
Thickness of Abutment shaft at Bottom	=	1.600m	1.600m

Solid Return Wall

Length of Return wall	=	7.100m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.200m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	13.000m	
abutment pedestal width	=	1.600m	
abutment pedestal Height	=	1.750m	
Width of Toe Slab	=	4.300m	
Width of Heel Slab	=	7.100m	
Thickness of Toe slab at tip	=	0.750m	
Thickness of Toe slab near shaft	=	1.750m	
Thickness of heel slab at tip	=	0.750m	
Thickness of heel slab near shaft	=	1.750m	
Width of backfill on heel slab	=	7.100m	
Thickness of heel slab at back fill edge	=	1.750m	
Height of back fill at bottom edge of heel slab	=	13.262m	
Height of back fill at back fill edge of heel slab	=	12.262m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1199.434m	Cross Slope (Bi-directional)	=	2.500%	
Deck level at Outer Edge =	1199.292m	Height of Superstructure	=	1.820m	
Deck level at center line =	1199.434m	Min. Height of Footpath Side Pedestal (1)	=	0.400m	
Soffit Level at center of bridge =	1197.549m	Height of Pedestal (2)	=	0.475m	
Abutment cap top level =	1196.949m	Height of Pedestal (3)	=	0.550m	
Abutment cap bottom lvl (uniform portion ends	1196.649m	Height of Pedestal (4)	=	0.625m	
Abutment cap bottom lvl (corbel portion ends)	1196.349m	Height of Pedestal (5)	=	0.000m	
Abutment shaft top level =	1196.349m	Height of Pedestal (6)	=	0.000m	
Ground level/LBL =	1188.351m	Distance of nearest girder to c.l. of deck	=	1.500m	
Abutment shaft bottom level =	1187.101m	Height (Avg.) of Dirt Wall	=	2.414m	
Foundation level =	1185.351m	Abutment shaft Above G.L	=	7.998m	
HFL	=	1190.351m	Abutment Shaft below G.L	=	1.250m
			Height of abutment shaft	=	9.248m
			MSL	=	1187.351m
			Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade		=	M 35	
Characteristic compressive strength of concrete, f_{ck}		=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}		=	15.63 Mpa at 28 (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}		=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}		=	0.02	
Ultimate Strain, ϵ_{cu2}		=	0.035	
E_{cm}		=	32308.250 N/mm ²	
Steel Grade		=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}		=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}		=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)		=	200000.00 Mpa	
Dry weight of Concrete		=	25 kN/m ³	
Dry unit weight of soil		=	20 kN/m ³	
Permissible Crack Width		=	0.3 mm	- For Moderate Exposure Condition
Maximum compressive stress in concrete under rare combination		=	0.48 f_{ck}	
		=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination		=	300	N/mm ²
<u>Creep Coefficient</u>				
For Abutment Shaft		=	2	for 90 days
For Footing		=	2	for 90 days
<u>Clear Cover to Reinforcement</u>				
Earth Face		=	75	mm
Non-Earth Face		=	50	mm
<u>Seismic Data:</u>				
Seismic Zone		=	5	
Z =Zone factor		=	0.36	
I =Importance factor		=	1.2	
R =Response Reduction factor		=	3	in Longitudinal direction
		=	1	In Transverse direction
<u>Properties of backfill material :</u>				
	c	=	0	
	ϕ	=	35	
	θ	=	90	
	β	=	0	
	δ	=	22.5	

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1 =	522.61	4.50
DL Reaction on Bearing No.-2 =	544.54	1.50
DL Reaction on Bearing No.-3 =	544.54	-1.50
DL Reaction on Bearing No.-4 =	522.61	-4.50

DL Reaction on Bearing No.-5 =	0.00	0.00
DL Reaction on Bearing No.-6 =	0.00	0.00
	2134.30	0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1 =	100.000	4.50
SIDL Reaction on Bearing No.-2 =	0.000	1.50
SIDL Reaction on Bearing No.-3 =	0.000	-1.50
SIDL Reaction on Bearing No.-4 =	100.000	-4.50
SIDL Reaction on Bearing No.-5 =	0.000	0.00
SIDL Reaction on Bearing No.-6 =	0.000	0.00
	200.00	0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1 =	68.613	4.50
SIDL Reaction on Bearing No.-2 =	82.335	1.50
SIDL Reaction on Bearing No.-3 =	82.335	-1.50
SIDL Reaction on Bearing No.-4 =	68.613	-4.50
SIDL Reaction on Bearing No.-5 =	0.000	0.00
SIDL Reaction on Bearing No.-6 =	0.000	0.00
	301.90	0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

	Max CWLL			Min CWLL	
CWLL Reaction on Bearing No.-1 =	23.48	4.50	CWLL Reaction on Bearing No.-8 =	5.015	4.50
CWLL Reaction on Bearing No.-2 =	692.01	1.50	CWLL Reaction on Bearing No.-9 =	26.750	1.50
CWLL Reaction on Bearing No.-3 =	379.41	-1.50	CWLL Reaction on Bearing No.-10 =	111.449	-1.50
CWLL Reaction on Bearing No.-4 =	83.76	-4.50	CWLL Reaction on Bearing No.-11 =	76.684	-4.50
CWLL Reaction on Bearing No.-5 =	0.00	0.00	CWLL Reaction on Bearing No.-12 =	0.00	0.00
CWLL Reaction on Bearing No.-6 =	0.00	0.00	CWLL Reaction on Bearing No.-13 =	0.00	0.00
CWLL Reaction on Bearing No.-7 =	0.00	0.00	CWLL Reaction on Bearing No.-14 =	0.00	0.00

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 4	=	0.625 x	0.800 x	0.800 =	0.4000 m ³	-4.500

Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.3120 m ³	-0.549

VOLUME CALCULATION

C.G. Of Footing = 6.500 m
 C.G. Of shaft from toe tip = 5.100 m
 Distance between c.g. of shaft and footing = 1.400 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.600	-5.900	0.000
-Trapering portion	1	12.50	0.300	1.414	5.302	-0.800	0.600	-5.900	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	0.300	-6.200	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.350	-6.150	0.000
Cap (uniform portion)	1	12.50	1.950	0.300	7.313	0.025	1.425	-5.075	0.000
Cap (Corbel Portion)	1	12.50	1.950	0.300	5.433	0.025	1.425	-5.075	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.195	5.998	89.563	0.197	1.597	-4.903	0.000
Shaft below HFL	1	12.50	1.495	2.500	46.705	0.051	1.451	-5.049	0.000
Solid Return Wall	1	7.10	0.850	12.833	77.447	-4.350	-2.950	-9.450	5.825
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.800	0.600	-5.900	5.825
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.800	0.600	-5.900	5.825
Footing									
Heel Slab	1	12.50	7.100	1.250	110.938		-2.477	-8.977	0.000
Toe Slab	1	12.50	4.300	1.250	67.188		4.063	-2.437	0.000
Portion between Heel and Toe	1	12.50	1.600	1.750	35.000		1.400	-5.100	0.000
Back filling above HFL over Heel Slab	1	12.50	7.100	9.083	806.116		-2.950	-9.450	0.000
Back filling below HFL over Heel Slab	1	12.50	7.100	3.750	332.813		-3.108	-9.608	0.000
Backfill above Heel slab	1	12.50	7.100	12.762	1132.605		-2.996	-9.496	0.000
Front Filling over Toe Slab	1	12.50	4.300	1.750	94.063		4.145	-2.355	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	4.300	0.750	40.313		2.472	-4.028	0.000
Side filling between heel and toe	1	0.00	1.600	1.750	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	0.300	-6.200	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.389	9.083	44.182		0.818	-5.682	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.211	3.750	9.884		0.670	-5.830	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.600	-5.900

SECTIONAL PROPERTIES

Width of Footing (B) = 13.000 m
 Length of Footing (L) = 12.500 m

A = 13.000 x 12.500 = 162.500 m²
 ZL = 12.500 x 28.167 = 352.083 m³
 ZT = IT1 + IT2
 distance of extreme point from centre

IT1 = 13.000 x 162.760 = 2115.89 m⁴
 IT2 (moment of inertia of triangle) = 13.000 x 0.000 + 0.500 x 13.000 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 2115.89 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 338.542 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20

Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 11.998 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

= 13.655 m

Abutment Cap Top Level - Foundation Level

= 11.598 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.30 m

Moment of Inertia , $I_{longitudinal}$ = 1.716 m^4

Moment of Inertia , $I_{transverse}$ = 211.589 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 101.391 KN
 D = 2636.19 KN
 T = 0.3225 sec

Transverse Direction

Force = 10383.549 KN
 D = 2906.195 KN
 T = 0.0335 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.502

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.502

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.502

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.502

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.324

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.324	In Transverse direction
Av	=	0.216	In Vertical direction

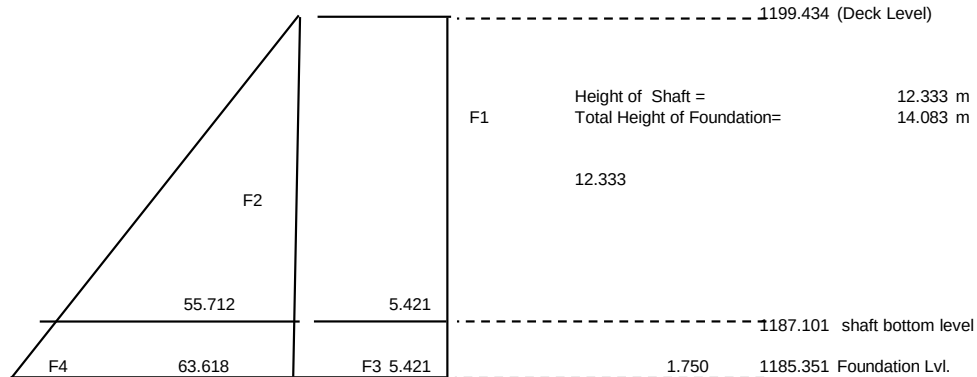
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.324	In Transverse direction
Av	=	0.216	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1187.101 m (at Shaft Base)			
@ RL				1185.351 m (at Foundation Level)			
Due to Live Load Surcharge							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m^2
F1	=	5.421	x	12.333	x	12.500	= 835.685 kN
M1	=	835.69	x	6.17	=	5153.252	kN.m at Shaft Bottom
F3	=	5.421	x	14.083	x	12.500	= 954.265 kN
M3	=	954.265	x	7.041	=	6719.459	kN.m at Foundation
Due to Active Earth Pressure							
Intensity for triangular portion (At Shaft bottom level)	=	0.226	x	20	x	12.333	= 55.712 kN/m^2
F2	=	0.5	x	55.71	x	12.333	x 12.50
	=	4294.377	kN				
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)							
M2	=	4294.38	x	5.18	=	22244.272	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)	=	0.226	x	20	x	14.083	= 63.618 kN/m^2
F4	=	0.5	x	63.62	x	14.083	x 12.50
	=	5599.549	kN				
M4	=	5599.55	x	5.91	=	33120.550	kN.m at Foundation
Force Due To Fluid Pressure							
As per Cl. 214.1 of IRC :6 -2014			γ fluid	=		4.8	kN/m^3
Intensity for triangular portion (At Shaft bottom level)	=	4.800	x	12.333	=	59.198	kN/m^2
F	=	0.5	x	59.198	x	12.333	x 12.500
	=	4563.087	kN				
M	=	4563.09	x	4.111	=	18758.849	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)	=	4.800	x	14.083	=	67.60	kN/m^2
F	=	0.5	x	67.598	x	14.08	x 12.500
	=	5949.927	kN				
M	=	5949.93	x	4.694	=	27930.939	kN.m at Foundation
Intensity of Passive pressure							
	=	5.249	x	20	x	0.000	= 0.000 kN/m^2

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 0.000 x 12.50
 = **0.000 kN**

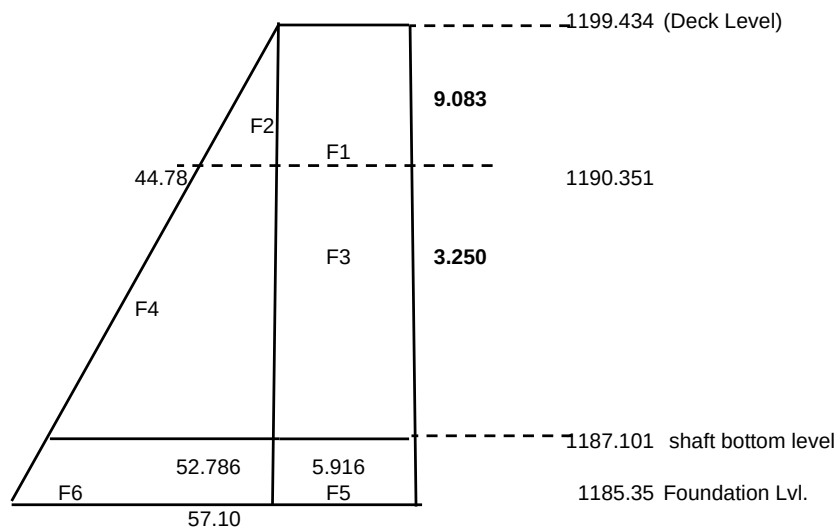
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = **0.000 kN.m** at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	22244.272	33120.550	4294.377	5599.549
Due to Minimum Fluid Pressure	18758.849	27930.939	4563.087	5949.927
Governing of Two	22244.272	33120.550	4563.087	5949.927
Due to Live Load Surcharge	5153.252	6719.459	835.685	954.265
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246	active component
	Kp'	=	5.249	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1187.1 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	12.333	x	12.500	=	911.952 kN
M1	=	911.95	x	6.17	=	5623.554 kN.m		at Shaft Bottom
F3	=	5.916	x	14.083	x	12.500	=	1041.354 kN
M3	=	1041.35	x	7.04	=	7332.697 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	9.083	=	44.776 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.250	=	8.011 kN/m ²
F2	=	0.5	x	44.78	x	9.083	x	12.50
	=	2541.855 kN						
F4	=	$\left(\frac{44.78 + 52.79}{2} \right) \times$				3.25	x	12.50
	=	1981.724 kN						
Total Force	=	4523.579 kN						
M2	=	2541.86	x	7.06	=	17957.850 kN.m		
M4	=	1981.72	x	1.58	=	3132.165 kN.m		

Total Moment = 21090.01 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 9.083 = 44.776 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.000 = 12.324 \text{ kN/m}^2$$

$$\begin{aligned} \text{F2} &= 0.5 \times 44.78 \times 9.083 \times 12.50 \\ &= 2541.855 \text{ kN} \end{aligned}$$

$$\begin{aligned} \text{F6} &= \left(\frac{44.78 + 57.10}{2} \right) \times 5.00 \times 12.50 \\ &= 3183.601 \text{ kN} \end{aligned}$$

Total Force = 5725.456 kN

$$\text{M2} = 2541.86 \times 8.81 = 22406.096 \text{ kN.m}$$

$$\text{M6} = 3183.60 \times 2.40 = 7638.064 \text{ kN.m}$$

Total Moment = 30044.16 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$\begin{aligned} &= 0.5 \times 0.000 \times 12.50 \\ &= 0.000 \text{ kN} \end{aligned}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	21090.015	30044.160	4523.579	5725.456
Due to Minimum Fluid Pressure	18758.849	27930.939	4563.087	5949.927
Governing of Two	21090.015	30044.160	4563.087	5949.927
Due to Live Load Surcharge	5623.554	7332.697	911.952	1041.354
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.180	
αv	=	0.216	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

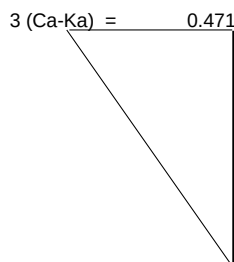
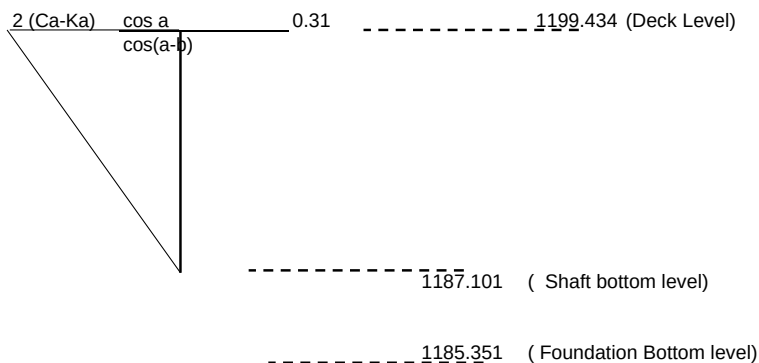
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.147 \\ 0.226 \end{matrix}$$

$$C_a = \begin{matrix} 1 \\ 0.383 \end{matrix} \begin{matrix} 2 \\ 0.297 \end{matrix}$$

Ca	=	0.383	0.297	
Ka	=	0.226		
Dynamic Increment	=	0.383	-0.226	0.157

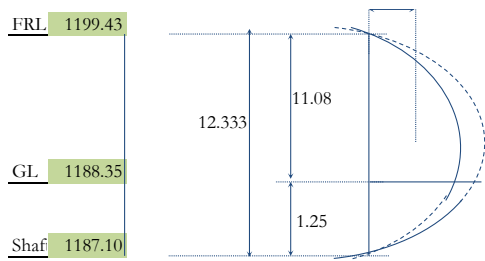
3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

Active Earth Pressure**Surcharge Earth Pressure****Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.314	x	20.00	x	1.2	=	7.532 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.532	x	12.333	x	12.500
	=	580.598	kN					
M1	=	580.598	x	8.263			=	4797.547 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.532	x	12.333	x	12.500
	=	580.598	kN					
M2	=	580.598	x	10.013			=	5813.593 kN.m

Due to Dynamic Active Earth Pressure



Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height	=	29.03 t/m ²
h	=	12.333 m
y	=	4.9165 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	29.03 t/m ²
h	=	12.333 m
y	=	-4.9165 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	2897.8	6.3
Parabola below Water Level	85.7	0.8
Total Dynamic Earth Pressure	2983.5	6.2

$$E3 = 2983.549 \text{ kN}$$

$$E4 = 2983.549 \text{ kN}$$

$$M3 = 2983.55 \times 6.17 = 18398.054 \text{ kN.m} \quad (\text{ Shaft bottom level})$$

$$M4 = 2983.55 \times 7.92 = 23619.264 \text{ kN.m} \quad (\text{ Foundation Bottom level})$$

Summary of Moment and Horizontal Force

Dry Seismic Case

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	22244.272	33120.550	4294.377	5599.549
Due to active Earth Pressure (dynamic Increment)	18398.054	23619.264	2983.549	2983.549
Total Earth Pressure	40642.326	56739.814	7277.926	8583.098
Due to Minimum Fluid Pressure	18758.849	27930.939	4563.087	5949.927
Governing of Two	22244.272	56739.814	7277.926	8583.098
Due to Live Load Surcharge (Static)	5153.252	6719.459	835.685	954.265
Due to Live Load Surcharge(Dynamic)	4797.547	5813.593	580.598	580.598
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

αh	=	0.180			
αv	=	0.216			
ϕ	=	35.00		0.611	
δ	=	11.25		0.196	
α	=	0.00		0.000	
β	=	0.00		0.000	
Ws	=	20.00	Kn/m3	2.00	gm/cm3
λ	=	$\tan^{-1} \frac{Ws}{Ws-1}$		$\frac{\alpha h}{(1 \pm \alpha v)}$	=
					0.288
					0.431
C_a'	=	0.555		0.516	
Ca'	=			0.555	
Ka'	=			0.246	
Dynamic Increment	=			0.555	-0.246
					0.309
Dynamic Increment	=				0.309
γ_d	=				20 kN/m ³
γ_{sat}	=				10 kN/m ³
γ_{water}	=				10 kN/m ³
Equivalent Live Load Surcharge height	=				1.2 m
Foundation	=				13.00 m
Dynamic Active earth pressure Variation					
3 (ca'-ka')					
Dynamic Surcharge earth pressure Variation					
2 (Ca'-Ka')					
$\cos a$					1199.434 (Deck Level)
$\cos(a-b)$					
				9.083	
				1190.351 HFL	
				5.000	
				3.250	
				1187.101 shaft bottom level	
				1185.351 Foundation Bottom Lvl.	

Earth Pressure Diagram

h'	=	3.250
h	=	12.333

Dynamic active earth pressure		
3 (ca'-ka')	=	0.471 at deck level
3 (ca'-ka')	=	0.926 at deck level
3 (ca'-ka')h'/h	=	0.244 at HFL level

Dynamic Surcharge earth pressure				
2 (Ca'-Ka')	$\frac{\cos a}{\cos(a-b)}$	=	0.617 at deck level	Pressure = 14.81 kN/m ²
		=	0.163 at HFL level	Pressure = 3.90 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level	=	7.532 kN/m ²
Dynamic surcharge pressure in Submerge condition at HFL level	=	3.90 kN/m ²

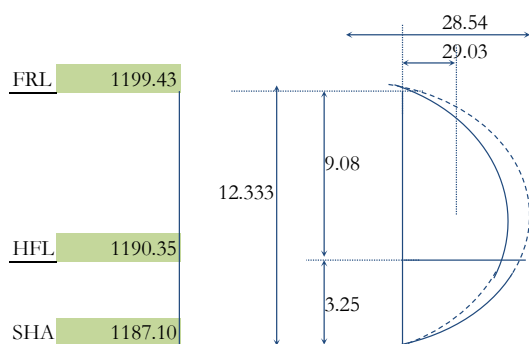
at Shaft Bottom Level

F1	=	5.717	x	9.083	x	12.500	=	649.145 kN
M1	=	649.14	x	7.79	=	5057.812 kN.m		

$$\begin{aligned}
 F2 &= 0.50 \times 3.903 \times 3.250 \times 12.500 \\
 &= \mathbf{79.272 \text{ kN}} \\
 M2 &= 79.27 \times 2.18 = \mathbf{172.614 \text{ kN.m}} \\
 \text{Total Force at Abutment shaft level} &= 728.417 \text{ kN} \\
 \text{Total Moment at Abutment shaft level} &= 5230.426 \text{ kN.m}
 \end{aligned}$$

at Foundation Bottom Level

$$\begin{aligned}
 F3 &= 5.717 \times 9.083 \times 12.500 = \mathbf{649.145 \text{ kN}} \\
 M3 &= 649.14 \times 9.54 = \mathbf{6193.815 \text{ kN.m}} \\
 F4 &= 0.500 \times 3.903 \times 3.250 \times 12.500 \\
 &= \mathbf{79.272 \text{ kN}} \\
 M4 &= 79.27 \times 3.93 = \mathbf{311.340 \text{ kN.m}} \\
 \text{Total Force at Founding level} &= 728.417 \text{ kN} \\
 \text{Total Moment at Founding level} &= 6505.155 \text{ kN.m}
 \end{aligned}$$

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation**Parabola above Water Level**

$$\begin{aligned}
 p_{\text{mid\_height}} &= 29.03 \text{ t/m}^2 \\
 h &= 12.333 \text{ m} \\
 y &= 2.9165 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Parabola below Water Level

$$\begin{aligned}
 p_{\text{mid\_height}} &= 28.54 \text{ t/m}^2 \\
 h &= 12.333 \text{ m} \\
 y &= -2.9165 \text{ m} \\
 L &= 12.500 \text{ m}
 \end{aligned}$$

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	2471.2	7.0
Parabola below Water Level	503.7	2.1
Total Dynamic Earth Pressure	2974.9	6.2

Total Force (F1 + F2)	=	2974.873 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	2974.873 kN	at Foundation Bottom Level

$$M1 = 2974.87 \times 6.18 = \mathbf{18379.758 \text{ kN.m}}$$

Total Mome = 18379.758 kN.m at Shaft Bottom

$$M1 = 2974.87 \times 7.93 = \mathbf{23585.787 \text{ kN.m}}$$

Total Mome = 23585.787 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force**MOMENTS****HORIZONTAL FORCE**

	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	21090.015	30044.160	4523.579	5725.456
Due to active Earth Pressure (Dynamic Increment)	18379.758	23585.787	2974.873	2974.873
Total Earth Pressure	39469.773	53629.947	7498.453	8700.329
Due to Minimum Fluid Pressure	18758.849	27930.939	4563.087	5949.927
Governing of Two	39469.773	53629.947	7498.453	8700.329
Due to Live Load Surcharge(Static)	5623.554	7332.697	911.952	1041.354
Due to Live Load Surcharge (Dynamic Increment)	5230.426	6505.155	728.417	728.417
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2134.30	1.35	1.35	2881.30	2881.30	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	301.90	1.75	1.75	528.32	528.32	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW + 1-CLASS A)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax-Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.55	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.55	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.55	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1423.55	183.981	895.754	1239.564	1423.545	
DL+SIDL+LL-Max Reaction case		3737.75	1469.09	186.888	921.430	1282.197	1469.085	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	1469.09	194.574	929.117	1274.511	1469.085	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	1469.09	192.076	926.619	1277.009	1469.085	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	427.064	183.981	397.513	243.082	427.064	
DL+SIDL+LL-Max Reaction case		3737.75	472.604	186.888	423.189	285.716	472.604	Dry Case

DL+SIDL+LL-Min Reaction case		3891.49	472.604	194.574	430.876	278.029	472.604	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	472.604	192.076	428.378	280.527	472.604	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.35	1.35	2881.30	2881.30
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	301.90	1.75	1.75	528.32	528.32
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax-Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0.000	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.550	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0.000	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.550	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0.000	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.550	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1921.79	183.981	1144.874	1737.805	1921.786	
DL+SIDL+LL-Max Reaction case		3897.62	1967.33	194.881	1178.544	1772.445	1967.326	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	1967.33	223.706	1207.369	1743.620	1967.326	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	1967.33	214.338	1198.001	1752.988	1967.326	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	576.536	183.981	472.249	392.555	576.536	
DL+SIDL+LL-Max Reaction case		3897.62	622.076	194.881	505.919	427.195	622.076	Dry Case

DL+SIDL+LL-Min Reaction case		4474.12	622.076	223.706	534.744	398.370	622.076	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	622.076	214.338	525.376	407.738	622.076	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1	1.00	2134.30	2134.30
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	301.90	1	1.00	301.90	301.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax- Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	0.000	131.810	131.810	-131.810	131.810	
DL+SIDL+LL-Max Reaction case	2926.86	227.700	146.343	260.193	81.357	260.193	(1-70RW + 1-CLASS A)
	4130.01	0.000	206.500	206.500	-206.500	206.500	SV Loading
DL+SIDL+LL-Min Reaction case	3695.53	227.700	184.776	298.626	42.924	298.626	(1-70RW + 1-CLASS A)
	4562.38	0.000	228.119	228.119	-228.119	228.119	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3445.72	227.700	172.286	286.136	55.414	286.136	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	1281.191	131.810	772.405	1149.381	1281.191	
DL+SIDL+LL-Max Reaction case	2694.33	1326.731	134.716	798.082	1192.014	1326.731	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	1326.731	142.403	805.768	1184.328	1326.731	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	1326.731	139.905	803.270	1186.826	1326.731	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	384.357	131.810	323.988	252.547	384.357	
DL+SIDL+LL-Max Reaction case	2694.33	429.897	134.716	349.665	295.181	429.897	Dry Case

DL+SIDL+LL-Min Reaction case	2848.06	429.897	142.403	357.352	287.494	429.897	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	429.897	139.905	354.854	289.992	429.897	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.1	1.10	2347.73	2347.73
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	301.90	1.35	1.35	407.56	407.56
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2975.29	0.000	148.764	148.764	-148.764	148.764	
DL+SIDL+LL-Max Reaction case	3411.29	341.550	170.564	341.339	170.986	341.339	(1-70RW + 1-CLASS A)
	4469.10	0.000	223.455	223.455	-223.455	223.455	SV Loading
DL+SIDL+LL-Min Reaction case	4564.29	341.550	228.214	398.989	113.336	398.989	(1-70RW + 1-CLASS A)
	4901.48	0.000	245.074	245.074	-245.074	245.074	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4189.57	341.550	209.479	380.254	132.071	380.254	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	1921.79	148.764	1109.657	1773.021	1921.786	
DL+SIDL+LL-Max Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	576.536	148.764	437.032	427.771	576.536	
DL+SIDL+LL-Max Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	Dry Case

DL+SIDL+LL-Min Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	576.536	148.764	437.032	427.771	576.536	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2134.30	1	1	1	2134.30	2134.30	2134.30
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	301.90	1.20	1.20	1.20	362.27	362.27	362.27
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax-Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2987.24	227.700	149.362	263.212	78.338	263.212	(1-70RW + 1-CLASS A)
	4190.38	0.000	209.519	209.519	-209.519	209.519	SV Loading
DL+SIDL+LL-Min Reaction case	3755.91	227.700	187.795	301.645	39.905	301.645	(1-70RW + 1-CLASS A)
	4622.76	0.000	231.138	231.138	-231.138	231.138	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3506.10	227.700	175.305	289.155	52.395	289.155	

Dry Case

HFL Case

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2914.57	170.775	145.729	231.116	25.046	231.116	Dry Case
DL+SIDL+LL-Min Reaction case	3491.07	170.775	174.554	259.941	-3.779	259.941	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3303.72	170.775	165.186	250.573	5.589	250.573	

Normal Case: Quasi Permanant Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	Dry Case
DL+SIDL+LL-Min Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	HFL Case

DL+SIDL+LL-Max Transv. Moment case	2696.57	0.000	134.829	134.829	-134.829	134.829

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

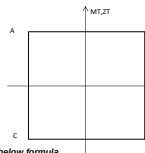
Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1185.351 m

Properties of Footing Base:

A	=	162.500	m ²
ZL	=	352.083	m ³
ZT	=	338.542	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		3736.592		-18.000
Dead Load	1			2134.300	1.400	2988.019	0.000	0.000
SIDL except Wearing Course	1			200.000	1.400	280.000	0.000	0.000
Wearing Course	1			301.895	1.400	422.653	0.000	0.000
Bearing Pedestal	1	25	1.312	32.800	1.400	45.920	-0.549	-18.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.600	56.250	0.000	0.000
Dirt Wall-Tapered portion	1	25	5.302	132.559	0.600	79.523	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.300	8.437	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.350	4.922	0.000	0.000
Cap - (uniform portion)	1	25	7.313	182.813	1.425	260.508	0.000	0.000
Cap - (corbel portion)	25	5.433	135.826	1.425	193.552	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.600	0.000	5.825	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.600	0.000	5.825	0.000
RCC Railing or Crash Barrier	1	25	0.000	0.000	0.600	0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.300	49.219	0.000	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	77.447	1936.179	-2.950	-5711.728	5.825	11278.242
Abutment Shaft	1	25	136.268	3406.710	1.451	4944.753	0.000	0.000
Back filling over heel slab	1	20	1132.605	22652.106	-2.996	-67873.922	0.000	0.000
Front Filling over toe slab	1	20	94.063	1881.250	4.145	7798.229	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	110.938	2773.438	-2.477	-6868.880	0.000	0.000
Toe slab	1	25	67.188	1679.688	4.063	6825.130	0.000	0.000
Portion between heel & toe	1	25	35.000	875.000	1.400	1225.000	0.000	0.000
Vertical Components of active earth pressure	1			2464.540	-6.500	-16019.512	0.000	0.000
Total				38750.236		-74876.119		11278.242
				42198.408		-70470.316		11260.242

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1920.870	-5.100	-9796.435
0.900	180.000	-5.100	-918.000
0.900	301.895	-5.100	-1539.665
0.900	29.520	-5.100	-150.552
	2432.285		-12404.652
0.900	84.375	-5.900	-497.813
0.900	119.295	-5.900	-703.782
0.900	25.313	-6.200	-156.938
0.900	12.656	-6.150	-77.836
0.900	164.531	-5.075	-834.996
0.900	122.243	-5.075	-620.384
0.900	0.000	-5.900	0.000
0.900	0.000	-5.900	0.000
0.900	25.200	-5.900	-148.680
0.900	147.655	-6.200	-915.469
	701.260		-3955.897
0.900	1742.561	-9.450	-16467.201
0.900	3966.039	-5.049	-15478.975
0.900	20386.896	-9.496	-193601.351
0.900	1693.125	-2.365	-3986.906
0.900	0.000	0.000	0.000
0.900	2496.094	-8.977	-22406.602
0.900	1511.719	-2.437	-3683.555
0.900	787.500	-5.100	-4016.250
0.900	2218.086	-13.000	-28835.122
	34875.212		-294005.375
	38008.756		-310365.924

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.549	1607.815
due to Earth pressure	1	5949.927		33120.550

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
131.81	1607.82	0.00	0.00
5949.93	33120.55	0.00	0.00
6081.736	34728.365	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1197.549	1814.628
due to Earth pressure	1.5	8924.890		49680.825
		9073.654		51495.453

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
148.76	1814.63	0.00	0.00
8924.89	49680.82	0.00	0.00
9073.654	51495.453	0.000	0.000

Summary of Forces For SBC

P	42198.408	kN
ML	-35741.951	kNm
MT	11260.242	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		42198.408		-70470.316		11260.242
CWLL-Max. Reaction case	1	1059.332	1.400	1483.065	0.950	1006.366
Vertical Components of LL Surcharge	1	395.270	-6.500	-2569.253	0.000	0.000
Total		43653.010		-71556.503		12266.608

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	38008.7565	-5.100	-19365.92
0.900		-13.000	-4624.65
	38008.756		-314990.58

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.193	1197.549	3173.836
due to Earth pressure	1	5949.927		33120.550
due to Live load surcharge	1	854.295		6719.459

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
260.19	3173.84	0.00	0.00
5949.93	33120.55	0.00	0.00
854.295	6719.459	0.00	0.00
7164.39	43013.84	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		341.339	1197.549	4163.659
due to Earth pressure	1.5	8924.890		49680.825
due to Live load surcharge	1.2	1145.116		8063.351
		10411.348		61907.835

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
341.34	4163.66	0.00	0.00
8924.89	49680.82	0.00	0.00
1145.12	8063.35	0.00	0.00
10411.348	61907.835	0.000	0.000

Summary of Forces For SBC

P	43653.010	kN
ML	-28542.659	kNm
MT	12266.608	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		3736.592		-18.000
Substructure & Foundation -Portion 1								
				779.177		669.211		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	77.447	1936.179	-2.950	-5711.728	5.825	11278.242
Shaft above HFL	1	25	89.563	2239.076	1.597	3576.771	0.000	0.000
Shaft below HFL	1	15	46.705	700.581	1.451	1016.875	0.000	0.000
Back filling above HFL over heel slab	1	20	806.116	16122.325	-2.950	-47560.859	0.000	0.000
Back filling below HFL over heel slab	1	10	332.813	3328.125	-3.108	-10343.079	0.000	0.000
Front Filling over toe slab	1	10	94.063	940.625	2.472	2325.434	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	110.938	1664.063	-2.477	-4121.328	0.000	0.000
Toe slab	1	15	67.188	1007.813	4.063	4095.078	0.000	0.000
Portion between Heel & Toe	1	15	35.000	525.000	1.400	735.000	0.000	0.000
Vertical Components of active earth pressure	1			2464.540	-6.500	-16019.512	0.000	0.000
Total				31910.812		-71218.022		11278.242
				35358.984		-66812.219		11260.242

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2432.285		-12404.652
	701.260		-3955.897
0.900	1742.561	-9.450	-16467.201
0.900	2015.168	-4.903	-9879.498
0.900	630.522	-5.049	-3183.209
0.900	14510.092	-9.450	-137120.374
0.900	2995.313	-9.608	-28778.297
0.900	846.563	-4.028	-3409.766
0.900	0.000	0.000	0.000
0.900	1497.656	-8.977	-13443.561
0.900	907.031	-2.437	-2210.133
0.900	472.500	-5.100	-2409.750
0.900	2218.086	-13.000	-28835.122
	28719.731		-250774.470
	31853.275		-267135.019

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.549	1607.815
due to Earth pressure	1	5949.927		30044.160

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
131.81	1607.82	0.00	0.00
5949.93	30044.16	0.00	0.00
6081.74	31651.98	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1197.549	1814.628
due to Earth pressure	1.5	8924.890		45066.240
		9073.654		46880.868

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
148.76	1814.63	0.00	0.00
8924.89	45066.24	0.00	0.00
9073.65	46880.87	0.00	0.00

Summary of Forces For SBC

P	35358.984	kN
ML	-35160.244	kNm
MT	11260.242	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		35358.984		-66812.219		11260.242
CWLL-Min. Reaction case	1	290.668	1.400	406.935	0.950	276.134
Vertical Components of LL Surcharge	1	431.343	-6.500	-2803.730	0.000	0.000
Total		36080.995		-69209.014		11536.376

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	31853.275	0.000	-267135.019
0.900	388.209	-13.000	-5046.715
	32241.484		-272181.734

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	298.626	1197.549	3642.644
due to Earth pressure	1	5949.927		30044.160
due to live load surcharge	1	1041.354		7332.697

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
298.63	3642.64	0.00	0.00
5949.93	30044.16	0.00	0.00
1041.354	7332.697	0.000	0.000
7289.91	41019.50	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	398.989	1197.549	4866.872
due to Earth pressure	1.5	8924.890		45066.240
due to live load surcharge	1.2	1249.626		8799.237
		10573.505		58732.348

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
398.99	4866.87	0.00	0.00
8924.89	45066.24	0.00	0.00
1249.626	8799.237	0.000	0.000
10573.50	58732.35	0.00	0.00

Summary of Forces For SBC

P	36080.995 KN
ML	-28189.513 kNm
MT	11536.376 kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.243	In Longitudinal direction	Weight of shaft below Ground level	=	501.105 KN
		ah=	0.324	In Transverse direction	Weight of back fill below Ground level	=	2218.750 KN
		av=	0.216	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			2134.300		207.716	138.477	1.400	2988.019	193.868	1198.762		0.000	0.000	2785.744
SIDL except Wearing Course	1			200.000		19.465	12.976	1.400	280.000	18.167	1199.883		0.000	0.000	262.857
Wearing Course	1			301.895		29.381	19.587	1.400	422.653	27.422	1199.434		0.000	0.000	413.776
Bearing Pedestal	1	25	1.312	32.800		3.192	2.128	1.400	45.920	2.979			-0.549	-18.000	
				2668.995		259.754	173.169		3736.592	242.437				-18.000	3482.376
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	3.750	93.750	22.781	9.124	6.083	0.600	56.250	3.650	1198.934	309.438	0.000	0.000	123.931
Dirt Wall-Tapered portion	1	25	5.302	132.539	32.207	12.899	8.599	0.600	79.523	5.160	1197.727		0.000	0.000	159.640
Bracket - Uniform portion	1	25	1.125	28.125				0.300	8.437						
Bracket - Tapered portion	1	25	0.563	14.063				0.350	4.922						
Cap - (uniform portion)	1	25	7.313	182.813	44.423	17.792	11.861	1.425	260.508	16.902	1196.799	508.560	0.000	0.000	203.680
Cap - (corbel portion)	1	25	5.433	135.826	33.006	13.219	8.813	1.425	193.552	12.558	1196.499	367.947	0.000	0.000	147.365
Cantilever Return Wall-Rectangle of	1	25	0.000	0.000	0.000	0.000	0.000	0.600	0.000	0.000	1199.434	0.000	5.825	0.000	0.000
Cantilever Return Wall-Triangle port	1	25	0.000	0.000	0.000	0.000	0.000	0.600	0.000	0.000	1199.434	0.000	5.825	0.000	0.000
RCC Railing or Crash Barrier	1			26.000				0.600	16.800					0.000	
Approach Slab	1	25	6.563	164.063				0.300	49.219					0.000	
				779.177	132.417	53.034	35.356		669.211	38.269		1584.542		0.000	634.616
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	77.447	1936.179	470.491	188.434	125.623	-2.950	-5711.728	-370.587	1193.053	3623.784	5.825	11278.242	1451.342
Abutment Shaft	1	25	136.268	3406.710	706.062	282.781	188.521	1.451	4944.753	273.633	1192.350	4941.728	0.000	0.000	1979.185
Back filling over heel slab	1	20	1132.605	22652.106	0.000	0.000	0.000	-2.996	-67873.922	0.000	1193.053	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	94.063	1881.250				4.145	7798.229					0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000	0.000				0.000	0.000
Heel slab	1	25	110.938	2773.438				-2.477	-6868.880					0.000	0.000
Toe slab	1	25	67.188	1679.688				4.063	6825.130					0.000	0.000
portion between heel & toe	1	25	35.000	875.000				1.400	1225.000					0.000	0.000
Vertical component of active earth pressure	1			2319.409			-6.500	-15076.160						0.000	0.000
Vertical component of dynamic increment of earth pressure	1			1235.826			-6.500	-8032.872						0.000	0.000
				39840.931	1176.554	471.215	314.143		-81965.639	-96.954		8565.512		11278.242	3430.528
Total =				43289.103	1308.971	784.003	-522.668		-77559.835	183.752		10150.054		11260.242	7547.520

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.9			1920.870	124.629	-5.100	-9796.435	-635.610
SIDL except Wearing Course	0.9			180.000	11.679	-5.100	-918.000	-59.561
Wearing Course	1.00			301.895	19.587	-5.100	-1539.665	-99.896
Bearing Pedestal	0.9	25	1.312	32.800		-5.100	-160.552	
				2432.285	155.896		-12404.652	-795.067
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	3.750	93.750	5.474	-5.900	-497.813	-32.299
Dirt Wall-Tapered portion	0.9	25	5.302	132.539	7.739	-5.900	-703.782	-45.663
Bracket - Uniform portion	0.9	25	1.125	28.125				
Bracket - Tapered portion	0.9	25	0.563	14.063				
Cap - (uniform portion)	0.9	25	7.313	182.813	10.675	-5.075	-834.996	-54.176
Cap - (corbel portion)	0.9	25	5.433	135.826	7.931	-5.075	-620.384	-40.252
Cantilever Return Wall-Rectangle of	0.9	25	0.000	0.000	0.000	-5.900	0.000	0.000
Cantilever Return Wall-Triangle port	0.9	25	0.000	0.000	0.000	-5.900	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.900	-148.680	
Approach Slab	0.9	25	6.563	164.063		-6.200	-915.469	
				701.260	31.820		-3721.124	-172.389
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	136.268	3066.039	166.417	-5.049	-15478.975	-840.163
Solid Return wall	0.9	25	77.447	1742.561	113.060	-9.450	-16467.201	-1068.421
Back filling over heel slab	0.9	20	1132.605	20386.896	0.000	-9.496	-193601.4	0.000
Front Filling over toe	0.9	20	94.063	1693.125		-2.355	-3895.996	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	110.938	2496.094		-8.977	-22406.602	
Toe slab	0.9	25	67.188	1511.719		-2.437	-3683.555	
portion between heel & toe	0.9	25	35.000	787.500		-5.100	-4016.250	
Vertical component of active earth pressure	0.9			2218.086		-13.000	-28835.122	
Vertical component of dynamic increment of earth pressure	0.9			1112.244		-13.000	-14459.169	
				35987.456	279.478		-308464.54	-1908.584
Total =				39121.000	467.194		-324590.32	-2876.040

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
0.9			
1.0			
1.0	22.781	1198.934	309.438
1.0	32.207	1197.727	398.598
1.0	44.423	1196.799	508.560
1.0	33.006	1196.499	367.947
1.0	0.000	1199.434	0.000
1.0	0.000	1199.434	0.000
	132.417		1584.542
1.0	692.532	1192.350	4847.033
1.0	470.491	1193.053	3623.784
1.0	0.000	1193.053	0.000
	1163.024		8470.817
	1295.441		10055.359

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	259.754	1197.549	15627.963	3482.376
due to Substructure	1	1308.971	524.249		10150.054	4065.144
due to Earth pressure	1	8583.098			56739.814	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1281.19	15627.96	0.00	0.00	0.00	0.00	259.75	3482.38
1308.97	10150.05	0.00	0.00	0.00	0.00	524.25	4065.14
8583.10	56739.81						
11179.26	82517.83	0.00	0.00	0.00	0.00	784.00	7547.52

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1921.786	1197.549	23441.94
due to Substructure	1.5	1943.162		15083.04
due to Active Earth pressure	1	5598.549		31220.55
due to dynamic Earth pressure	1.5	4475.323		35428.90
		13939.820		107074.429

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	155.896	0.000	-12404.65	-795.067
Forces from Substructure				36688.716	311.298	0.000	-312185.67	-2080.973
CWLL-Max. Reaction case	0.00			0.00	0.000	-5.100	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-13.000	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-13.000	0.00	
Total =				39121.000	467.194		-324590.32	-2876.040
					-467.194			2876.040

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	280.373	1197.549	16183.459	3797.503
due to Substructure	1	1308.971	524.249		10150.054	4065.144
due to Earth pressure	1	8583.098			56739.814	
due to Live load surcharge	0.20	306.973			2506.610	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1326.73	16183.46	0.00	0.00	0.00	0.00	280.37	3797.50
1308.97	10150.05	0.00	0.00	0.00	0.00	524.25	4065.14
8583.10	56739.81						
306.97	2506.61						
11525.77	85579.94	0.00	0.00	0.00	0.00	804.62	7862.65

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.549	23441.944
due to Substructure	1.5	1943.162		15083.039
due to Active Earth pressure	1	5599.549		33120.550
due to dynamic Earth pressure	1.5	4475.323		35428.897
due to Live load surcharge	0	0		
due to dynamic increment of live load surcharge	0	0		
		13939.820		107074.429

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	23441.94	0.00	0.00
1943.16	15083.04	0.00	0.00
5599.549	33120.550		
4475.323	35428.897		
0.000	0.000		
0.000	0.000		
13939.82	107074.43	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	44164.536	43091.707 kN
ML	7593.224	7287.230 kNm
MT	19324.162	19324.162 kNm

Summary of Restoring Forces

Vertical Load	38953.807 kN
Moment	-327466.360 kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995	259.754	173.169			3736.592	242.437				-18.000	3482.376
Substructure & Foundation -Portion 1				779.177	132.417	53.034	35.356		669.211	38.269		1584.542		0.000	634.616
Substructure & Foundation -Portion 2															
Solid Return wall	1		77.45	1836.18	470.491	189.434	125.623	-2.95	-5711.728	-370.587	1193.05	3623.784	5.83	11278.242	1451.342
Shall above HFL	1	25	89.563	2239.076	544.095	217.913	145.275	1.597	3576.771	232.067	1193.350	4352.219	0.000	0.000	1743.084
Shall below HFL	1	15	46.705	700.581	161.967	64.868	43.246	1.451	1016.875	62.770	1189.351	647.867	0.000	0.000	259.474
Back filling above HFL over heel slab	1	20	806.116	16122.325	0.000	0.000	0.000	-2.950	-47560.859	0.000	1194.893	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	332.813	3328.125	0.000	0.000	0.000	-3.108	-10343.073	0.000	1188.289	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	94.063	940.625	2.472	2325.434							0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000							0.000	0.000	
Heel slab	1	15	110.938	1664.063	0.000	-9.450		-2.477	-4121.328	0.000	0.000		0.000	0.000	
Toe slab	1	15	67.188	1007.813	0.000	4.063		4.063	4095.078	0.000	0.000		0.000	0.000	
portion between heel & toe	1	15	35.000	525.000	0.000	1.400		1.400	735.000	0.000	0.000		0.000	0.000	
Vertical component of active earth pressure	1			2371.561				-6.500	-15415.149	0.000	0.000		0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			1232.233				-6.500	-8009.514	0.000	0.000		0.000	0.000	
				33050.066	1415.298	566.833	377.889		-79412.492	-75.750		10412.019		11278.242	4170.062
Total =				36498.238	1547.715	879.621	586.414		-75006.689	204.956		11996.561		11260.242	8287.055
							-586.414			-204.956					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	155.896		-12404.652	-795.067
Substructure & Foundation -Portion 1				701.260	31.820		-3721.124	-172.389
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	77.447155	1742.561	113.060	-9.45	-16467.201	-1068.421
Shall above HFL	0.9	25	89.563	2015.168	130.748	-4.903	-9879.498	-640.999
Shall below HFL	0.9	15	46.705	630.522	35.670	-5.049	-3183.209	-180.080
Back filling above HFL over heel slab	0.9	20	806.116	14510.092	0.000	-4.903	-37120.374	0.000
Back filling below HFL over heel slab	0.9	10	332.813	2995.313	0.000	-9.608	-28778.297	0.000
Front Filling over toe	0.9	10	94.063	845.563	0.000	-4.028	-3409.766	0.000
Side filling between heel and toe	0.9	10	0.000	0.000	0.000			0.000
Heel slab	0.9	15	110.938	1497.656	0.000	-8.977	-13443.961	0.000
Toe slab	0.9	15	67.188	907.031	0.000	-2.437	-2210.133	0.000
portion between heel & toe	0.9	15	35.000	472.500	0.000	-5.100	-2409.750	0.000
Vertical component of active earth pressure	0.9			2134.405		-13.000	-27747.268	0.000
Vertical component of dynamic increment of earth pressure	0.9			1109.010		-13.000	-14417.125	0.000
				29745.059	336.849		-264103.74	-2216.320
Total =				32878.604	524.565		-280229.52	-3183.776
					-524.565			3183.776

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1584.542
1.0	470.491	1193.053	3623.784
1.0	544.095	1193.350	4352.219
1.0	148.437	1189.351	593.747
1.0	0.000	1194.893	0.000
1.0	0.000	1188.289	0.000
	1163.024		8569.750
	1295.441		10154.292

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	259.754	1197.549	15627.963	3482.378
due to Substructure	1	1547.715	619.867		11996.561	4804.678
due to Earth pressure	1	8700.329			53629.947	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1281.19	15627.96	0.00	0.00	0.00	0.00	259.75	3482.38
1547.72	11996.56	0.00	0.00	0.00	0.00	619.87	4804.68
8700.33	53629.95						
11529.23	81254.47	0.00	0.00	0.00	0.00	879.62	8287.05

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.549	23441.944
due to Substructure	1.5	1943.162		15231.438
due to Active Earth pressure	1	5775.458		30044.160
due to dynamic Earth pressure	1.5	4462.310		35378.680
		14052.713		104096.222

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	23441.94	0.00	0.00
1943.16	15231.44	0.00	0.00
5775.458	30044.160		
4462.310	35378.680		
14052.71	104096.22	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	37084.652	35911.824 kN
ML	6452.737	6042.825 kNm
MT	19547.297	19547.297 kNm

Summary of Restoring Forces

Vertical Load	32354.039 kN
Moment	-283413.294 kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995	259.754	173.169			3736.592	242.437				-18.000	3482.376
Forces from Substructure				33829.243	1547.715	619.867	413.245		-78743.281	-37.480		11996.561		11278.242	4804.678
CWLL-Max. Reaction case	0.20			58.13	5.658	3.772		1.400	81.387	5.281	1200.634		0.950	55.227	86.467
Vertical component of LL Surcharge	0.20			86.27				-6.500	-560.746				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			60.34				-6.500	-392.236				0.000	0.000	
Total =				36702.884	1547.715	885.278	590.186		-75878.284	210.237		11996.561		11315.469	8373.522
							-590.186			-210.237					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	155.896		-12404.652	-795.067
Forces from Substructure				30446.319	368.669		-267824.87	-2388.709
CWLL-Max. Reaction case	0.00			0.00	0.00		-5.10	0.00
Vertical component of LL Surcharge	0.00			0.00		-5.100	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-13.000	0.000	0.000
Total =				32878.604	524.565		-280224.62	-3183.776
					-524.565			3183.776

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	265.411	1197.549	16183.459	3568.843
due to Substructure	1	1547.715	619.887		11995.561	4804.678
due to Earth pressure	1	8700.329			53629.947	
due to Live load surcharge	0.20	353.954			2767.571	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.549	23441.944
due to Substructure	1.5	1943.162		15231.438
due to Active Earth pressure	1	5725.456		30044.160
due to dynamic Earth pressure	1.5	4462.310		35378.68
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		14052.713		104096.222

Summary of Forces For SBC

	Downward	Upward
P	37293.170	36112.798 kN
ML	8909.490	8489.017 kNm
MT	19688.991	19688.991 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN.	FL = 0.3 x ah x P (kN)	FT = 0.3 x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		865.845	173.169		3736.592	242.437				-18.000	11607.921
Substructure & Foundation -Portion 1				779.177	39.725	176.779	35.356		669.211	38.269		475.363		0.000	2115.388
Substructure & Foundation -Portion 2				39840.931	352.966	1570.717	314.143		-81965.639	-96.954		2569.654		11278.242	11435.092
Total =				43289.103	392.691	2613.342	522.668	-522.668	-77599.835	183.752		3045.016		11260.242	25158.402

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	155.896		-12404.65	-795.067
Substructure & Foundation -Portion 1				701.260	31.820		-3721.12	-172.389
Substructure & Foundation -Portion 2				35987.456	279.478		-308464.54	-1908.584
Total =				39121.000	467.194		-324590.32	-2876.040

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1584.542
	1163.024		8470.817
	1295.441		10055.359

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.357	865.845	1197.549	4688.389	11607.921
due to Substructure	1	392.691	1747.496		3045.016	13550.480
due to Earth pressure	1	8583.098			56739.814	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.549	7032.583
due to Substructure	1.5	1943.162		15083.039
due to Active Earth pressure	1	5699.549		33120.550
due to dynamic Earth pressure	1.5	1342.597		10628.669
due to dynamic Earth pressure		9461.844		65864.844

Summary of Forces For SBC

	Downward	Upward
P	43811.771	42766.435 kN
ML	-12902.864	-13270.368 kNm
MT	36418.644	36418.644 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	43628.122	536.415	-78089.71	202.997	11461.515

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	934.577	1197.549	5243.886	12658.342
due to Substructure	1	392.691	1747.496		3045.016	13550.480
due to Earth pressure	1	8583.098			56739.814	
due to Live load surcharge	0.2	306.973			2506.610	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.549	7032.583
due to Substructure	1.5	582.95		4524.912
due to Active Earth pressure	1	5699.55		33120.550
due to dynamic Earth pressure	1.5	1342.60		10628.669
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		8101.63		55306.714

Summary of Forces For SBC

	Downward	Upward
P	44164.536	43091.707 kN
ML	-10351.388	-10757.382 kNm
MT	37670.338	37670.338 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	2668.995	173.169	3736.592	242.437	-18.000
Substructure & Foundation -Portion 1	779.177	35.356	669.211	38.269	0.000
Substructure & Foundation -Portion 2	33050.066	377.889	-79412.492	-75.500	11278.242
Total =	36498.238	586.414	-75005.689	204.956	11260.242

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.36	865.85	1197.55	4688.39	11607.92
due to Substructure	1	464.31	2066.22		3598.97	16015.59
due to Earth pressure	1	8700.33			53629.95	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.549	7032.58
due to Substructure	1.5	582.948		4569.43
due to Active Earth pressure	1	5725.456		30044.16
due to dynamic Earth pressure	1.5	4462.310		35378.68
due to dynamic Earth pressure		8223.633		52259.78

Summary of Forces For SBC

	Downward	Upward
P	37084.652	35911.824 kN
ML	-12884.429	-13294.341 kNm
MT	38883.758	38883.758 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1326.73	16183.46	0.00	0.00	0.00	0.00	265.41	3568.84
1547.72	11996.56	0.00	0.00	0.00	0.00	619.87	4804.68
8700.33	53629.95						
353.95	2767.57						
11928.73	84577.54	0.00	0.00	0.00	0.00	885.28	8373.52

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1921.79	23441.94	0.00	0.00
1943.16	15231.44	0.00	0.00
5725.456	30044.160		
4462.310	35378.680		
0.000	0.000		
0.000	0.000		
14052.71	104096.22	0.00	0.00

Summary of Restoring Forces

Vertical Load	32354.039 kN
Moment	-283418.394 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.35	4688.39	0.00	0.00	0.00	0.00	865.85	11607.92
392.69	3045.02	0.00	0.00	0.00	0.00	1747.50	13550.48
8583.10	56739.81						
9360.15	64473.22	0.00	0.00	0.00	0.00	2613.34	25158.40

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7032.58	0.00	0.00
1943.16	15083.04	0.00	0.00
5599.549	33120.550		
1342.597	10628.669		
9461.84	65864.84	0.00	0.00

Summary of Restoring Forces

Vertical Load	38653.807 kN
Moment	-327466.360 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	39121.000	467.194	-324590.32	-2876.040

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
429.90	5243.89	0.00	0.00	0.00	0.00	934.58	12658.34
392.69	3045.02	0.00	0.00	0.00	0.00	1747.50	13550.48
8583.10	56739.81						
306.97	2506.61						
9712.66	67535.33	0.00	0.00	0.00	0.00	2682.07	26208.82

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7032.58	0.00	0.00
582.95	4524.91	0.00	0.00
5599.549	33120.550		
1342.597	10628.669		
0.000	0.000		
0.000	0.000		
8101.63	55306.71	0.00	0.00

Summary of Restoring Forces

Vertical Load	38653.807 kN
Moment	-327466.360 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	2432.285	155.896		-12404.652	-795.067
Substructure & Foundation	701.260	31.820		-3721.124	-172.389
Substructure & Foundation	29745.059	336.849		-254103.742	-2216.320
Total =	32978.604	524.565		-280229.518	-3183.776

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	4688.39	0.00	0.00	0.00	0.00	865.85	11607.92
464.31	3598.97	0.00	0.00	0.00	0.00	2066.22	16015.59
8700.33	53629.95						
9400.00	61917.30	0.00	0.00	0.00	0.00	2932.07	27623.52

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7032.58	0.00	0.00
582.95	4569.43	0.00	0.00
5725.456	30044.160		
4462.310	35378.680		
8223.63	52259.78	0.00	0.00

Summary of Restoring Forces

Vertical Load	32354.039 kN
Moment	-283413.294 kNm

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeLT
Total =	36702.984	590.186	-75878.28	210.237	11315.469
		-590.186		-210.237	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	884.7043	1197.549	5243.886	11896.144
due to Substructure	1	454.315	2066.2337	3598.869	16015.595	
due to Earth pressure	1	8700.329			53629.947	
due to Live load surcharge	0.2	353.954			2767.571	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.549	7032.58
due to Substructure	1.5	582.95		4569.43
due to Active Earth pressure	1	5725.46		30044.16
due to dynamic Earth pressure	1.5	1338.69		10613.60
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		8223.63		52259.78

Summary of Forces For SBC

	Downward	Upward
P	37293.170	36112.796
ML	-10427.676	-10848.150
MT	39227.208	39227.208

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	32878.604	524.565		-280234.62	-3183.776
		-524.565			3183.776

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
429.90	5243.89	0.00	0.00	0.00	0.00	884.70	11896.14
454.31	3598.97	0.00	0.00	0.00	0.00	2066.22	16015.59
8700.33	53629.95						
353.95	2767.57						
9948.50	65240.37	0.00	0.00	0.00	0.00	2950.93	27911.74

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7032.58	0.00	0.00
582.95	4569.43	0.00	0.00
5725.456	30044.160		
1338.693	10613.604		
0.000	0.000		
0.000	0.000		
8223.63	52259.78	0.00	0.00

Summary of Restoring Forces

Vertical Load	32854.039
Moment	-283418.394

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00						
Transverse Moment due to C.F.	=	0.000	x (	1200.634	-	1185.351	)			

	=	0.000	kN							
	=	0.000	kNm							

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sinθ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00						
Transverse Moment due to C.F.	=	0.000	x (	1200.634	-	1185.351	)			

	=	0.000	kN							
	=	0.000	kNm							

	0.00	0.00	0.00	0.00

Base pressure on corner A	=	σ _a	=	P/A - ML/ZL + MT/ZT
Base pressure on corner B	=	σ _b	=	P/A + ML/ZL + MT/ZT
Base pressure on corner C	=	σ _c	=	P/A - ML/ZL - MT/ZT
Base pressure on corner D	=	σ _d	=	P/A + ML/ZL - MT/ZT

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK		OVERTURNING CHECK		
	P	ML	MT	σ _a	σ _b	σ _c	σ _d	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= μP + c.A + Fp	FOS	Overturning moment	Restoring Moment = ΣP.eToe+M _r
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm
Case 1 : DL+SIDL-Normal Dry Case	42198.408	-35741.951	11260.242	394.459	191.428	327.937	124.906	394.459	124.906	9073.654	26606.130	2.93	51495.453	310365.92
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	43653.010	-28542.659	12266.608	385.935	223.800	313.468	151.332	385.935	151.332	10411.348	26606.130	2.56	61907.835	314990.58
								SAFE	SAFE			SAFE		SAFE
Normal HFLCase														
Case 3 : DL+SIDL-Normal HFL Case	35358.984	-35160.244	11260.242	350.718	150.991	284.196	84.469	350.718	84.469	9073.654	22297.293	2.46	46880.868	267135.02
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	36080.995	-28189.513	11536.376	336.178	176.049	268.025	107.895	336.178	107.895	10573.505	22569.039	2.13	58732.348	272181.73
								SAFE	SAFE			SAFE		SAFE
Longitudinal Seismic Dry Case														
Case 5 : DL+SIDL-Long. Seismic Dry Case	43811.771	5141.748	18807.762	310.562	339.770	199.452	228.659	339.770	199.452	13939.820	27057.665	1.94	107074.429	327466.36
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	44164.536	7693.224	19324.162	307.012	350.713	192.851	236.552	350.713	192.851	13939.820	27057.665	1.94	107074.429	327466.36
								SAFE	SAFE			SAFE		SAFE
Longitudinal Seismic HFL Case														
Case 7 : DL+SIDL-Long. Seismic HFL Case	37084.652	8452.737	19547.297	267.626	304.280	152.146	188.801	304.280	152.146	14052.713	22647.827	1.61	104096.222	283413.29
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	37293.170	8909.490	19688.991	262.350	312.960	146.033	196.643	312.960	146.033	14052.713	22647.827	1.61	104096.222	283418.39
								SAFE	SAFE			SAFE		SAFE
Transverse Seismic Dry Case														
Case 9 : DL+SIDL-Trans. Seismic Dry Case	43811.771	-12902.864	36418.644	413.833	340.539	198.683	125.389	413.833	125.389	9461.844	27057.665	2.86	65864.841	327466.36
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	44164.536	-10351.388	37670.338	412.455	353.654	189.910	131.109	412.455	131.109	8101.630	27057.665	3.34	55306.714	327466.36
								SAFE	SAFE			SAFE		SAFE
Transverse Seismic HFL Case														
Case 11 : DL+SIDL-Trans. Seismic HFL Case	37084.652	-12884.429	38883.758	379.665	306.475	149.951	76.762	379.665	76.762	8223.633	22647.827	2.75	52259.779	283413.29
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	37293.170	-10427.676	39227.208	374.985	315.750	143.242	84.008	374.985	84.008	8223.633	22647.827	2.75	52259.779	283418.39
								SAFE	SAFE			SAFE		SAFE

DESIGN OF ABUTMENT(A2) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
87+006

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	23.750m	23.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	25.000m	25.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m²
SBC of soil-Normal Case = 417 kN/m²
SBC of soil-Seismic Case = 522 kN/m² Assumed

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	1.414m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.950m	1.950m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m
Projection of Abutment Cap (Span Side)	=	0.500m	0.500m
Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.366m	1.366m
Thickness of Abutment shaft at Bottom	=	1.600m	1.600m

Solid Return Wall

Length of Return wall	=	7.100m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.200m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	13.000m	
abutment pedestal width	=	1.600m	
abutment pedestal Height	=	1.750m	
Width of Toe Slab	=	4.300m	
Width of Heel Slab	=	7.100m	
Thickness of Toe slab at tip	=	0.750m	
Thickness of Toe slab near shaft	=	1.750m	
Thickness of heel slab at tip	=	0.750m	
Thickness of heel slab near shaft	=	1.750m	
Width of backfill on heel slab	=	7.100m	
Thickness of heel slab at back fill edge	=	1.750m	
Height of back fill at bottom edge of heel slab	=	13.289m	
Height of back fill at back fill edge of heel slab	=	12.289m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1199.461m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1199.319m	Height of Superstructure	=	1.820m
Deck level at center line =	1199.461m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1197.576m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1196.976m	Height of Pedestal (3)	=	0.550m
Abutment cap bottom lvl (uniform portion ends)	1196.676m	Height of Pedestal (4)	=	0.625m
Abutment cap bottom lvl (corbel portion ends)	1196.376m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1196.376m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1188.721m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1187.101m	Height (Avg.) of Dirt Wall	=	2.414m
Foundation level =	1185.351m	Abutment shaft Above G.L	=	7.655m
HFL =	1190.721m	Abutment Shaft below G.L	=	1.620m

Height of abutment shaft	=	9.275m
MSL	=	1187.351m
Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete, fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z = Zone factor	=	0.36	
I = Importance factor	=	1.2	
R = Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	522.61 4.50
DL Reaction on Bearing No.-2	=	544.54 1.50
DL Reaction on Bearing No.-3	=	544.54 -1.50
DL Reaction on Bearing No.-4	=	522.61 -4.50
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2134.30 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	100.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	100.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		200.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	68.613 4.50
SIDL Reaction on Bearing No.-2	=	82.335 1.50
SIDL Reaction on Bearing No.-3	=	82.335 -1.50
SIDL Reaction on Bearing No.-4	=	68.613 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		301.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

		Max CWLL			Min CWLL	
CWLL Reaction on Bearing No.-1	=	23.48	4.50	CWLL Reaction on Bearing No.-8	=	5.015 4.50
CWLL Reaction on Bearing No.-2	=	692.01	1.50	CWLL Reaction on Bearing No.-9	=	26.750 1.50
CWLL Reaction on Bearing No.-3	=	379.41	-1.50	CWLL Reaction on Bearing No.-10	=	111.449 -1.50
CWLL Reaction on Bearing No.-4	=	83.76	-4.50	CWLL Reaction on Bearing No.-11	=	76.684 -4.50
CWLL Reaction on Bearing No.-5	=	0.00	0.00	CWLL Reaction on Bearing No.-12	=	0.00 0.00
CWLL Reaction on Bearing No.-6	=	0.00	0.00	CWLL Reaction on Bearing No.-13	=	0.00 0.00
CWLL Reaction on Bearing No.-7	=	0.00	0.00	CWLL Reaction on Bearing No.-14	=	0.00 0.00

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 4	=	0.625 x	0.800 x	0.800 =	0.4000 m ³	-4.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.3120 m ³	-0.549

VOLUME CALCULATION

C.G. Of Footing	=	6.500 m
C.G. Of shaft from toe tip	=	5.100 m
Distance between c.g. of shaft and footing	=	1.400 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.600	-5.900	0.000
-Trapering portion	1	12.50	0.300	1.414	5.302	-0.800	0.600	-5.900	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	0.300	-6.200	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.350	-6.150	0.000
Cap (uniform portion)	1	12.50	1.950	0.300	7.313	0.025	1.425	-5.075	0.000
Cap (Corbel Portion)	1	12.50	1.950	0.300	5.433	0.025	1.425	-5.075	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.183	5.655	83.617	0.204	1.604	-4.896	0.000
Shaft below HFL	1	12.50	1.483	2.870	53.199	0.057	1.457	-5.043	0.000
Solid Return Wall	1	7.10	0.850	12.860	77.610	-4.350	-2.950	-9.450	5.825
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.800	0.600	-5.900	5.825
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.800	0.600	-5.900	5.825
Footing									
Heel Slab	1	12.50	7.100	1.250	110.938		-2.477	-8.977	0.000
Toe Slab	1	12.50	4.300	1.250	67.188		4.063	-2.437	0.000
Portion between Heel and Toe	1	12.50	1.600	1.750	35.000		1.400	-5.100	0.000
Back filling above HFL over Heel Slab	1	12.50	7.100	8.740	775.675		-2.950	-9.450	0.000
Back filling below HFL over Heel Slab	1	12.50	7.100	4.120	365.650		-3.094	-9.594	0.000
Backfill above Heel slab	1	12.50	7.100	12.789	1135.002		-2.996	-9.496	0.000
Front Filling over Toe Slab	1	12.50	4.300	2.120	113.950		4.181	-2.319	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	4.300	0.750	40.313		2.472	-4.028	0.000
Side filling between heel and toe	1	0.00	1.600	2.120	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	0.300	-6.200	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.366	8.740	39.966		0.822	-5.678	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.234	4.120	12.060		0.678	-5.822	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.600	-5.900

SECTIONAL PROPERTIES

Width of Footing (B)	=	13.000 m							
Length of Footing (L)	=	12.500 m							
A	=	13.000	x	12.500	=	162.500	m ²		
ZL	=	12.500	x	28.167	=	352.083	m ³		
ZT	=	IT1	+	IT2					
		distance of extreme point from centre							
IT1	=	13.000	x	162.760	=	2115.89	m ⁴		
IT2 (moment of inertia of triangle)	=	13.000	x	0.000	+	0.500 x	13.000 x	0.000 x	39.063
from centre of footing	=	0.000	m ⁴						
Moment of inertia of two triangle	=	0.000	m ⁴						
Total moment of inertia	=	2115.89	m ⁴						
Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250	m		
Total Section modulus (ZT)	=	338.542	m ³						

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20

Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 12.025 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

= 13.682 m

Abutment Cap Top Level - Foundation Level

= 11.625 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.30 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.716 m^4

Moment of Inertia , $I_{\text{transverse}}$ = 211.589 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force	=	100.698	KN
D	=	2636.19	KN
T	=	0.3236	sec

Transverse Direction

Force	=	10316.401	KN
D	=	2906.195	KN
T	=	0.0336	sec

For Hard or Rocky Strata, with $N > 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.504$$

For Medium Strata, with $N > 10 \& N < 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.504$$

For Soft Soil Strata, with $N < 10$

$$\frac{S_a}{g} = 2.5$$

$$\frac{S_a}{g} = 1.504$$

Medium Soil Strata

$$S_a/g = 2.5$$

$$S_a/g = 1.504$$

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.325

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.325	In Transverse direction
Av	=	0.217	In Vertical direction

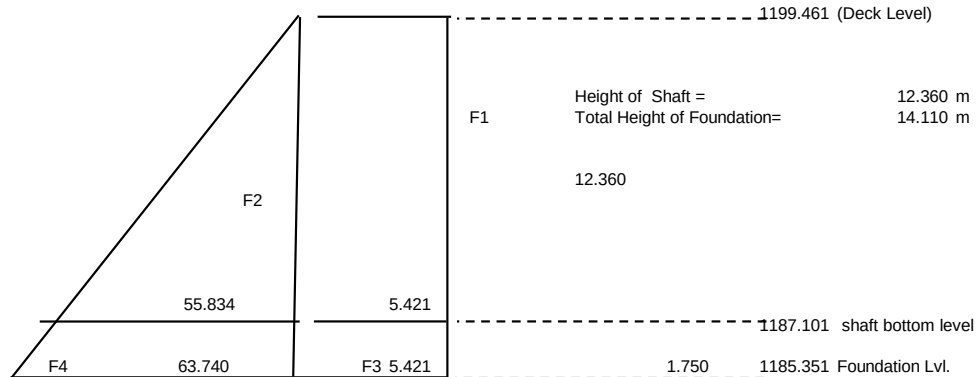
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.325	In Transverse direction
Av	=	0.217	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1187.101 m (at Shaft Base)		
@ RL					1185.351 m (at Foundation Level)		
Due to Live Load Surcharge							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m^2
F1	=	5.421	x	12.360	x	12.500	= 837.515 kN
M1	=	837.51	x	6.18	=	5175.841	kN.m at Shaft Bottom
F3	=	5.421	x	14.110	x	12.500	= 956.095 kN
M3	=	956.095	x	7.055	=	6745.249	kN.m at Foundation

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
=	0.226	x	20	x	12.360	=	55.834 kN/m ²
F2	=	0.5	x	55.83	x	12.360	x 12.50
=	4313.201	kN					

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)

M2	=	4313.20	x	5.19	=	22390.687	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
=	0.226	x	20	x	14.110	=	63.740 kN/m ²
F4	=	0.5	x	63.74	x	14.110	x 12.50
=	5621.041	kN					
M4	=	5621.04	x	5.93	=	33311.412	kN.m at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014				γ fluid	=	4.8 kN/m ³	
Intensity for triangular portion (At Shaft bottom level)							
=	4.800	x	12.360	=	59.328	kN/m ²	
F	=	0.5	x	59.328	x	12.360	x 12.500
=	4583.088	kN					
M	=	4583.09	x	4.120	=	18882.323	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
=	4.800	x	14.110	=	67.73	kN/m ²	
F	=	0.5	x	67.728	x	14.11	x 12.500
=	5972.763	kN					
M	=	5972.76	x	4.703	=	28091.895	kN.m at Foundation

Intensity of Passive pressure

$$\begin{aligned}
 &= 5.249 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2 \\
 \text{Force due to passive @ Foundation, F} &= 0.5 \times 0.000 \times 12.50 \\
 &= \mathbf{0.000 \text{ kN}}
 \end{aligned}$$

Moment due to passive @ Foundation, M

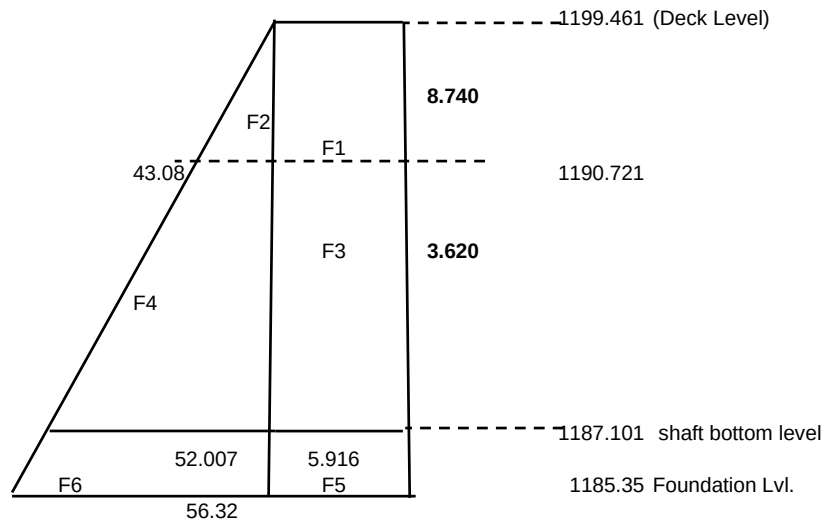
$$= 0.000 \times 0.000 = \mathbf{0.000 \text{ kN.m} \text{ at Foundation}}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	22390.687	33311.412	4313.201	5621.041
Due to Minimum Fluid Pressure	18882.323	28091.895	4583.088	5972.763
Governing of Two	22390.687	33311.412	4583.088	5972.763
Due to Live Load Surcharge	5175.841	6745.249	837.515	956.095
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246	active component
	Kp'	=	5.249	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Horizontal Forces and Moments @ RL****1187.1 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	12.360	x	12.500	=	913.949 kN
M1	=	913.95	x	6.18	=	5648.204 kN.m		at Shaft Bottom
F3	=	5.916	x	14.110	x	12.500	=	1043.351 kN
M3	=	1043.35	x	7.05	=	7360.841 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	8.740	=	43.085 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.620	=	8.923 kN/m ²
F2	=	0.5	x	43.08	x	8.740	x	12.50
	=	2353.504 kN						
F4	=	$\left(\frac{43.08 + 52.01}{2} \right) \times$				3.62	x	12.50
	=	2151.458 kN						
Total Force	=	4504.963 kN						
M2	=	2353.50	x	7.29	=	17158.930 kN.m		
M4	=	2151.46	x	1.75	=	3772.343 kN.m		
Total Moment	=	20931.27 kN.m		at Shaft Bottom				

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 8.740 = 43.085 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.370 = 13.236 \text{ kN/m}^2$$

$$F2 = 0.5 \times 43.08 \times 8.740 \times 12.50 = 2353.504 \text{ kN}$$

$$F6 = \left(\frac{43.08 + 56.32}{2} \right) \times 5.37 \times 12.50 = 3336.297 \text{ kN}$$

$$\text{Total Force} = 5689.801 \text{ kN}$$

$$M2 = 2353.50 \times 9.04 = 21277.563 \text{ kN.m}$$

$$M6 = 3336.30 \times 2.57 = 8560.368 \text{ kN.m}$$

$$\text{Total Moment} = 29837.93 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	20931.273	29837.931	4504.963	5689.801
Due to Minimum Fluid Pressure	18882.323	28091.895	4583.088	5972.763
Governing of Two	20931.273	29837.931	4583.088	5972.763
Due to Live Load Surcharge	5648.204	7360.841	913.949	1043.351
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.180	
αv	=	0.217	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

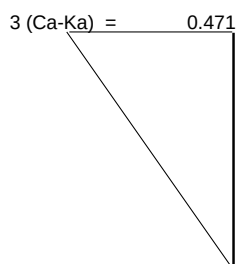
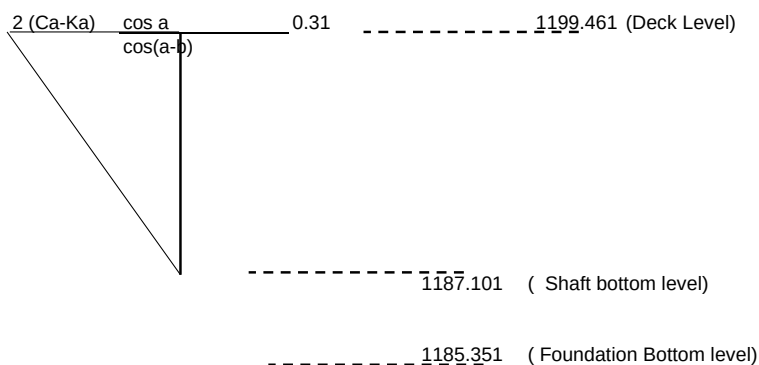
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.147 \\ 0.226 \end{matrix}$$

$$C_a = \begin{matrix} 1 \\ 0.383 \end{matrix} \begin{matrix} 2 \\ 0.297 \end{matrix}$$

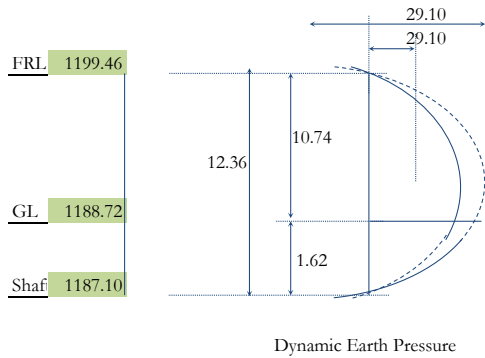
Ca	=	0.383	0.297	
Ka	=	0.226		
Dynamic Increment	=	0.383	-0.226	0.157

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

Active Earth Pressure**Surcharge Earth Pressure****Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.314	x	20.00	x	1.2	=	7.535 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.535	x	12.360	x	12.500
	=	582.052	kN					
M1	=	582.052	x	8.281			=	4820.087 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.535	x	12.360	x	12.500
	=	582.052	kN					
M2	=	582.052	x	10.031			=	5838.678 kN.m

Due to Dynamic Active Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p _{mid_height}	=	29.10 t/m ²
h	=	12.36 m
y	=	4.56 m
L	=	12.500 m

Parabola below Water Level

p _{mid_height}	=	29.10 t/m ²
h	=	12.36 m
y	=	-4.56 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	2856.6	6.4
Parabola below Water Level	141.0	1.1
Total Dynamic Earth Pressure	2997.6	6.2

$$E3 = 2997.567 \text{ kN}$$

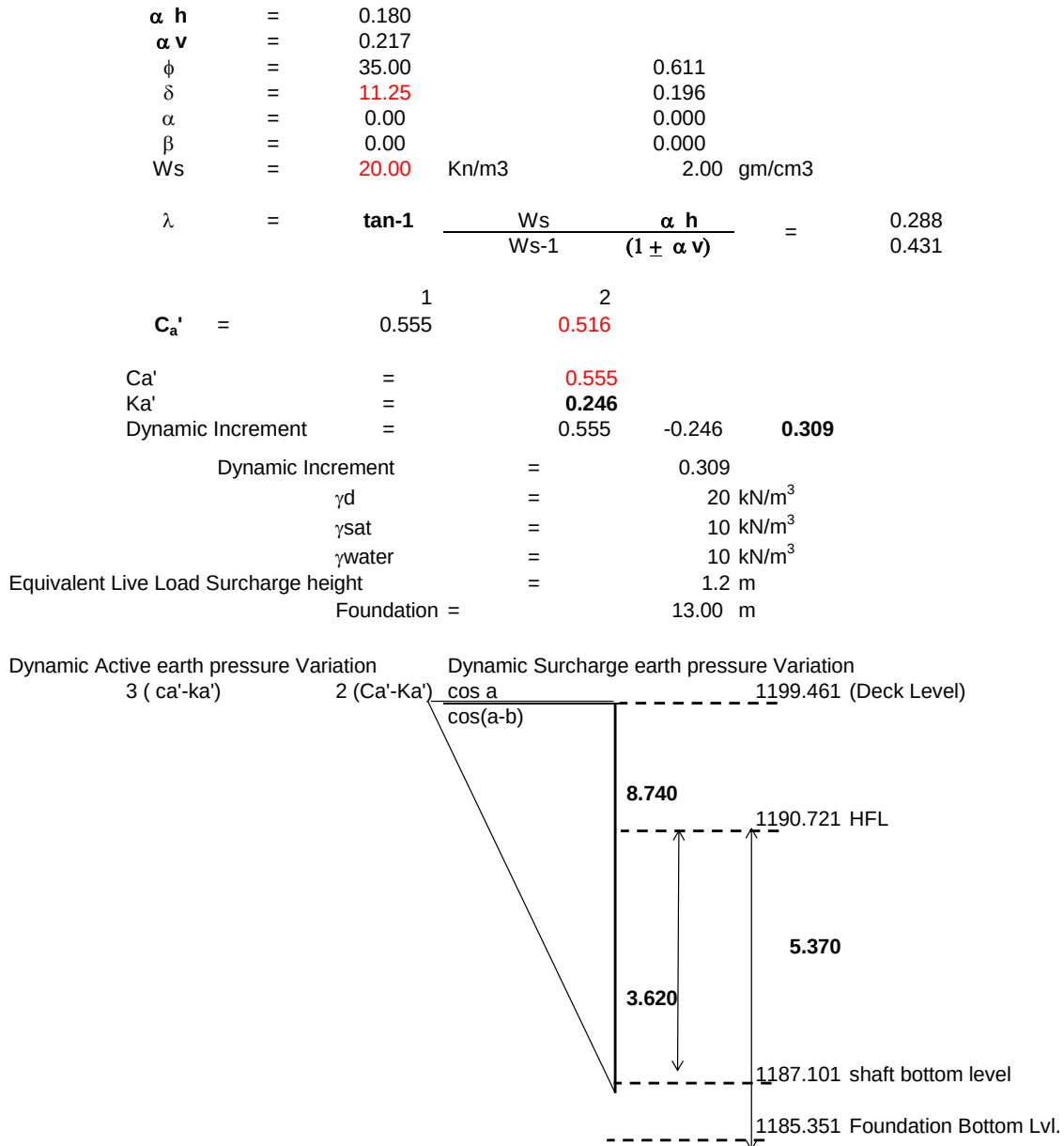
$$E4 = 2997.567 \text{ kN}$$

$$M3 = 2997.57 \times 6.18 = 18524.962 \text{ kN.m} \quad (\text{Shaft bottom level})$$

$$M4 = 2997.57 \times 7.93 = 23770.704 \text{ kN.m} \quad (\text{Foundation Bottom level})$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	22390.687	33311.412	4313.201	5621.041
Due to active Earth Pressure (dynamic Increment)	18524.962	23770.704	2997.567	2997.567
Total Earth Pressure	40915.649	57082.116	7310.767	8618.607
Due to Minimum Fluid Pressure	18882.323	28091.895	4583.088	5972.763
Governing of Two	22390.687	57082.116	7310.767	8618.607
Due to Live Load Surcharge (Static)	5175.841	6745.249	837.515	956.095
Due to Live Load Surcharge(Dynamic)	4820.087	5838.678	582.052	582.052
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case**Earth Pressure Diagram**

h'	=	3.620
h	=	12.360

Dynamic active earth pressure		
3 (ca'-ka')	=	0.471 at deck level
3 (ca'-ka')	=	0.926 at deck level
3 (ca'-ka')h'/h	=	0.271 at HFL level

Dynamic Surcharge earth pressure			
2 (Ca'-Ka') $\frac{\cos a}{\cos(a-b)}$	=	0.617 at deck level	Pressure = 14.81 kN/m ²
	=	0.181 at HFL level	Pressure = 4.34 kN/m ²

Due to Live Load Surcharge

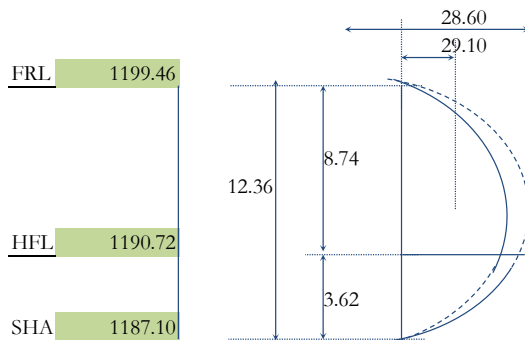
Dynamic surcharge pressure in dry condition at deck level = 7.535 kN/m²
 Dynamic surcharge pressure in Submerge condition at HFL level = 4.34 kN/m²

at Shaft Bottom Level

F1 = 5.936 x 8.740 x 12.500 = **648.542 kN**
 M1 = 648.54 x 7.99 = **5181.848 kN.m**
 F2 = 0.50 x 4.338 x 3.620 x 12.500
 = **98.146 kN**
 M2 = 98.15 x 2.43 = **238.044 kN.m**
 Total Force at Abutment shaft level = 746.688 **kN**
 Total Moment at Abutment shaft level = 5419.892 **kN.m**

at Foundation Bottom Level

F3 = 5.936 x 8.740 x 12.500 = **648.542 kN**
 M3 = 648.54 x 9.74 = **6316.796 kN.m**
 F4 = 0.500 x 4.338 x 3.620 x 12.500
 = **98.146 kN**
 M4 = 98.15 x 4.18 = **409.801 kN.m**
 Total Force at Founding level = 746.688 **kN**
 Total Moment at Founding level = 6726.597 **kN.m**

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height = 29.10 t/m²
 h = 12.36 m
 y = 2.56 m
 L = 12.500 m

Parabola below Water Level

p_mid_height = 28.60 t/m²
 h = 12.36 m
 y = -2.56 m
 L = 12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	2376.8	7.2
Parabola below Water Level	610.1	2.3
Total Dynamic Earth Pressure	2986.9	6.2

Total Force (F1 + F2)	=	2986.942 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	2986.942 kN	at Foundation Bottom Level

$$M1 = 2986.94 \times 6.19 = 18500.100 \text{ kN.m}$$

Total Mome = 18500.100 kN.m at Shaft Bottom

$$M1 = 2986.94 \times 7.94 = 23727.249 \text{ kN.m}$$

Total Mome = 23727.249 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	20931.273	29837.931	4504.963	5689.801
Due to active Earth Pressure (Dynamic Increment)	18500.100	23727.249	2986.942	2986.942
Total Earth Pressure	39431.372	53565.180	7491.905	8676.744
Due to Minimum Fluid Pressure	18882.323	28091.895	4583.088	5972.763
Governing of Two	39431.372	53565.180	7491.905	8676.744
Due to Live Load Surcharge(Static)	5648.204	7360.841	913.949	1043.351
Due to Live Load Surcharge (Dynamic Increment)	5419.892	6726.597	746.688	746.688
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2134.30	1.35	1.35	2881.30	2881.30	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	301.90	1.75	1.75	528.32	528.32	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW + 1-CLASS A)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax-Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.55	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.55	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.55	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1423.55	183.981	895.754	1239.564	1423.545	
DL+SIDL+LL-Max Reaction case		3737.75	1469.09	186.888	921.430	1282.197	1469.085	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	1469.09	194.574	929.117	1274.511	1469.085	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	1469.09	192.076	926.619	1277.009	1469.085	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)
DL+SIDL	2636.19	3679.62	427.064	183.981	397.513	243.082	427.064
DL+SIDL+LL-Max Reaction case		3737.75	472.604	186.888	423.189	285.716	472.604
DL+SIDL+LL-Min Reaction case		3891.49	472.604	194.574	430.876	278.029	472.604
DL+SIDL+LL-Max Transv. Moment case		3841.53	472.604	192.076	428.378	280.527	472.604

Dry Case

HFL Case

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.35	1.35	2881.30	2881.30
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	301.90	1.75	1.75	528.32	528.32
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax- Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)
DL+SIDL	3679.62	0.000	183.981	183.981	-183.981	183.981
DL+SIDL+LL-Max Reaction case	4115.62	341.550	205.781	376.556	135.769	376.556
	5609.43	0.000	280.472	280.472	-280.472	280.472
DL+SIDL+LL-Min Reaction case	5268.62	341.550	263.431	434.206	78.119	434.206
	5605.81	0.000	280.291	280.291	-280.291	280.291
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.550	244.695	415.470	96.855	415.470

(1-70RW + 1-CLASS A)

Dry Case

SV Loading

(1-70RW + 1-CLASS A)

HFL Case

SV Loading

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)
DL+SIDL	2636.19	3679.62	1921.79	183.981	1144.874	1737.805	1921.786
DL+SIDL+LL-Max Reaction case		3897.62	1967.33	194.881	1178.544	1772.445	1967.326
DL+SIDL+LL-Min Reaction case		4474.12	1967.33	223.706	1207.369	1743.620	1967.326
DL+SIDL+LL-Max Transv. Moment case		4286.76	1967.33	214.338	1198.001	1752.988	1967.326

Dry Case

HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	576.536	183.981	472.249	392.555	576.536	
DL+SIDL+LL-Max Reaction case		3897.62	622.076	194.881	505.919	427.195	622.076	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	622.076	223.706	534.744	398.370	622.076	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	622.076	214.338	525.376	407.738	622.076	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1	1.00	2134.30	2134.30
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	301.90	1	1.00	301.90	301.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax-Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	0.000	131.810	131.810	-131.810	131.810	
DL+SIDL+LL-Max Reaction case	2926.86	227.700	146.343	260.193	81.357	260.193	(1-70RW + 1-CLASS A)
	4130.01	0.000	206.500	206.500	-206.500	206.500	SV Loading
DL+SIDL+LL-Min Reaction case	3695.53	227.700	184.776	298.626	42.924	298.626	(1-70RW + 1-CLASS A)
	4562.38	0.000	228.119	228.119	-228.119	228.119	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3445.72	227.700	172.286	286.136	55.414	286.136	

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	1281.191	131.810	772.405	1149.381	1281.191	
DL+SIDL+LL-Max Reaction case	2694.33	1326.731	134.716	798.082	1192.014	1326.731	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	1326.731	142.403	805.768	1184.328	1326.731	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	1326.731	139.905	803.270	1186.826	1326.731	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)
DL+SIDL	2636.19	384.357	131.810	323.988	252.547	384.357
DL+SIDL+LL-Max Reaction case	2694.33	429.897	134.716	349.665	295.181	429.897
DL+SIDL+LL-Min Reaction case	2848.06	429.897	142.403	357.352	287.494	429.897
DL+SIDL+LL-Max Transv. Moment case	2798.10	429.897	139.905	354.854	289.992	429.897

Dry Case

HFL Case

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.1	1.10	2347.73	2347.73
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	301.90	1.35	1.35	407.56	407.56
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2975.29	0.000	148.764	148.764	-148.764	148.764	
DL+SIDL+LL-Max Reaction case	3411.29	341.550	170.564	341.339	170.986	341.339	(1-70RW + 1-CLASS A)
	4469.10	0.000	223.455	223.455	-223.455	223.455	SV Loading
DL+SIDL+LL-Min Reaction case	4564.29	341.550	228.214	398.989	113.336	398.989	(1-70RW + 1-CLASS A)
	4901.48	0.000	245.074	245.074	-245.074	245.074	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4189.57	341.550	209.479	380.254	132.071	380.254	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)
DL+SIDL	2636.19	2975.29	1921.79	148.764	1109.657	1773.021	1921.786
DL+SIDL+LL-Max Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786
DL+SIDL+LL-Min Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786
DL+SIDL+LL-Max Transv. Moment case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786

Dry Case

HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	576.536	148.764	437.032	427.771	576.536	
DL+SIDL+LL-Max Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	576.536	148.764	437.032	427.771	576.536	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2134.30	1	1	1	2134.30	2134.30	2134.30
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	301.90	1.20	1.20	1.20	362.27	362.27	362.27
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax-Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2987.24	227.700	149.362	263.212	78.338	263.212	(1-70RW + 1-CLASS A) Dry Case
	4190.38	0.000	209.519	209.519	-209.519	209.519	SV Loading
DL+SIDL+LL-Min Reaction case	3755.91	227.700	187.795	301.645	39.905	301.645	(1-70RW + 1-CLASS A) HFL Case
	4622.76	0.000	231.138	231.138	-231.138	231.138	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3506.10	227.700	175.305	289.155	52.395	289.155	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2914.57	170.775	145.729	231.116	25.046	231.116	Dry Case
DL+SIDL+LL-Min Reaction case	3491.07	170.775	174.554	259.941	-3.779	259.941	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3303.72	170.775	165.186	250.573	5.589	250.573	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	F _h	μ R	F _h /2 + μ R	F _h - μ R	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	Dry Case
DL+SIDL+LL-Min Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2696.57	0.000	134.829	134.829	-134.829	134.829	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

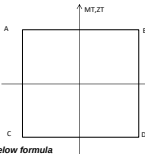
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1185.351 m

Properties of Footing Base:

A	=	162.500	m ²
ZL	=	352.083	m ³
ZT	=	338.542	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		3736.592		-18.000
Dead Load	1			2134.300	1.400	2988.019	0.000	0.000
SIDL except Wearing Course	1			200.000	1.400	280.000	0.000	0.000
Wearing Course	1			301.895	1.400	422.653	0.000	0.000
Bearing Pedestal	1	25	1.312	32.800	1.400	45.920	-0.549	-18.000
Substructure & Foundation -Portion 1				779.177		669.211		0.000
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.600	56.250	0.000	0.000
Dirt Wall-Tapered portion	1	25	5.302	132.559	0.600	79.523	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.300	8.437	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.350	4.922	0.000	0.000
Cap - (uniform portion)	1	25	7.313	182.813	1.425	260.508	0.000	0.000
Cap - (corbel portion)	25	5.433	135.826	1.425	193.552	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.600	0.000	5.825	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.600	0.000	5.825	0.000
RCC Railing or Crash Barrier	1	25	0.000	28.000	0.600	16.800	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.300	49.219	0.000	0.000
Substructure & Foundation -Portion 2				39182.344		-73346.419		11301.971
Solid Return wall	1	25	77.610	1940.252	-2.950	-5723.745	5.825	11301.971
Abutment Shaft	1	25	136.816	3420.411	1.457	4983.552	0.000	0.000
Back filling over heel slab	1	20	1135.002	22700.031	-2.996	-68015.301	0.000	0.000
Front Filling over toe slab	1	20	113.950	2279.000	4.181	9528.442	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	110.938	2773.438	-2.477	-6868.880	0.000	0.000
Toe slab	1	25	67.188	1679.688	4.063	6825.130	0.000	0.000
Portion between heel & toe	1	25	35.000	875.000	1.400	1225.000	0.000	0.000
Vertical Components of active earth pressure	1			2473.999	-6.500	-16080.996	0.000	0.000
Total				42630.516		-68940.616		11283.971

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1920.870	-5.100	-9796.435
0.900	180.000	-5.100	-918.000
0.900	301.895	-5.100	-1539.665
0.900	29.520	-5.100	-150.552
2432.285			-12404.652
0.900	84.375	-5.900	-497.813
0.900	119.295	-5.900	-703.782
0.900	25.313	-6.200	-156.938
0.900	12.656	-6.150	-77.836
0.900	164.531	-5.075	-834.996
0.900	122.243	-5.075	-620.384
0.900	0.000	-5.900	0.000
0.900	0.000	-5.900	0.000
0.900	25.200	-5.900	-148.680
0.900	147.656	-6.200	-915.469
701.260			-3955.897
0.900	1746.227	-9.450	-16501.848
0.900	3078.370	-5.043	-15524.210
0.900	20430.028	-9.496	-194008.953
0.900	2051.100	-2.319	-4756.552
0.900	0.000	0.000	0.000
0.900	2496.094	-8.977	-22406.602
0.900	1511.719	-2.437	-3683.555
0.900	787.500	-5.100	-4016.250
35264.110			-295161.133
38397.654			-311521.682

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.576	1611.374
due to Earth pressure	1	5972.763		33311.412

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
131.81	1611.37	0.00	0.00
5972.76	33311.41	0.00	0.00
6104.573	34922.786	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1197.576	1818.645
due to Earth pressure	1.5	8959.144		49967.118
		9107.909		51785.763

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
148.76	1818.64	0.00	0.00
8959.14	49967.12	0.00	0.00
9107.909	51785.763	0.000	0.000

Summary of Forces For SBC	
P	42630.516 kN
ML	-34017.830 kNm
MT	11283.971 kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		42630.516		-68940.616		11283.971
CWLL-Max. Reaction case	1	1059.332	1.400	1483.065	0.950	1006.366
Vertical Components of LL Surcharge	1	396.027	-6.500	-2574.178	0.000	0.000
Total		44085.876		-70031.729		12290.336

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	38397.65397	-5.100	-311521.68
0.900			-4633.52
38397.654			-316155.20

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.193	1197.576	3180.861
due to Earth pressure	1	5972.763		33311.412
due to Live load surcharge	1	856.095		6745.249

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
260.19	3180.86	0.00	0.00
5972.76	33311.41	0.00	0.00
856.095	6745.249	0.00	0.00
7189.05	43237.52	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		341.339	1197.576	4172.875
due to Earth pressure	1.5	8959.144		49967.118
due to Live load surcharge	1.2	1147.314		8594.299
		10447.796		62234.292

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
341.34	4172.88	0.00	0.00
8959.14	49967.12	0.00	0.00
1147.31	8594.30	0.00	0.00
10447.796	62234.292	0.000	0.000

Summary of Forces For SBC	
P	44085.876 kN
ML	-26794.207 kNm
MT	12290.336 kNm

Case 3 : DL+SIDL-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		3736.592		-18.000
Substructure & Foundation -Portion 1				779.177		669.211		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	77.610	1940.252	-2.950	-5723.745	5.825	11301.971
Shaft above HFL	1	25	83.617	2090.426	1.604	3352.689	0.000	0.000
Shaft below HFL	1	15	53.199	797.992	1.457	1162.677	0.000	0.000
Back fillno above HFL over heel slab	1	20	775.675	15513.500	-2.950	-45764.825	0.000	0.000
Back filling below HFL over heel slab	1	10	365.650	3656.500	-3.094	-11311.779	0.000	0.000
Front Filling over toe slab	1	10	113.950	2279.000	2.472	2817.097	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	110.938	2773.438	-2.477	-6868.880	0.000	0.000
Toe slab	1	15	67.188	1679.688	4.063	4095.078	0.000	0.000
Portion between Heel & Toe	1	15	35.000	875.000	1.400	735.000	0.000	0.000
Vertical Components of active earth pressure	1			2473.999	-6.500	-16080.996	0.000	0.000
Total				31728.967		-70101.385		11301.971
				35177.139		-65696.582		11283.971

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2432.285		-12404.652
	701.260		-3955.897
0.900	1746.227	-9.450	-16501.848
0.900	1881.383	-4.896	-9211.570
0.900	718.192	-5.043	-3621.841
0.900	13962.150	-9.450	-131942.318
0.900	3290.850	-8.594	-31571.126
0.900	1025.550	-4.028	-4130.687
0.900	0.000	0.000	0.000
0.900	1497.656	-8.977	-13443.961
0.900	907.031	-2.437	-2210.133
0.900	472.500	-5.100	-2409.750
0.900	2226.599	-13.000	-28945.793
28556.070			-248705.703
31688.614			-265066.252

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1197.576	1611.374
due to Earth pressure	1	5972.763		29637.931

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
131.81	1611.37	0.00	0.00
5972.76	29637.93	0.00	0.00
6104.57	31449.30	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1197.576	1818.645
due to Earth pressure	1.5	8959.144		44756.896
		9107.909		46575.541

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
148.76	1818.64	0.00	0.00
8959.14	44756.90	0.00	0.00
9107.91	46575.54	0.00	0.00

Summary of Forces For SBC	
P	35177.139 kN
ML	-34246.277 kNm
MT	11283.971 kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation							
	Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)	
Forces from Case : DL+SIDL							
		35177.139		-65695.582		11283.971	
	1	290.668	1.400	406.935	0.950	276.134	
	1	432.170	-6.500	-2809.106	0.000	0.000	
		35899.977		-68097.752		11560.105	

Vertical Forces For Restoring or Resisting Effect			
Load Factor	Vertical Load (P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	31689.614	-5.100	-265066.252
0.900	388.953	-13.000	-5056.390
	32078.568		-270122.643

Horizontal Forces For SBC Calculation				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	298.626	1197.576	35650.707
due to Earth pressure	1	5972.763		29837.931
due to live load surcharge	1	1043.351		7360.841

Forces along Long. Axis			
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
298.63	3520.71	0.00	0.00
5972.76	29837.93	0.00	0.00
1043.351	7360.841	0.00	0.00
7314.74	40849.48	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		398.989	1197.576	4877.644
due to Earth pressure	1.5	8959.144		44756.896
due to live load surcharge	1.2	10610.155		58467.550

Forces along Long. Axis			
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
398.99	4877.64	0.00	0.00
8959.14	44756.90	0.00	0.00
12512.021	69333.309	0.00	0.00
10610.15	58467.55	0.00	0.00

Summary of Forces For SBC	
P	35899.977 KN
ML	-2748.274 kNm
MT	11560.105 kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah= 0.243	In Longitudinal direction	Weight of shaft below Ground level	=	649.978 KN
		av= 0.325	In Transverse direction	Weight of back fill below Ground level	=	2875.500 KN
		av= 0.217	In Vertical direction			

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kNm ³)	Volume (m ³)	Vertical Load (P) kN	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			2134.300		207.941	138.627	1.400	2988.019	194.078	1198.789		0.000	0.000	2794.383
SIDL except Wearing Course	1			200.000		19.486	12.990	1.400	280.000	18.187	1199.910		0.000	0.000	263.690
Wearing Course	1			301.895		29.413	19.609	1.400	422.653	27.452	1199.461		0.000	0.000	415.019
Bearing Pedestal	1	25	1.312	32.800		3.196	2.130	1.400	45.920	2.983			-0.549	-18.000	
				2668.995		260.036	173.357		3736.592	242.700				-18.000	3493.092
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	3.750	93.750	22.781	9.134	6.089	0.600	56.250	3.654	1198.961	310.053	0.000	0.000	124.312
Dirt Wall-Tapered portion	1	25	5.302	132.539	32.207	12.913	8.609	0.600	79.523	5.165	1197.754	399.467	0.000	0.000	160.162
Bracket - Uniform portion	1	25	1.125	28.125				0.300	8.437						
Bracket - Tapered portion	1	25	0.563	14.063				0.350	4.922						
Cap - (uniform portion)	1	25	7.313	182.813	44.423	17.811	11.874	1.425	260.508	16.921	1196.826	509.759	0.000	0.000	204.383
Cap - (corbel portion)	1	25	5.433	135.826	33.006	13.233	8.822	1.425	193.552	12.572	1196.526	368.838	0.000	0.000	147.882
Cantilever Return Wall-Rectangle of	1	25	0.000	0.000	0.000	0.000	0.000	0.600	0.000	0.000	1199.461	0.000	5.825	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.600	0.000	0.000	1199.461	0.000	5.825	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.600	16.800	0.000			0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.300	49.219				0.000	0.000	
				779.177	132.417	53.091	35.394		669.211	38.311		1588.117		0.000	636.739
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	77.610	1940.252	471.481	189.036	126.024	-2.950	-5723.745	-371.770	1193.067	3637.773	5.825	11301.971	1458.527
Abutment Shaft	1	25	136.816	3420.411	673.215	269.919	179.946	1.457	4983.552	262.182	1192.549	4845.467	0.000	0.000	1942.739
Back filling over heel slab	1	20	1135.002	22700.031	0.000	0.000	0.000	-2.996	-68015.301	0.000	1193.067	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	113.950	2279.000				4.181	9528.442				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	110.938	2773.438				-2.477	-6868.880				0.000	0.000	
Toe slab	1	25	67.188	1679.688				4.063	6825.130				0.000	0.000	
portion between heel & toe	1	25	35.000	875.000				1.400	1225.000				0.000	0.000	
Vertical component of active earth pressure	1			2328.311				-6.500	-15134.024				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			1241.633				-6.500	-8070.613				0.000	0.000	
				40278.289	1144.697	458.954	305.969		-80470.059	-109.588		8483.240		11301.971	3401.266
Total =				43726.461	1277.114	772.081	514.721		-76064.256	171.423		10071.357		11283.971	7531.097
							-514.721			-171.423					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.9			1920.870	124.765	-5.100	-9796.435	-636.300
SIDL except Wearing Course	0.9			180.000	11.691	-5.100	-918.000	-59.626
Wearing Course	1.00			301.895	19.609	-5.100	-1539.665	-100.005
Bearing Pedestal	0.9	25	1.312	32.800		-5.100	-169.552	
				2432.285	156.065		-12404.652	-795.931
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	3.750	84.375	5.480	-5.900	-497.813	-32.334
Dirt Wall-Tapered portion	0.9	25	5.302	119.285	7.748	-5.900	-703.782	-45.712
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	7.313	164.531	10.687	-5.075	-834.996	-54.235
Cap - (corbel portion)	0.9	25	5.433	122.243	7.940	-5.075	-620.384	-40.295
Cantilever Return Wall-Rectangle of	0.9	25	0.000	0.000	0.000	-5.900	0.000	0.000
Cantilever Return Wall-Triangle port	0.9	25	0.000	0.000	0.000	-5.900	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.900	-148.680	
Approach Slab	0.9	25	6.563	147.656		-6.200	-915.469	
				701.290	31.855		-3721.124	-172.576
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	136.816	3078.370	157.729	-5.043	-15524.210	-795.429
Solid Return wall	0.9	25	77.610	1746.227	113.421	-9.450	-16501.848	-1071.831
Back filling over heel slab	0.9	20	1135.002	20430.028	0.000	-9.496	-194009.0	0.000
Front Filling over toe	0.9	20	113.950	2051.100		-2.319	-4756.552	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	110.938	2496.094		-8.977	-22406.602	
Toe slab	0.9	25	67.188	1511.719		-4.337	-3683.555	
portion between heel & toe	0.9	25	35.000	787.500		-5.100	-4016.250	
Vertical component of active earth pressure	0.9			2226.599		-13.000	-28945.793	
Vertical component of dynamic increment of earth pressure	0.9			1117.469		-13.000	-14527.103	
				36381.579	271.151		-309688.24	-1867.260
Total =				39515.123	459.070		-325814.01	-2835.767
					-459.070			2835.767

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	22.781	1198.961	310.053
1.0	32.207	1197.754	399.467
1.0	44.423	1196.826	509.759
1.0	33.006	1196.526	368.838
1.0	0.000	1199.461	0.000
1.0	0.000	1199.461	0.000
	132.417	1588.117	
1.0	655.666	1192.549	4719.155
1.0	471.481	1193.067	3637.773
1.0	0.000	1193.067	0.000
	1127.147		8356.928
	1259.564		9945.045

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	260.036	1197.576	15662.555	3493.092
due to Substructure	1	1277.114	512.045		10071.357	4038.005
due to Earth pressure	1	8618.607			57082.116	

Forces along Long. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ
1281.19	15662.55	0.00	0.00
1277.11	10071.36	0.00	0.00
8618.61	57082.12	0.00	0.00
11176.91	82816.03	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect				
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.576	23493.83
due to Substructure	1.5	1889.347		14917.57
due to Active Earth pressure	1	5621.041		33311.41
due to dynamic Earth pressure	1.5	4496.350		35656.06
		13928.523		107378.867

Forces along Long. Axis			
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1921.79	23493.83	0.00	0.00
1889.35	14917.57	0.00	0.00
5621.041	33311.412	0.00	0.00
4496.350	35656.055	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	156.065	0.000	-12404.65	-795.931
Forces from Substructure				37082.839	303.006	0.000	-313409.36	-2039.837
CWLL-Max. Reaction case				0.00	0.000	-5.100	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-13.000	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-13.000	0.00	
Total =				39515.123	459.070		-325814.01	-2835.767
					-459.070			2835.767

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	280.677	1197.576	16219.281	3809.118
due to Substructure	1	1277.114	512.045		10071.357	4038.005
due to Earth pressure	1	8618.607			57082.116	
due to Live load surcharge	0.20	307.629			2516.785	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1326.73	16219.28	0.00	0.00	0.00	0.00	280.68	3809.12
1277.11	10071.36	0.00	0.00	0.00	0.00	512.05	4038.01
8618.61	57082.12						
307.63	2516.79						
11530.08	85889.54	0.00	0.00	0.00	0.00	792.72	7847.12

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.576	23493.832
due to Substructure	1.5	1889.347		14917.568
due to Active Earth pressure	1	5621.041		33311.412
due to dynamic Earth pressure	1.5	4496.350		35656.055
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		13928.523		107378.867

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	23493.83	0.00	0.00
1889.35	14917.57	0.00	0.00
5621.041	33311.412		
4496.350	35656.055		
0.000	0.000		
0.000	0.000		
13928.52	107378.87	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	44594.233	43537.270 kN
ML	9484.327	9102.951 kNm
MT	19332.367	19332.367 kNm

Summary of Restoring Forces

Vertical Load	39056.053 kN
Moment	-328649.779 kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		260.036	173.357		3736.592	242.700				-18.000	3493.092
Substructure & Foundation -Portion 1				779.177	132.417	53.091	35.394		669.211	38.311		1588.117		0.000	636.739
Substructure & Foundation -Portion 2															
Solid Return wall	1		77.61	1940.25	471.481	189.036	126.024	-2.95	-5723.745	-371.770	1193.07	3637.773	5.83	11301.971	1458.527
Shall above HFL	1	25	83.617	2090.426	507.973	203.667	135.778	1.604	3352.689	217.765	1193.549	4164.112	0.000	0.000	1669.557
Shall below HFL	1	15	53.199	797.992	165.242	66.252	44.168	1.457	1162.677	64.353	1189.721	722.107	0.000	0.000	289.521
Back filling above HFL over heel slab	1	20	775.675	15513.500	0.000	0.000	0.000	-2.950	-45764.825	0.000	1195.091	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	365.650	3656.500	0.000	0.000	0.000	-3.084	-11311.778	0.000	1188.474	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	113.950	1139.500	0.000	0.000	0.000	2.472	2817.097	0.000	0.000	0.000	0.000	0.000	0.00
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Heel slab	1	15	110.938	1664.063	0.000	-9.450	-4.477	-2.477	-4121.328	0.000	0.000	0.000	0.000	0.000	0.00
Toe slab	1	15	67.188	1007.813	0.000	-9.450	-4.477	4.063	4095.078	0.000	0.000	0.000	0.000	0.000	0.00
portion between heel & toe	1	15	35.000	525.000	0.000	-9.450	-4.477	1.400	735.000	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of active earth pressure	1			2356.793				-6.500	-15319.153	0.000	0.000	0.000	0.000	0.000	0.00
Vertical component of dynamic increment of earth pressure	1			1237.232				-6.500	-8042.008	0.000	0.000	0.000	0.000	0.000	0.00
				32848.992	1368.238	548.581	365.720		-78120.298	-89.652		10207.743		11301.971	4092.687
Total =				36297.164	1500.655	861.708	574.472		-73714.495	191.358		11795.860		11283.971	8222.519
							-574.472			-191.358					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	156.065		-12404.652	-795.931
Substructure & Foundation -Portion 1				701.260	31.855		-3721.124	-172.576
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	77.6101	1746.227	113.421	-9.45	-16501.848	-1071.831
Shall above HFL	0.9	25	83.617	1881.383	122.200	-4.896	-9211.570	-598.312
Shall below HFL	0.9	15	53.199	718.192	35.529	-5.043	-3621.841	-179.175
Back filling above HFL over heel slab	0.9	20	775.675	13962.150	0.000	-9.450	-131942.318	0.000
Back filling below HFL over heel slab	0.9	10	365.650	3290.850	0.000	-9.594	-31571.126	0.000
Front Filling over toe	0.9	10	113.950	1025.550	0.000	-4.028	-4130.687	0.000
Side filling between heel and toe	0.9	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.9	15	110.938	1497.656	0.000	-9.977	-13443.961	0.000
Toe slab	0.9	15	67.188	907.031	0.000	-2.437	-2210.133	0.000
portion between heel & toe	0.9	15	35.000	472.500	0.000	-5.100	-2409.750	0.000
Vertical component of active earth pressure	0.9			2121.114		-13.000	-27574.615	0.000
Vertical component of dynamic increment of earth pressure	0.9			1113.509		-13.000	-14475.476	0.000
				29564.093	324.927		-261810.00	-2155.676
Total =				32697.637	512.846		-277935.78	-3124.183
							3124.183	

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1588.117
1.0	471.481	1193.067	3637.773
1.0	507.973	1193.549	4164.112
1.0	147.692	1189.721	645.416
1.0	0.000	1195.091	0.000
1.0	0.000	1188.474	0.000
	1127.147		8447.301
	1259.564		10035.418

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	260.036	1197.576	15662.555	3493.092
due to Substructure	1	1500.655	601.672		11795.860	4729.426
due to Earth pressure	1	8676.744			53565.180	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1281.19	15662.55	0.00	0.00	0.00	0.00	260.04	3493.09
1500.66	11795.86	0.00	0.00	0.00	0.00	601.67	4729.43
8676.74	53565.18						
11468.59	81023.99	0.00	0.00	0.00	0.00	861.71	8222.52

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.576	23493.832
due to Substructure	1.5	1889.347		15053.128
due to Active Earth pressure	1	5689.801		29817.931
due to dynamic Earth pressure	1.5	4480.414		35590.874
		13981.347		103975.764

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	23493.83	0.00	0.00
1889.35	15053.13	0.00	0.00
5689.801	29817.931		
4480.414	35590.874		
13981.35	103975.76	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	36871.636	35722.693 kN
ML	7500.458	7117.741 kNm
MT	19506.489	19506.489 kNm

Summary of Restoring Forces

Vertical Load	32184.791 kN
Moment	-281059.960 kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995		260.036	173.357		3736.592	242.700				-18.000	3493.092
Forces from Substructure				33628.170	1500.655	601.672	401.115		-77451.087	-51.341		11795.860		11301.971	4729.426
CWLL-Max. Reaction case	0.20			58.13		5.664	3.776	1.400	81.387	5.286	1200.661		0.950	55.227	86.714
Vertical component of LL Surcharge	0.20			86.43				-6.500	-561.821				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			61.86				-6.500	-402.075				0.000	0.000	
Total =				36503.590	1500.655	867.371	578.248		-74597.004	196.645		11795.860		11339.198	8309.232
							-578.248			-196.645					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	156.065		-12404.652	-795.931
Forces from Substructure				30265.353	356.781		-265531.12	-2328.253
CWLL-Max. Reaction case	0.00			0.00	0.00		-5.10	0.00
Vertical component of LL Surcharge	0.00					-5.100	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-13.000	0.000	0.000
Total =				32697.637	512.846		-277940.88	-3124.183
					-512.846			3124.183

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	265.699	1197.576	16219.281	3579.806
due to Substructure	1	1500.655	601.672		11795.860	4729.426
due to Earth pressure	1	8676.744			53565.180	
due to Live load surcharge	0.20	358.008			2817.488	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1197.576	23493.832
due to Substructure	1.5	1889.347		15069.128
due to Active Earth pressure	1	5689.801		29837.931
due to dynamic Earth pressure	1.5	4480.414		35590.874
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		13981.347		103975.764

Summary of Forces For SBC

	Downward	Upward
P	37081.837	35925.342 kN
ML	9997.450	9604.160 kNm
MT	19648.430	19648.430 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = 0.3 x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		866.785	173.357		3736.592	242.700				-18.000	11643.641
Substructure & Foundation -Portion 1				779.177	39.725	176.971	35.394		669.211	38.311		476.435		0.000	2122.463
Substructure & Foundation -Portion 2				40278.289	343.409	1529.847	305.969		-80470.059	-109.588		2544.972		11301.971	11337.554
Total =				43726.461	383.134	2573.603	514.721	-514.721	-76064.256	171.423		3021.407		11283.971	25103.658

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	156.065		-12404.65	-795.931
Substructure & Foundation -Portion 1				701.260	31.855		-3721.12	-172.576
Substructure & Foundation -Portion 2				36381.579	271.151		-309688.24	-1867.260
Total =				39515.123	459.070		-325814.01	-2835.767

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	132.417		1588.117
	1127.147		8356.928
	1259.564		9945.045

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.357	866.785	1197.576	4698.766	11643.641
due to Substructure	1	383.134	1706.818		3021.407	13460.017
due to Earth pressure	1	8618.607			57082.116	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.576	7048.150
due to Substructure	1.5	1889.347		14917.568
due to Active Earth pressure	1	5621.041		33311.412
due to dynamic Earth pressure	1.5	1348.905		10696.817
due to dynamic increment of live load surcharge	0	0.00		0.000
		9435.828		65973.946

Summary of Forces For SBC

	Downward	Upward
P	44241.181	43211.740 kN
ML	-11090.544	-11433.389 kNm
MT	36387.628	36387.628 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	44065.751	528.482	-76595.90	190.688	11485.244

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	935.591	1197.576	5255.493	12697.060
due to Substructure	1	383.134	1706.818		3021.407	13460.017
due to Earth pressure	1	8618.607			57082.116	
due to Live load surcharge	0.2	307.629			2516.785	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.576	7048.150
due to Substructure	1.5	566.80		4475.270
due to Active Earth pressure	1	5621.04		33311.412
due to dynamic Earth pressure	1.5	1348.90		10696.817
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		8113.29		55531.649

Summary of Forces For SBC

	Downward	Upward
P	44594.233	43537.270 kN
ML	-8520.411	-8910.788 kNm
MT	37642.321	37642.321 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	2668.995	173.357	3736.592	242.700	-18.000
Substructure & Foundation -Portion 1	779.177	35.394	669.211	38.311	0.000
Substructure & Foundation -Portion 2	32848.992	365.720	-78120.298	-89.652	11301.971
Total =	36297.164	574.472	-73714.495	191.358	11283.971

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.36	866.79	1197.58	4698.77	11643.64
due to Substructure	1	450.20	2005.57		3538.76	15764.75
due to Earth pressure	1	8676.74			53565.18	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1197.576	7048.15
due to Substructure	1.5	566.804		4515.94
due to Active Earth pressure	1	5689.801		29837.93
due to dynamic Earth pressure	1.5	1348.174		10677.20
		8177.265		52079.28

Summary of Forces For SBC

	Downward	Upward
P	36871.636	35722.693 kN
ML	-11720.432	-12103.149 kNm
MT	38692.366	38692.366 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1326.73	16219.28	0.00	0.00	0.00	0.00	265.70	3579.81
1500.66	11795.86	0.00	0.00	0.00	0.00	601.67	4729.43
8676.74	53565.18						
358.01	2817.49						
11862.14	84397.81	0.00	0.00	0.00	0.00	867.37	8309.23

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1921.79	23493.83	0.00	0.00
1889.35	15063.13	0.00	0.00
5689.801	29837.931		
4480.414	35590.874		
0.000	0.000		
0.000	0.000		
13981.35	103975.76	0.00	0.00

Summary of Restoring Forces

Vertical Load	32184.791 kN
Moment	-281055.060 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	4698.77	0.00	0.00	0.00	0.00	866.79	11643.64
383.13	3021.41	0.00	0.00	0.00	0.00	1706.82	13460.02
8618.61	57082.12						
307.63	2516.79						
9386.10	64802.29	0.00	0.00	0.00	0.00	2573.60	25103.66

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7048.15	0.00	0.00
1889.35	14917.57	0.00	0.00
5621.041	33311.412		
1348.905	10696.817		
9435.82	65973.95	0.00	0.00

Summary of Restoring Forces

Vertical Load	39056.053 kN
Moment	-328649.779 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	39515.123	459.070	-325814.01	-2835.767

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
429.90	5255.49	0.00	0.00	0.00	0.00	935.59	12697.06
383.13	3021.41	0.00	0.00	0.00	0.00	1706.82	13460.02
8618.61	57082.12						
307.63	2516.79						
9739.27	67875.80	0.00	0.00	0.00	0.00	2642.41	26157.08

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7048.15	0.00	0.00
566.80	4475.27	0.00	0.00
5621.041	33311.412		
1348.905	10696.817		
0.000	0.000		
0.000	0.000		
8113.29	55531.65	0.00	0.00

Summary of Restoring Forces

Vertical Load	39056.053 kN
Moment	-328649.779 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	2432.285	156.065		-12404.652	-795.931
Substructure & Foundation -Portion 1	701.260	31.855		-3721.124	-172.576
Substructure & Foundation -Portion 2	29564.093	324.927		-261810.001	-2155.676
Total =	32997.637	512.846	-512.846	-277935.776	-3124.183

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	4698.77	0.00	0.00	0.00	0.00	866.79	11643.64
450.20	3538.76	0.00	0.00	0.00	0.00	2005.57	15764.75
8676.74	53565.18						
9511.30	61802.70	0.00	0.00	0.00	0.00	2872.36	27408.40

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	7048.15	0.00	0.00
566.80	4515.94	0.00	0.00
5689.801	29837.931		
1348.124	10677.202		
8177.26	52079.28	0.00	0.00

Summary of Restoring Forces

Vertical Load	32184.791 kN
Moment	-281055.060 kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN	Fv = 0.3 x sv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	36503.590	578.248	-74597.00	196.645	11339.198
		-578.248		-196.645	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	885.66489	1197.576	5255.493	11932.686
due to Substructure	1	450.197	2005.5732		3538.758	15764.755
due to Earth pressure	1	8676.744			53965.180	
due to Live load surcharge	0.2	358.008			2817.488	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1197.576	7048.15
due to Substructure	1.5	566.80		4515.94
due to Active Earth pressure	1	5689.80		29837.93
due to dynamic Earth pressure	1.5	1344.12		10677.26
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
			8177.26	52079.28

Summary of Forces For SBC

	Downward	Upward
P	37081.837	35925.342 kN
ML	-9223.441	-9616.730 kNm
MT	39036.638	-39036.638 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 kN (1185.351)

Transverse Moment due to C.F. = 0.000 x (1200.661 - 1185.351) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 kN (1185.351)

Transverse Moment due to C.F. = 0.000 x (1200.661 - 1185.351) = 0.000 kNm

Base pressure on corner A = σ_a = P/A - ML/ZL + MT/ZT

Base pressure on corner B = σ_b = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_c = P/A - ML/ZL - MT/ZT

Base pressure on corner D = σ_d = P/A + ML/ZL - MT/ZT

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN	Fv = 0.3 x sv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	32697.637	512.846		-277940.88	-3124.183
		-512.846			3124.183

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
429.90	5255.49	0.00	0.00	0.00	0.00	885.66	11932.69
450.20	3538.76	0.00	0.00	0.00	0.00	2005.57	15764.75
8676.74	53565.18						
358.01	2817.49						
9914.85	65176.92	0.00	0.00	0.00	0.00	2891.24	27697.44

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	7048.15	0.00	0.00
566.80	4515.94	0.00	0.00
5689.801	29837.931		
1344.124	10677.262		
0.000	0.000		
0.000	0.000		
8177.26	52079.28	0.00	0.00

Summary of Restoring Forces

Vertical Load	32184.791 kN
Moment	-281065.050 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_a	σ_b	σ_c	σ_d	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + cA + F_p$	FOS	Overturning moment	Restoring Moment = $\sum P e_{Toe} + M_B$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	42630.516	-34017.830	11283.971	392.291	199.054	325.629	132.392	392.291	132.392	9107.909	26878.358	2.95	51785.763	311521.68	6.02
Case 2 : DL+SIDL+LL- (Maximum Reaction Case)-Normal Dry Case	44085.876	-26794.207	12290.336	383.703	231.500	311.096	158.892	383.703	158.892	10447.798	26878.358	2.57	62234.292	316155.20	5.0
								SAFE	SAFE			SAFE			SAFE
Normal HFL Case															
Case 3 : DL+SIDL-Normal HFL Case	35177.139	-34246.277	11283.971	347.073	152.538	280.411	85.876	347.073	85.876	9107.909	22182.730	2.44	46575.541	265066.25	5.69
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	35899.977	-27248.274	11560.105	332.461	177.678	264.168	109.385	332.461	109.385	10610.155	22454.997	2.12	58467.550	270122.64	4.62
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	44241.181	6923.194	18815.068	308.167	347.494	197.013	236.340	347.494	197.013	13928.523	27339.237	1.96	107378.867	328649.78	3.06
Case 6 : DL+SIDL+LL- (Maximum Reaction Case)-Long. Seismic Dry Case	44594.233	9484.327	19332.367	304.593	358.469	190.383	244.259	358.469	190.383	13928.523	27339.237	1.96	107378.867	328649.78	3.06
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	36871.636	7500.458	19506.489	263.218	305.825	147.980	190.586	305.825	147.980	13981.347	22529.354	1.61	103975.764	281059.96	2.70
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	37081.837	9997.450	19648.430	257.839	314.629	141.762	198.553	314.629	141.762	13981.347	22529.354	1.61	103975.764	281065.06	2.70
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	44241.181	-11090.544	36387.628	411.237	348.237	196.270	133.270	411.237	133.270	9435.828	27339.237	2.90	65973.946	328649.78	4.98
Case 10 : DL+SIDL+LL- (Maximum Reaction Case)-Trans. Seismic Dry Case	44594.233	-8529.411	37642.321	409.841	361.390	187.462	139.011	409.841	139.011	8113.286	27339.237	3.37	55531.649	328649.78	5.92
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	36871.636	-11720.432	38692.366	374.482	307.905	145.900	79.322	374.482	79.322	8177.265	22529.354	2.76	52079.281	281059.96	5.40
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	37081.837	-9223.441	39036.638	369.701	317.307	139.084	86.691	369.701	86.691	8177.265	22529.354	2.76	52079.281	281065.06	5.40
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION
Abutment A1 for Minor Bridge at Ch.
87+880**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians
 COS θ = 1.000
 SIN θ = 0.000

Radius of Curvature of Superstructure = 72 m
 Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing

Coeff. Of Friction for Paper Tar Bearing	=	0.5	
Type of Soil	=	1	Hard or Rocky Strata
NBC of soil -Normal Case	=	350 kN/m ²	(as per geotechnical report with ground improvement)
SBC of soil-Normal Case	=	380 kN/m ²	
SBC of soil-Seismic Case	=	475 kN/m ²	
Coeff. of friction between concrete and soil	=	0.7	for weathered rock
Permissible FOS against Sliding	=	1	Normal Case
	=	1	Seismic Case
Permissible FOS against Overturning	=	1	Normal Case
	=	1	Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	0.600m	
Height of Trapering portion	0.409m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	=	0.720m	0.720m
Projection of Abutment Cap (Span Side)	=	0.000m	0.000m
Projection of Abutment Cap Back Side	=	0.000m	0.000m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.000m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.868m	0.868m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	4.400m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation

Along Traffic Direction:

Total Width of Footing	=	8.100m
abutment pedestal width	=	1.000m
abutment pedestal Height	=	1.000m
Width of Toe Slab	=	2.700m
Width of Heel Slab	=	4.400m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.000m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.000m
Width of backfill on heel slab	=	4.400m
Thickness of heel slab at back fill edge	=	1.000m
Height of back fill at bottom edge of heel slab	=	8.149m
Height of back fill at back fill edge of heel slab	=	7.649m

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)
Width of foundation -Tapering portion	=	12.500m (skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
	1 Minor Bridge	80+355	1200.279	1194.773	1191.773	8.506

Levels

Deck Level at Median Edge=	1200.279m
Deck level at Outer Edge =	1200.564m
Deck level at center line =	1200.279m
Soffit Level at center of bridge =	1199.414m
Abutment cap top level =	1199.413m
Abutment cap bottom lvl (uniform portion ends	1199.113m
Abutment cap bottom lvl (corbel portion ends)	1199.113m
Abutment shaft top level =	1199.113m
Ground level/LBL =	1194.773m
Abutment shaft bottom level =	1192.773m
Foundation level =	1191.773m
HFL	1195.773m

Cross Slope (Bi-directional)	=	2.500%
Height of Superstructure	=	0.800m
Min. Height of Footpath Side Pedestal (1)	=	0.000m
Height of Pedestal (2)	=	0.000m
Height of Pedestal (3)	=	0.000m
Height of Pedestal (4)	=	0.000m
Distance of nearest girder to c.l. of deck	=	0.000m
Height (Avg.) of Dirt Wall	=	1.009m
Abutment shaft Above G.L	=	4.340m
Abutment Shaft below G.L	=	2.000m
Height of abutment shaft	=	6.340m
MSL	=	1194.773m
Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 d (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	

Dry weight of Concrete	=	25	kN/m ³
Dry unit weight of soil	=	20	kN/m ³
Permissible Crack Width	=	0.3	mm - For Moderrate/ severe Exposure Condition
Maximum compressive stress in concrete under rare combination	=	0.48	f _{ck}
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z = Zone factor	=	0	
I = Importance factor	=	1.2	
R = Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
φ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.160m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.80	x	10.00	x	12.50	x	25.00
	=	2500.00	KN					
Reaction at one end	=	1250.00	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	10.00
	=	160.00	KN			
Reaction at one end	=	80.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	10	x	12.5
	=	275	KN			
Reaction at one end	=	137.5	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Reduction Factor =

Congestion factor =

0.9 (for 3 Lane)**1** (As per Table 3 of IRC :112-2014)**Min CWLL**

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transvers e ecc
2561.34	0.30

Min CWLL

Vertical	Transvers e ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap = **1.144**
 Impact Factor for Abut. Shaft Base = **1.000**

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap = **1.144**
 Impact Factor for Abut. Shaft Base = **1.000**

VOLUME CALCULATION

C.G. Of Footing = 4.050 m
 C.G. Of shaft from toe tip = 3.200 m
 Distance between c.g. of shaft and footing = 0.850 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m^3	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.640	-3.410	0.000
-Trapering portion	1	12.50	0.300	0.409	1.532	-0.210	0.640	-3.410	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.340	-3.710	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-0.460	0.390	-3.660	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.850	-3.200	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.850	-3.200	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.794	3.340	33.139	0.102	0.952	-3.098	0.000
Shaft below HFL	1	12.50	0.934	2.500	29.180	0.032	0.882	-3.168	0.000
Solid Return Wall	2	4.40	0.500	8.041	35.380	-2.700	-1.850	-5.900	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.350	-3.700	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.350	-3.700	0.000
Footing									
Heel Slab	1	12.50	4.400	0.750	41.250		-1.606	-5.656	0.000
Toe Slab	1	12.50	2.700	0.750	25.313		2.550	-1.500	0.000
Portion between Heel and Toe	1	12.50	1.000	1.000	12.500		0.850	-3.200	0.000
Back filling above HFL over Heel Slab	1	12.50	4.400	4.506	247.830		-1.850	-5.900	0.000
Back filling below HFL over Heel Slab	1	12.50	4.400	3.250	178.750		-1.906	-5.956	0.000
Backfill above Heel slab	1	12.50	4.400	7.899	434.418		-1.873	-5.923	0.000
Front Filling over Toe Slab	1	12.50	2.700	2.250	75.938		2.650	-1.400	0.000
Side filling between heel and toe	1	0.00	1.000	2.250	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.340	-3.710	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.148	4.506	8.308		0.458	-3.592	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.132	3.250	5.382		0.394	-3.656	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN		-0.210	0.640	-3.410

SECTIONAL PROPERTIES

Width of Footing (B) = 8.1 m
 Length of Footing (L) = 12.500 m

A = 8.100 x 12.500 = 101.250 m²

ZL = 12.500 x 10.935 = 136.688 m³

ZT = $\frac{IT1 + IT2}{\text{distance of extreme point from centre}}$

IT1 = 8.100 x 162.760 = 1318.36 m⁴

IT2 (moment of inertia of triangle) = 8.100 x 0.000 + 0.500 x 8.100 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1318.36 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 210.938 m³

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviciilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case
	Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
	Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case
	Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
	Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case
	Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case
	Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case
	Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case
	Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone	5.0

Feq	=	Seismic forces to be resisted
Feq	=	Ah x (Dead load + Appropriate Live load)
Ah	=	horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \quad \frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 7.640 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 8.217 m

Abutment Cap Top Level - Foundation Level
= 7.640 m

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.86	m
Moment of Inertia , $I_{\text{longitudinal}}$	=	0.663	m^4
Moment of Inertia , $I_{\text{transverse}}$	=	139.974	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction

Force	=	72.003	KN
D	=	1467.50	KN
T	=	0.2855	sec

Transverse Direction

Force	=	13662.804	KN
D	=	1747.220	KN
T	=	0.0226	sec

Hard or Rocky Strata

$$S_a/g = 2.5$$

$$S_a/g = 2.5$$

$$\text{Seismic Coeff. In Longitudinal Direction} = 0$$

$$\text{Seismic Coeff. In Transverse Direction} = 0$$

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

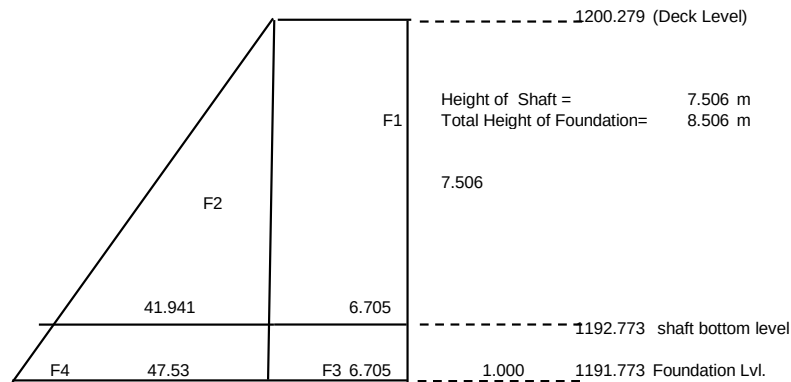
Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m

Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1192.773 m (at Shaft Base)		
@ RL					1191.773 m (at Foundation Level)		
Due to Live Load Surcharge							
Intensity for rectangular portion	=	0.279	x	20	x	1.2	= 6.705 kN/m^2
F1	=	6.705	x	7.506	x	12.500	= 629.116 kN
M1	=	629.12	x	3.75	=	2361.073 kN.m	at Shaft Bottom
F3	=	6.705	x	8.506	x	12.500	= 712.931 kN
M3	=	712.931	x	4.253	=	3032.096 kN.m	at Foundation

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

$$= 0.279 \times 20 \times 7.506 = 41.941 \text{ kN/m}^2$$

F2 = 0.5 × 41.94 × 7.506 × 12.50

= **1967.561 kN**

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2 = 1967.56 × 3.15 = **6202.774 kN.m** at Shaft Bottom

Intensity for triangular portion (At Foundation level)

$$= 0.279 \times 20 \times 8.506 = 47.529 \text{ kN/m}^2$$

F4 = 0.5 × 47.53 × 8.506 × 12.50

= **2526.747 kN**

M4 = 2526.75 × 3.57 = **9026.854 kN.m** at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 $\gamma_{\text{fluid}} = 4.8 \text{ kN/m}^3$

Intensity for triangular portion (At Shaft bottom level)

$$= 4.800 \times 7.506 = 36.029 \text{ kN/m}^2$$

F = 0.5 × 36.029 × 7.506 × 12.500

= **1690.201 kN**

M = 1690.20 × 2.502 = **4228.883 kN.m** at Shaft Bottom

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 8.506 = 40.83 \text{ kN/m}^2$$

F = 0.5 × 40.829 × 8.51 × 12.500

= **2170.561 kN**

M = 2170.56 × 2.835 = **6154.264 kN.m** at Foundation

Intensity of Passive pressure

= 3.766 × 20 × 0.000 = 0.000 kN/m²

Force due to passive @ Foundation, F

= 0.5 × 0.000 × 12.50

= **0.000 kN**

Moment due to passive @ Foundation, M

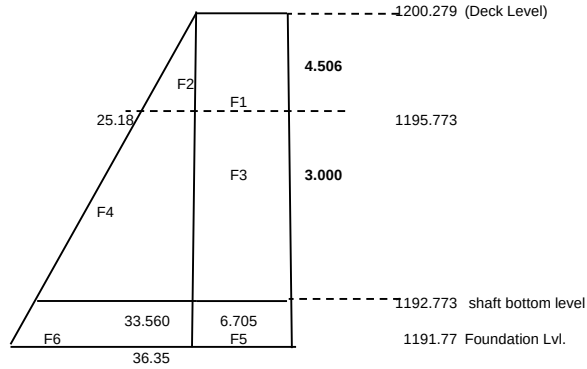
= 0.000 × 0.000 = **0.000 kN.m** at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	6202.774	9026.854	1967.561	2526.747
Due to Minimum Fluid Pressure	4228.883	6154.264	1690.201	2170.561
Governing of Two	6202.774	9026.854	1967.561	2526.747
Due to Live Load Surcharge	2361.073	3032.096	629.116	712.931
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279	active component
	Kph	=	3.766	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL 1192.8 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	7.506	x	12.500	=	629.116 kN
M1	=	629.12	x	3.75	=	2361.073 kN.m		at Shaft Bottom
F3	=	6.705	x	8.506	x	12.500	=	712.931 kN
M3	=	712.93	x	4.25	=	3032.096 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	4.506	=	25.178 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	3.000	=	8.382 kN/m ²
F2	=	0.5	x	25.18	x	4.506	x	12.50
	=	709.077 kN						
F4	=	(25.18 + 33.56)	x	3.00	x	12.50		
	=	1101.330 kN						

Total Force = 1810.407 kN

M2 = 709.08 x 4.89 = 3469.173 kN.m

M4 = 1101.33 x 1.43 = 1573.419 kN.m

Total Mome = 5042.59 kN.m at Shaft Bottom

Intensity for
triangular portion

Upto HFL = 0.279 x 20 x 4.506 = 25.178 kN/m²

at
Foundation
level = 0.279 x 10 x 4.000 = 11.175 kN/m²

F2 = 0.5 x 25.18 x 4.506 x 12.50
= 709.077 kN

F6 = $\frac{(25.18 + 36.35)}{2} \times 4.00 \times 12.50$
= 1538.286 kN

Total Force = 2247.363 kN

M2 = 709.08 x 5.89 = 4178.250 kN.m

M6 = 1538.29 x 1.88 = 2890.317 kN.m

Total Mome = 7068.57 kN.m Foundation Lvl.

Intensity of Passive pressure:

= 3.766 x 10 x 0.00 = 0.000 kN/m²

Force due to passive @ Foundation, F
= 0.5 x 0.000 x 12.50
= 0.000 kN

Moment due to passive @ Foundation, M
= 0.000 x 0.000 = 0.000 kN.m Foundation Lvl.

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	5042.592	7068.567	1810.407	2247.363
Due to Minimum Fluid Pressure	4228.883	6154.264	1690.201	2170.561
Governing of Two	5042.592	7068.567	1810.407	2247.363
Due to Live Load Surcharge	2361.073	3032.096	629.116	712.931
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000	
αv	=	0.000	
ϕ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

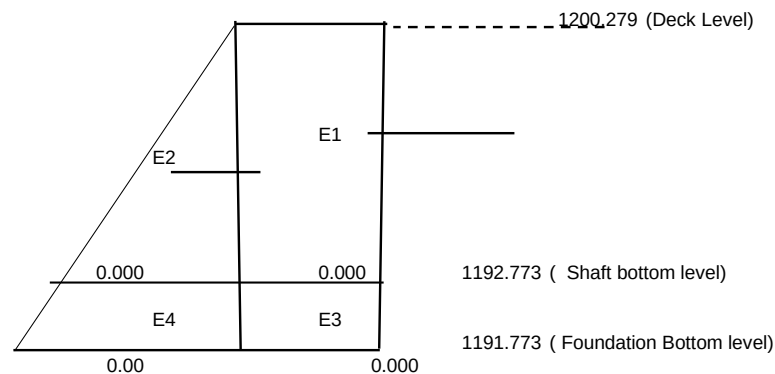
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \frac{0.000}{0.000}$$

$$C_a = \frac{1}{0.279} \frac{2}{0.279}$$

Ca	=	0.279	
Ka	=	0.279	
Dynamic Increment	=	0.279	-0.279 0.000

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

**Earth Pressure Diagram for Dynamic Increment**

Horizontal Forces and Moments @ RL

1192.8 m (at Shaft Base)
1191.8 m (at Foundation Bottom Level)

Due to Dynamic Live Load Surcharge

=	0.000	x	20	x	1.2	=	0.000 kN/m ²
<u>at Shaft Bottom Level</u>							
E1	=	0.000	x	7.506	x	12.500	= 0.000 kN
M1	=	0.000	x	5.029			= 0.000 kN.m
<u>at Foundation Bottom Level</u>							
E3	=	0.000	x	8.506	x	12.500	= 0.000 kN
M3	=	0.000	x	5.699			= 0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 7.506 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 8.506 = 0.000 \text{ kN/m}^2$$

$$E2 = 0.50 \times 0.00 \times 7.51 \times 12.500 = \mathbf{0.000} \text{ kN}$$

$$E4 = 0.50 \times 0.00 \times 8.51 \times 12.500 = \mathbf{0.000} \text{ kN}$$

$$M2 = 0.00 \times \mathbf{3.75} = \mathbf{0.000} \text{ kN.m (Shaft bottom level)}$$

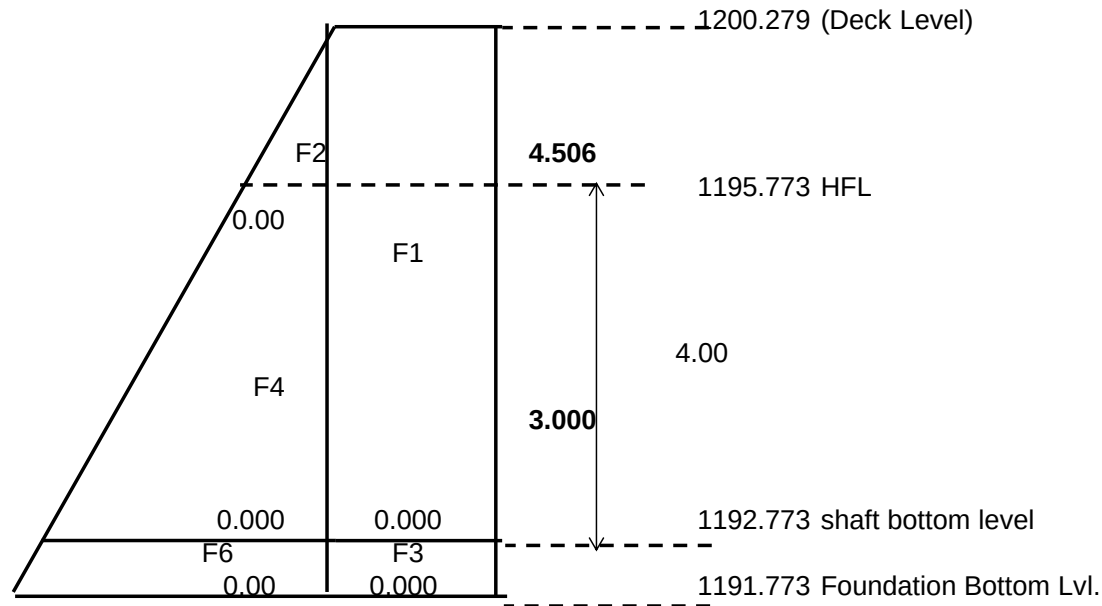
$$M4 = 0.00 \times 4.25 = \mathbf{0.000} \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	6202.774	9026.854	1967.561	2526.747
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	6202.774	9026.854	1967.561	2526.747
Due to Minimum Fluid Pressure	4228.883	6154.264	1690.201	2170.561
Governing of Two	6202.774	9026.854	1967.561	2526.747
Due to Live Load Surcharge (Static)	2361.073	3032.096	629.116	712.931
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL
1192.773 m (at Shaft Base)
1191.773 m (at Foundation Bottom Level)

Due to Live Load Surcharge

Intensity for rectangular portion = 0.000 x 20 x 1.200 = 0.000 kN/m²

at Shaft Bottom Level

$$F1 = 0.000 \times 7.506 \times 12.500 = 0.000 \text{ kN}$$

$$M1 = 0.00 \times 4.95 = 0.000 \text{ kN.m}$$

at Foundation Bottom Level

$$F3 = 0.000 \times 8.506 \times 12.500 = 0.000 \text{ kN}$$

$$M3 = 0.00 \times 5.61 = 0.000 \text{ kN.m}$$

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

$$\text{Upto HFL} = 0.000 \times 20 \times 4.506 = 0.000 \text{ kN/m}^2$$

$$\text{(At Shaft bottom level) Below HFL} = 0.000 \times 10 \times 3.000 = 0.000 \text{ kN/m}^2$$

$$\text{(At Foundation bottom level) Below HFL} = 0.000 \times 10 \times 4.000 = 0.000 \text{ kN/m}^2$$

$$F2 = 0.5 \times 0.00 \times 4.51 \times 12.50 = 0.000 \text{ kN}$$

$$F4 = \frac{(0.00 + 0.00)}{2} \times 3.00 \times 12.50 = 0.000 \text{ kN}$$

$$F6 = \frac{(0.00 + 0.00)}{2} \times 4.00 \times 12.50 = 0.000 \text{ kN}$$

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

$$M2 = 0.00 \times 5.25 = 0.000 \text{ kN.m}$$

$$M4 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Shaft Bottom

$$M2 = 0.00 \times 6.25 = 0.000 \text{ kN.m}$$

$$M6 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	5042.592	7068.567	1810.407	2247.363
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	5042.592	7068.567	1810.407	2247.363
Due to Minimum Fluid Pressure	4228.883	6154.264	1690.201	2170.561
Governing of Two	5042.592	7068.567	1810.407	2247.363
Due to Live Load Surcharge(Static)	2361.073	3032.096	629.116	712.931
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing

Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax-Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Longitudinal Seismic Case:

Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case

Design Speed	V	=	40.00	kmph
Live Load	W	=	932.33	kN
Radius of Curvature	R	=	72.00	m
CENTRIFUGAL FORCE	C	=	163.14	kN

Seismic Case

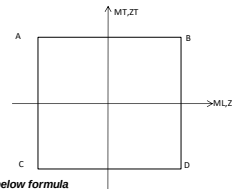
40.00	kmph
932.33	kN
72.00	m
163.14	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1191.773 m

Properties of Footing Base:

A	=	101.250	m ²
ZL	=	136.688	m ³
ZT	=	210.938	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	1.010	1262.500	0.000	0.000
SIDL except Wearing Course				80.000	1.010	80.800	0.000	0.000
Wearing Course	1			137.500	1.010	138.875	0.000	0.000
				1467.500		1482.175		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.640	36.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.640	24.510	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.340	9.563	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.390	5.484	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.850	57.375	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.850	0.000	0.000	0.000
Cantilever Return Wall-Rectangle pc	1	25	0.000	0.000	0.350	0.000	0.000	0.000
Cantilever Return Wall-Triangle port	1	25	0.000	0.000	0.350	0.000	0.000	0.000
RCC Railing or Crash Barrier	1	25	0.000	0.000	0.640	17.920	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.340	55.781	0.000	0.000
				396.297		206.633		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	35.380	884.510	-1.850	-1636.344	0.000	0.000
Abutment Shaft	1	25	62.319	1557.976	0.882	1374.664	0.000	0.000
Back filling over heel slab	1	25	434.418	8688.350	-1.873	-16275.114	0.000	0.000
Front Filling over toe slab	1	20	75.938	1518.750	2.650	4024.688	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	41.250	1031.250	-1.606	-1655.729	0.000	0.000
Toe slab	1	25	25.313	632.813	2.550	1613.672	0.000	0.000
portion between heel & toe	1	25	12.500	312.500	0.850	265.625	0.000	0.000
Vertical Components of active earth pressure	1			919.661	-4.050	-3724.626	0.000	0.000
				15819.627		-15896.561		0.000
Total				17683.423		-14207.753		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-3.040	-3610.000
0.950	76.000	-3.040	-231.040
1.000	137.500	-3.040	-418.000
	1401.000		-4259.040
0.950	53.438	-3.410	-182.222
0.950	36.382	-3.410	-124.063
0.950	26.719	-3.710	-99.127
0.950	13.359	-3.660	-48.895
0.950	64.125	-3.200	-205.200
0.950	0.000	-3.200	0.000
0.950	0.000	-3.700	0.000
0.950	0.000	-3.700	0.000
0.950	26.600	-3.410	-90.706
0.950	155.859	-3.710	-578.238
	376.482		-1328.451
0.950	840.285	-5.900	-4957.679
0.950	1480.077	-3.168	-4688.382
0.950	8253.933	-5.923	-48889.785
0.950	1442.813	-1.400	-2019.938
0.950	0.000	0.000	0.000
0.950	979.688	-5.656	-5540.677
0.950	601.172	-1.500	-901.758
0.950	296.875	-3.200	-950.000
0.950	873.678	-8.100	-7076.789
	15028.645		-75959.506
	16806.127		-81546.997

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.414	5606.584
due to Earth pressure	1	2526.747		9026.854

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
733.75	5606.58	0.00	0.00
2526.75	9026.85	0.00	0.00
3260.497	14633.438	0.000	0.000

Forces along Trans. Axis**Horizontal Forces For Overturning or Sliding Effect**

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Earth pressure	1.5	3790.120		13540.281
		4581.183		19584.789

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
791.06	6044.51	0.00	0.00
3790.12	13540.28	0.00	0.00
4581.183	19584.789	0.000	0.000

Forces along Trans. Axis**Summary of Forces For SBC**

P	17683.423	kN
ML	425.684	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		17683.423		-14207.753		0.000
CWLL-Max. Reaction case	1	932.327	1.010	941.650	2.411	2248.220
Vertical Components of LL Surcharge	1	259.486	-4.050	-1050.917	0.000	0.000
Total		18875.236		-14317.020		2248.220

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	16806.127	-3.040	-81547.00
0.950		-8.100	-1996.74
	16806.127		-83543.74

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.414	5606.584
due to Earth pressure	1	2526.747		9026.854

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
733.75	5606.58	0.00	0.00
2526.75	9026.85	0.00	0.00

Forces along Trans. Axis

Design Calculation

due to Live load surcharge	1	712.931	3032.096

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Earth pressure	1.5	3790.120		13540.281
due to Live load surcharge	1.2	855.517		3638.516
		5436.700		23223.305

Summary of Forces For SBC

P	18875.236	KN
ML	3348.513	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		17683.423		-14207.753		0.000
CWLL-Max. Reaction case	1	2561.336	1.010	2586.949	0.300	768.401
Vertical Components of LL Surcharge	1	259.486	-4.050	-1050.917	0.000	0.000
Total		20504.245		-12671.721		768.401

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712.931	3032.096	0.000	0.000
3973.43	17665.53	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
3790.12	13540.28	0.00	0.00
855.52	3638.52	0.00	0.00
5436.700	23223.305	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16806.12728		-81546.997
0.000		-3.040	0.00
0.950		-8.100	-1996.74
	16806.127		-83543.74

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.414	5606.584
due to Earth pressure	1	2526.747		9026.854
due to Live load surcharge	1	712.931		3032.096

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Earth pressure	1.5	3790.120		13540.281
due to Live load surcharge	1.2	855.517		3638.516
		5436.700		23223.305

Summary of Forces For SBC

P	20504.245	kN
ML	4993.813	kNm
MT	788.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		1482.175		0.000
Substructure & Foundation -Portion 1				396.297		206.633		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	35.380	884.510	-1.850	-1636.344	0.000	0.000
Shaft above HFL	1	25	33.139	828.481	0.952	786.598	0.000	0.000
Shaft below HFL	1	15	29.180	437.697	0.882	386.198	0.000	0.000
Back filling above HFL over heel slab	1	20	247.830	4956.600	-1.850	-9169.710	0.000	0.000
Back filling below HFL over heel slab	1	10	178.750	1787.500	-1.906	-3407.708	0.000	0.000
Front Filling over toe slab	1	10	75.938	759.375	2.650	2012.344	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	41.250	618.750	-1.606	-993.438	0.000	0.000
Toe slab	1	15	25.313	379.688	2.550	968.203	0.000	0.000
Portion between Heel & Toe	1	15	12.500	187.500	0.850	159.375	0.000	0.000
Vertical Components of active earth pressure	1			817.973	-4.050	-3312.792	0.000	0.000
				11878.066		-14107.933		0.000
Total				13741.863		-12419.125		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.414	5606.584
due to Earth pressure	1	2247.363		7068.567

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Earth pressure	1.5	3371.045		10602.850
		4162.107		16647.359

Summary of Forces For SBC

P	13741.863	kN
ML	256.025	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		13741.863		-12419.125		0.000
CW/LL-Min. Reaction case	1	466.273	1.010	470.936	3.109	1449.594
Vertical Components of LL Surcharge	1	259.486	-4.050	-1050.917	0.000	0.000
Total		14467.622		-12999.106		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.414	5606.584
due to Earth pressure	1	2247.363		7068.567
due to Live load surcharge	1	712.931		3032.096

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Earth pressure	1.5	3371.045		10602.850
due to live load surcharge	1.2	855.517		3638.516

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5606.58	0.00	0.00
2526.75	9026.85	0.00	0.00
712.931	3032.096	0.000	0.000
3973.43	17665.53	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
3790.12	13540.28	0.00	0.00
855.52	3638.52	0.00	0.00
5436.700	23223.305	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-4259.040
	376.482		-1328.451
0.950	840.285	-5.900	-4957.679
0.950	787.057	-3.098	-2436.317
0.950	415.812	-3.168	-1317.152
0.950	4708.770	-5.900	-27781.743
0.950	1698.125	-5.956	-10114.729
0.950	721.406	-1.400	-1009.969
0.950	0.000	0.000	0.000
0.950	587.813	-5.656	-3324.406
0.950	360.703	-1.500	-541.055
0.950	178.125	-3.200	-570.000
0.950	777.075	-8.100	-6294.305
	11284.163		-59103.397
	13061.645		-64690.887

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5606.58	0.00	0.00
2247.36	7068.57	0.00	0.00
2981.11	12675.15	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
3371.04	10602.85	0.00	0.00
4162.11	16647.36	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	13061.645		-64690.887
0.000	0.000	-3.040	0
0.950	246.511	-8.100	-1996.743
	13308.156		-66687.630

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5606.58	0.00	0.00
2247.36	7068.57	0.00	0.00
712.931	3032.096	0.000	0.000
3694.04	15707.25	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
3371.04	10602.85	0.00	0.00
855.517	3638.516	0.000	0.000

5017.625

20285.874

5017.62

20285.87

0.00

0.00

Summary of Forces For SBC		
P	14467.622	kN
ML	2708.140	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		13741.863		-12419.125		0.000
CWLL-Min. Reaction case	1	858.664	1.010	867.251	0.300	257.599
Vertical Components of LL Surcharge	1	259.486	-4.050	-1050.917	0.000	0.000
Total		14860.013		-12602.792		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.414	5606.584
due to Earth pressure	1	2247.363		7068.567
due to Live load surcharge	1	712.931		3032.096

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	13061.645		-64690.887
0.000	0.000	-3.040	0.00
0.950	246.511	-8.100	-1996.743
	13308.156		-66687.630

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5606.58	0.00	0.00
2247.36	7068.57	0.00	0.00
712.931	3032.096	0.000	0.000
3694.04	15707.25	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Earth pressure	1.5	3371.045		10602.850
due to live load surcharge	1.2	855.517		3638.516
		5017.625		20285.874

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
3371.04	10602.85	0.00	0.00
855.517	3638.516	0.000	0.000
5017.62	20285.87	0.00	0.00

Summary of Forces For SBC

P	14860.013	kN
ML	3104.455	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.553	kN
		ah=	0.000	In Transverse direction	Weight of back fill below Ground level	=	2200.000	kN
		av=	0.000	In Vertical direction				

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	1.010	1262.500	0.000	1199.947		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	1.010	80.800	0.000	1200.728		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	1.010	138.875	0.000	1200.279		0.000	0.000	0.000
				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.640	36.000	0.000	1199.979	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.000	0.000	0.000	0.640	24.510	0.000	1199.475	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.340	9.563						
Bracket - Tapered portion	1	25	0.563	14.063				0.390	5.484						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.850	57.375	0.000	1199.263	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.850	0.000	0.000	1199.113	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.350	0.000	0.000	1200.564	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.350	0.000	0.000	1200.564	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.640	17.920				0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.340	55.781				0.000	0.000	
				396.297	0.000	0.000	0.000		206.633	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	35.380	884.510	0.000	0.000	0.000	-1.850	-1636.344	0.000	1196.330	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	62.319	1557.976	0.000	0.000	0.000	0.882	-1374.864	0.000	1196.943	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	434.418	8688.350	0.000	0.000	0.000	-1.873	-16275.114	0.000	1196.330	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	75.938	1518.750				2.650	4024.688				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	41.250	1031.250				-1.606	-1655.729				0.000	0.000	
Toe slab	1	25	25.313	632.813				2.550	1613.672				0.000	0.000	
portion between heel & toe	1	25	12.500	312.500				0.850	265.625				0.000	0.000	
Vertical component of active earth pressure	1			919.661				-4.050	-3724.626				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.050	0.000				0.000	0.000	
				15819.627	0.000	0.000	0.000		-15896.561	0.000		0.000		0.000	0.000
Total =				17683.423	0.000	0.000	0.000		-14207.753	0.000		0.000		0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-3.040	-3610.000	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-3.040	-231.040	0.000
Wearing Course	1.00			137.500	0.000	-3.040	-418.000	0.000
				1401.000	0.000		-4259.040	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-3.410	-182.222	0.000
Dirt Wall-Tapered portion	0.95	25	1.532	36.382	0.000	-3.410	-124.063	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-3.200	-205.200	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-3.200	0.000	0.000
Cantilever Return Wall-Rectangle pt	0.95	25	0.000	0.000	0.000	-3.700	0.000	0.000
Cantilever Return Wall-Triangle port	0.95	25	0.000	0.000	0.000	-3.700	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-3.410	-90.706	
Approach Slab	0.95	25	6.563	155.859		-3.710	-578.238	
				376.482	0.000		-1180.429	0.000
Substructure & Foundation -Portion 2								
Aboutment Shaft	0.95	25	62.319	1480.077	0.000	-3.168	-4688.382	0.000
Solid Return wall	0.95	25	35.380	840.285	0.000	-5.900	-4957.679	0.000
Back filling over heel slab	0.95	20	434.418	8253.933	0.000	-5.923	-48889.785	0.000
Front Filling over Pile Cap	0.95	20	75.938	1442.813		-1.400	-2019.938	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	41.250	979.688		-5.656	-5540.677	
Toe slab	0.95	25	25.313	601.172		-1.500	-901.758	
portion between heel & toe	0.95	25	12.500	296.875		-3.200	-950.000	
Vertical component of active earth pressure	0.95			873.678		-8.100	-7076.789	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.100	0.000	
				15028.645	0.000		-75959.51	0.000
Total =				16806.127	0.000		-81398.98	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.414	5606.584	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2526.747			9026.854	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.51
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3790.120		13540.28
due to dynamic Earth pressure	1.5	0.000		0.00
		4581.183		19584.789

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	0.000	1199.979	0.000
1.0	0.000	1199.475	0.000
1.0	0.000	1199.263	0.000
1.0	0.000	1199.113	0.000
1.0	0.000	1200.564	0.000
1.0	0.000	1200.564	0.000
	0.000		0.000
1.0	0.000	1196.943	0.000
1.0	0.000	1196.330	0.000
1.0	0.000	1196.330	0.000
	0.000		0.000
	0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5606.58	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2526.75	9026.85						
3260.50	14633.44	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3790.120	13540.281	0.000	0.000
0.000	0.000	0.000	0.000
4581.18	19584.79	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17683.423	17683.423	kN
ML	425.684	425.684	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	16806.127	kN
Moment	-81398.975	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Forces from Substructure				16215.923	0.000	0.000	0.000		-15689.928	0.000				0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	1.010	188.330	0.000	1201.479		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			51.90				-4.050	-210.183				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.050	0.000				0.000	0.000	
Total =				17921.786	0.000	0.000	0.000		-14229.607	0.000		0.000		449.644	0.000

0.000
0.000**Vertical Forces For Restoring or Resisting Effect**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-4259.04	0.000
Forces from Substructure				15405.127	0.000	0.000	-77139.94	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.040	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-8.100	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.100	0.00	
Total =				16806.127	0.000		-81398.98	0.000

0.000
0.000**Horizontal Forces For SBC Calculation**

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.414	5606.584	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2526.747			9026.854	
due to Live load surcharge	0.20	142.586			606.419	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5606.58	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2526.75	9026.85						
142.59	606.42						
3403.08	15239.86	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3790.120		13540.281
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		4581.183		19584.789

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3790.120	13540.281		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4581.18	19584.79	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17921.786	17921.786	kN
ML	1010.250	1010.250	kNm
MT	449.644	449.644	kNm

Summary of Restoring Forces

Vertical Load	16806.127	kN
Moment	-81398.975	kNm

Case 7 : DL+SIDL-Long_Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load/ P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		206.633	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	35.38	884.51	0.000	0.000	0.000	-1.95	-1636.344	0.000	1196.33	0.000	0.00	0.000	0.000
Shaft above HFL	1	15	33.139	828.481	0.000	0.000	0.000	0.952	788.698	0.000	1197.443	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	29.180	437.697	0.000	0.000	0.000	0.882	386.198	0.000	1195.273	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	247.830	4956.600	0.000	0.000	0.000	-1.850	-9169.710	0.000	1198.026	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	178.750	1787.500	0.000	0.000	0.000	-1.906	-3407.708	0.000	1194.023	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	75.938	759.375	0.000	0.000	0.000	2.650	2012.344	0.000		0.000	0.000	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
Heel slab	1	15	41.250	618.750	0.000	0.000	0.000	-1.606	-993.438	0.000		0.000	0.000	0.000	0.000
Toe slab	1	15	25.313	379.688	0.000	0.000	0.000	2.550	968.203	0.000		0.000	0.000	0.000	0.000
portion between heel & toe	1	15	12.500	187.500	0.000	0.000	0.000	0.850	159.375	0.000		0.000	0.000	0.000	0.000
Vertical component of active earth pressure	1			817.973				-4.050	-3312.792				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.050	0.000				0.000	0.000	
				11878.066	0.000	0.000	0.000		-14205.174	0.000		0.000		0.000	0.000
Total =				13741.863	0.000	0.000	0.000		-12516.366	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load/ P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-4259.040	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1180.429	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	35.3804	840.285	0.000	-5.90	-4957.679	0.000
Shaft above HFL	0.95	25	33.139	787.057	0.000	-3.098	-2438.317	0.000
Shaft below HFL	0.95	15	29.180	415.812	0.000	-3.168	-1317.152	0.000
Back filling above HFL over heel slab	0.95	20	247.830	4708.770	0.000	-5.900	-27781.743	0.000
Back filling below HFL over heel slab	0.95	10	178.750	1698.125	0.000	-5.956	-10114.729	0.000
Front Filling over Pile Cap	0.95	10	75.938	721.406	0.000	-1.400	-1009.969	0.000
Side filling between heel and toe	0.95	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.95	15	41.250	587.813	0.000	-5.656	-3324.406	0.000
Toe slab	0.95	15	25.313	360.703	0.000	-1.500	-541.055	0.000
portion between heel & toe	0.95	15	12.500	178.125	0.000	-3.200	-570.000	0.000
Vertical component of active earth pressure	0.95			777.075		-8.100	-6294.305	0.000
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.100	0.000	0.000
				11284.163	0.000		-59103.397	0.000
Total =				13061.645	0.000		-64542.87	0.000

0.000

0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1196.330	0.000
1.0	0.000	1197.443	0.000
1.0	0.000	1195.273	0.000
1.0	0.000	1198.026	0.000
1.0	0.000	1194.023	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.414	5606.584	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2247.363			7068.567	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3371.045		10602.850
due to dynamic Earth pressure	1.5	0.000		0.000
		4162.107		16647.359

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5606.58	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2247.36	7068.57						
2981.11	12675.15	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3371.045	10602.850		
0.000	0.000		
4162.11	16647.36	0.00	0.00

Vertical Load	13061.645	kN
Moment	-64542.865	kNm

Vertical Forces For SBC Calculation

Vertical Forces For Restoring or Resisting Effect								
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Forces from Superstructure				1401.000	0.000		-4259.040	0.000
Forces from Substructure				11660.645	0.000		-60283.825	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.04	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.040	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.100	0.000	0.000
Total =				13061.645	0.000		-64545.91	0.000
					0.000			0.000

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.414	5606.584	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2247.363			7088.567	
due to Live load surcharge	0.20	142.586			606.419	

Horizontal Forces For Overturning or Sliding Effect

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3371.045	10602.850		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4162.11	16647.36	0.00	0.00

Vertical Load	13061.645	kN
Moment	-64545.905	kNm

Vertical Forces For SBC Calculation

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Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-4259.04	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1180.43	0.000
Substructure & Foundation -Portion 2				15028.645	0.000		-75959.51	0.000
Total =				16806.127	0.000		-81398.98	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.414	5606.584	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2526.747			9026.854	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.509
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	3790.120		13540.2806
due to dynamic Earth pressure	1.5	0.000		0
		4581.183		19584.789

Summary of Forces For SBC

	Downward	Upward	
P	17683.423	17683.423	kN
ML	425.684	425.684	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	16806.127 kN
Moment	-81398.975 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = Px eL1	MLs due to Fv	MT = Px eT
Total =	17921.786	0.000	-14229.61	0.000	449.644
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.414	5606.584	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2526.747			9026.854	
due to Live load surcharge	0.2	142.586			606.419	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1199.414	6044.509
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	3790.12		13540.281
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		4581.18		19584.789

Summary of Forces For SBC

	Downward	Upward	
P	17921.786	17921.786	kN
ML	1010.250	1010.250	kNm
MT	449.644	449.644	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = Px eL1	MLs due to Fv	MT = Px eT
Superstructure	1467.500	0.000	1482.175	0.000	0.000
Substructure & Foundation -Portion 1	396.297	0.000	206.633	0.000	0.000
Substructure & Foundation -Portion 2	11878.066	0.000	-14205.174	0.000	0.000
Total =	13741.863	0.000	-12516.366	0.000	0.000
		0.000		0.000	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = Px eL2	MLs due to Fv
Total =	16806.127	0.000	-81398.98	0.000
		0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5606.58	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2526.75	9026.85						
142.59	606.42						
3403.08	15239.86	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3790.120	13540.281		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4581.18	19584.79	0.00	0.00

Summary of Restoring Forces

Vertical Load	16806.127 kN
Moment	-81398.975 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure	1401.000	0.000		-4259.040	0.000
Substructure & Foundation	376.482	0.000		-1180.429	0.000
Substructure & Foundation	11284.163	0.000		-59103.397	0.000
Total =	13061.645	0.000		-64542.865	0.000
		0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1199.41	5606.58	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	2247.36			7068.57	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.414	6044.51
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3371.045		10602.85
due to dynamic Earth pressure	1.5	0.000		0.00
		4162.107		16647.36

Summary of Forces For SBC

	Downward	Upward	
P	13741.863	13741.863	kN
ML	158.785	158.785	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	13887.015	0.000	-12632.36	0.000	289.919
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1199.414	5606.584	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	2247.363			7068.567	
due to Live load surcharge	0.2	142.586			606.419	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1199.414	6044.51
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	3371.04		10602.85
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		4162.11		16647.36

Summary of Forces For SBC

	Downward	Upward	
P	13887.015	13887.015	kN
ML	649.208	649.208	kNm
MT	289.919	289.919	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	163.14		=	163.137 KN	Normal
Transverse Moment due to C.F.	=	163.137	x (	1201.764 -	1191.773)	=	1629.900 kNm	

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	163.14		=	32.627 KN	Seismic
Transverse Moment due to C.F.	=	32.627	x (	1201.764 -	1191.773)	=	325.980 kNm	

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Forces= $\mu P + cA + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_n$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	17683.423	425.684	0.000	171.537	177.765	171.537	177.765	177.765	171.537	4581.183	11764.289	2.57	19584.789	81547.00	4.16

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	5606.58	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2247.36	7068.57						
2981.11	12675.15	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3371.045	10602.850		
0.000	0.000		
4162.11	16647.36	0.00	0.00

Summary of Restoring Forces

Vertical Load	13061.645 kN
Moment	-64542.865 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	13061.645	0.000		-64545.91	0.000
		0.000			0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	5606.58	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2247.36	7068.57						
142.59	606.42						
3123.70	13281.57	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6044.51	0.00	0.00
0.00	0.00	0.00	0.00
3371.045	10602.850		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4162.11	16647.36	0.00	0.00

Summary of Restoring Forces

Vertical Load	13061.645 kN
Moment	-64545.905 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
163.14	1629.90	0.00	0.00

32.63	325.98	0.00	0.00

Case 2 : DL+SIDL+LL- (Maximum Reaction Case)-Normal Dry Case	18875.236	4978.413	2248.220	160.658	233.502	139.342	212.186	233.502	139.342	5436.700	11764.289	2.16	23223.305	83543.74	3.60
Case 2A : DL+SIDL+LL- (Maximum Reaction Case)-Normal Dry Case- SV Load Case	20504.245	4993.813	768.401	169.619	242.688	162.334	235.403	242.688	162.334	5436.700	11764.289	2.16	23223.305	83543.74	3.60
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	13741.863	256.025	0.000	133.849	137.595	133.849	137.595	137.595	133.849	4162.107	9143.151	2.20	16647.359	64690.89	3.89
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	14467.622	4338.040	1449.594	118.025	181.499	104.281	167.755	181.499	104.281	5017.625	9315.709	1.86	20285.874	66687.63	3.29
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case- SV Load Case	14860.013	3104.455	257.599	125.275	170.699	122.832	168.256	170.699	122.832	5017.625	9315.709	1.86	20285.874	66687.63	3.29
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	17683.423	425.684	0.000	171.537	177.765	171.537	177.765	177.765	171.537	4581.183	11764.289	2.57	19584.789	81398.98	4.16
Case 6 : DL+SIDL+LL- (Maximum Reaction Case)-Long. Seismic Dry Case	17921.786	1336.230	449.644	169.361	188.913	165.098	184.649	188.913	165.098	4581.183	11764.289	2.57	19584.789	81398.98	4.16
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	13741.863	158.785	0.000	134.560	136.884	134.560	136.884	136.884	134.560	4162.107	9143.151	2.20	16647.359	64542.87	3.88
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	13887.015	975.188	289.919	131.396	145.665	128.647	142.916	145.665	128.647	4162.107	9143.151	2.20	16647.359	64545.91	3.88
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	17683.423	425.684	0.000	171.537	177.765	171.537	177.765	177.765	171.537	4581.183	11764.289	2.57	19584.789	81398.98	4.16
Case 10 : DL+SIDL+LL- (Maximum Reaction Case)-Trans. Seismic Dry Case	17921.786	1010.250	775.624	173.291	188.073	165.937	180.719	188.073	165.937	4581.183	11764.289	2.57	19584.789	81398.98	4.16
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	13741.863	158.785	0.000	134.560	136.884	134.560	136.884	136.884	134.560	4162.107	9143.151	2.20	16647.359	64542.87	3.88
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	13887.015	649.208	615.899	135.326	144.825	129.486	138.985	144.825	129.486	4162.107	9143.151	2.20	16647.359	64545.91	3.88
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment A2
for Minor Bridge at Ch. 87+880**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 72 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case
Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.409m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	= 0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	= 0.720m	0.720m
Projection of Abutment Cap (Span Side)	= 0.000m	0.000m
Projection of Abutment Cap Back Side	= 0.000m	0.000m
Abutmentcap thickness (Uniform portion)	= 0.300m	
Abutmentcap thickness (Tapering Portion)	= 0.000m	
Length of Abutment Cap at top (Uniform portion)	= 12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.872m	0.872m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	4.400m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.000m
Thickness of Return wall at Bottom	=	0.000m

Foundation**Along Traffic Direction:**

Total Width of Footing	=	8.100m
abutment pedestal width	=	1.000m
abutment pedestal Height	=	1.000m
Width of Toe Slab	=	2.700m
Width of Heel Slab	=	4.400m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.000m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.000m
Width of backfill on heel slab	=	4.400m
Thickness of heel slab at back fill edge	=	1.000m
Height of back fill at bottom edge of heel slab	=	8.375m
Height of back fill at back fill edge of heel slab	=	7.875m

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)
Width of foundation -Tapering portion	=	12.500m (skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
	1 Minor Bridge	80+355	1200.505	1194.773	1191.773	8.732

Levels

Deck Level at Median Edge=	1200.505m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1200.790m	Height of Superstructure	=	0.800m
Deck level at center line =	1200.505m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1199.640m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1199.639m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lvl (uniform portion ends)	1199.339m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1199.339m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1199.339m	Height (Avg.) of Dirt Wall	=	1.009m
Ground level/LBL =	1194.773m	Abutment shaft Above G.L	=	4.566m
Abutment shaft bottom level =	1192.773m	Abutment Shaft below G.L	=	2.000m
Foundation level =	1191.773m	Height of abutment shaft	=	6.566m
HFL	1195.773m	MSL	=	1194.773m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²
<u>Creep Coefficient</u>			
For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days
<u>Clear Cover to Reinforcement</u>			
Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.160m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.80	x	10.00	x	12.50	x	25.00
	=	2500.00	KN					
Reaction at one end	=	1250.00	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	10.00
	=	160.00	KN			
Reaction at one end	=	80.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	10	x	12.5
	=	275	KN			
Reaction at one end	=	137.5	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transverse ecc
2561.34	0.30

Min CWLL

Vertical	Transverse ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

VOLUME CALCULATION

C.G. Of Footing	=	4.050 m
C.G. Of shaft from toe tip	=	3.200 m
Distance between c.g. of shaft and footing	=	0.850 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.640	-3.410	0.000
-Trapering portion	1	12.50	0.300	0.409	1.532	-0.210	0.640	-3.410	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.340	-3.710	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-0.460	0.390	-3.660	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.850	-3.200	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.850	-3.200	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.796	3.566	35.483	0.101	0.951	-3.099	0.000
Shaft below HFL	1	12.50	0.936	2.500	29.251	0.031	0.881	-3.169	0.000
Solid Return Wall	2	4.40	0.500	8.267	36.375	-2.700	-1.850	-5.900	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.350	-3.700	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.350	-3.700	0.000
Footing									
Heel Slab	1	12.50	4.400	0.750	41.250		-1.606	-5.656	0.000
Toe Slab	1	12.50	2.700	0.750	25.313		2.550	-1.500	0.000
Portion between Heel and Toe	1	12.50	1.000	1.000	12.500		0.850	-3.200	0.000
Back filling above HFL over Heel Slab	1	12.50	4.400	4.732	260.260		-1.850	-5.900	0.000
Back filling below HFL over Heel Slab	1	12.50	4.400	3.250	178.750		-1.906	-5.956	0.000
Backfill above Heel slab	1	12.50	4.400	8.125	446.848		-1.873	-5.923	0.000
Front Filling over Toe Slab	1	12.50	2.700	2.250	75.938		2.650	-1.400	0.000
Side filling between heel and toe	1	0.00	1.000	2.250	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.340	-3.710	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.152	4.732	8.995		0.457	-3.593	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.128	3.250	5.197		0.393	-3.657	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN		-0.210	0.640	-3.410

SECTIONAL PROPERTIES

Width of Footing (B)	=	8.1 m							
Length of Footing (L)	=	12.500 m							
A	=	8.100	x	12.500	=	101.250	m ²		
ZL	=	12.500	x	10.935	=	136.688	m ³		
ZT	=	IT1	+	IT2					
		distance of extreme point from centre							
IT1	=	8.100	x	162.760	=	1318.36	m ⁴		
IT2 (moment of inertia of triangle)	=	8.100	x	0.000	+	0.500 x	8.100 x	0.000 x	39.063
from centre of footing	=	0.000	m ⁴						
Moment of inertia of two triangle	=	0.000	m ⁴						
Total moment of inertia	=	1318.36	m ⁴						
Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250	m		
Total Section modulus (ZT)	=	210.938	m ³						

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL (Service)	1.500	0.20
CWLL and Associate load and FPLL (Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviceability Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone	5.0

Feq	=	Seismic forces to be resisted
Feq	=	Ah x (Dead load + Appropriate Live load)
Ah	=	horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \quad \frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 7.866 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 8.443 m

Abutment Cap Top Level - Foundation Level
= 7.866 m

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.86	m

Moment of Inertia , $I_{\text{longitudinal}}$ =	0.663	m^4
Moment of Inertia , $I_{\text{transverse}}$ =	139.974	m^4

$$E_{cm} = 3.231E+07 \text{ kN/m}^2$$

Longitudinal Direction

Force	=	65.973	KN
D	=	1467.50	KN
T	=	0.2983	sec

Transverse Direction

Force	=	12555.393	KN
D	=	1747.220	KN
T	=	0.0236	sec

Hard or Rocky Strata

$$\text{Sa/g} = 2.5 \qquad \text{Sa/g} = 2.5$$

Seismic Coeff. In Longitudinal Direction = 0

Seismic Coeff. In Transverse Direction = 0

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

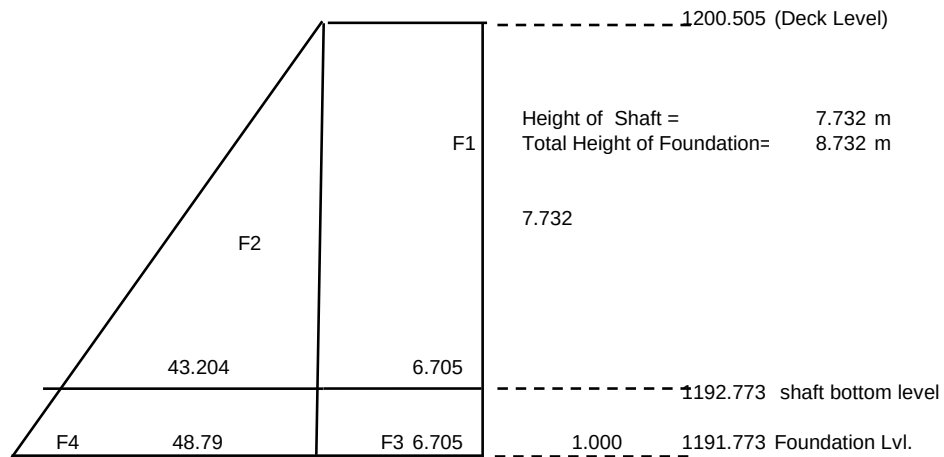
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1192.773 m (at Shaft Base)			
@ RL				1191.773 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.279	x	20	x	1.2	= 6.705 kN/m^2
F1	=	6.705	x	7.732	x	12.500	= 648.058 kN
M1	=	648.06	x	3.87	=	2505.393 kN.m	at Shaft Bottom
F3	=	6.705	x	8.732	x	12.500	= 731.873 kN
M3	=	731.873	x	4.366	=	3195.359 kN.m	at Foundation

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)	=	0.279	x	20	x	7.732	= 43.204 kN/m ²
F2	=	0.5	x	43.20	x	7.732	x 12.50
	=	2087.828 kN					

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2	=	2087.83	x	3.25	=	6780.095 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)	=	0.279	x	20	x	8.732	= 48.792 kN/m ²
F4	=	0.5	x	48.79	x	8.732	x 12.50
	=	2662.799 kN					
M4	=	2662.80	x	3.67	=	9765.657 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014	γ fluid	=	4.8 kN/m ³	
Intensity for triangular portion (At Shaft bottom level)	= 4.800	x 7.732	= 37.114 kN/m^2	
F	= 0.5	x 37.114	x 7.732	x 12.500
	= 1793.515 kN			
M	= 1793.51	x 2.577	= 4622.485 kN.m	at Shaft Bottom

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 8.732 = 41.91 \text{ kN/m}^2$$

$$F = 0.5 \times 41.914 \times 8.73 \times 12.500 = 2287.435 \text{ kN}$$

$$M = 2287.43 \times 2.911 = 6657.960 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

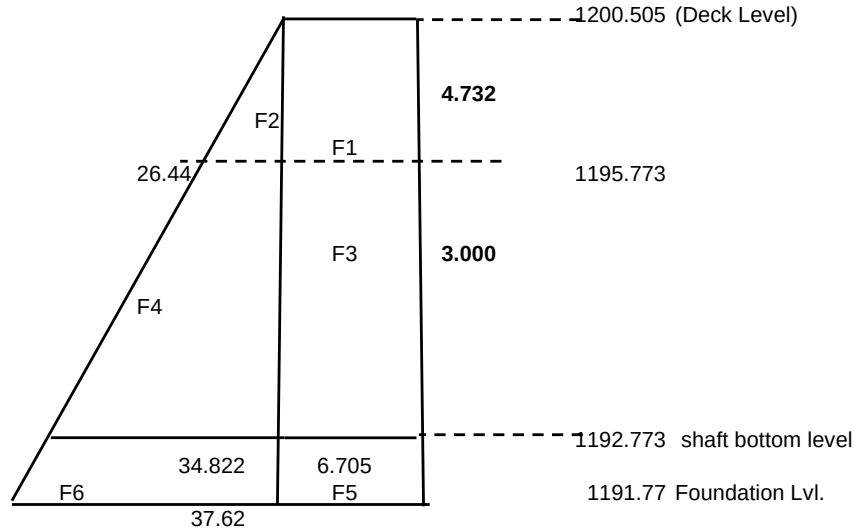
$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl kN	At Foundation Lvl kN
Due to active Earth Pressure	6780.095	9765.657	2087.828	2662.799
Due to Minimum Fluid Pressure	4622.485	6657.960	1793.515	2287.435
Governing of Two	6780.095	9765.657	2087.828	2662.799
Due to Live Load Surcharge	2505.393	3195.359	648.058	731.873
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1192.8 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	7.732	x	12.500	=	648.058 kN
M1	=	648.06	x	3.87	=	2505.393 kN.m		at Shaft Bottom
F3	=	6.705	x	8.732	x	12.500	=	731.873 kN
M3	=	731.87	x	4.37	=	3195.359 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	4.732	=	26.441 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	3.000	=	8.382 kN/m ²
F2	=	0.5	x	26.44	x	4.732	x	12.50
	=	781.989 kN						
F4	=	$\frac{(26.44 + 34.82)}{2}$	x	3.00	x	12.50		
	=	1148.686 kN						
Total Force =		1930.674 kN						
M2	=	781.99	x	4.99	=	3900.121 kN.m		
M4	=	1148.69	x	1.43	=	1644.452 kN.m		
Total Mome =		5544.57 kN.m		at Shaft Bottom				

Intensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 4.732 = 26.441 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 26.44 \times 4.732 = 781.989 \text{ kN}$$

$$F6 = \frac{(26.44 + 37.62)}{2} \times 4.00 \times 12.50$$

$$= 1601.427 \text{ kN}$$

$$\text{Total Force} = 2383.416 \text{ kN}$$

$$M2 = 781.99 \times 5.99 = 4682.110 \text{ kN.m}$$

$$M6 = 1601.43 \times 1.88 = 3016.598 \text{ kN.m}$$

$$\text{Total Mome} = 7698.71 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	5544.574	7698.708	1930.674	2383.416
Due to Minimum Fluid Pressure	4622.485	6657.960	1793.515	2287.435
Governing of Two	5544.574	7698.708	1930.674	2383.416
Due to Live Load Surcharge	2505.393	3195.359	648.058	731.873
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry CaseAs per Clause 219.5.4, IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000	
αv	=	0.000	
ϕ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

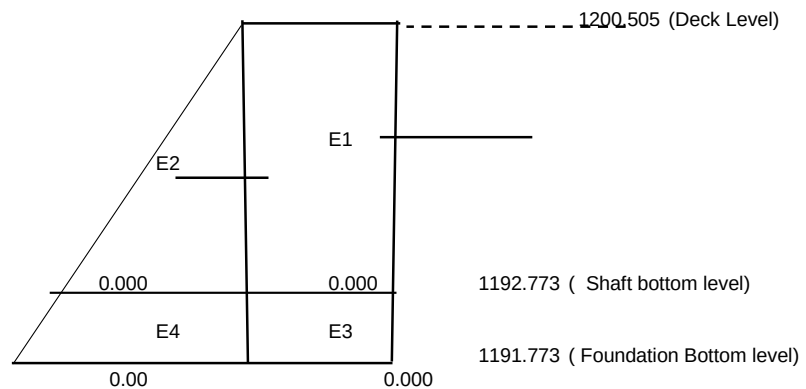
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \frac{0.000}{0.000}$$

$$C_a = \frac{1}{0.279} \frac{2}{0.279}$$

Ca	=	0.279	
Ka	=	0.279	
Dynamic Increment	=	0.279	-0.279 0.000

3 Earth Pressure :**DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

**Earth Pressure Diagram for Dynamic Increment****Horizontal Forces and Moments @ RL****1192.8 m (at Shaft Base)****1191.8 m (at Foundation Bottom Level)****Due to Dynamic Live Load Surcharge**

=	0.000	x	20	x	1.2	=	0.000 kN/m ²
at Shaft Bottom Level							
E1	=	0.000	x	7.732	x	12.500	= 0.000 kN
M1	=	0.000	x	5.180			= 0.000 kN.m
at Foundation Bottom Level							
E3	=	0.000	x	8.732	x	12.500	= 0.000 kN
M3	=	0.000	x	5.850			= 0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

=	0.000	x	20	x	7.732	=	0.000 kN/m ²
(at Foundation Bottom Level)							
=	0.000	x	20	x	8.732	=	0.000 kN/m ²
E2	=	0.50	x	0.00	x	7.73	x 12.500
=	0.000	kN					

Design Calculation

RODIC

Earth_Seismic_Dry

E4	=	0.50	x	0.00	x	8.73	x	12.500
	=	0.000	kN					
M2	=	0.00	x	3.87	=	0.000	kN.m	(Shaft bottom level)
M4	=	0.00	x	4.37	=	0.000	kN.m	(Foundation Bottom level)

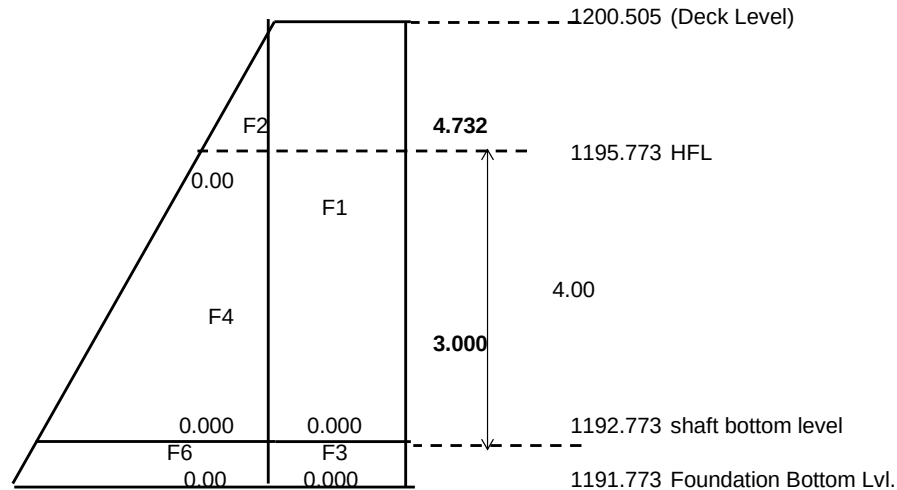
Summary of Moment and Horizontal Force

Dry Seismic Case

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	6780.095	9765.657	2087.828	2662.799
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	6780.095	9765.657	2087.828	2662.799
Due to Minimum Fluid Pressure	4622.485	6657.960	1793.515	2287.435
Governing of Two	6780.095	9765.657	2087.828	2662.799
Due to Live Load Surcharge (Static)	2505.393	3195.359	648.058	731.873
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1192.773 m (at Shaft Base)****1191.773 m (at Foundation Bottom Level)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.000	x	20	x	1.200	=	0.000 kN/m ²

at Shaft Bottom Level

F1	=	0.000	x	7.732	x	12.500	=	0.000 kN
M1	=	0.00	x	5.10	=	0.000 kN.m		

at Foundation Bottom Level

F3	=	0.000	x	8.732	x	12.500	=	0.000 kN
M3	=	0.00	x	5.76	=	0.000 kN.m		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.000	x	20	x	4.732	=	0.000 kN/m ²

(At Shaft bottom level) Below HFL	=	0.000	x	10	x	3.000	=	0.000 kN/m ²

(At Foundation bottom level) Below HFL	=	0.000	x	10	x	4.000	=	0.000 kN/m ²

F2	=	0.5	x	0.00	x	4.73	x	12.50
	=	0.000 kN						

F4	=	(0.00 + 0.00)	x	3.00	x	12.50
	=	0.000 kN				

F6	=	(0.00 + 0.00)	x	4.00	x	12.50
	=	0.000 kN				

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

M2	=	0.00	x	5.37	=	0.000 kN.m

M4	=	0.00	x	0.00	=	0.000 kN.m

Total Mome = 0.000 kN.m at Shaft Bottom

M2 = 0.00 x 6.37 = 0.000 kN.m

M6 = 0.00 x 0.00 = 0.000 kN.m

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	5544.574	7698.708	1930.674	2383.416
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	5544.574	7698.708	1930.674	2383.416
Due to Minimum Fluid Pressure	4622.485	6657.960	1793.515	2287.435
Governing of Two	5544.574	7698.708	1930.674	2383.416
Due to Live Load Surcharge(Static)	2505.393	3195.359	648.058	731.873
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax-Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case:

Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063

Dry Case

HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063

Dry Case

HFL Case

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

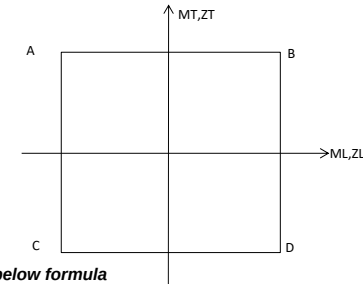
Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	932.33	kN	932.33	kN
Radius of Curvature	R	=	72.00	m	72.00	m
CENTRIFUGAL FORCE	C	=	163.14	kN	163.14	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1191.773 m

Properties of Footing Base:

A	=	101.250	m ²
ZL	=	136.688	m ³
ZT	=	210.938	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = Px eL1 (kNm)	Trans. Ecc (eT) (m)	MT = Px eT (kNm)
Superstructure								
Dead Load	1			1250.000	1.010	1262.500	0.000	0.000
SIDL except Wearing Course	1			80.000	1.010	80.800	0.000	0.000
Wearing Course	1			137.500	1.010	138.875	0.000	0.000
				1467.500		1482.175		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.640	36.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.640	24.510	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.340	9.563	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.390	5.484	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.850	57.375	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.850	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.350	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.350	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.640	17.920	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.340	55.781	0.000	0.000
				396.297		206.633		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	36.375	909.370	-1.850	-1682.335	0.000	0.000
Abutment Shaft	1	25	64.734	1618.357	0.881	1426.184	0.000	0.000
Back filling over heel slab	1	20	446.848	8936.950	-1.873	-16735.024	0.000	0.000
Front Filling over toe slab	1	20	75.938	1518.750	2.650	4024.688	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	41.250	1031.250	-1.606	-1655.729	0.000	0.000
Toe slab	1	25	25.313	632.813	2.550	1613.672	0.000	0.000
portion between heel & toe	1	25	12.500	312.500	0.850	265.625	0.000	0.000
Vertical Components of active earth pressure	1			969.180	-4.050	-3925.178	0.000	0.000
				16213.011		-16547.556		0.000
Total				18076.808		-14858.748		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = Px eL2 (kNm)
0.950	1187.500	-3.040	-3610.000
0.950	76.000	-3.040	-231.040
1.000	137.500	-3.040	-418.000
	1401.000		-4259.040
0.950	53.438	-3.410	-182.222
0.950	36.382	-3.410	-124.063
0.950	26.719	-3.710	-99.127
0.950	13.359	-3.660	-48.895
0.950	64.125	-3.200	-205.200
0.950	0.000	-3.200	0.000
0.950	0.000	-3.700	0.000
0.950	0.000	-3.700	0.000
0.950	26.600	-3.410	-90.706
0.950	155.859	-3.710	-578.238
	376.482		-1328.451
0.950	863.902	-5.900	-5097.019
0.950	1537.439	-3.169	-4871.754
0.950	8490.103	-5.923	-50283.188
0.950	1442.813	-1.400	-2019.938
0.950	0.000	0.000	0.000
0.950	979.688	-5.656	-5540.677
0.950	601.172	-1.500	-901.758
0.950	296.875	-3.200	-950.000
0.950	920.721	-8.100	-7457.838
	15402.360		-78091.100
	17179.842		-83678.590

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.640	5772.411
due to Earth pressure	1	2662.799		9765.657

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5772.41	0.00	0.00
2662.80	9765.66	0.00	0.00

3396.549 15538.068 0.000 0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Earth pressure	1.5	3994.199		14648.485
		4785.261		20871.774

Summary of Forces For SBC

P	18076.808	kN
ML	679.320	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		18076.808		-14858.748		0.000
CWLL-Max. Reaction case	1	932.327	1.010	941.650	2.411	2248.220
Vertical Components of LL Surcharge	1	266.380	-4.050	-1078.840	0.000	0.000
Total		19275.514		-14995.938		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.640	5772.411
due to Earth pressure	1	2662.799		9765.657
due to Live load surcharge	1	731.873		3195.359

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Earth pressure	1.5	3994.199		14648.485
due to Live load surcharge	1.2	878.248		3834.431
		5663.510		24706.205

Summary of Forces For SBC

P	19275.514	kN
ML	3737.489	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		18076.808		-14858.748		0.000
CWLL-Max. Reaction case	1	2561.336	1.010	2586.949	0.300	768.401
Vertical Components of LL Surcharge	1	266.380	-4.050	-1078.840	0.000	0.000
Total		20904.524		-13350.638		768.401

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
3994.20	14648.49	0.00	0.00
4785.261	20871.774	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	17179.842		-83678.59
0.000		-3.040	0.00
0.950		-8.100	-2049.80
	17179.842		-85728.39

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5772.41	0.00	0.00
2662.80	9765.66	0.00	0.00
731.873	3195.359	0.000	0.000
4128.42	18733.43	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
3994.20	14648.49	0.00	0.00
878.25	3834.43	0.00	0.00
5663.510	24706.205	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	17179.84213		-83678.5905
0.000		-3.040	0.00
0.950		-8.100	-2049.80
	17179.842		-85728.39

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.640	5772.411
due to Earth pressure	1	2662.799		9765.657
due to Live load surcharge	1	731.873		3195.359

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Earth pressure	1.5	3994.199		14648.485
due to Live load surcharge	1.2	878.248		3834.431
		5663.510		24706.205

Summary of Forces For SBC		
P	20904.524	kN
ML	5382.789	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = Px eL1 (kNm)	Trans. Ecc (eT) (m)	MT = Px eT (kNm)
Superstructure				1467.500		1482.175		0.000
Substructure & Foundation -Portion 1				396.297		206.633		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	36.375	909.370	-1.850	-1682.335	0.000	0.000
Shaft above HFL	1	25	35.483	887.081	0.951	843.412	0.000	0.000
Shaft below HFL	1	15	29.251	438.766	0.881	386.664	0.000	0.000
Back filling above HFL over heel slab	1	20	260.260	5205.200	-1.850	-9629.620	0.000	0.000
Back filling below HFL over heel slab	1	10	178.750	1787.500	-1.906	-3407.708	0.000	0.000
Front Filling over toe slab	1	10	75.938	759.375	2.650	2012.344	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	41.250	618.750	-1.606	-993.438	0.000	0.000
Toe slab	1	15	25.313	379.688	2.550	968.203	0.000	0.000
Portion between Heel & Toe	1	15	12.500	187.500	0.850	159.375	0.000	0.000
Vertical Components of active earth pressure	1			867.492	-4.050	-3513.344	0.000	0.000
				12272.590		-14753.880		0.000
Total				14136.387		-13065.071		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.640	5772.411
due to Earth pressure	1	2383.416		7698.708

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Earth pressure	1.5	3575.123		11548.063
		4366.186		17771.351

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5772.41	0.00	0.00
2662.80	9765.66	0.00	0.00
731.873	3195.359	0.000	0.000
4128.42	18733.43	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
3994.20	14648.49	0.00	0.00
878.25	3834.43	0.00	0.00
5663.510	24706.205	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = Px eL2 (kNm)
	1401.000		-4259.040
	376.482		-1328.451
0.950	863.902	-5.900	-5097.019
0.950	842.726	-3.099	-2611.801
0.950	416.828	-3.169	-1320.821
0.950	4944.940	-5.900	-29175.146
0.950	1698.125	-5.956	-10114.729
0.950	721.406	-1.400	-1009.969
0.950	0.000	0.000	0.000
0.950	587.813	-5.656	-3324.406
0.950	360.703	-1.500	-541.055
0.950	178.125	-3.200	-570.000
0.950	824.118	-8.100	-6675.354
	11658.961		-61234.977
	13436.443		-66822.468

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5772.41	0.00	0.00
2383.42	7698.71	0.00	0.00
3117.17	13471.12	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
3575.12	11548.06	0.00	0.00
4366.19	17771.35	0.00	0.00

Summary of Forces For SBC		
P	14136.387	kN
ML	406.048	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		14136.387		-13065.071		0.000
CWLL-Min. Reaction case	1	466.273	1.010	470.936	3.109	1449.594
Vertical Components of LL Surcharge	1	266.380	-4.050	-1078.840	0.000	0.000
Total		14869.041		-13672.975		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.640	5772.411
due to Earth pressure	1	2383.416		7698.708
due to Live load surcharge	1	731.873		3195.359

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Earth pressure	1.5	3575.123		11548.063
due to live load surcharge	1.2	878.248		3834.431
		5244.434		21605.782

Summary of Forces For SBC		
P	14869.041	kN
ML	2993.504	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		14136.387		-13065.071		0.000
CWLL-Min. Reaction case	1	858.664	1.010	867.251	0.300	257.599
Vertical Components of LL Surcharge	1	266.380	-4.050	-1078.840	0.000	0.000
Total		15261.431		-13276.660		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1199.640	5772.411
due to Earth pressure	1	2383.416		7698.708
due to Live load surcharge	1	731.873		3195.359

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	13436.443		-66822.468
0.000	0.000	-3.040	0
0.950	253.061	-8.100	-2049.795
	13689.504		-68872.263

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5772.41	0.00	0.00
2383.42	7698.71	0.00	0.00
731.873	3195.359	0.000	0.000
3849.04	16666.48	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
3575.12	11548.06	0.00	0.00
878.248	3834.431	0.000	0.000
5244.43	21605.78	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	13436.443		-66822.468
0.000	0.000	-3.040	0.00
0.950	253.061	-8.100	-2049.795
	13689.504		-68872.263

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5772.41	0.00	0.00
2383.42	7698.71	0.00	0.00
731.873	3195.359	0.000	0.000
3849.04	16666.48	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Earth pressure	1.5	3575.123		11548.063
due to live load surcharge	1.2	878.248		3834.431
		5244.434		21605.782

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
3575.12	11548.06	0.00	0.00
878.248	3834.431	0.000	0.000
5244.43	21605.78	0.00	0.00

Summary of Forces For SBC

P	15261.431	kN
ML	3389.818	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.583 KN
		ah=	0.000	In Transverse direction	Weight of back fill below Ground level	=	2200.000 KN
		av=	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	1.010	1262.500	0.000	1200.173		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	1.010	80.800	0.000	1200.954		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	1.010	138.875	0.000	1200.505		0.000	0.000	0.000
				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.640	36.000	0.000	1200.205	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.000	0.000	0.000	0.640	24.510	0.000	1199.701	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.340	9.563						
Bracket - Tapered portion	1	25	0.563	14.063				0.390	5.484						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.850	57.375	0.000	1199.489	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.850	0.000	0.000	1199.339	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.350	0.000	0.000	1200.790	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.350	0.000	0.000	1200.790	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.640	17.920				0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.340	55.781				0.000	0.000	
				396.297	0.000	0.000	0.000		206.633	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	36.375	909.370	0.000	0.000	0.000	-1.850	-1682.335	0.000	1196.443	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	64.734	1618.357	0.000	0.000	0.000	0.881	1426.184	0.000	1197.056	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	446.848	8936.950	0.000	0.000	0.000	-1.873	-16735.024	0.000	1196.443	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	75.938	1518.750				2.650	4024.688				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	41.250	1031.250				-1.606	-1655.729				0.000	0.000	
Toe slab	1	25	25.313	632.813				2.550	1613.672				0.000	0.000	
portion between heel & toe	1	25	12.500	312.500				0.850	265.625				0.000	0.000	
Vertical component of active earth pressure	1			969.180				-4.050	-3925.178				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.050	0.000				0.000	0.000	
				16213.011	0.000	0.000	0.000		-16547.556	0.000		0.000		0.000	0.000
Total =				18076.808	0.000	0.000	0.000		-14858.748	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-3.040	-3610.000	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-3.040	-231.040	0.000
Wearing Course	1.00			137.500	0.000	-3.040	-418.000	0.000
				1401.000	0.000		-4259.040	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-3.410	-182.222	0.000
Dirt Wall-Tapered portion	0.95	25	1.532	36.382	0.000	-3.410	-124.063	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-3.200	-205.200	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-3.200	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-3.700	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-3.700	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-3.410	-90.706	
Approach Slab	0.95	25	6.563	155.859		-3.710	-578.238	
				376.482	0.000		-1180.429	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	64.734	1537.439	0.000	-3.169	-4871.754	0.000
Solid Return wall	0.95	25	36.375	863.902	0.000	-5.900	-5097.019	0.000
Back filling over heel slab	0.95	20	446.848	8490.103	0.000	-5.923	-50283.188	0.000
Front Filling over Pile Cap	0.95	20	75.938	1442.813		-1.400	-2019.938	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	41.250	979.688		-5.656	-5540.677	
Toe slab	0.95	25	25.313	601.172		-1.500	-901.758	
portion between heel & toe	0.95	25	12.500	296.875		-3.200	-950.000	
Vertical component of active earth pressure	0.95			920.721		-8.100	-7457.838	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.100	0.000	
				15402.360	0.000		-78091.10	0.000
Total =				17179.842	0.000		-83530.57	0.000

0.000

0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	0.000	1200.205	0.000
1.0	0.000	1199.701	0.000
1.0	0.000	1199.489	0.000
1.0	0.000	1199.339	0.000
1.0	0.000	1200.790	0.000
1.0	0.000	1200.790	0.000
	0.000		0.000
1.0	0.000	1197.056	0.000
1.0	0.000	1196.443	0.000
1.0	0.000	1196.443	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.640	5772.411	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2662.799			9765.657	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.29
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3994.199		14648.49
due to dynamic Earth pressure	1.5	0.000		0.00
		4785.261		20871.774

Summary of Forces For SBC

	Downward	Upward	
P	18076.808	18076.808	kN
ML	679.320	679.320	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2662.80	9765.66						
3396.55	15538.07	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3994.199	14648.485	0.000	0.000
0.000	0.000	0.000	0.000
4785.26	20871.77	0.00	0.00

Summary of Restoring Forces

Vertical Load	17179.842	kN
Moment	-83530.569	kNm

MT	0.000	0.000	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1482.175	0.000		0.000		0.000	0.000
Forces from Substructure				16609.308	0.000	0.000	0.000		-16340.923	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	1.010	188.330	0.000	1201.705	0.000	2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			53.28				-4.050	-215.768				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.050	0.000				0.000	0.000	
Total =				18316.549	0.000	0.000	0.000		-14886.186	0.000		0.000		449.644	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-4259.04	0.000
Forces from Substructure				15778.842	0.000	0.000	-79271.53	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.040	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-8.100	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.100	0.00	
Total =				17179.842	0.000		-83530.57	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.640	5772.411	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2662.799			9765.657	
due to Live load surcharge	0.20	146.375			639.072	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2662.80	9765.66						
146.37	639.07						
3542.92	16177.14	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3994.199		14648.485
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0

4785.261

20871.774

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3994.199	14648.485		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4785.26	20871.77	0.00	0.00

Summary of Forces For SBC**Summary of Restoring Forces**

	Downward	Upward	
P	18316.549	18316.549	kN
ML	1290.954	1290.954	kNm
MT	449.644	449.644	kNm

Vertical Load	17179.842	kN
Moment	-83530.569	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		206.633	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		36.37	909.37	0.000	0.000	0.000	-1.85	-1682.335	0.000	1196.44	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	35.483	887.081	0.000	0.000	0.000	0.951	843.412	0.000	1197.556	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	29.251	438.766	0.000	0.000	0.000	0.881	386.664	0.000	1195.273	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	260.260	5205.200	0.000	0.000	0.000	-1.850	-9629.620	0.000	1198.139	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	178.750	1787.500	0.000	0.000	0.000	-1.906	-3407.708	0.000	1194.023	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	75.938	759.375				2.650	2012.344				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	41.250	618.750				-1.606	-993.438				0.000	0.000	
Toe slab	1	15	25.313	379.688				2.550	968.203				0.000	0.000	
portion between heel & toe	1	15	12.500	187.500				0.850	159.375				0.000	0.000	
Vertical component of active earth pressure	1			867.492				-4.050	-3513.344				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.050	0.000				0.000	0.000	
				12272.590	0.000	0.000	0.000		-14856.446	0.000		0.000		0.000	0.000
Total =				14136.387	0.000	0.000	0.000		-13167.638	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-4259.040	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1180.429	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	36.3748	863.902	0.000	-5.90	-5097.019	0.000
Shaft above HFL	0.95	25	35.483	842.726	0.000	-3.099	-2611.801	0.000
Shaft below HFL	0.95	15	29.251	416.828	0.000	-3.169	-1320.821	0.000
Back filling above HFL over heel slab	0.95	20	260.260	4944.940	0.000	-5.900	-29175.146	0.000
Back filling below HFL over heel slab	0.95	10	178.750	1698.125	0.000	-5.956	-10114.729	0.000
Front Filling over Pile Cap	0.95	10	75.938	721.406		-1.400	-1009.969	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	41.250	587.813		-5.656	-3324.406	
Toe slab	0.95	15	25.313	360.703		-1.500	-541.055	
portion between heel & toe	0.95	15	12.500	178.125		-3.200	-570.000	
Vertical component of active earth pressure	0.95			824.118		-8.100	-6675.354	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.100	0.000	

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1196.443	0.000
1.0	0.000	1197.556	0.000
1.0	0.000	1195.273	0.000
1.0	0.000	1198.139	0.000
1.0	0.000	1194.023	0.000

				11658.961	0.000		-61234.977	0.000
Total =				13436.443	0.000		-66674.45	0.000
				0.000		0.000		

	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.640	5772.411	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2383.416			7698.708	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2383.42	7698.71						
3117.17	13471.12	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3575.123		11548.063
due to dynamic Earth pressure	1.5	0.000		0.000
		4366.186		17771.351

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3575.123	11548.063		
0.000	0.000		
4366.19	17771.35	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	14136.387	14136.387	kN
ML	303.482	303.482	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	13436.443	kN
Moment	-66674.446	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Forces from Substructure				12668.887	0.000	0.000	0.000		-14649.813	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	1.010	94.187	0.000	1201.705		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			53.28				-4.050	-215.768				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.050	0.000				0.000	0.000	
Total =				14282.918	0.000	0.000	0.000		-13289.219	0.000		0.000		289.919	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-4259.040	0.000
Forces from Substructure				12035.443	0.000		-62415.406	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.04	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.040	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.100	0.000	0.000
Total =				13436.443	0.000		-66677.49	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.640	5772.411	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2383.416			7698.708	
due to Live load surcharge	0.20	146.375			639.072	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	3575.123		11548.063
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		4366.186		17771.351

Summary of Forces For SBC

	Downward	Upward	
P	14282.918	14282.918	kN
ML	820.973	820.973	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	13436.443	kN
Moment	-66677.486	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1482.175	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		206.633	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				16213.011	0.000	0.000	0.000		-16547.556	0.000		0.000		0.000	0.000
Total =				18076.808	0.000	0.000	0.000		-14858.748	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-4259.04	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1180.43	0.000
Substructure & Foundation -Portion 2				15402.360	0.000		-78091.10	0.000
Total =				17179.842	0.000		-83530.57	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.640	5772.411	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2383.42	7698.71						
146.37	639.07						
3263.54	14110.19	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3575.123	11548.063		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4366.19	17771.35	0.00	0.00

Design Calculation

RODIC

Stability of Foundation

due to Substructure	1	0.000	0.000	0.000	0.000
due to Earth pressure	1	2662.799		9765.657	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.289
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	3994.199		14648.485
due to dynamic Earth pressure	1.5	0.000		0
		4785.261		20871.774

Summary of Forces For SBC

	Downward	Upward	
P	18076.808	18076.808	kN
ML	679.320	679.320	kNm
MT	0.000	0.000	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	18316.549	0.000	-14886.19	0.000	449.644
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1199.640	5772.411	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2662.799			9765.657	
due to Live load surcharge	0.2	146.375			639.072	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1199.640	6223.289
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	3994.20		14648.485
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		4785.26		20871.774

Summary of Forces For SBC

	Downward	Upward	
P	18316.549	18316.549	kN
ML	1290.954	1290.954	kNm
MT	449.644	449.644	kNm

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2662.80	9765.66						
3396.55	15538.07	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3994.199	14648.485		
0.000	0.000		
4785.26	20871.77	0.00	0.00

Summary of Restoring Forces

Vertical Load	17179.842	kN
Moment	-83530.569	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	17179.842	0.000	-83530.57	0.000
		0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2662.80	9765.66						
146.37	639.07						
3542.92	16177.14	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3994.199	14648.485		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4785.26	20871.77	0.00	0.00

Summary of Restoring Forces

Vertical Load	17179.842	kN
Moment	-83530.569	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Superstructure		1467.500	0.000	1482.175	0.000	0.000
Substructure & Foundation -Portion 1		396.297	0.000	206.633	0.000	0.000
Substructure & Foundation -Portion 2		12272.590	0.000	-14856.446	0.000	0.000
Total =		14136.387	0.000	-13167.638	0.000	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1199.64	5772.41	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	2383.42			7698.71	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1199.640	6223.29
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3575.123		11548.06
due to dynamic Earth pressure	1.5	0.000		0.00
		4366.186		17771.35

Summary of Forces For SBC

	Downward	Upward	
P	14136.387	14136.387	kN
ML	303.482	303.482	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Total =	14282.918	0.000	-13289.22	0.000	289.919

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1199.640	5772.411	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	2383.416			7698.708	
due to Live load surcharge	0.2	146.375			639.072	

Vertical Forces For Restoring or Resisting Effect

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times e_{L2}$	MLs due to F_v
Superstructure		1401.000	0.000		-4259.040	0.000
Substructure & Foundation		376.482	0.000		-1180.429	0.000
Substructure & Foundation		11658.961	0.000		-61234.977	0.000
Total =		13436.443	0.000		-66674.446	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2383.42	7698.71						
3117.17	13471.12	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3575.123	11548.063		
0.000	0.000		
4366.19	17771.35	0.00	0.00

Summary of Restoring Forces

Vertical Load	13436.443	kN
Moment	-66674.446	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times e_{L2}$	MLs due to F_v
Total =	13436.443	0.000		-66677.49	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5772.41	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2383.42	7698.71						
146.37	639.07						
3263.54	14110.19	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1199.640	6223.29
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	3575.12		11548.06
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		4366.19		17771.35

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6223.29	0.00	0.00
0.00	0.00	0.00	0.00
3575.123	11548.063		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4366.19	17771.35	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	14282.918	14282.918	kN
ML	820.973	820.973	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	13436.443	kN
Moment	-66677.486	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	163.14	=	163.137 kN	Normal
Transverse Moment due to C.F.	=	163.137	x (	1201.990 -	1191.773)	=	1666.769 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
163.14	1666.77	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	163.14	=	32.627 kN	Seismic
Transverse Moment due to C.F.	=	32.627	x (	1201.990 -	1191.773)	=	333.354 kNm

32.63	333.35	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe+M_p}$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	18076.808	679.320	0.000	173.566	183.506	173.566	183.506	183.506	173.566	4785.261	12025.889	2.51	20871.774	83678.59	4.01
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	19275.514	5404.258	2248.220	161.496	240.571	140.180	219.255	240.571	140.180	5663.510	12025.889	2.12	24706.205	85728.39	3.47
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	20904.524	5382.789	768.401	170.727	249.487	163.441	242.202	249.487	163.441	5663.510	12025.889	2.12	24706.205	85728.39	3.47
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	14136.387	406.048	0.000	136.648	142.589	136.648	142.589	142.589	136.648	4366.186	9405.510	2.15	17771.351	66822.47	3.76

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	14869.041	4660.272	1449.594	119.633	187.821	105.888	174.077	187.821	105.888	5244.434	9582.653	1.83	21605.782	68872.26	3.19
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	15261.431	3389.818	257.599	127.152	176.751	124.709	174.309	176.751	124.709	5244.434	9582.653	1.83	21605.782	68872.26	3.19
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	18076.808	679.320	0.000	173.566	183.506	173.566	183.506	183.506	173.566	4785.261	12025.889	2.51	20871.774	83530.57	4.00
Case 6 : DL+SIDL+LL- (Maximum Reaction Case)-Long. Seismic Dry Case	18316.549	1624.307	449.644	171.152	194.919	166.889	190.656	194.919	166.889	4785.261	12025.889	2.51	20871.774	83530.57	4.00
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	14136.387	303.482	0.000	137.398	141.839	137.398	141.839	141.839	137.398	4366.186	9405.510	2.15	17771.351	66674.45	3.75
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	14282.918	1154.326	289.919	133.995	150.885	131.246	148.136	150.885	131.246	4366.186	9405.510	2.15	17771.351	66677.49	3.75
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	18076.808	679.320	0.000	173.566	183.506	173.566	183.506	183.506	173.566	4785.261	12025.889	2.51	20871.774	83530.57	4.00
Case 10 : DL+SIDL+LL- (Maximum Reaction Case)-Trans. Seismic Dry Case	18316.549	1290.954	782.998	175.172	194.061	167.748	186.637	194.061	167.748	4785.261	12025.889	2.51	20871.774	83530.57	4.00
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	14136.387	303.482	0.000	137.398	141.839	137.398	141.839	141.839	137.398	4366.186	9405.510	2.15	17771.351	66674.45	3.75
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	14282.918	820.973	623.273	138.014	150.027	132.105	144.117	150.027	132.105	4366.186	9405.510	2.15	17771.351	66677.49	3.75
								SAFE	SAFE			SAFE			SAFE

DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
89+130

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 110 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 24.400m	24.400m
Thickness of Expansion Joint	= 0.025m	0.025m
Slab projection Beyond C/L of Bearing (Back Side) =	0.588m	0.588m
Slab projection Beyond C/L of Bearing (Span Side) =	0.000m	0.000m
Span -c/c of E.J.	= 25.000m	25.01m
Type of Superstructure	= RCC Voids Slab	
Width of Crash barrier (Both Side)	= 0.450m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on one side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

No of Bearings = 3
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m² Assumed
SBC of soil-Normal Case = 410 kN/m²
SBC of soil-Seismic Case = 513 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case
Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 1.965m	
Height of Trapering portion	= 0.546m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.575m	1.575m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m
Projection of Abutment Cap (Span Side)	=	0.150m	0.150m
Projection of Abutment Cap Back Side	=	0.425m	0.425m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.000m	1.000m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	5.700m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	1.000m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	10.000m	
abutment pedestal width	=	1.000m	
abutment pedestal Height	=	1.500m	
Width of Toe Slab	=	3.300m	
Width of Heel Slab	=	5.700m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.500m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.500m	
Width of backfill on heel slab	=	5.700m	
Thickness of heel slab at back fill edge	=	1.500m	
Height of back fill at bottom edge of heel slab	=	11.001m	
Height of back fill at back fill edge of heel slab	=	10.001m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1198.000m
Deck level at Outer Edge =	1198.403m
Deck level at center line =	1198.000m
Soffit Level at center of bridge =	1196.435m
Abutment cap top level =	1195.690m
Abutment cap bottom lvl (uniform portion ends)	1195.390m
Abutment cap bottom lvl (corbel portion ends)	1195.090m
Abutment shaft top level =	1195.090m
Ground level/LBL =	1189.725m
Abutment shaft bottom level =	1188.200m
Foundation level =	1186.700m
HFL	= 1191.725m

Cross Slope (Bi-directional)	=	7.000%
Height of Superstructure	=	1.500m
Min. Height of Footpath Side Pedestal (1)	=	0.500m
Height of Pedestal (2)	=	0.710m
Height of Pedestal (3)	=	0.710m
Height of Pedestal (4)	=	0.000m
Height of Pedestal (5)	=	0.000m
Height of Pedestal (6)	=	0.000m
Distance of nearest girder to c.l. of deck	=	0.000m
Height (Avg.) of Dirt Wall	=	2.511m
Abutment shaft Above G.L	=	5.365m
Abutment Shaft below G.L	=	1.525m
Height of abutment shaft	=	6.890m
MSL	=	1188.700m
Wedge over girder flange	=	0.0700m

Material Specification

Concrete Grade	=	M 35
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)
Tensile strength of concrete , fctm	=	2.77 MPa
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02
Ultimate Strain, ϵ_{cu2}	=	0.035
Ecm	=	32308.250 N/mm ²
Steel Grade	=	Fe 500D (HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa (1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa

Dry weight of Concrete	=	25 kN/m³
Dry unit weight of soil	=	20 kN/m³
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition
Maximum compressive stress in concrete under rare combination	=	0.48 fck
	=	16.8 N/mm ²
Maximum tensile stress in steel under rare combination	=	300 N/mm ²

Creep Coefficient

For Abutment Shaft	=	2 for 90 days
For Footing	=	2 for 90 days

Clear Cover to Reinforcement

Earth Face	=	75 mm
Non-Earth Face	=	50 mm

Seismic Data:

Seismic Zone	=	5
Z =Zone factor	=	0.36
I =Importance factor	=	1.2
R =Response Reduction factor	=	3 in Longitudinal direction
	=	1 In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	-0.013m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	1223.00 3.00
DL Reaction on Bearing No.-2	=	910.00 0.00
DL Reaction on Bearing No.-3	=	711.00 -3.00
DL Reaction on Bearing No.-4	=	0.00 0.00
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2844.00 0.540

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	177.000 3.00
SIDL Reaction on Bearing No.-2	=	-64.000 0.00
SIDL Reaction on Bearing No.-3	=	86.000 -3.00
SIDL Reaction on Bearing No.-4	=	0.000 0.00
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		199.00 1.372

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	151.700 3.00
SIDL Reaction on Bearing No.-2	=	65.400 0.00
SIDL Reaction on Bearing No.-3	=	95.700 -3.00
SIDL Reaction on Bearing No.-4	=	0.000 0.00
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		312.80 0.537

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW +1 Class A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1033.88	KN	Corr. Transv	=	982.185 kNm	ecc.	0.95
min	=	316.12	KN	Corr. Transv	=	300.315 kNm	ecc.	0.95

SV Loading

max	=	1881.89	KN	Corr. Transv	=	564.566 kNm	ecc.	0.30
min	=	1538.11	KN	Corr. Transv	=	461.434 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	732.68	KN	Corr. Transv	=	2311.597 kNm	ecc.	3.16
min	=	167.32	KN	Corr. Transv	=	527.903 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.074
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.074
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.500 x	0.800 x	0.800 =	0.3200 m ³	3.000
Pedestal 2	=	0.710 x	0.800 x	0.800 =	0.4544 m ³	0.000
Pedestal 3	=	0.710 x	0.800 x	0.800 =	0.4544 m ³	-3.000
Pedestal 4	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.2288 m ³	-0.328

VOLUME CALCULATION

C.G. Of Footing = 5.000 m
 C.G. Of shaft from toe tip = 3.800 m
 Distance between c.g. of shaft and footing = 1.200 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.965	7.369	-0.775	0.425	-4.575	0.000
-Trapering portion	1	12.50	0.300	0.546	2.048	-0.775	0.425	-4.575	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.075	0.125	-4.875	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.025	0.175	-4.825	0.000
Cap (uniform portion)	1	12.50	1.575	0.300	5.906	-0.138	1.063	-3.938	0.000
Cap (Corbel Portion)	1	12.50	1.575	0.300	4.787	-0.138	1.063	-3.938	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.000	3.365	42.063	0.000	1.200	-3.800	0.000
Shaft below HFL	1	12.50	1.000	3.025	37.812	0.000	1.200	-3.800	0.000
Solid Return Wall	2	5.70	0.750	10.702	91.506	-3.350	-2.150	-7.150	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.700	-4.300	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.700	-4.300	0.000
Footing									
Heel Slab	1	12.50	5.700	1.000	71.250		-1.675	-6.675	0.000
Toe Slab	1	12.50	3.300	1.000	41.250		3.075	-1.925	0.000
Portion between Heel and Toe	1	12.50	1.000	1.500	18.750		1.200	-3.800	0.000
Back filling above HFL over Heel Slab	1	12.50	5.700	6.275	447.094		-2.150	-7.150	0.000
Back filling below HFL over Heel Slab	1	12.50	5.700	4.025	286.781		-2.268	-7.268	0.000
Backfill above Heel slab	1	12.50	5.700	10.501	748.214		-2.195	-7.195	0.000
Front Filling over Toe Slab	1	12.50	3.300	2.025	83.531		3.214	-1.786	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.300	1.000	41.250		1.875	-3.125	0.000
Side filling between heel and toe	1	0.00	1.000	2.025	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.075	0.125	-4.875	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.000	6.275	0.000		0.000	0.000	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.000	4.025	0.000		0.000	0.000	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN		-0.775	0.425	-4.575

SECTIONAL PROPERTIES

Width of Footing (B) = 10.000 m
 Length of Footing (L) = 12.500 m

A = 10.000 x 12.500 = 125.000 m²
 ZL = 12.500 x 16.667 = 208.333 m³
 ZT = IT1 + IT2

distance of extreme point from centre

IT1 = 10.000 x 162.760 = 1627.60 m⁴
 IT2 (moment of inertia of triangle) = 10.000 x 0.000 + 0.500 x 10.000 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1627.60 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 260.417 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 9.490 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 11.030 m

Abutment Cap Top Level - Foundation Level

= 8.990 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.00 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 0.781 m^4

Moment of Inertia , $I_{\text{transverse}}$ = 162.760 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 96.194 KN
 D = 3355.80 KN
 T = 0.3736 sec

Transverse Direction

Force = 16198.584 KN
 D = 3625.800 KN
 T = 0.0299 sec

For Hard or Rocky Strata, with $N > 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.449

For Medium Strata, with $N > 10 \& N < 30$

$\frac{S_a}{g}$ = 2.500

$\frac{S_a}{g}$ = 1.449

For Soft Soil Strata, with $N < 10$

$\frac{S_a}{g}$ = 2.5

$\frac{S_a}{g}$ = 1.449

Medium Soil Strata

S_a/g = 2.5

S_a/g = 1.449

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.313

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.313	In Transverse direction
Av	=	0.209	In Vertical direction

For Design of Foundation

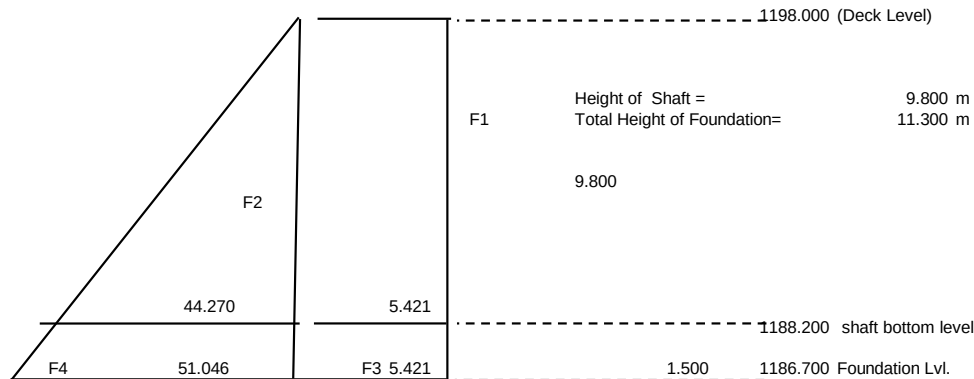
(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.313	In Transverse direction
Av	=	0.209	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1188.200 m (at Shaft Base)		
@ RL					1186.700 m (at Foundation Level)		
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m ²
F1	=	5.421	x	9.800	x	12.500	= 664.049 kN
M1	=	664.05	x	4.90	=	3253.839	kN.m at Shaft Bottom
F3	=	5.421	x	11.300	x	12.500	= 765.689 kN
M3	=	765.689	x	5.650	=	4326.143	kN.m at Foundation

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
	=	0.226	x	20	x	9.800	= 44.270 kN/m ²
F2	=	0.5	x	44.27	x	9.800	x 12.50
	=	2711.533	kN				

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)

M2	=	2711.53	x	4.12	=	11160.669	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.226	x	20	x	11.300	= 51.046 kN/m ²
F4	=	0.5	x	51.05	x	11.300	x 12.50
	=	3605.119	kN				
M4	=	3605.12	x	4.75	=	17109.894	kN.m at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014				γ fluid	=	4.8	kN/m ³
Intensity for triangular portion (At Shaft bottom level)							
	=	4.800	x	9.800	=	47.040	kN/m ²
F	=	0.5	x	47.040	x	9.800	x 12.500
	=	2881.200	kN				
M	=	2881.20	x	3.267	=	9411.920	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	4.800	x	11.300	=	54.24	kN/m ²
F	=	0.5	x	54.240	x	11.30	x 12.500
	=	3830.700	kN				
M	=	3830.70	x	3.767	=	14428.970	kN.m at Foundation

Intensity of Passive pressure

$$\begin{aligned}
 &= 5.249 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2 \\
 \text{Force due to passive @ Foundation, F} &= 0.5 \times 0.000 \times 12.50 \\
 &= \mathbf{0.000 \text{ kN}}
 \end{aligned}$$

Moment due to passive @ Foundation, M

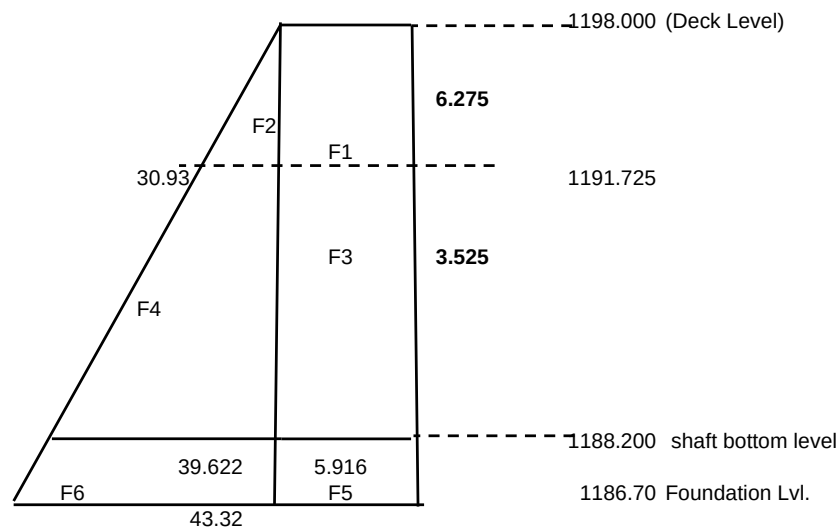
$$= 0.000 \times 0.000 = \mathbf{0.000 \text{ kN.m} \text{ at Foundation}}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	11160.669	17109.894	2711.533	3605.119
Due to Minimum Fluid Pressure	9411.920	14428.970	2881.200	3830.700
Governing of Two	11160.669	17109.894	2881.200	3830.700
Due to Live Load Surcharge	3253.839	4326.143	664.049	765.689
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246	active component
	Kp'	=	5.249	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1188.2 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	9.800	x	12.500	=	724.652 kN
M1	=	724.65	x	4.90	=	3550.795 kN.m		at Shaft Bottom
F3	=	5.916	x	11.300	x	12.500	=	835.568 kN
M3	=	835.57	x	5.65	=	4720.960 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	6.275	=	30.933 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.525	=	8.688 kN/m ²
F2	=	0.5	x	30.93	x	6.275	x	12.50
	=	1213.164 kN						
F4	=	(30.93 + 39.62)	x	3.52	x	12.50		
	=	1554.414 kN						
Total Force	=	2767.579 kN						
M2	=	1213.16	x	6.16	=	7473.699 kN.m		
M4	=	1554.41	x	1.69	=	2627.198 kN.m		

Total Moment = 10100.90 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 6.275 = 30.933 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.025 = 12.386 \text{ kN/m}^2$$

$$\text{F2} = 0.5 \times 30.93 \times 6.275 = 12.50$$

$$= 1213.164 \text{ kN}$$

$$\text{F6} = \left(\frac{30.93 + 43.32}{2} \right) \times 5.02 \times 12.50$$

$$= 2331.982 \text{ kN}$$

Total Force = 3545.147 kN

$$\text{M2} = 1213.16 \times 7.66 = 9293.445 \text{ kN.m}$$

$$\text{M6} = 2331.98 \times 2.37 = 5533.330 \text{ kN.m}$$

Total Moment = 14826.77 kN.m Foundation Lvl.

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	10100.896	14826.775	2767.579	3545.147
Due to Minimum Fluid Pressure	9411.920	14428.970	2881.200	3830.700
Governing of Two	10100.896	14826.775	2881.200	3830.700
Due to Live Load Surcharge	3550.795	4720.960	724.652	835.568
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

αh	=	0.180	
αv	=	0.209	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.148 \\ 0.224 \end{matrix}$$

$$C_a = \begin{matrix} 1 \\ 0.381 \end{matrix} \begin{matrix} 2 \\ 0.298 \end{matrix}$$

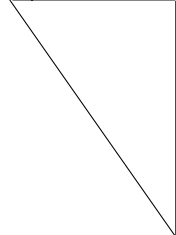
Ca	=	0.381	0.298	
Ka	=	0.226		
Dynamic Increment	=	0.381	-0.226	0.155

3 Earth Pressure : DRY CASE (Seismic case)

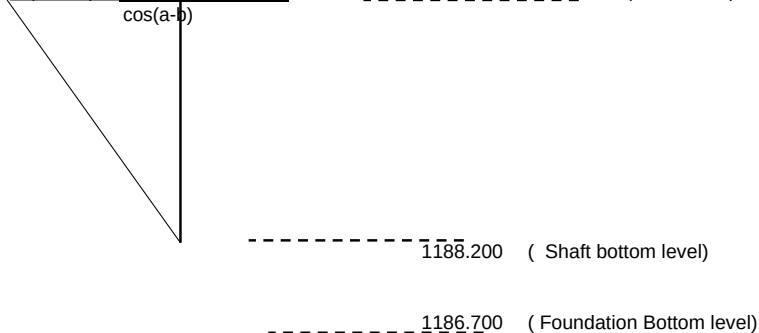
Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

Active Earth Pressure

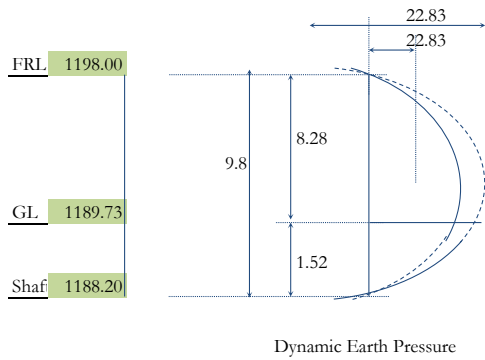
$$3 (Ca - Ka) = 0.466$$

**Surcharge Earth Pressure**

$$2 (Ca - Ka) \frac{\cos \alpha}{\cos(\alpha - \beta)} = 0.31$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.311	x	20.00	x	1.2	=	7.455 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.455	x	9.800	x	12.500
	=	456.646	kN					
M1	=	456.646	x	6.566			=	2998.340 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.455	x	9.800	x	12.500
	=	456.646	kN					
M2	=	456.646	x	8.066			=	3683.309 kN.m

Due to Dynamic Active Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height	=	22.83 t/m ²
h	=	9.8 m
y	=	3.375 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	22.83 t/m ²
h	=	9.8 m
y	=	-3.375 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	1743.2	5.2
Parabola below Water Level	121.4	1.0
Total Dynamic Earth Pressure	1864.6	4.9

$$E3 = 1864.639 \text{ kN}$$

$$E4 = 1864.639 \text{ kN}$$

$$M3 = 1864.64 \times 4.90 = 9136.732 \text{ kN.m} \quad (\text{ Shaft bottom level})$$

$$M4 = 1864.64 \times 6.40 = 11933.691 \text{ kN.m} \quad (\text{ Foundation Bottom level})$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	11160.669	17109.894	2711.533	3605.119
Due to active Earth Pressure (dynamic Increment)	9136.732	11933.691	1864.639	1864.639
Total Earth Pressure	20297.401	29043.586	4576.172	5469.758
Due to Minimum Fluid Pressure	9411.920	14428.970	2881.200	3830.700
Governing of Two	11160.669	29043.586	4576.172	5469.758
Due to Live Load Surcharge (Static)	3253.839	4326.143	664.049	765.689
Due to Live Load Surcharge(Dynamic)	2998.340	3683.309	456.646	456.646
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

αh	=	0.180			
αv	=	0.209			
ϕ	=	35.00		0.611	
δ	=	11.25		0.196	
α	=	0.00		0.000	
β	=	0.00		0.000	
W_s	=	20.00	Kn/m3	2.00	gm/cm3
λ	=	$\tan^{-1} \frac{W_s}{W_s - 1}$		$\frac{\alpha h}{(1 \pm \alpha v)}$	=
					0.289
					0.427
C_a'	=	0.554		0.515	
Ca'	=			0.554	
Ka'	=			0.246	
Dynamic Increment	=	0.554		-0.246	0.307
Dynamic Increment	=			0.307	
γ_d	=			20	kN/m ³
γ_{sat}	=			10	kN/m ³
γ_{water}	=			10	kN/m ³
Equivalent Live Load Surcharge height	=			1.2	m
Foundation	=			10.00	m
Dynamic Active earth pressure Variation					
$3 (ca' - ka')$					
Dynamic Surcharge earth pressure Variation					
$2 (Ca' - Ka')$					
$\frac{\cos a}{\cos(a-b)}$					
					1198.000 (Deck Level)
					6.275
					1191.725 HFL
					5.025
					3.525
					1188.200 shaft bottom level
					1186.7 Foundation Bottom Lvl.

Earth Pressure Diagram

h'	=	3.525
h	=	9.800

Dynamic active earth pressure		
$3 (ca - ka)$	=	0.466 at deck level
$3 (ca' - ka')$	=	0.922 at deck level
$3 (ca' - ka')h'/h$	=	0.332 at HFL level

Dynamic Surcharge earth pressure				
$2 (Ca' - Ka')$	$\frac{\cos a}{\cos(a-b)}$	=	0.615 at deck level	Pressure = 14.75 kN/m ²
		=	0.221 at HFL level	Pressure = 5.30 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level = 7.455 kN/m²
 Dynamic surcharge pressure in Submerge condition at HFL level = 5.30 kN/m²

at Shaft Bottom Level

F1 = 6.380 x 6.275 x 12.500 = **500.442 kN**

M1 = 500.44 x 6.66 = **3334.192 kN.m**

F2 = 0.50 x 5.305 x 3.525 x 12.500
 = **116.872 kN**

M2 = 116.87 x 2.36 = **276.022 kN.m**

Total Force at Abutment shaft level = 617.313 kN

Total Moment at Abutment shaft level = 3610.214 kN.m

at Foundation Bottom Level

F3 = 6.380 x 6.275 x 12.500 = **500.442 kN**

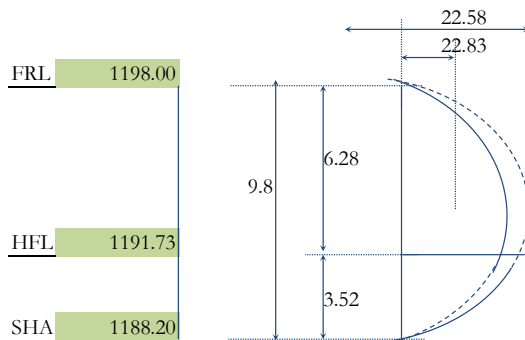
M3 = 500.44 x 8.16 = **4084.855 kN.m**

F4 = 0.500 x 5.305 x 3.525 x 12.500
 = **116.872 kN**

M4 = 116.87 x 3.86 = **451.329 kN.m**

Total Force at Founding level = 617.313 kN

Total Moment at Founding level = 4536.184 kN.m

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation**Parabola above Water Level**

p_{mid_height} = 22.83 t/m²
 h = 9.8 m
 y = 1.375 m
 L = 12.500 m

Parabola below Water Level

p_{mid_height} = 22.58 t/m²
 h = 9.8 m
 y = -1.375 m
 L = 12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1314.4	6.0
Parabola below Water Level	544.2	2.3
Total Dynamic Earth Pressure	1858.6	4.9

Total Force (F1 + F2)	=	1858.633 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	1858.633 kN	at Foundation Bottom Level

M1 = 1858.63 x 4.91 = **9123.175 kN.m**

Total Mome = 9123.175 kN.m at Shaft Bottom

$$M1 = 1858.63 \times 6.41 = 11911.125 \text{ kN.m}$$

Total Mome = 11911.125 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	10100.896	14826.775	2767.579	3545.147
Due to active Earth Pressure (Dynamic Increment)	9123.175	11911.125	1858.633	1858.633
Total Earth Pressure	19224.071	26737.900	4626.212	5403.780
Due to Minimum Fluid Pressure	9411.920	14428.970	2881.200	3830.700
Governing of Two	19224.071	26737.900	4626.212	5403.780
Due to Live Load Surcharge(Static)	3550.795	4720.960	724.652	835.568
Due to Live Load Surcharge (Dynamic Increment)	3610.214	4536.184	617.313	617.313
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2844.00	1.35	1.35	3839.40	3839.40	
SIDL except wc	=	199.00	1.35	1.35	268.65	268.65	
WC	=	312.80	1.75	1.75	547.40	547.40	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1033.88	1.5	0.20	1550.82	206.78	(1-70RW +1 Class A)
CWLLmax-Reaction case	=	1881.89	1	0.20	1881.89	376.38	SV Loading
CWLLmin	=	316.12	1.5	0.20	474.18	63.22	(1-70RW +1 Class A)
CWLLmin	=	1538.11	1	0.20	1538.11	307.62	SV Loading
CWLLmax-Transv. Moment Case		732.68	1.5	0.20	1099.02	146.54	(1-70RW)

Braking Force = 0.2 x 1000 + 0.05 x 554
 = 0 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	4655.45	0	232.773	232.773	-232.773	232.773	
DL+SIDL+LL-Max Reaction case	5129.63	0	256.482	256.482	-256.482	256.482	(1-70RW +1 Class A)
	6667.75	0	333.387	333.387	-333.387	333.387	SV Loading
DL+SIDL+LL-Min Reaction case	6206.27	0	310.313	310.313	-310.313	310.313	(1-70RW +1 Class A)
	6537.34	0	326.867	326.867	-326.867	326.867	SV Loading
DL+SIDL+LL-Max Transv. Moment case	5754.47	0	287.723	287.723	-287.723	287.723	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	4655.45	0.00	232.773	232.773	-232.773	232.773	
DL+SIDL+LL-Max Reaction case		4718.67	0.00	235.934	235.934	-235.934	235.934	Dry Case
DL+SIDL+LL-Min Reaction case		4862.23	0.00	243.111	243.111	-243.111	243.111	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4801.99	0.00	240.099	240.099	-240.099	240.099	

Transverse Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	4655.45	0.000	232.773	232.773	-232.773	232.773	
DL+SIDL+LL-Max Reaction case		4718.67	0.000	235.934	235.934	-235.934	235.934	Dry Case

DL+SIDL+LL-Min Reaction case		4862.23	0.000	243.111	243.111	-243.111	243.111	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4801.99	0.000	240.099	240.099	-240.099	240.099	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2844.00	1.35	1.35	3839.40	3839.40
SIDL except wc	=	199.00	1.35	1.35	268.65	268.65
WC	=	312.80	1.75	1.75	547.40	547.40
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	1033.88	1.5	0.75	1550.82	775.41
CWLLmax- Transv. Moment Case	=	732.68	1.5	0.75	1099.02	549.51
CWLLmin	=	316.12	1.5	0.75	474.18	237.09

Braking Force = 0 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	4655.45	0.000	232.773	232.773	-232.773	232.773	
DL+SIDL+LL-Max Reaction case	5129.63	0.000	256.482	256.482	-256.482	256.482	(1-70RW +1 Class A)
	6667.75	0.000	333.387	333.387	-333.387	333.387	SV Loading
DL+SIDL+LL-Min Reaction case	6206.27	0.000	310.313	310.313	-310.313	310.313	(1-70RW +1 Class A)
	6537.34	0.000	326.867	326.867	-326.867	326.867	SV Loading
DL+SIDL+LL-Max Transv. Moment case	5754.47	0.000	287.723	287.723	-287.723	287.723	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	4655.45	0.00	232.773	232.773	-232.773	232.773	
DL+SIDL+LL-Max Reaction case		4892.54	0.00	244.627	244.627	-244.627	244.627	Dry Case
DL+SIDL+LL-Min Reaction case		5430.86	0.00	271.543	271.543	-271.543	271.543	HFL Case
DL+SIDL+LL-Max Transv. Moment case		5204.96	0.00	260.248	260.248	-260.248	260.248	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	$F_h/2 + \mu R$	$F_h - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	4655.45	0.000	232.773	232.773	-232.773	232.773	
DL+SIDL+LL-Max Reaction case		4892.54	0.000	244.627	244.627	-244.627	244.627	Dry Case

DL+SIDL+LL-Min Reaction case		5430.86	0.000	271.543	271.543	-271.543	271.543	HFL Case
DL+SIDL+LL-Max Transv. Moment case		5204.96	0.000	260.248	260.248	-260.248	260.248	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2844.00	1	1.00	2844.00	2844.00
SIDL except wc	=	199.00	1	1.00	199.00	199.00
WC	=	312.80	1	1.00	312.80	312.80
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	1033.88	1	0.20	1033.88	206.78
CWLLmax- Transv. Moment Case		732.68	1	0.20	732.68	146.54
CWLLmin	=	316.12	1	0.20	316.12	63.22

Braking Force = 0 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	0.000	167.790	167.790	-167.790	167.790	
DL+SIDL+LL-Max Reaction case	3671.92	0.000	183.596	183.596	-183.596	183.596	(1-70RW +1 Class A)
	4893.91	0.000	244.696	244.696	-244.696	244.696	SV Loading
DL+SIDL+LL-Min Reaction case	4389.68	0.000	219.484	219.484	-219.484	219.484	(1-70RW +1 Class A)
	5237.69	0.000	261.884	261.884	-261.884	261.884	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4088.48	0.000	204.424	204.424	-204.424	204.424	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	1630.919	167.790	983.249	1463.129	1630.919	
DL+SIDL+LL-Max Reaction case	3419.02	1630.919	170.951	986.411	1459.968	1630.919	Dry Case
DL+SIDL+LL-Min Reaction case	3562.58	1630.919	178.129	993.588	1452.790	1630.919	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3502.34	1630.919	175.117	990.576	1455.802	1630.919	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	489.276	167.790	412.428	321.486	489.276	
DL+SIDL+LL-Max Reaction case	3419.02	489.276	170.951	415.589	318.324	489.276	Dry Case
DL+SIDL+LL-Min Reaction case	3562.58	489.276	178.129	422.767	311.147	489.276	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3502.34	489.276	175.117	419.755	314.159	489.276	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2844.00	1.1	1.10	3128.40	3128.40
SIDL except wc	=	199.00	1.1	1.10	218.90	218.90
WC	=	312.80	1.35	1.35	422.28	422.28
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1033.88	1.5	0.00	1550.82	0.00
CWLLmax- Transv. Moment Case		732.68	1.5	0.00	1099.02	0.00
CWLLmin	=	316.12	1.5	0.00	474.18	0.00

Braking Force = 0 KN

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3769.58	0.000	188.479	188.479	-188.479	188.479	
DL+SIDL+LL-Max Reaction case	4243.76	0.000	212.188	212.188	-212.188	212.188	(1-70RW +1 Class A)
	5307.69	0.000	265.385	265.385	-265.385	265.385	SV Loading
DL+SIDL+LL-Min Reaction case	5320.40	0.000	266.020	266.020	-266.020	266.020	(1-70RW +1 Class A)
	5651.47	0.000	282.573	282.573	-282.573	282.573	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4868.60	0.000	243.430	243.430	-243.430	243.430	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	3769.58	0.00	188.479	188.479	-188.479	188.479	
DL+SIDL+LL-Max Reaction case		3769.58	0.00	188.479	188.479	-188.479	188.479	Dry Case
DL+SIDL+LL-Min Reaction case		3769.58	0.00	188.479	188.479	-188.479	188.479	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3769.58	0.00	188.479	188.479	-188.479	188.479	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3355.80	3769.58	0.000	188.479	188.479	-188.479	188.479	
DL+SIDL+LL-Max Reaction case		3769.58	0.000	188.479	188.479	-188.479	188.479	Dry Case
DL+SIDL+LL-Min Reaction case		3769.58	0.000	188.479	188.479	-188.479	188.479	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3769.58	0.000	188.479	188.479	-188.479	188.479	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2844.00	1	1	1	2844.00	2844.00	2844.00
SIDL except wc	=	199.00	1	1	1	199.00	199.00	199.00
WC	=	312.80	1.20	1.20	1.20	375.36	375.36	375.36
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	1033.88	1	0.75	0	1033.88	775.41	0.00
CWLLmax-Transv. Moment Case	=	732.68	1	0.75	0	732.68	549.51	0.00
CWLLmin	=	316.12	1	0.75	0	316.12	237.09	0.00

Braking Force = 0 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3418.36	0.000	170.918	170.918	-170.918	170.918	
DL+SIDL+LL-Max Reaction case	3734.48	0.000	186.724	186.724	-186.724	186.724	(1-70RW +1 Class A)
	4956.47	0.000	247.824	247.824	-247.824	247.824	SV Loading
DL+SIDL+LL-Min Reaction case	4452.24	0.000	222.612	222.612	-222.612	222.612	(1-70RW +1 Class A)
	5300.25	0.000	265.012	265.012	-265.012	265.012	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4151.04	0.000	207.552	207.552	-207.552	207.552	

Dry Case

HFL Case

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3418.36	0.000	170.918	170.918	-170.918	170.918	
DL+SIDL+LL-Max Reaction case	3655.45	0.000	182.773	182.773	-182.773	182.773	Dry Case
DL+SIDL+LL-Min Reaction case	4193.77	0.000	209.688	209.688	-209.688	209.688	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3967.87	0.000	198.393	198.393	-198.393	198.393	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3418.36	0.000	170.918	170.918	-170.918	170.918	
DL+SIDL+LL-Max Reaction case	3418.36	0.000	170.918	170.918	-170.918	170.918	Dry Case
DL+SIDL+LL-Min Reaction case	3418.36	0.000	170.918	170.918	-170.918	170.918	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3418.36	0.000	170.918	170.918	-170.918	170.918	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1033.88	kN	1033.88	kN
Radius of Curvature	R	=	110.00	m	110.00	m
CENTRIFUGAL FORCE	C	=	118.41	kN	118.41	kN

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1186.700 m

Properties of Footing Base:

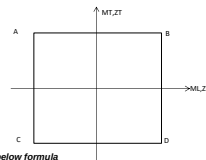
A	=	125.000	m ²
ZL	=	208.333	m ³
ZT	=	260.417	m ³

For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			2844.000	1.188	3377.250	0.540	1536.000
SIDL except Wearing Course	1			199.000	1.188	236.313	1.372	273.000
Wearing Course	1			312.800	1.188	371.450	0.537	168.000
Bearing Pedestal	1	25	1.229	30.720	1.188	36.480	-0.328	-10.080
				3386.520		4021.493		1966.920
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	7.369	184.219	0.425	78.293	0.000	0.000
Dirt Wall-Tapered portion	1	25	2.048	51.211	0.425	21.765	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.125	3.516	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.175	2.461	0.000	0.000
Cap - (uniform portion)	1	25	5.906	147.656	1.063	156.885	0.000	0.000
Cap - (corbel portion)	1	25	4.787	119.687	1.063	127.168	0.000	0.000
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.700	0.000	0.000	0.000
Cantilever Return Wall-Triangle por	1	25	0.000	0.000	0.700	0.000	0.000	0.000
RCC Railings or Crash Barrier	1			28.000	0.425	11.900	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.125	20.508	0.000	0.000
				737.023		422.494		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	91.506	2287.659	-2.150	-4918.468	0.000	0.000
Abutment Shaft	1	25	79.875	1996.875	1.200	2396.250	0.000	0.000
Back filling over heel slab	1	20	748.214	14964.281	-2.195	-32850.080	0.000	0.000
Front Filling over toe slab	1	20	83.531	1670.625	3.214	5369.719	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	71.250	1781.250	-1.675	-2983.594	0.000	0.000
Toe slab	1	25	41.250	1031.250	3.075	3171.094	0.000	0.000
portion between heel & toe	1	25	18.750	468.750	1.200	562.500	0.000	0.000
Vertical Components of active earth pressure	1			1586.728	-5.000	-7933.639	0.000	0.000
				25787.419		-37186.218		0.000
Total				29910.962		-32742.231		1966.920

**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML @ toe = PxeL2 (kNm)
0.900	2559.600	-3.813	-9758.475
0.900	179.100	-3.813	-682.819
1.000	312.800	-3.813	-1192.550
0.900	27.648	-3.813	-105.408
	3079.148		-11739.252
0.900	165.797	-4.575	-758.521
0.900	46.090	-4.575	-210.861
0.900	25.313	-4.875	-123.398
0.900	12.656	-4.825	-61.066
0.900	132.891	-3.938	-523.257
0.900	107.718	-3.938	-424.141
0.900	0.000	-4.300	0.000
0.900	0.000	-4.300	0.000
0.900	25.200	-4.575	-115.290
0.900	147.656	-4.875	-719.824
	663.321		-2936.359
0.900	2058.893	-7.150	-14721.088
0.900	1797.187	-3.800	-6829.312
0.900	13467.853	-7.195	-96904.337
0.900	1503.562	-1.786	-2685.066
0.900	0.000	0.000	0.000
0.900	1603.125	-6.675	-10700.859
0.900	928.125	-1.925	-1786.641
0.900	421.875	-3.800	-1603.125
0.900	1428.055	-10.000	-14280.551
	23208.677		-149510.980
	26951.145		-164186.590

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	167.790	1196.435	1633.436
due to Earth pressure	1	3830.700		17109.894

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.479	1196.435	1834.843
due to Earth pressure	1.5	5746.050		25664.842
		5934.529		27499.685

Summary of Forces For SBC		
P	29910.962	kN
ML	-13998.901	kNm
MT	1966.920	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		29910.962		-32742.231		1966.920
CW/LL-Max. Reaction case	1	1033.879	1.188	1227.731	0.950	982.185
Vertical Components of LL Surcharge	1	317.159	-5.000	-1585.794	0.000	0.000
Total		31261.999		-33100.294		2949.105

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	183.596	1196.435	1787.308
due to Earth pressure	1	3830.700		17109.894
due to Live load surcharge	1	765.689		4326.143

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		212.188	1196.435	2065.651
due to Earth pressure	1.5	5746.050		25664.842
due to Live load surcharge	1.2	918.627		5191.371
		6877.065		32921.864

Summary of Forces For SBC		
P	31261.999	kN
ML	-9576.949	kNm
MT	2949.105	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
167.79	1633.44	0.00	0.00
3830.70	17109.89	0.00	0.00
3998.490	18743.330	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
188.48	1834.84	0.00	0.00
5746.05	25664.84	0.00	0.00
5934.529	27499.685	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	26951.14548	-3.813	-164186.59
0.900		-10.000	-2854.43
	26951.145		-167041.02

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
183.60	1787.31	0.00	0.00
3830.70	17109.89	0.00	0.00
765.689	4326.143	0.000	0.000
4779.99	23223.34	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
212.19	2065.65	0.00	0.00
5746.05	25664.84	0.00	0.00
918.83	5191.37	0.00	0.00
6877.065	32921.864	0.000	0.000

Case 3 : DL+SIDL-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				3386.520		4021.493		1966.920
Substructure & Foundation -Portion 1				737.023		422.494		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	91.506	2287.659	-2.150	-4918.468	0.000	0.000
Shaft above HFL	1	25	42.063	1051.563	1.200	1261.875	0.000	0.000
Shaft below HFL	1	15	37.812	567.187	1.200	680.625	0.000	0.000
Back filling above HFL over heel sla	1	20	447.094	8941.875	-2.150	-19225.031	0.000	0.000
Back filling below HFL over heel sla	1	10	286.781	2867.812	-2.268	-6504.234	0.000	0.000
Front Filling over toe slab	1	10	83.531	835.312	1.875	1566.211	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	71.250	1068.750	-1.675	-1190.156	0.000	0.000
Toe slab	1	15	41.250	618.750	3.075	1902.656	0.000	0.000
Portion between Heel & Toe	1	15	18.750	281.250	1.200	337.500	0.000	0.000
Vertical Components of active earth pressure	1			1586.728	-5.000	-7933.639	0.000	0.000
				20106.887		-34622.662		0.000
Total				24230.430		-30178.675		1966.920

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	167.790	1196.435	1633.436
due to Earth pressure	1	3830.700		14626.775

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.479	1196.435	1834.843
due to Earth pressure	1.5	5746.050		22240.162
		5934.529		24075.005

Summary of Forces For SBC

P	24230.430	kN
ML	-13718.464	kNm
MT	1966.920	kNm

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	3079.148		-11739.252
	663.321		-2936.359
0.900	2058.893	-7.150	-14721.088
0.900	946.406	-3.800	-3596.344
0.900	510.469	-3.800	-1939.781
0.900	8047.688	-7.150	-57540.966
0.900	2581.031	-7.268	-18758.967
0.900	751.781	-3.125	-2349.316
0.900	0.000	0.000	0.000
0.900	961.875	-6.675	-6420.516
0.900	556.875	-1.925	-1071.984
0.900	253.125	-3.800	-961.875
0.900	1428.055	-10.000	-14280.551
	18096.199		-121641.388
	21838.667		-136316.999

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
167.79	1833.44	0.00	0.00
3830.70	14626.77	0.00	0.00
3998.49	16460.21	0.00	0.00

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
188.48	1834.84	0.00	0.00
5746.05	22240.16	0.00	0.00
5934.53	24075.01	0.00	0.00

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		24230.430		-30178.675		1966.920
CWLL-Min. Reaction case	1	316.121	1.188	375.394	0.950	300.315
Vertical Components of LL Surcharge	1	346.104	-5.000	-1730.518	0.000	0.000
Total		24892.655		-31533.799		2267.235

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN	Long. Ecc. (eL2) @ Toe (m)	ML @ toe = PxeL2 (kNm)
0.000	21838.667	0.000	-136316.999
0.900	311.493	-10.000	-3114.933
	22150.161		-139431.932

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	219.484	1198.435	2136.676
due to Earth pressure	1	3830.700		14826.775
due to Live load surcharge	1	835.568		4720.960

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
219.48	2136.68	0.00	0.00
3830.70	14826.77	0.00	0.00
835.568	4720.960	0.000	0.000
4885.75	21684.41	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		266.020	1196.435	2589.704
due to Earth pressure	1.5	5746.050		22240.162
due to live load surcharge	1.2	1002.682		5665.152
		7014.752		30495.018

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
266.02	2589.70	0.00	0.00
5746.05	22240.16	0.00	0.00
1002.682	5665.152	0.000	0.000
7014.75	30495.02	0.00	0.00

Summary of Forces For SBC

P	24892.655	kN
ML	-9849.388	kNm
MT	2267.235	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.243	In Longitudinal direction	Weight of shaft below Ground level	=	476.562 KN
		ah=	0.313	In Transverse direction	Weight of back fill below Ground level	=	2173.125 KN
		av=	0.209	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN	FL = ah x P (kN)	FT = 0.3 x av x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			2844.000		267.007	178.005	1.188	3377.250	211.381	1197.435		0.540	1536.000	2866.322
SIDL except Wearing Course	1			199.000		18.683	12.455	1.188	236.313	14.791	1198.449		1.372	273.000	219.505
Wearing Course	1			312.800		29.367	19.578	1.188	371.450	23.249	1198.000		0.537	168.000	331.847
Bearing Pedestal	1	25	1.229	30.720		2.884	1.923	1.188	36.480	2.283			-0.328	-10.880	
				3386.520		317.941	211.961		4021.493	251.704				1966.920	3417.674
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	7.369	184.219	44.765	17.295	11.530	0.425	78.293	4.900	1197.018	461.864	0.000	0.000	178.444
Dirt Wall-Tapered portion	1	25	2.048	51.211	12.444	4.808	3.205	0.425	21.765	1.362	1195.762	112.768	0.000	0.000	43.569
Bracket - Uniform portion	1	25	1.125	28.125			0.125	0.125	3.516						
Bracket - Tapered portion	1	25	0.563	14.063			0.175	0.175	2.461						
Cap - (uniform portion)	1	25	5.906	147.656	35.880	13.863	9.242	1.063	156.885	9.819	1195.540	317.183	0.000	0.000	122.546
Cap - (corbel portion)	1	25	4.787	119.687	29.084	11.237	7.491	1.063	127.168	7.959	1195.240	248.377	0.000	0.000	95.962
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.000	0.000	0.700	0.000	0.000	0.000	1198.403	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle port	1	25	0.000	0.000	0.000	0.000	0.700	0.000	0.000	0.000	1198.403	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000			0.425	11.900					0.000	0.000	
Approach Slab	1	25	6.563	164.063			0.125	20.508					0.000	0.000	
				737.023	122.174	47.203	31.468		422.494	24.041		1140.193		0.000	440.520
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	91.506	2287.659	555.901	214.775	143.184	-2.150	-4918.468	-307.845	1192.749	3362.855	0.000	0.000	1299.257
Abutment Shaft	1	25	79.875	1996.875	369.436	142.734	95.156	1.200	2396.250	114.187	1192.408	2108.556	0.000	0.000	814.652
Back filling over heel slab	1	20	748.214	14964.281	0.000	0.000	0.000	-2.195	-32850.080	0.000	1192.749	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	83.531	1670.625			3.214	0.000	5369.719				0.000	0.000	
Heel slab	1	25	0.000	0.000			0.000	0.000	0.000				0.000	0.000	
Toe slab	1	25	71.250	1781.250			1.675	-1.675	-2983.594				0.000	0.000	
portion between heel & toe	1	25	41.250	1031.250			3.075	3171.094					0.000	0.000	
Vertical component of active earth pressure	1			1493.289			-5.000	-7466.446					0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			772.359			-5.000	-3861.794					0.000	0.000	
				26466.339	925.337	357.509	238.339		-40580.819	-193.658		5471.411		0.000	2113.909
Total =				30589.882	1047.511	722.653	481.769		-36136.832	82.087		6611.604		1966.920	5972.103

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.9			2559.600	160.204	-3.813	-9758.475	-610.779
SIDL except Wearing Course	0.9			179.100	11.210	-3.813	-682.819	-42.737
Wearing Course	1.00			312.800	19.578	-3.813	-1192.550	-74.641
Bearing Pedestal	0.9	25	1.2288	27.648		-3.813	-105.408	
				3079.148	190.992		-11739.252	-728.157
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	7.369	165.797	10.377	-4.575	-758.521	-47.475
Dirt Wall-Tapered portion	0.9	25	2.048	46.080	2.885	-4.575	-210.861	-13.198
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	5.906	132.891	8.318	-3.938	-523.257	-32.750
Cap - (corbel portion)	0.9	25	4.787	107.718	6.742	-3.938	-424.141	-26.547
Cantilever Return Wall-Rectangle p	0.9	25	0.000	0.000	0.000	-4.300	0.000	0.000
Cantilever Return Wall-Triangle port	0.9	25	0.000	0.000	0.000	-4.300	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-4.575	-115.290	
Approach Slab	0.9	25	6.563	147.656		-4.575	-710.924	
				663.321	28.322		-2751.894	-119.970
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	79.875	1797.187	82.657	-3.800	-6829.312	-314.098
Solid Return wall	0.9	25	91.506	2058.893	128.865	-7.150	-14721.088	-921.387
Back filling over heel slab	0.9	20	748.214	13467.853	0.000	-7.195	-96904.3	0.000
Front Filling over toe	0.9	20	83.531	1503.562		-1.786	-2685.066	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	71.250	1603.125		-6.675	-10700.859	
Toe slab	0.9	25	41.250	928.125		-1.925	-1786.641	
portion between heel & toe	0.9	25	18.750	421.875		-3.800	-1603.125	
Vertical component of active earth pressure	0.9			1428.055		-10.000	-14280.551	
Vertical component of dynamic increment of earth pressure	0.9			695.123		-10.000	-6951.230	
				23903.800	211.523		-156462.21	-1235.485
Total =				27646.268	430.836		-170953.36	-2083.613

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	44.765	1197.018	461.864
1.0	12.444	1195.762	112.768
1.0	35.880	1195.540	317.183
1.0	29.084	1195.240	248.377
1.0	0.000	1198.403	0.000
1.0	0.000	1198.403	0.000
1.0	122.174		1140.193
1.0	356.569	1192.408	2035.116
1.0	555.901	1192.749	3362.855
1.0	0.000	1192.749	0.000
	912.470		5397.971
	1034.644		6538.165

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1630.919	317.941	1196.435	15876.995	3417.674
due to Substructure	1	1047.511	404.712		6611.604	2554.429
due to Earth pressure	1	5469.758			29043.586	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1630.919	1196.435	1834.84
due to Substructure	1.5	1551.966		9807.25
due to Active Earth pressure	1	3605.119		17109.89
due to dynamic Earth pressure	1.5	2796.959		17900.54
			8142.523	46652.521

Summary of Forces For SBC

	Downward	Upward
P	31071.650	30108.113
ML	15477.439	15313.266
MT	7939.023	7939.023

Summary of Restoring Forces

Vertical Load	27215.432
Moment	-173036.968

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1630.92	15876.99	0.00	0.00	0.00	0.00	317.94	3417.67
1047.51	6611.60	0.00	0.00	0.00	0.00	404.71	2554.43
5469.76	29043.59						
8148.19	51532.18	0.00	0.00	0.00	0.00	722.65	5972.10

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1630.92	15876.99	0.00	0.00
1047.51	6611.60	0.00	0.00
3605.119	17109.894	0.000	0.000
2796.959	17900.537	0.000	0.000
8142.52	46652.52	0.00	0.00

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long, Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT1) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				3386.520		317.941	211.961		4021.493	251.704		6611.604		1966.920	3417.674
Forces from Substructure				27203.362		404.712	269.808		-40158.324	-169.617				0.000	2554.429
CWLL-Max. Reaction case	0.20			206.78		19.413	12.942	1.188	245.546	15.369	1199.200		0.950	196.437	242.663
Vertical component of LL Surcharge	0.20			63.43				-5.000	-317.159				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			37.83				-5.000	-189.149				0.000	0.000	
Total =				30897.919	1047.511	742.066	494.711		-36397.593	97.455		6611.604		2163.357	6214.766

-494.711

-97.455

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				3079.148	190.992	0.000	-11739.25	-728.157
Forces from Substructure				24567.120	239.844	0.000	-159214.10	-1355.455
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.813	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-10.000	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-10.000	0.00	
Total =				27646.268	430.836		-170953.36	-2083.613

-430.836

2083.613

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1630.919	337.264	1196.435	15876.995	3660.337
due to Substructure	1	1047.511	404.712		6611.604	2554.429
due to Earth pressure	1	5469.758			29043.586	
due to Live load surcharge	0.20	244.467			1601.890	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.479	1196.435	1834.843
due to Substructure	1.5	1551.966		9807.247
due to Active Earth pressure	1	3605.119		17109.894
due to dynamic Earth pressure	1.5	2796.959		17900.5368
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0

Summary of Forces For SBC

	Downward	Upward
P	31392.630	30403.208
ML	16833.937	16639.026
MT	8378.123	8378.123

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kNm ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				3386.520	317.941	211.961			4021.493	251.704				1966.920	3417.674
Substructure & Foundation -Portion 1				737.023	122.174	47.203	31.468		422.494	24.041		1140.193		0.000	440.520
Substructure & Foundation -Portion 2															
Solid Return wall	1		91.51	2287.66	555.901	214.775	143.184	-2.15	-4918.468	-307.845	1192.75	3362.855	0.00	0.000	1299.257
Shaft above HFL	1	25	42.063	1051.563	255.530	98.725	65.817	1.200	1261.875	78.980	1193.408	1713.965	0.000	0.000	662.200
Shaft below HFL	1	15	37.812	567.187	113.966	44.008	29.339	1.200	680.625	35.207	1190.725	458.473	0.000	0.000	177.133
Back filling above HFL over heel sla	1	20	447.094	8941.875	0.000	0.000	0.000	-2.150	-19225.031	0.000	1194.863	0.00	0.000	0.000	0.00
Back filling below HFL over heel sla	1	10	286.781	2867.812	0.000	0.000	0.000	-2.268	-6504.234	0.000	1189.588	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	83.531	835.312	0.000	0.000	0.000	1.875	1566.211	0.000		0.000	0.000	0.000	0.00
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.00
Heel slab	1	15	71.250	1068.750				-1.675	-1790.156			0.000	0.000	0.000	0.00
Toe slab	1	15	41.250	618.750				3.075	1902.656			0.000	0.000	0.000	0.00
portion between heel & toe	1	15	18.750	281.250				1.200	337.500			0.000	0.000	0.000	0.00
Vertical component of active earth pressure	1			1468.448				-5.000	-7342.239			0.000	0.000	0.000	0.00
Vertical component of dynamic increment of earth pressure	1			769.871				-5.000	-3849.356			0.000	0.000	0.000	0.00
				20758.478	925.337	357.509	238.339		-37880.617	-193.658		5535.293		0.000	2138.591
Total =				24882.022	1047.511	722.653	481.769		-33436.631	82.087		6675.486		1966.920	5996.785

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Superstructure				3079.148	190.992		-11739.252	-728.157
Substructure & Foundation -Portion 1				663.321	28.322		-2751.894	-119.970
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	91.506375	2058.893	128.865	-7.15	-14721.088	-921.387
Shaft above HFL	0.9	25	42.063	946.406	59.235	-3.800	-3696.344	-225.094
Shaft below HFL	0.9	15	37.812	510.469	23.422	-3.800	-1939.781	-89.004
Back filling above HFL over heel sla	0.9	20	447.094	8047.688	0.000	-7.150	-57540.966	0.000
Back filling below HFL over heel sla	0.9	10	286.781	2581.031	0.000	-7.268	-18758.967	0.000
Front Filling over toe	0.9	10	83.531	751.781	0.000	-3.125	-2349.316	0.000
Side filling between heel and toe	0.9	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.9	15	71.250	961.875	0.000	-6.675	-6420.516	0.000
Toe slab	0.9	15	41.250	566.875	0.000	-1.925	-1071.884	0.000
portion between heel & toe	0.9	15	18.750	253.125	0.000	-3.800	-961.875	0.000
Vertical component of active earth pressure	0.9			1321.603	0.000	-10.000	-13216.031	0.000
Vertical component of dynamic increment of earth pressure	0.9			692.884	0.000	-10.000	-6928.841	0.000
				18682.631	211.523		-127505.71	-1235.485
Total =				22425.099	430.836		-141996.85	-2083.613

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1630.919	317.941	1196.435	15876.995	3417.674
due to Substructure	1	1047.511	404.712		6675.486	2579.110
due to Earth pressure	1	5403.780			26737.300	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.479	1196.435	1834.843
due to Substructure	1.5	1551.966		9895.544
due to Active Earth pressure	1	3545.147		14826.775
due to dynamic Earth pressure	1.5	2787.950		17866.688

Summary of Forces For SBC

	Downward	Upward
P	25363.790	24400.253
ML	15935.837	15771.664
MT	7963.705	7963.705

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1630.92	15876.99	0.00	0.00	0.00	0.00	337.35	3660.34
1047.51	6611.60	0.00	0.00	0.00	0.00	404.71	2554.43
5469.76	29043.59						
244.47	1601.89						
8392.66	53134.07	0.00	0.00	0.00	0.00	742.07	6214.77

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
188.48	1834.84	0.00	0.00
1551.97	9807.25	0.00	0.00
3605.119	17109.894		
2796.959	17900.537		
0.000	0.000		
0.000	0.000		
8142.52	46652.52	0.00	0.00

Summary of Restoring Forces

Vertical Load	27215.432
Moment	-173036.968

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLS due to FL
			1140.193
1.0	555.901	1192.749	3362.855
1.0	255.530	1193.408	1713.965
1.0	101.039	1190.725	406.682
1.0	0.000	1194.863	0.000
1.0	0.000	1189.588	0.000
	912.470		5483.503
	1034.644		6623.696

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1630.92	15876.99	0.00	0.00	0.00	0.00	317.94	3417.67
1047.51	6675.49	0.00	0.00	0.00	0.00	404.71	2579.11
5403.78	26737.30						
8082.21	49290.38	0.00	0.00	0.00	0.00	722.65	5996.78

Forces along Long. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
188.48	1834.84	0.00	0.00
1551.97	9895.54	0.00	0.00
3545.147	14826.775		
2787.950	17866.688		
8073.54	44463.85	0.00	0.00

Summary of Restoring Forces

Vertical Load	21994.263
Moment	-144080.467

Case 10 : DL+SIDL+I.L.(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times av \times P$ (kN)	$M_L = P \times e_L1$	M_L s due to F_v	$M_T = P \times e_T$
Total =	30897.919	494.711	-36397.59	97.455	2163.357
		-494.711		-97.455	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	489.276	1124.514	1196.435	4763.098	12201.122
due to Substructure	1	314.253	1349.039		1983.481	8514.764
due to Earth pressure	1	5469.758			29043.586	
due to Live load surcharge	0.2	244.467			1601.890	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.48	1196.435	1834.843
due to Substructure	1.5	465.59		2942.174
due to Active Earth pressure	1	3605.12		17109.894
due to dynamic Earth pressure	1.5	839.09		5370.161
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5098.28		27257.073

Summary of Forces For SBC

	Downward	Upward
P	31392.630	30403.208
ML	1091.918	897.007
MT	22879.243	22879.243

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times av \times P$ (kN)	$M_L = P \times e_L1$	M_L s due to F_v	$M_T = P \times e_T$
Superstructure	3386.520	211.961	4021.493	251.704	1966.920
Substructure & Foundation -Portion 1	737.023	31.468	422.494	24.041	0.000
Substructure & Foundation -Portion 2	20758.478	238.339	-37880.617	-193.658	0.000
Total =	24882.022	481.769	-33436.631	82.087	1966.920
		-481.769		-82.087	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times av \times P$ (kN)	$M_L = P \times e_L2$	M_L s due to F_v
Total =	27646.268	430.836	-170953.36	-2083.613
		-430.836		2083.613

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
489.28	4763.10	0.00	0.00	0.00	0.00	1124.51	12201.12
314.25	1983.48	0.00	0.00	0.00	0.00	1349.04	8514.76
5469.76	29043.59						
244.47	1601.89						
6517.75	37392.06	0.00	0.00	0.00	0.00	2473.55	20715.89

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
188.48	1834.84	0.00	0.00
465.59	2942.17	0.00	0.00
3605.119	17109.894		
839.088	5370.161		
0.000	0.000		
0.000	0.000		
5098.28	27257.07	0.00	0.00

Summary of Restoring Forces

Vertical Load	27215.432
Moment	-173036.968

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times av \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$M_L = P \times e_L2$	M_L s due to F_v
Superstructure	3079.148	190.992		-11739.252	-728.157
Substructure & Foundation	663.321	28.322		-2751.894	-119.970
Substructure & Foundation	18682.631	211.523		-127505.709	-1235.485
Total =	22425.099	430.836		-141996.855	-2083.613
		-430.836			2083.613

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	489.28	1059.80	1196.44	4763.10	11392.25
due to Substructure	1	314.25	1349.04		2002.65	8597.03
due to Earth pressure	1	5403.78			26737.90	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.479	1196.435	1834.84
due to Substructure	1.5	465.590		2980.66
due to Active Earth pressure	1	3545.147		14826.77
due to dynamic Earth pressure	1.5	836.395		5360.01
		5035.600		25002.29

Summary of Forces For SBC

	Downward	Upward
P	23983.790	24400.253
ML	149.101	-35.073
MT	21956.202	21956.202

Summary of Restoring Forces

Vertical Load	21994.263
Moment	-144080.467

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans, Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	25065.606	485.726	-33963.35	86.786	2026.983
		-485.726		-86.786	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	22425.099	430.836		-142000.67	-2083.613
		-430.836			2083.613

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	489.276	1079.5902	1196.435	4763.098	11639.5706
due to Substructure	1	314.253	1349.0386		2002.646	8597.0348
due to Earth pressure	1	5403.780			26737.900	
due to Live load surcharge	0.2	290.576			1851.429	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		188.48	1196.435	1834.84
due to Substructure	1.5	465.59		2980.66
due to Active Earth pressure	1	3545.15		14826.77
due to dynamic Earth pressure	1.5	836.39		5360.01
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		5035.60		25002.29

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
489.28	4763.10	0.00	0.00	0.00	0.00	1059.80	11392.25
314.25	2002.65	0.00	0.00	0.00	0.00	1349.04	8597.03
5403.78	26737.90						
6207.31	33503.64	0.00	0.00	0.00	0.00	2408.84	19989.28

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
188.48	1834.84	0.00	0.00
465.59	2980.66	0.00	0.00
3545.147	14826.775		
836.385	5360.006		
5035.60	25002.29	0.00	0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
489.28	4763.10	0.00	0.00	0.00	0.00	1079.59	11639.57
314.25	2002.65	0.00	0.00	0.00	0.00	1349.04	8597.03
5403.78	26737.90						
290.58	1851.43						
6497.89	35355.07	0.00	0.00	0.00	0.00	2428.63	20236.61

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
188.48	1834.84	0.00	0.00
465.59	2980.66	0.00	0.00
3545.147	14826.775		
836.385	5360.006		
0.000	0.000		
0.000	0.000		
5035.60	25002.29	0.00	0.00

Summary of Forces For SRC			
	Downward	Upward	
P	25551.332	24579.881	kN
ML	1478.504	1304.932	kNm
MT	22263.588	22263.588	kNm

Summary of Restoring Forces	
Vertical Load	21994.263 kN
Moment	-144084.280 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	118.41	=	118.411 KN	Normal
Transverse Moment due to C.F.	=	118.411	x (	1199.603	-	1186.700	) = 1527.802 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	118.41	=	23.682 KN	Seismic
Transverse Moment due to C.F.	=	23.682	x (	1199.603	-	1186.700	) = 305.560 kNm

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
118.41	1527.80	0.00	0.00

23.68	305.56	0.00	0.00

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK		OVERTURNING CHECK			
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force = $\mu P + c_A + F_p$	FOS	Overturning moment	Restoring Moment = $\sum P_i e_i + M_D$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	29910.962	-13998.901	1966.920	314.035	179.646	298.929	164.540	314.035	164.540	5934.529	18865.802	3.18	27499.685	164186.59	5.97
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	31261.999	-8349.147	2949.105	301.496	221.345	278.847	198.696	301.496	198.696	6877.065	18865.802	2.74	32921.864	167041.02	5.07
								SAFE	SAFE			SAFE			SAFE
Normal HFL Case															
Case 3 : DL+SIDL-Normal HFL Case	24230.430	-13718.464	1966.920	267.245	135.548	252.139	120.442	267.245	120.442	5934.529	15287.067	2.58	24075.005	136317.00	5.66
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	24892.655	-8321.587	2267.235	247.791	167.904	230.379	150.491	247.791	150.491	7014.752	15505.112	2.21	30495.018	139431.93	4.57
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	31071.650	15477.439	7939.023	204.767	353.351	143.796	292.379	353.351	143.796	8142.523	19050.803	2.34	46652.521	173036.97	3.71
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	31392.630	17139.497	8378.123	201.043	365.583	136.699	301.239	365.583	136.699	8142.523	19050.803	2.34	46652.521	173036.97	3.71
								SAFE	SAFE			SAFE			SAFE

Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	25363.790	15935.837	7963.705	156.999	309.983	95.838	248.822	309.983	95.838	8073.542	15395.984	1.91	44463.850	144080.47	3.24
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	25551.332	17570.801	8097.965	151.167	319.847	88.975	257.654	319.847	88.975	8073.542	15395.984	1.91	44463.850	144084.28	3.24
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	31071.650	-264.580	21873.931	333.839	331.299	165.847	163.307	333.839	163.307	6184.651	19050.803	3.08	34122.145	173036.97	5.07
Case 10 : DL+SIDL+LL- (Maximum Reaction Case)-Trans. Seismic Dry Case	31392.630	1091.918	23184.803	334.929	345.412	156.870	167.353	345.412	156.870	5098.275	19050.803	3.74	27257.073	173036.97	6.35
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	25363.790	149.101	21956.202	286.506	287.938	117.883	119.314	287.938	117.883	5035.600	15395.984	3.06	25002.287	144080.47	5.76
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	25551.332	1478.504	22569.149	283.979	298.173	110.648	124.842	298.173	110.648	5035.600	15395.984	3.06	25002.287	144084.28	5.76
								SAFE	SAFE			SAFE			SAFE

DESIGN OF ABUTMENT(A1) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
89+723

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 78 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 23.750m	23.750m
Thickness of Expansion Joint	= 0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	= 25.000m	25.00m
Type of Superstructure	= PSC precast Girder	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.000m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on one side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m² Assumed
SBC of soil-Normal Case = 410 kN/m²
SBC of soil-Seismic Case = 513 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case
Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 1.000m	
Height of Trapering portion	= 1.556m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.950m	1.950m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m
Projection of Abutment Cap (Span Side)	=	0.500m	0.500m
Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.220m	1.220m
Thickness of Abutment shaft at Bottom	=	1.400m	1.400m

Solid Return Wall

Length of Return wall	=	6.300m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.900m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	11.500m	
abutment pedestal width	=	1.400m	
abutment pedestal Height	=	1.500m	
Width of Toe Slab	=	3.800m	
Width of Heel Slab	=	6.300m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.500m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.500m	
Width of backfill on heel slab	=	6.300m	
Thickness of heel slab at back fill edge	=	1.500m	
Height of back fill at bottom edge of heel slab	=	11.916m	
Height of back fill at back fill edge of heel slab	=	10.916m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1205.094m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1205.237m	Height of Superstructure	=	1.820m
Deck level at center line =	1205.094m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1203.209m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1202.609m	Height of Pedestal (3)	=	0.550m
Abutment cap bottom lvl (uniform portion ends	1202.309m	Height of Pedestal (4)	=	0.625m
Abutment cap bottom lvl (corbel portion ends)	1202.009m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1202.009m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1195.749m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1194.249m	Height (Avg.) of Dirt Wall	=	2.556m
Foundation level =	1192.749m	Abutment shaft Above G.L	=	6.260m
HFL	= 1197.749m	Abutment Shaft below G.L	=	1.500m
		Height of abutment shaft	=	7.760m
		MSL	=	1194.749m
		Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²
<u>Creep Coefficient</u>			
For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days
<u>Clear Cover to Reinforcement</u>			
Earth Face	=	75	mm
Non-Earth Face	=	50	mm
<u>Seismic Data:</u>			
Seismic Zone	=	5	
Z =Zone factor	=	0.36	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction
<u>Properties of backfill material :</u>			
c	=	0	
ϕ	=	35	
θ	=	90	
β	=	0	
δ	=	22.5	

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g. of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g. of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	522.61 4.50
DL Reaction on Bearing No.-2	=	544.54 1.50
DL Reaction on Bearing No.-3	=	544.54 -1.50
DL Reaction on Bearing No.-4	=	522.61 -4.50

DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2134.30 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	100.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	100.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		200.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	68.613 4.50
SIDL Reaction on Bearing No.-2	=	82.335 1.50
SIDL Reaction on Bearing No.-3	=	82.335 -1.50
SIDL Reaction on Bearing No.-4	=	68.613 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		301.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 4	=	0.625 x	0.800 x	0.800 =	0.4000 m ³	-4.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.3120 m ³	-0.549

VOLUME CALCULATION

C.G. Of Footing	=	5.750 m
C.G. Of shaft from toe tip	=	4.500 m
Distance between c.g. of shaft and footing	=	1.250 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.450	-5.300	0.000
-Trapering portion	1	12.50	0.300	1.556	5.836	-0.800	0.450	-5.300	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	0.150	-5.600	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	0.200	-5.550	0.000
Cap (uniform portion)	1	12.50	1.950	0.300	7.313	0.025	1.275	-4.475	0.000
Cap (Corbel Portion)	1	12.50	1.950	0.300	5.433	0.025	1.275	-4.475	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.110	4.260	59.097	0.143	1.393	-4.357	0.000
Shaft below HFL	1	12.50	1.310	3.000	49.117	0.044	1.294	-4.456	0.000
Solid Return Wall	1	6.30	0.700	11.488	50.660	-3.850	-2.600	-8.350	5.900
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.700	0.550	-5.200	5.900
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.700	0.550	-5.200	5.900
Footing									
Heel Slab	1	12.50	6.300	1.000	78.750		-2.075	-7.825	0.000
Toe Slab	1	12.50	3.800	1.000	47.500		3.533	-2.217	0.000
Portion between Heel and Toe	1	12.50	1.400	1.500	26.250		1.250	-4.500	0.000
Back filling above HFL over Heel Slab	1	12.50	6.300	7.345	578.419		-2.600	-8.350	0.000
Back filling below HFL over Heel Slab	1	12.50	6.300	4.000	315.000		-2.731	-8.481	0.000
Backfill above Heel slab	1	12.50	6.300	11.416	899.030		-2.646	-8.396	0.000
Front Filling over Toe Slab	1	12.50	3.800	2.000	95.000		3.692	-2.058	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.800	1.000	47.500		2.283	-3.467	0.000
Side filling between heel and toe	1	0.00	1.400	2.000	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	0.150	-5.600	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.220	7.345	20.161		0.702	-5.048	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.180	4.000	9.021		0.610	-5.140	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.450	-5.300

SECTIONAL PROPERTIES

Width of Footing (B)	=	11.500 m							
Length of Footing (L)	=	12.500 m							
A	=	11.500	x	12.500	=	143.750	m ²		
ZL	=	12.500	x	22.042	=	275.521	m ³		
ZT	=	IT1	+	IT2					
		distance of extreme point from centre							
IT1	=	11.500	x	162.760	=	1871.74	m ⁴		
IT2 (moment of inertia of triangle)	=	11.500	x	0.000	+	0.500 x	11.500 x	0.000 x	39.063
from centre of footing	=	0.000	m ⁴						
Moment of inertia of two triangle	=	0.000	m ⁴						
Total moment of inertia	=	1871.74	m ⁴						
Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250	m		
Total Section modulus (ZT)	=	299.479	m ³						

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 10.260 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

= 11.917 m

Abutment Cap Top Level - Foundation Level

= 9.860 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.20 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 1.350 m^4

Moment of Inertia , $I_{\text{transverse}}$ = 195.313 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force	=	128.672	KN
D	=	2636.19	KN
T	=	0.2863	sec

Transverse Direction

Force	=	15042.113	KN
D	=	2906.195	KN
T	=	0.0278	sec

For Hard or Rocky Strata, with $N > 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.417$$

For Medium Strata, with $N > 10 \& N < 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.417$$

For Soft Soil Strata, with $N < 10$

$$\frac{S_a}{g} = 2.5$$

$$\frac{S_a}{g} = 1.417$$

Medium Soil Strata

$$S_a/g = 2.5$$

$$S_a/g = 1.417$$

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.306

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.306	In Transverse direction
Av	=	0.204	In Vertical direction

For Design of Foundation

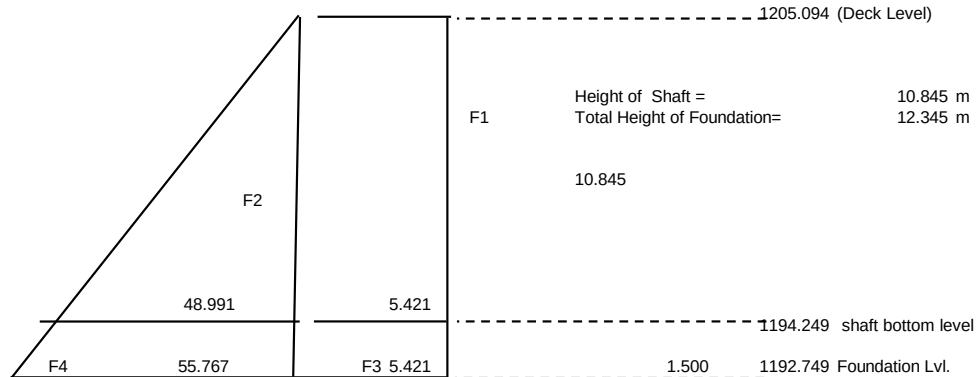
(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.306	In Transverse direction
Av	=	0.204	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1194.249 m (at Shaft Base)			
@ RL				1192.749 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.226	x	20	x	1.2	= 5.421 kN/m^2
F1	=	5.421	x	10.845	x	12.500	= 734.858 kN
M1	=	734.86	x	5.42	=	3984.768	kN.m at Shaft Bottom
F3	=	5.421	x	12.345	x	12.500	= 836.498 kN
M3	=	836.498	x	6.173	=	5163.286	kN.m at Foundation
<u>Due to Active Earth Pressure</u>							
Intensity for triangular portion (At Shaft bottom level)							
	=	0.226	x	20	x	10.845	= 48.991 kN/m^2
F2	=	0.5	x	48.99	x	10.845	x 12.50
	=	3320.640 kN					
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)							
M2	=	3320.64	x	4.55	=	15125.184	kN.m at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.226	x	20	x	12.345	= 55.767 kN/m^2
F4	=	0.5	x	55.77	x	12.345	x 12.50
	=	4302.738 kN					
M4	=	4302.74	x	5.18	=	22309.266	kN.m at Foundation
<u>Force Due To Fluid Pressure</u>							
As per Cl. 214.1 of IRC :6 -2014				γ fluid	=	4.8 kN/m^3	
Intensity for triangular portion (At Shaft bottom level)							
	=	4.800	x	10.845	=	52.056 kN/m^2	
F	=	0.5	x	52.056	x	10.845	x 12.500
	=	3528.421 kN					
M	=	3528.42	x	3.615	=	12755.241	kN.m at Shaft Bottom

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 12.345 = 59.26 \text{ kN/m}^2$$

$$F = 0.5 \times 59.256 \times 12.35 \times 12.500 = 4571.971 \text{ kN}$$

$$M = 4571.97 \times 4.115 = 18813.660 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 5.249 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

$$\begin{aligned} \text{Force due to passive @ Foundation, F} &= 0.5 \times 0.000 \times 12.50 \\ &= 0.000 \text{ kN} \end{aligned}$$

Moment due to passive @ Foundation, M

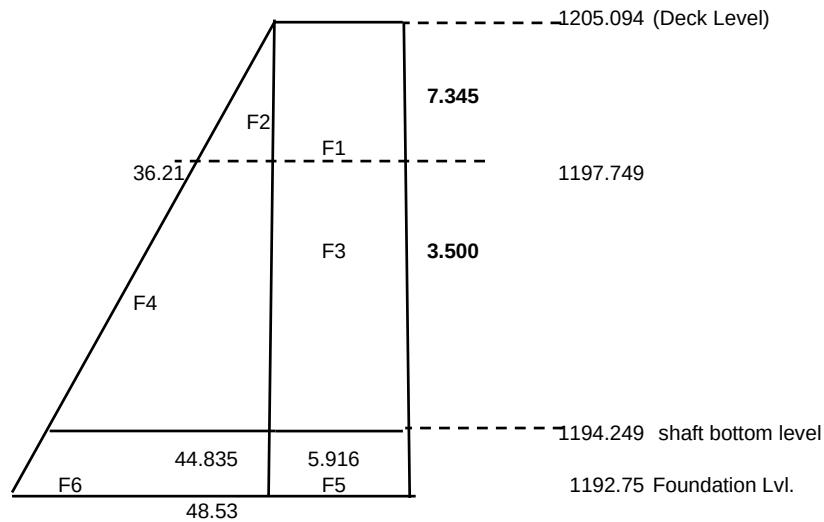
$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	15125.184	22309.266	3320.640	4302.738
Due to Minimum Fluid Pressure	12755.241	18813.660	3528.421	4571.971
Governing of Two	15125.184	22309.266	3528.421	4571.971
Due to Live Load Surcharge	3984.768	5163.286	734.858	836.498
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1194.2 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	10.845	x	12.500	=	801.924 kN
M1	=	801.92	x	5.42	=	4348.430 kN.m		at Shaft Bottom
F3	=	5.916	x	12.345	x	12.500	=	912.840 kN
M3	=	912.84	x	6.17	=	5634.503 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	7.345	=	36.208 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.500	=	8.627 kN/m ²
F2	=	0.5	x	36.21	x	7.345	x	12.50
	=	1662.171 kN						
F4	=	$\frac{(36.21 + 44.83)}{2}$	x	3.50	x	12.50		
	=	1772.809 kN						
Total Force	=	3434.980 kN						
M2	=	1662.17	x	6.58	=	10945.231 kN.m		
M4	=	1772.81	x	1.69	=	2992.335 kN.m		
Total Moment	=	13937.57 kN.m		at Shaft Bottom				

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 7.345 = 36.208 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.000 = 12.324 \text{ kN/m}^2$$

$$F2 = 0.5 \times 36.21 \times 7.345 \times 12.50 = 1662.171 \text{ kN}$$

$$F6 = \left(\frac{36.21 + 48.53}{2} \right) \times 5.00 \times 12.50 = 2648.122 \text{ kN}$$

$$\text{Total Force} = 4310.293 \text{ kN}$$

$$M2 = 1662.17 \times 8.08 = 13438.488 \text{ kN.m}$$

$$M6 = 2648.12 \times 2.38 = 6299.368 \text{ kN.m}$$

$$\text{Total Moment} = 19737.86 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 0.00 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	13937.566	19737.856	3434.980	4310.293
Due to Minimum Fluid Pressure	12755.241	18813.660	3528.421	4571.971
Governing of Two	13937.566	19737.856	3528.421	4571.971
Due to Live Load Surcharge	4348.430	5634.503	801.924	912.840
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.180	
αv	=	0.204	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.148 \\ 0.222 \end{matrix}$$

$$C_a = \begin{matrix} 1 \\ 0.380 \end{matrix} \begin{matrix} 2 \\ 0.299 \end{matrix}$$

Ca	=	0.380	0.299	
Ka	=	0.226		
Dynamic Increment	=	0.380	-0.226	0.154

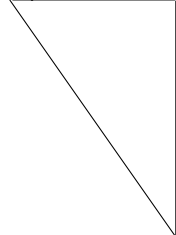
3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height = 1.2 m

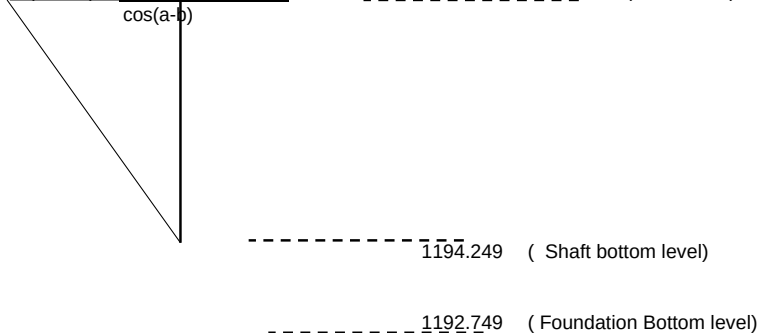
Assuming $\gamma_{dry} = 20 \text{ kN/m}^3$
 $\gamma_{water} = 10.00 \text{ kN/m}^3$

Active Earth Pressure

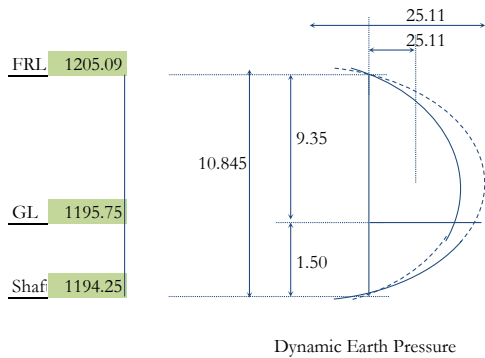
$$3 (Ca - Ka) = 0.463$$

**Surcharge Earth Pressure**

$$2 (Ca - Ka) \frac{\cos \alpha}{\cos(\alpha - \beta)} = 0.31$$

**Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.309	x	20.00	x	1.2	=	7.409 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.409	x	10.845	x	12.500
	=	502.217	kN					
M1	=	502.217	x	7.266			=	3649.187 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.409	x	10.845	x	12.500
	=	502.217	kN					
M2	=	502.217	x	8.766			=	4402.513 kN.m

Due to Dynamic Active Earth Pressure**Dyanmic Earth Pressure Calculation****Parabola above Water Level**

p_mid_height	=	25.11 t/m ²
h	=	10.845 m
y	=	3.9225 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	25.11 t/m ²
h	=	10.845 m
y	=	-3.9225 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	2151.2	5.7
Parabola below Water Level	118.2	1.0
Total Dynamic Earth Pressure	2269.4	5.4

$$E3 = 2269.395 \text{ kN}$$

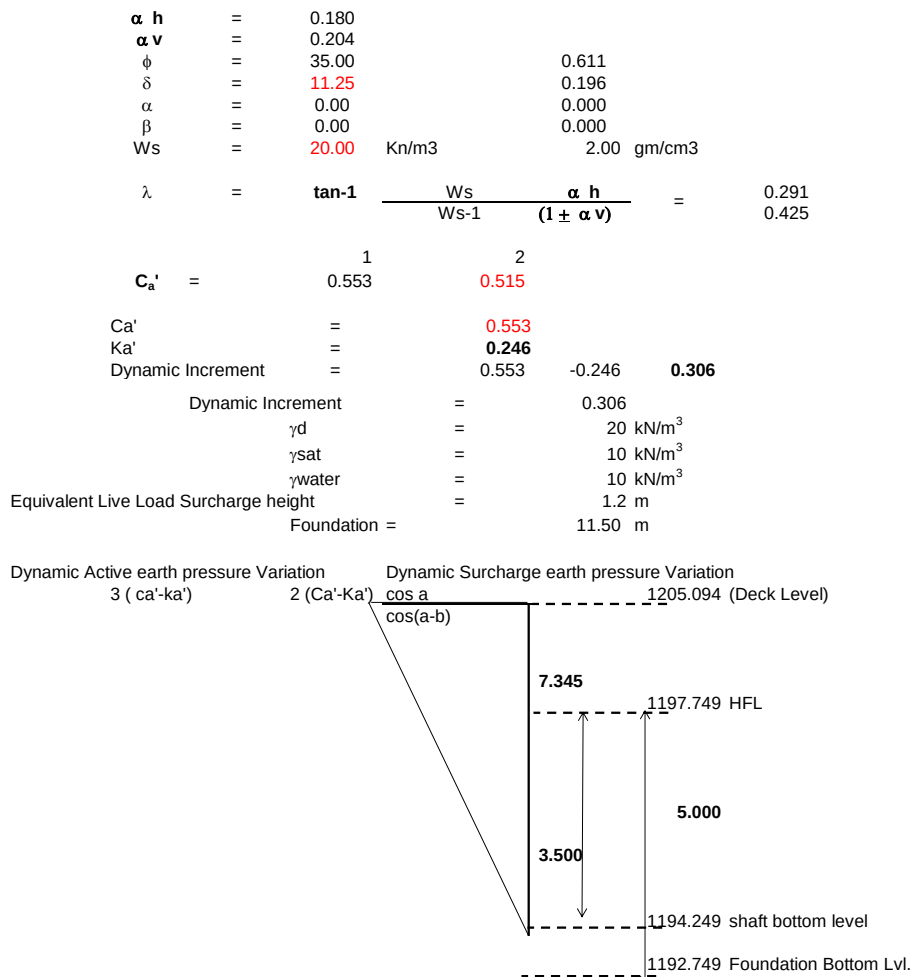
$$E4 = 2269.395 \text{ kN}$$

$$M3 = 2269.39 \times 5.42 = 12305.794 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 2269.39 \times 6.92 = 15709.886 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	15125.184	22309.266	3320.640	4302.738
Due to active Earth Pressure (dynamic Increment)	12305.794	15709.886	2269.395	2269.395
Total Earth Pressure	27430.978	38019.152	5590.035	6572.133
Due to Minimum Fluid Pressure	12755.241	18813.660	3528.421	4571.971
Governing of Two	15125.184	38019.152	5590.035	6572.133
Due to Live Load Surcharge (Static)	3984.768	5163.286	734.858	836.498
Due to Live Load Surcharge(Dynamic)	3649.187	4402.513	502.217	502.217
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case**Earth Pressure Diagram**

h' = 3.500

h = 10.845

Dynamic active earth pressure

$3 (ca'-ka)$ = 0.463 at deck level

$3 (ca'-ka')$ = 0.919 at deck level

$3 (ca'-ka')h'/h$ = 0.297 at HFL level

Dynamic Surcharge earth pressure

$2 (Ca'-Ka') \frac{\cos a}{\cos(a-b)}$ = 0.613 at deck level Pressure = 14.71 kN/m²

$\cos(a-b)$ = 0.198 at HFL level Pressure = 4.75 kN/m²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level = 7.409 kN/m²

Dynamic surcharge pressure in Submerge condition at HFL level = 4.75 kN/m²

at Shaft Bottom Level

F1 = 6.079 x 7.345 x 12.500 = 558.093 kN

M1 = 558.09 x 7.17 = 4002.923 kN.m

F2 = 0.50 x 4.748 x 3.500 x 12.500

= 103.859 kN

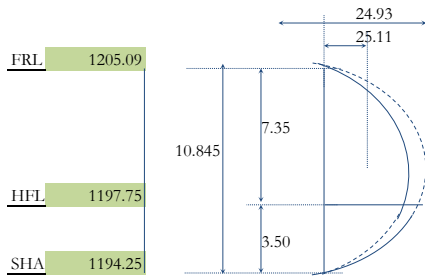
M2 = 103.86 x 2.35 = 243.550 kN.m

Total Force at Abutment shaft level = 661.952 kN
 Total Moment at Abutment shaft level = 4246.473 kN.m

at Foundation Bottom Level

F3 = 6.079 x 7.345 x 12.500 = **558.093 kN**
 M3 = 558.09 x 8.67 = **4840.063 kN.m**
 F4 = 0.500 x 4.748 x 3.500 x 12.500
 = **103.859 kN**
 M4 = 103.86 x 3.85 = **399.339 kN.m**

Total Force at Founding level = 661.952 kN
 Total Moment at Founding level = 5239.401 kN.m

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height = 25.11 t/m²
 h = 10.845 m
 y = 1.9225 m
 L = 12.500 m

Parabola below Water Level

p_mid_height = 24.93 t/m²
 h = 10.845 m
 y = -1.9225 m
 L = 12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	1712.9	6.5
Parabola below Water Level	552.5	2.3
Total Dynamic Earth Pressure	2265.4	5.4

Total Force (F1 + F2)	=	2265.368 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	2265.368 kN	at Foundation Bottom Level

M1 = 2265.37 x 5.43 = **12296.720 kN.m**

Total Mome = **12296.720 kN.m** at Shaft Bottom

M1 = 2265.37 x 6.93 = **15694.773 kN.m**

Total Mome = **15694.773 kN.m** at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	13937.566	19737.856	3434.980	4310.293
Due to active Earth Pressure (Dynamic Increment)	12296.720	15694.773	2265.368	2265.368
Total Earth Pressure	26234.286	35432.628	5700.349	6575.662
Due to Minimum Fluid Pressure	12755.241	18813.660	3528.421	4571.971
Governing of Two	26234.286	35432.628	5700.349	6575.662
Due to Live Load Surcharge(Static)	4348.430	5634.503	801.924	912.840
Due to Live Load Surcharge (Dynamic Increment)	4246.473	5239.401	661.952	661.952
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2134.30	1.35	1.35	2881.30	2881.30	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	301.90	1.75	1.75	528.32	528.32	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW + 1-CLASS A)
CWLLmax- Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW + 1-CLASS A)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax- Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)

Braking Force = 0.2 x 1000 + 0.05 x 554
= 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	3679.62	0	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.55	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.55	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.55	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1423.55	183.981	895.754	1239.564	1423.545	
DL+SIDL+LL-Max Reaction case		3737.75	1469.09	186.888	921.430	1282.197	1469.085	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	1469.09	194.574	929.117	1274.511	1469.085	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	1469.09	192.076	926.619	1277.009	1469.085	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	427.064	183.981	397.513	243.082	427.064	
DL+SIDL+LL-Max Reaction case		3737.75	472.604	186.888	423.189	285.716	472.604	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	472.604	194.574	430.876	278.029	472.604	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	472.604	192.076	428.378	280.527	472.604	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.35	1.35	2881.30	2881.30
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	301.90	1.75	1.75	528.32	528.32
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax- Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	3679.62	0.000	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.550	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0.000	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.550	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0.000	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.550	244.695	415.470	96.855	415.470	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1921.79	183.981	1144.874	1737.805	1921.786	
DL+SIDL+LL-Max Reaction case		3897.62	1967.33	194.881	1178.544	1772.445	1967.326	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	1967.33	223.706	1207.369	1743.620	1967.326	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	1967.33	214.338	1198.001	1752.988	1967.326	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	576.536	183.981	472.249	392.555	576.536	
DL+SIDL+LL-Max Reaction case		3897.62	622.076	194.881	505.919	427.195	622.076	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	622.076	223.706	534.744	398.370	622.076	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	622.076	214.338	525.376	407.738	622.076	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1	1.00	2134.30	2134.30
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	301.90	1	1.00	301.90	301.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax- Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	0.000	131.810	131.810	-131.810	131.810	
DL+SIDL+LL-Max Reaction case	2926.86	227.700	146.343	260.193	81.357	260.193	(1-70RW + 1-CLASS A)
	4130.01	0.000	206.500	206.500	-206.500	206.500	SV Loading
DL+SIDL+LL-Min Reaction case	3695.53	227.700	184.776	298.626	42.924	298.626	(1-70RW + 1-CLASS A)
	4562.38	0.000	228.119	228.119	-228.119	228.119	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3445.72	227.700	172.286	286.136	55.414	286.136	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	1281.191	131.810	772.405	1149.381	1281.191	
DL+SIDL+LL-Max Reaction case	2694.33	1326.731	134.716	798.082	1192.014	1326.731	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	1326.731	142.403	805.768	1184.328	1326.731	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	1326.731	139.905	803.270	1186.826	1326.731	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	384.357	131.810	323.988	252.547	384.357	
DL+SIDL+LL-Max Reaction case	2694.33	429.897	134.716	349.665	295.181	429.897	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	429.897	142.403	357.352	287.494	429.897	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	429.897	139.905	354.854	289.992	429.897	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.1	1.10	2347.73	2347.73
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	301.90	1.35	1.35	407.56	407.56
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2975.29	0.000	148.764	148.764	-148.764	148.764	
DL+SIDL+LL-Max Reaction case	3411.29	341.550	170.564	341.339	170.986	341.339	(1-70RW + 1-CLASS A) Dry Case
	4469.10	0.000	223.455	223.455	-223.455	223.455	SV Loading
DL+SIDL+LL-Min Reaction case	4564.29	341.550	228.214	398.989	113.336	398.989	(1-70RW + 1-CLASS A) HFL Case
	4901.48	0.000	245.074	245.074	-245.074	245.074	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4189.57	341.550	209.479	380.254	132.071	380.254	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	1921.79	148.764	1109.657	1773.021	1921.786	
DL+SIDL+LL-Max Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	576.536	148.764	437.032	427.771	576.536	
DL+SIDL+LL-Max Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	576.536	148.764	437.032	427.771	576.536	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2134.30	1	1	1	2134.30	2134.30	2134.30
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	301.90	1.20	1.20	1.20	362.27	362.27	362.27
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax- Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2987.24	227.700	149.362	263.212	78.338	263.212	(1-70RW + 1-CLASS A) Dry Case
	4190.38	0.000	209.519	209.519	-209.519	209.519	SV Loading
DL+SIDL+LL-Min Reaction case	3755.91	227.700	187.795	301.645	39.905	301.645	(1-70RW + 1-CLASS A) HFL Case
	4622.76	0.000	231.138	231.138	-231.138	231.138	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3506.10	227.700	175.305	289.155	52.395	289.155	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2914.57	170.775	145.729	231.116	25.046	231.116	Dry Case
DL+SIDL+LL-Min Reaction case	3491.07	170.775	174.554	259.941	-3.779	259.941	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3303.72	170.775	165.186	250.573	5.589	250.573	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	Dry Case
DL+SIDL+LL-Min Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2696.57	0.000	134.829	134.829	-134.829	134.829	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	78.00	m	78.00	m
CENTRIFUGAL FORCE	C	=	171.10	kN	171.10	kN

Possible Load Combination

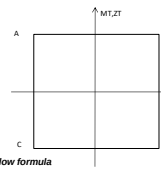
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1192.749 m

Properties of Footing Base:

A	=	143.750	m ²
ZL	=	275.521	m ³
ZT	=	299.479	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			2134.300	1.250	2667.874	0.000	0.000
SIDL except Wearing Course	1			200.000	1.250	250.000	0.000	0.000
Wearing Course	1			301.895	1.250	377.369	0.000	0.000
Bearing Pedestal	1	25	1.312	32.800	1.250	41.000	-0.549	-18.000
				2668.995		3336.243		-18.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.450	42.188	0.000	0.000
Dirt Wall-Tapered portion	1	25	5.836	145.898	0.450	65.654	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.150	4.219	0.000	0.000
Bracket - Tapered portion	25	0.563	14.063	0.200	2.813	0.000	0.000	0.000
Cap - (uniform portion)	1	25	7.313	182.813	1.275	233.086	0.000	0.000
Cap - (corbel portion)	1	25	5.433	135.826	1.275	173.178	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.550	0.000	5.900	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.550	0.000	5.900	0.000
RCC Railing or Crash Barrier	1			28.000	0.450	12.600	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.150	24.609	0.000	0.000
				792.537		558.346		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	50.660	1266.497	-2.600	-3292.892	5.900	7472.332
Abutment Shaft	1	25	108.214	2716.345	1.294	3509.899	0.000	0.000
Back filling over heel slab	1	20	899.030	17980.594	-2.646	-47576.419	0.000	0.000
Front Filling over toe slab	1	20	95.000	1900.000	3.692	7014.167	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	78.750	1968.750	-2.075	-4085.156	0.000	0.000
Toe slab	1	25	47.500	1187.500	3.533	4195.833	0.000	0.000
portion between heel & toe	1	25	26.250	656.250	1.250	820.313	0.000	0.000
Vertical Components of active earth pressure	1			1893.772	-5.750	-10889.191	0.000	0.000
				30142.338		-49929.537		7472.332
Total				33603.869		-46034.947		7454.332

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1920.870	-4.500	-8643.913
0.900	180.000	-4.500	-810.000
1.000	301.895	-4.500	-1358.528
0.900	29.520	-4.500	-132.840
	2432.285		-10945.281
0.900	84.375	-5.300	-447.188
0.900	131.309	-5.300	-695.936
0.900	25.313	-5.600	-141.750
0.900	12.656	-5.550	-70.242
0.900	164.531	-4.475	-736.277
0.900	122.243	-4.475	-547.038
0.900	0.000	-5.200	0.000
0.900	0.000	-5.200	0.000
0.900	25.200	-5.300	-133.560
0.900	147.656	-5.600	-826.875
	713.283		-3598.866
0.900	1139.847	-8.350	-9517.724
0.900	2434.810	-4.456	-10949.350
0.900	16182.534	-8.396	-135668.350
0.900	1710.000	-2.058	-3519.750
0.900	0.000	0.000	0.000
0.900	1771.875	-7.825	-13864.922
0.900	1068.750	-2.217	-2369.063
0.900	590.625	-4.500	-2657.813
0.900	1704.395	-11.500	-19600.543
	27128.104		-200899.048
	30273.672		-215443.195

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1203.209	1378.730
due to Earth pressure	1	4571.971		22309.266

Forces along Long. Axis

FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
131.81	1378.73	0.00	0.00
4571.97	22309.27	0.00	0.00
4703.780	23687.996	0.000	0.000

Forces along Trans. Axis

FL Sin θ	ML Sin θ
0.00	0.00
0.00	0.00
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1203.209	1556.076
due to Earth pressure	1.5	6857.956		33463.899
		7006.721		35019.975

Forces along Long. Axis

FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
148.76	1556.08	0.00	0.00
6857.96	33463.90	0.00	0.00
7006.721	35019.975	0.000	0.000

Forces along Trans. Axis

FL Sin θ	ML Sin θ
0.00	0.00
0.00	0.00
0.000	0.000

Summary of Forces For SBC

P	33603.869	kN
ML	-22346.952	kNm
MT	7454.332	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case -DL+SIDL		33603.869		-46034.947		7454.332
CWLL-Max. Reaction case	1	1059.332	1.250	1324.165	0.950	1006.366
Vertical Components of LL Surcharge	1	346.489	-5.750	-1992.311	0.000	0.000
Total		35009.690		-46703.093		8460.697

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	30273.67165		-215443.19
0.900			
		-4.500	0.00
		-11.500	-3586.16
	30273.672		-219029.36

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.193	1203.209	2721.620
due to Earth pressure	1	4571.971		22309.266
due to Live load surcharge	1	836.498		5163.286

Forces along Long. Axis

FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
260.19	2721.62	0.00	0.00
4571.97	22309.27	0.00	0.00
836.498	5163.286	0.000	0.000
5668.66	30194.17	0.00	0.00

Forces along Trans. Axis

FL Sin θ	ML Sin θ
0.00	0.00
0.00	0.00
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		341.339	1203.209	3570.411
due to Earth pressure	1.5	6857.956		33463.899
due to Live load surcharge	1.2	1003.286		6195.943
		8203.094		43230.253

Forces along Long. Axis

FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
341.34	3570.41	0.00	0.00
6857.96	33463.90	0.00	0.00
1003.80	6195.94	0.00	0.00
8203.094	43230.253	0.000	0.000

Forces along Trans. Axis

FL Sin θ	ML Sin θ
0.00	0.00
0.00	0.00
0.000	0.000

Summary of Forces For SBC

P	35009.690	kN
ML	-19509.922	kNm
MT	8460.697	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
				2668.995		3336.243		-18.000
Substructure & Foundation -Portion 1								
				792.537		558.346		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	50.660	1266.497	-2.600	-3292.892	5.900	7472.332
Shaft above HFL	1	25	59.097	1477.413	1.393	2058.469	0.000	0.000
Shaft below HFL	1	15	49.117	736.759	1.294	953.416	0.000	0.000
Back filling above HFL over heel slab	1	20	578.419	11568.375	-2.600	-30077.775	0.000	0.000
Back filling below HFL over heel slab	1	10	315.000	3150.000	-2.731	-8603.438	0.000	0.000
Front Filling over toe slab	1	10	95.000	950.000	2.283	2169.167	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	78.750	1181.250	-2.075	-2451.094	0.000	0.000
Toe slab	1	15	47.500	712.500	3.533	2517.500	0.000	0.000
Portion between Heel & Toe	1	15	26.250	393.750	1.250	492.188	0.000	0.000
Vertical Components of active earth pressure	1			1893.772	-5.750	-10889.191	0.000	0.000
				23823.740		-46785.542		7472.332
Total				27285.271		-42890.953		7454.332

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2432.285		-10945.281
	713.283		-3598.866
0.900	1139.847	-8.350	-9517.724
0.900	1329.672	-4.357	-5792.990
0.900	663.083	-4.456	-2954.654
0.900	10411.538	-8.350	-86936.338
0.900	2835.000	-8.481	-24044.344
0.900	855.000	-3.467	-2964.000
0.900	0.000	0.000	0.000
0.900	1063.125	-7.825	-8318.953
0.900	641.250	-2.217	-1421.438
0.900	354.375	-4.500	-1594.688
0.900	1704.395	-11.500	-19600.543
	21441.366		-165394.843
	24586.934		-179938.999

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1203.209	1378.730
due to Earth pressure	1	4571.971		19737.856

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1203.209	1556.076
due to Earth pressure	1.5	6857.956		29606.784
		7006.721		31162.859

Summary of Forces For SBC

P	27285.271	kN
ML	-21774.367	kNm
MT	7454.332	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc. (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		27285.271		-42890.953		7454.332
CWLL-Min. Reaction case	1	290.668	1.250	363.335	0.950	276.134
Vertical Components of LL Surcharge	1	378.111	-5.750	-2174.136	0.000	0.000
Total		27954.050		-44701.754		7730.466

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	298.636	1203.209	3123.632
due to Earth pressure	1	4571.971		19737.856
due to Live load surcharge	1	912.840		5634.503

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		398.989	1203.209	4173.428
due to Earth pressure	1.5	6857.956		29606.784
due to live load surcharge	1.2	1095.408		6761.403
		8352.353		40541.615

Summary of Forces For SBC

P	27954.050	kN
ML	-16205.764	kNm
MT	7730.466	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

ah= 0.243 In Longitudinal direction
ah= 0.306 In Transverse direction
av= 0.204 In Vertical direction

Weight of shaft below Ground level

= 558.956 kN

Weight of back fill below Ground level

= 2362.500 kN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			2134.300	195.974		130.649	1.250	2667.874	163.312	1204.422		0.000	0.000	2287.669
SIDL except Wearing Course	1			200.000	18.364		12.243	1.250	250.000	15.304	1205.543		0.000	0.000	234.950
Wearing Course	1			301.895	27.720		18.480	1.250	377.369	23.100	1205.094		0.000	0.000	342.208
Bearing Pedestal	1	25	1.312	32.890	3.012	0.000	2.008	1.250	41.090	2.510			-0.548	-18.000	
				2668.995	245.070		163.380		3336.243	204.225				-18.000	2864.827
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	3.750	93.750	22.781	8.608	5.739	0.450	42.188	2.582	1204.594	269.844	0.000	0.000	101.965
Dirt Wall-Tapered portion	1	25	5.836	145.898	35.453	13.397	8.931	0.450	65.654	4.019	1203.316	374.631	0.000	0.000	141.560
Bracket - Uniform portion	1	25	1.125	28.125				0.150	4.219						
Bracket - Tapered portion	1	25	0.563	14.063				0.200	2.913						
Cap - (uniform portion)	1	25	7.313	182.813	44.423	16.786	11.191	1.275	233.086	14.268	1202.459	431.352	0.000	0.000	162.993
Cap - (corbel portion)	1	25	5.433	135.826	33.006	12.472	8.314	1.275	173.178	10.601	1202.159	310.583	0.000	0.000	117.359
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.550	0.000	0.000	1205.237	0.000	5.900	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.550	0.000	0.000	1205.237	0.000	5.900	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.450	12.600				0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.150	24.609				0.000	0.000	
				792.537	135.664	51.263	34.175		568.346	31.471		1386.410		0.000	523.876
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	50.660	1266.497	307.759	116.291	77.527	-2.600	-3292.892	-201.571	1199.386	2042.556	5.900	7472.332	771.810
Abutment Shaft	1	25	108.214	2705.345	521.573	197.084	131.389	1.294	3500.899	170.027	1198.879	3197.240	0.000	0.000	1208.125
Back filling over heel slab	1	20	899.030	17980.594	0.000	0.000	0.000	-2.648	-47576.419	0.000	1199.386	0.000	0.000	0.000	0.000
Front Filling over toe	1	20	95.000	1900.000				3.692	7014.167				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	78.750	1968.750				-2.075	-4085.156				0.000	0.000	
Toe slab	1	25	47.500	1187.500				3.533	4195.833				0.000	0.000	
portion between heel & toe	1	25	26.250	656.250				1.250	820.313				0.000	0.000	
Vertical component of active earth pressure	1			1782.252				-5.750	-10247.951				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			940.014				-5.750	-5405.081				0.000	0.000	
				30970.832	829.331	313.375	208.917		-54693.379	-31.545		5239.796		7472.332	1979.935
Total =				34432.363	964.995	609.708	406.472		-50798.789	204.151		6626.206		7454.332	5368.637

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Superstructure								
Dead Load	0.9			1920.870	117.584	-4.500	-8643.913	-529.130
SIDL except Wearing Course	0.9			180.000	11.019	-4.500	-810.000	-49.583
Wearing Course	1.00			301.895	18.480	-4.500	-1358.528	-83.161
Bearing Pedestal	0.9	25	1.312	29.520		-4.500	-132.840	
				2432.285	147.083		-10945.261	-661.874
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.9	25	3.750	84.375	5.165	-5.300	-447.188	-27.374
Dirt Wall-Tapered portion	0.9	25	5.836	131.309	8.038	-5.300	-695.936	-42.601
Bracket - Uniform portion	0.9	25	1.125	25.313				
Bracket - Tapered portion	0.9	25	0.563	12.656				
Cap - (uniform portion)	0.9	25	7.313	164.531	10.072	-4.475	-736.277	-45.071
Cap - (corbel portion)	0.9	25	5.433	122.243	7.483	-4.475	-547.038	-33.486
Cantilever Return Wall-Rectangle portion	0.9	25	0.000	0.000	0.000	-5.200	0.000	0.000
Cantilever Return Wall-Triangle portion	0.9	25	0.000	0.000	0.000	-5.200	0.000	0.000
RCC Railing or Crash Barrier	0.9			25.200		-5.300	-133.560	
Approach Slab	0.9	25	6.563	147.656		-5.600	-326.875	
				713.283	30.758		-3386.874	-148.532
Substructure & Foundation -Portion 2								
Abutment Shaft	0.9	25	108.214	2434.810	114.829	-4.456	-10849.350	-511.669
Solid Return wall	0.9	25	50.660	1139.847	69.775	-8.350	-9517.724	-582.619
Back filling over heel slab	0.9	20	899.030	16182.534	0.000	-8.396	-135868.3	0.000
Front Filling over toe	0.9	20	95.000	1710.000		-2.058	-3519.750	
Side filling between heel and toe	0.9	20	0.000	0.000		0.000	0.000	
Heel slab	0.9	25	78.750	1771.875		-7.825	-13864.922	
Toe slab	0.9	25	47.500	1068.750		-2.217	-2369.063	
portion between heel & toe	0.9	25	26.250	590.625		-4.500	-2657.813	
Vertical component of active earth pressure	0.9			1704.395		-11.500	-19600.543	
Vertical component of dynamic increment of earth pressure	0.9			846.013		-11.500	-9729.146	
				27974.117	184.604		-210628.19	-1094.288
Total =				31119.684	362.444		-224960.35	-1904.695

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLS due to FL
1.0	22.781	1204.594	269.844
1.0	35.453	1203.316	374.631
1.0	44.423	1202.459	431.352
1.0	33.006	1202.159	310.583
1.0	0.000	1205.237	0.000
1.0	0.000	1205.237	0.000
	135.664		1386.410
1.0	506.481	1198.879	3104.727
1.0	307.759	1199.386	2042.556
1.0	0.000	1199.386	0.000
	814.240		5147.283
	949.903		6533.693

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	245.070	1203.209	13401.253	2864.827
due to Substructure	1	964.995	364.638		6626.206	2503.811
due to Earth pressure	1	6572.133			38019.152	

Horizontal Forces For Overturning or Sliding Effect						
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)		
due to Superstructure		1921.786	1203.209	20101.88		
due to Substructure	1.5	1424.855		9800.54		
due to Active Earth pressure	1	4302.738		22309.27		
due to dynamic Earth pressure	1.5	3404.092		23564.83		
		11053.471		75776.515		

Summary of Forces For SBC			
	Downward	Upward	
P	34838.835	34025.891	kN
ML	7451.973	7043.671	kNm
MT	12822.969	12822.969	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1281.19	13401.25	0.00	0.00	0.00	0.00	245.07	2864.83
964.99	6626.21	0.00	0.00	0.00	0.00	364.64	2503.81
6572.13	38019.15						
8818.32	58046.61	0.00	0.00	0.00	0.00	609.71	5368.64

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1921.79	20101.88	0.00	0.00
1424.85	9800.54	0.00	0.00
4302.738	22309.266	0.00	0.00
3404.092	23564.829	0.00	0.00
11053.47	75776.51	0.00	0.00

Summary of Restoring Forces	
Vertical Load	30757.240 kN
Moment	-22865.044 kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long, Seismic Dry Case

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\phi_h \times P$ (kN)	FT = $0.3 \times \phi_h \times P$ (kN)	Fv = $0.3 \times \phi_v \times P$ (kN)	Long Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995		245.070	163.380		3336.243	204.225				-18.000	2864.827
Forces from Substructure				31763.369	964.995	364.638	243.092		-54135.033	-0.074				7472.332	2503.811
CWLL-Max. Reaction case	0.20			211.87		19.454	12.969	1.250	264.833	16.212	1206.294	6626.206	0.950	201.273	263.502
Vertical component of LL Surcharge	0.20			69.30				-5.750	-398.462				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			41.61				-5.750	-239.229				0.000	0.000	
Total =				34755.133	964.995	629.162	419.441		-51171.648	220.362		6626.206		7655.605	5632.139
									-419.441						
										-220.362					

Vertical Forces For Restoring or Resisting Effect								
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x α x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	147.083	0.000	-10945.28	-661.874
Forces from Substructure				28687.400	215.361	0.000	-214015.07	-1242.821
CWLL-Max. Reaction case	0.00			0.00	0.000	-4.500	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-11.500	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-11.500	0.00	
Total =				31119.684	362.444		-224960.35	-1904.695
					-362.444			
								1904.695

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	264.524	1203.209	13877.602	3128.329
due to Substructure	1	964.995	364.638		6626.206	2503.811
due to Earth pressure	1	6572.133			38019.152	
due to Live load surcharge	0.20	267.743			1913.160	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1326.73	13877.60	0.00	0.00	0.00	0.00	264.52	3128.33
964.99	6626.21	0.00	0.00	0.00	0.00	364.64	2503.81
6572.13	38019.15						
267.74	1913.16						
9131.60	60436.12	0.00	0.00	0.00	0.00	629.16	5632.14

Horizontal Forces For Overturning or Sliding Effect						
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)		
due to Superstructure		1921.786	1203.209	20101.880		
due to Substructure	1.5	1424.855		9800.539		
due to Active Earth pressure	1	4302.738		22309.266		
due to dynamic Earth pressure	1.5	3404.092		23564.829		
due to Live load surcharge	0	0		0		
due to dynamic increment of live load surcharge	0	0		0		
		11053.471		75776.515		

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
1921.79	20101.88	0.00	0.00
1424.85	9800.54	0.00	0.00
4302.738	22309.266		
3404.092	23564.829		
0.000	0.000		
0.000	0.000		
11053.47	75776.51	0.00	0.00

Summary of Forces For SBC			
	Downward	Upward	
P	35174.574	34335.691	kN
ML	9484.834	9044.109	kNm
MT	13287.744	13287.744	kNm

Summary of Restoring Forces	
Vertical Load	30757.240 kN
Moment	-22865.044 kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\phi_h \times P$ (kN)	FT = $0.3 \times \phi_h \times P$ (kN)	Fv = $0.3 \times \phi_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MT's due to FT
Superstructure				2668.995		245.070	163.380		3336.243	204.225				-18.000	2864.827
Substructure & Foundation -Portion 1				792.537	135.664	51.263	34.175		558.346	31.471		1386.410		0.000	523.876
Substructure & Foundation -Portion 2															
Solid Return wall	1		50.66	1266.50	307.759	116.291	77.527	-2.60	-3292.892	-201.571	1199.39	2042.556	5.90	7472.332	771.810
Shaft above HFL	1	25	59.097	1477.413	358.011	135.658	90.439	1.393	2058.465	126.007	1199.879	2559.751	0.000	0.000	967.240
Shaft below HFL	1	15	49.117	736.759	162.561	61.426	40.951	1.294	953.416	52.993	1196.749	650.245	0.000	0.000	245.705
Back filling above HFL over heel slab	1	20	578.419	11568.375	0.000	0.000	0.000	-2.600	-30077.775	0.000	1201.422	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	315.000	3150.000	0.000	0.000	0.000	-2.731	-8603.438	0.000	1195.624	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	95.000	950.000				2.283	2169.167				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	78.750	1181.250				-2.075	-2451.094				0.000	0.000	
Toe slab	1	15	47.500	712.500				3.523	2517.500				0.000	0.000	
portion between heel & toe	1	15	26.250	393.750				1.250	492.188				0.000	0.000	
Vertical component of active earth pressure	1			1785.382				-5.750	-10265.947				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			938.346				-5.750	-5395.491				0.000	0.000	
				24653.696	949.233	358.682	239.121		-51895.897	-22.571		6014.184		7472.332	2272.549
Total =				28115.227	1084.897	655.015	436.676		-48001.307	213.125		7400.593		7454.332	5661.251
									-436.676						
										-213.125					

Vertical Forces For Restoring or Resisting Effect								
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load/ P kN.	Fv = 0.3 x α x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	147.083		-10945.281	-661.874
Substructure & Foundation -Portion 1				713.283	30.758		-3386.874	-148.532
Substructure & Foundation -Portion 2								
Solid Return wall	0.9	25	50.659875	1139.847	69.775	-8.35	-9517.724	-582.619
Shaft above HFL	0.9	25	59.097	1329.672	81.395	-4.357	-5792.990	-354.613
Shaft below HFL	0.9	15	49.117	663.083	33.434	-4.456	-2954.654	-148.980
Back filling above HFL over heel slab	0.9	20	578.419	10411.538	0.000	-8.350	-86936.338	0.000
Back filling below HFL over heel slab	0.9	10	315.000	2835.000	0.000	-8.481	-24044.344	0.000
Front Filling over toe	0.9	10	95.000	855.000			-3467	-2964.000
Side filling between heel and toe	0.9	10	0.000	0.000			0.000	0.000
Heel slab	0.9	15	78.750	1063.125		-7.825	-8318.953	
Toe slab	0.9	15	47.500	641.250		-2.217	-1421.438	
portion between heel & toe	0.9	15	26.250	354.375		-4.500	-1594.688	
Vertical component of active earth pressure	0.9			1606.844		-11.500	-18478.704	
Vertical component of dynamic increment of earth pressure	0.9			844.512		-11.500	-9711.884	
				22188.327	211.788		-173984.89	-1223.893
Total =				25333.894	399.628		-188317.04	-2034.299
							-389.628	
								2034.299

For Overturning or Sliding Effect			
Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	135.664		1386.410
1.0	307.759	1199.386	2042.556
1.0	359.011	1199.879	2559.751
1.0	147.469	1196.749	589.878
1.0	0.000	1201.422	0.000
1.0	0.000	1195.624	0.000
	814.240		5192.185
	940.903		6578.594

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	245.070	1203.209	13401.253	2864.827
due to Substructure	1	1084.897	409.945		7400.593	2796.424
due to Earth pressure	1	6575.662			35432.628	

Horizontal Forces For Overturning or Sliding Effect					
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)	
due to Superstructure		1921.786	1203.209	20101.880	
due to Substructure	1.5	1424.855		9867.892	
due to Active Earth pressure	1	4310.293		19737.856	
due to dynamic Earth pressure	1.5	3398.052		23542.159	
		11054.986		73249.786	

Summary of Forces For SBC			
	Downward	Upward	
P	28551.904	27678.551	kN
ML	8446.292	8020.043	kNm
MT	13115.583	13115.583	kNm

Summary of Restoring Forces	
Vertical Load	24944.266 kN
Moment	-190351.341 kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load/ P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995		245.070	163.380		3336.243	204.225				-18.000	2864.827
Forces from Substructure				25446.233	1084.897	409.945	273.296		-51337.550	8.899		7400.593		7472.332	2796.424
CWLL-Max. Reaction case	0.20			56.13		5.338	3.559	1.250	72.667	4.448	1206.294			0.950	55.227
Vertical component of LL Surcharge	0.20			75.62				-5.750	-434.827					0.000	0.000
Vertical component of dynamic increment LL Surcharge	0.20			54.84				-5.750	-315.318					0.000	0.000
Total =				28303.821	1084.897	660.353	440.235		-48678.785	217.573		7400.593		7509.558	5733.553

Vertical Forces For Restoring or Resisting Effect									
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv	
Forces from Superstructure				2432.285	147.083		-10945.281	-661.874	
Forces from Substructure				22901.610	242.545		-177371.76	-1372.425	
CWLL-Max. Reaction case	0.00			0.00	0.00		-4.50	0.00	
Vertical component of LL Surcharge	0.00			0.00		-4.500	0.00	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-11.500	0.000	0.000	
Total =				25333.894	389.628		-188321.54	-2034.299	
								-389.628	2034.299

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	250.408	1263.209	13877.602	2937.129
due to Substructure	1	1084.897	409.945		7400.593	2796.424
due to Earth pressure	1	6575.662			35432.628	
due to Live load surcharge	0.20	314.958			2174.781	

Horizontal Forces For Overturning or Sliding Effect					
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)	
due to Superstructure		1921.786	1203.209	20101.880	
due to Substructure	1.5	1424.855		9867.8917	
due to Active Earth pressure	1	4310.293		19737.856	
due to dynamic Earth pressure	1.5	3398.052		23542.159	
due to Live load surcharge	0	0		0	
due to dynamic increment of live load surcharge	0	0		0	
		11054.986		73249.786	

Summary of Forces For SBC			
	Downward	Upward	
P	28744.056	27863.586	kN
ML	10424.391	9989.246	kNm
MT	13243.111	13243.111	kNm

Summary of Restoring Forces	
Vertical Load	24944.266 kN
Moment	-190355.841 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation															
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		816.901	163.380		3336.243	204.225				-18.000	9549.423
Substructure & Foundation -Portion 1				792.537	40.699	170.875	34.175		558.346	31.471		415.923		0.000	1746.252
Substructure & Foundation -Portion 2				30970.832	248.799	1044.584	208.917		-54693.379	-31.545		1571.939		7472.332	6599.784
Total =				34432.363	289.498	2032.360	406.472		-50798.789	284.151		1987.862		7454.332	17895.458
							-406.472			-204.151					

Vertical Forces For Restoring or Resisting Effect									
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv	
Superstructure				2432.285	147.083		-10945.28	-661.874	
Substructure & Foundation -Portion 1				713.283	30.758		-3386.87	-148.532	
Substructure & Foundation -Portion 2				27974.117	184.604		-210628.19	-1094.288	
Total =				31119.684	362.444		-224960.35	-1904.695	
								-362.444	1904.695

For Overturning or Sliding Effect			
Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLS due to FL
	135.664		1386.410
	814.240		5147.283
	949.903		6533.693

Horizontal Forces For SBC Calculation						
	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.357	816.901	1203.209	4020.376	9549.423
due to Substructure	1	289.498	1215.459		1987.862	8346.035
due to Earth pressure	1	6572.133			38019.152	

Horizontal Forces For Overturning or Sliding Effect					
	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)	
due to Superstructure		576.536	1203.209	6930.584	
due to Substructure	1.5	1424.855		9800.5395	
due to Active Earth pressure	1	4302.738		22309.266	
due to dynamic Earth pressure	1.5	1021.228		7069.4488	
		7325.356		45209.818	

Summary of Forces For SBC			
	Downward	Upward	
P	34838.835	34025.891	kN
ML	-6567.249	-6975.550	kNm
MT	25349.789	25349.789	kNm

Summary of Restoring Forces	
Vertical Load	30757.240 kN
Moment	-226865.044 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation					
Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLS due to Fv	MT = PxeT
Total =	34755.133	419.441	-51171.65	220.362	7655.605
		-419.441		-220.362	

Vertical Forces For Restoring or Resisting Effect				
Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLS due to Fv
Total =	31119.684	362.444	-224960.35	-1904.695
			-362.444	1904.695

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	881.747	1203.209	4496.724	10427.763
due to Substructure	1	289.498	1215.459		1987.862	8346.035
due to Earth pressure	1	6572.133			38019.152	
due to Live load surcharge	0.2	267.743			1913.160	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1203.209	6030.564
due to Substructure	1.5	427.46		2940.162
due to Active Earth pressure	1	4302.74		22309.266
due to dynamic Earth pressure	1.5	1021.23		7069.449
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		6327.96		38349.441

Summary of Forces For SBC

	Downward	Upward
P	35174.574	34335.691
ML	-4534.387	-4975.112
MT	26429.403	26429.403

Case 11 : DL+SIDL+Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	2668.995	163.380	3336.243	204.225	-18.000
Substructure & Foundation -Portion 1	792.537	34.175	558.346	31.471	0.000
Substructure & Foundation -Portion 2	24653.696	239.121	-51895.897	-22.571	7472.332
Total =	28115.227	436.676	-48001.307	213.125	7454.332
		-436.676		-213.125	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.36	816.90	1203.21	4020.38	9549.42
due to Substructure	1	325.47	1366.48		2220.18	9321.41
due to Earth pressure	1	6575.66			35432.63	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1203.209	6030.56
due to Substructure	1.5	427.456		2960.37
due to Active Earth pressure	1	4310.293		19737.86
due to dynamic Earth pressure	1.5	1019.416		7062.65
		6333.701		35791.43

Summary of Forces For SBC

	Downward	Upward
P	28551.904	27678.551
ML	-6115.000	-6541.250
MT	26325.169	26325.169

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	28303.821	440.235	-48678.79	217.573	7509.558
		-440.235		-217.573	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	834.69367	1203.209	4496.724	9790.4284
due to Substructure	1	325.469	1366.4817		2220.178	9321.4147
due to Earth pressure	1	6575.662			35432.628	
due to Live load surcharge	0.2	314.958			2174.781	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1203.209	6030.56
due to Substructure	1.5	427.46		2960.37
due to Active Earth pressure	1	4310.29		19737.86
due to dynamic Earth pressure	1.5	1019.42		7062.65
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		6333.70		35791.43

Summary of Forces For SBC

	Downward	Upward
P	28744.056	27863.586
ML	-4136.901	-4572.047
MT	26621.401	26621.401

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	171.10	=	171.102	kN	Normal
Transverse Moment due to C.F.	=	171.102	x (	1206.437	-	1192.749	)	

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	171.10	=	34.220	kN	Seismic
Transverse Moment due to C.F.	=	34.220	x (	1206.437	-	1192.749	)	

Base pressure on corner A	=	σ_A	=	P/A - ML/ZL + MT/ZT
Base pressure on corner B	=	σ_B	=	P/A + ML/ZL + MT/ZT
Base pressure on corner C	=	σ_C	=	P/A - ML/ZL - MT/ZT
Base pressure on corner D	=	σ_D	=	P/A + ML/ZL - MT/ZT

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK		OVERTURNING CHECK			
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force: $\mu P + cA + F_p$	FOS	Overturning moment	Restoring Moment: $= \Sigma P.e_{Toe} + M_R$	FOS
	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Normal Dry Case															
Case 1 : DL+SIDL-Normal Dry Case	33603.869	-22346.952	7454.332	339.765	177.549	289.983	127.767	339.765	127.767	7006.721	21191.570	3.02	35019.975	215443.19	6.15
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	35009.690	-14166.970	8460.697	323.216	220.378	266.713	163.875	323.216	163.875	8203.094	21191.570	2.58	43230.253	219029.36	5.07
								SAFE	SAFE			SAFE			SAFE
Normal HFL Case															
Case 3 : DL+SIDL-Normal HFL Case	27285.271	-21774.367	7454.332	293.731	135.672	243.949	85.890	293.731	85.890	7006.721	17210.854	2.46	31162.859	179938.99	5.77
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	27954.050	-13863.812	7730.466	270.595	169.957	218.968	118.331	270.595	118.331	8352.353	17449.063	2.09	40541.615	183852.43	4.53
								SAFE	SAFE			SAFE			SAFE

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
429.90	4496.72	0.00	0.00	0.00	0.00	881.75	10427.76
289.50	1987.86	0.00	0.00	0.00	0.00	1215.46	8346.04
6572.13	38019.15						
267.74	1913.16						
7595.27	46416.90	0.00	0.00	0.00	0.00	2097.21	18773.80

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	6030.56	0.00	0.00
427.46	2940.16	0.00	0.00
4302.738	22309.266		
1021.228	7069.449		
0.000	0.000		
0.000	0.000		
6327.96	38349.44	0.00	0.00

Summary of Restoring Forces

Vertical Load	30757.240	kN
Moment	-228665.044	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	2432.285	147.083		-10945.281	-661.874
Substructure & Foundation	713.283	30.758		-3386.874	-148.532
Substructure & Foundation	22188.327	211.788		-173984.888	-1223.883
Total =	25333.894	389.628		-188317.042	-2034.299
		-389.628			2034.299

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
384.36	4020.38	0.00	0.00	0.00	0.00	816.90	9549.42
325.47	2220.18	0.00	0.00	0.00	0.00	1366.48	9321.41
6575.66	35432.63						
7285.49	41673.18	0.00	0.00	0.00	0.00	2183.38	18870.84

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	6030.56	0.00	0.00
427.46	2960.37	0.00	0.00
4310.293	19737.856		
1019.418	7062.648		
6333.70	35791.43	0.00	0.00

Summary of Restoring Forces

Vertical Load	24944.266	kN
Moment	-190351.341	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	25333.894	389.628		-188321.54	-2034.299
		-389.628			2034.299

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
429.90	4496.72	0.00	0.00	0.00	0.00	834.69	9790.43
325.47	2220.18	0.00	0.00	0.00	0.00	1366.48	9321.41
6575.66	35432.63						
314.96	2174.78						
7645.99	44324.31	0.00	0.00	0.00	0.00	2201.18	19111.84

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	6030.56	0.00	0.00
427.46	2960.37	0.00	0.00
4310.293	19737.856		
1019.416	7062.648		
0.000	0.000		
0.000	0.000		
6333.70	35791.43	0.00	0.00

Summary of Restoring Forces

Vertical Load	24944.266	kN
Moment	-190355.841	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Sin θ	FT Sin θ	MT Sin θ
171.10	2341.95	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Sin θ	FT Sin θ	MT Sin θ
34.22	468.39	0.00	0.00

Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	34838.835	7451.973	12822.969	258.128	312.222	172.493	226.586	312.222	172.493	11053.471	21530.068	1.95	75776.515	226865.04	2.99
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	35174.574	9953.224	13287.744	252.937	325.187	164.198	236.448	325.187	164.198	11053.471	21530.068	1.95	75776.515	226865.04	2.99
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	28551.904	8446.292	13115.583	211.761	273.072	124.172	185.483	273.072	124.172	11054.986	17460.986	1.58	73249.786	190351.34	2.60
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	28744.056	10892.782	13243.111	204.644	283.714	116.203	195.273	283.714	116.203	11054.986	17460.986	1.58	73249.786	190355.84	2.60
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	34838.835	-6567.249	25349.789	350.839	303.168	181.547	133.875	350.839	133.875	7325.356	21530.068	2.94	45209.818	226865.04	5.02
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	35174.574	-4534.387	26897.793	350.965	318.050	171.335	138.420	350.965	138.420	6327.958	21530.068	3.40	38349.441	226865.04	5.92
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	28551.904	-6115.000	26325.169	308.719	264.331	132.913	88.524	308.719	88.524	6333.701	17460.986	2.76	35791.435	190351.34	5.32
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	28744.056	-4136.901	27089.792	305.430	275.400	124.517	94.487	305.430	94.487	6333.701	17460.986	2.76	35791.435	190355.84	5.32
								SAFE	SAFE			SAFE			SAFE

DESIGN OF ABUTMENT(A2) WITH
OPEN FOUNDATION
FOR MINOR BRIDGE AT CH-
89+723

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 78 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	23.750m	23.750m
Thickness of Expansion Joint	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side) =	0.600m	0.600m
Slab projection Beyond C/L of Bearing (Span Side) =	0.600m	0.600m
Span -c/c of E.J.	25.000m	25.00m
Type of Superstructure	PSC precast Girder	
Width of Crash barrier (Both Side)	0.500m	
Width of Carriageway	11.000m	
Projection beyond crash barrier	0.050m	
Thickness of Wearing coat	0.065m	
Length of Approach Slab (Right)	3.500m	3.500m
Width of Footpath on one side	0.000m	
Railing/kerb on footpath edge	0.000m	
Total Width of Superstructure	12.500m	
Median Width minus 20mm gap	0.000m	

Bearings

No of Bearings = 4
Type of Bearing = SPHERICAL BEARING
Coeff. Of Friction for POT-PTFE Bearing = 0.05
C/C Distance of Bearing in Transverse Direction = 3.000m (Right) 3.000 (Skew)

Type of Soil = 2 Medium Soil Strata

NBC of soil -Normal Case = 350 kN/m²
SBC of soil-Normal Case = 410 kN/m² Assumed
SBC of soil-Seismic Case = 513 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	0.300m	0.300m
Width of Dirt wall at Bottom	0.300m	0.300m
Height of Uniform portion	1.000m	
Height of Trapering portion	1.556m	
Length of Dirt Wall at top (Uniform portion)	12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.950m	1.950m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m
Projection of Abutment Cap (Span Side)	=	0.500m	0.500m
Projection of Abutment Cap Back Side	=	0.450m	0.450m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.063m	1.063m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.000m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	9.200m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	1.250m	
Width of Toe Slab	=	3.000m	
Width of Heel Slab	=	5.000m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.250m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.250m	
Width of backfill on heel slab	=	5.000m	
Thickness of heel slab at back fill edge	=	1.250m	
Height of back fill at bottom edge of heel slab	=	9.362m	
Height of back fill at back fill edge of heel slab	=	8.612m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Levels

Deck Level at Median Edge=	1205.649m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1205.792m	Height of Superstructure	=	1.820m
Deck level at center line =	1205.649m	Min. Height of Footpath Side Pedestal (1)	=	0.400m
Soffit Level at center of bridge =	1203.764m	Height of Pedestal (2)	=	0.475m
Abutment cap top level =	1203.164m	Height of Pedestal (3)	=	0.550m
Abutment cap bottom lvl (uniform portion ends)	1202.864m	Height of Pedestal (4)	=	0.625m
Abutment cap bottom lvl (corbel portion ends)	1202.564m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1202.564m	Height of Pedestal (6)	=	0.000m
Ground level/LBL =	1198.858m	Distance of nearest girder to c.l. of deck	=	1.500m
Abutment shaft bottom level =	1197.108m	Height (Avg.) of Dirt Wall	=	2.556m
Foundation level =	1195.858m	Abutment shaft Above G.L	=	3.706m
HFL	= 1200.858m	Abutment Shaft below G.L	=	1.750m

Height of abutment shaft	=	5.456m
MSL	=	1197.858m
Wedge over girder flange	=	0.0250m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	2	for 90 days
For Footing	=	2	for 90 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

Seismic Zone	=	5	
Z =Zone factor	=	0.36	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.5

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

		eT
DL Reaction on Bearing No.-1	=	522.61 4.50
DL Reaction on Bearing No.-2	=	544.54 1.50
DL Reaction on Bearing No.-3	=	544.54 -1.50
DL Reaction on Bearing No.-4	=	522.61 -4.50
DL Reaction on Bearing No.-5	=	0.00 0.00
DL Reaction on Bearing No.-6	=	0.00 0.00
		2134.30 0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	100.000 4.50
SIDL Reaction on Bearing No.-2	=	0.000 1.50
SIDL Reaction on Bearing No.-3	=	0.000 -1.50
SIDL Reaction on Bearing No.-4	=	100.000 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		200.00 0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	68.613 4.50
SIDL Reaction on Bearing No.-2	=	82.335 1.50
SIDL Reaction on Bearing No.-3	=	82.335 -1.50
SIDL Reaction on Bearing No.-4	=	68.613 -4.50
SIDL Reaction on Bearing No.-5	=	0.000 0.00
SIDL Reaction on Bearing No.-6	=	0.000 0.00
		301.90 0.000

Carriageway Live Load Reactions**MAXIMUM REACTION CASE:****(1-70RW + 1-CLASS A)**

Reduction Factor = 0.9 (for 3 Lane)

		Max CWLL			Min CWLL	
CWLL Reaction on Bearing No.-1	=	23.48	4.50	CWLL Reaction on Bearing No.-8	=	5.015 4.50
CWLL Reaction on Bearing No.-2	=	692.01	1.50	CWLL Reaction on Bearing No.-9	=	26.750 1.50
CWLL Reaction on Bearing No.-3	=	379.41	-1.50	CWLL Reaction on Bearing No.-10	=	111.449 -1.50
CWLL Reaction on Bearing No.-4	=	83.76	-4.50	CWLL Reaction on Bearing No.-11	=	76.684 -4.50
CWLL Reaction on Bearing No.-5	=	0.00	0.00	CWLL Reaction on Bearing No.-12	=	0.00 0.00
CWLL Reaction on Bearing No.-6	=	0.00	0.00	CWLL Reaction on Bearing No.-13	=	0.00 0.00
CWLL Reaction on Bearing No.-7	=	0.00	0.00	CWLL Reaction on Bearing No.-14	=	0.00 0.00

max	=	1059.33	KN	Corr. Transv	=	1006.366 kNm	ecc.	0.95
min	=	290.67	KN	Corr. Transv	=	276.134 kNm	ecc.	0.95

SV Loading

max	=	1926.19	KN	Corr. Transv	=	577.857 kNm	ecc.	0.30
min	=	1493.81	KN	Corr. Transv	=	448.143 kNm	ecc.	0.30

MAXIMUM TRASVERSE MOMENT CASE:**(1-70RW)**

Reduction Factor = 1 (for 2 Lane)

max	=	809.52	KN	Corr. Transv	=	2554.049 kNm	ecc.	3.16
min	=	190.48	KN	Corr. Transv	=	600.951 kNm	ecc.	3.16

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.076
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.400 x	0.800 x	0.800 =	0.2560 m ³	4.500
Pedestal 2	=	0.475 x	0.800 x	0.800 =	0.3040 m ³	1.500
Pedestal 3	=	0.550 x	0.800 x	0.800 =	0.3520 m ³	-1.500
Pedestal 4	=	0.625 x	0.800 x	0.800 =	0.4000 m ³	-4.500
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
Pedestal 6	=	0.000 x	0.800 x	0.800 =	0.0000 m ³	0.000
					1.3120 m ³	-0.549

VOLUME CALCULATION

C.G. Of Footing = 4.600 m
 C.G. Of shaft from toe tip = 3.600 m
 Distance between c.g. of shaft and footing = 1.000 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	1.000	3.750	-0.800	0.200	-4.400	0.000
-Trapering portion	1	12.50	0.300	1.556	5.836	-0.800	0.200	-4.400	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-1.100	-0.100	-4.700	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-1.050	-0.050	-4.650	0.000
Cap (uniform portion)	1	12.50	1.950	0.300	7.313	0.025	1.025	-3.575	0.000
Cap (Corbel Portion)	1	12.50	1.950	0.300	5.433	0.025	1.025	-3.575	0.000
		12.50	1.000						
Shaft above HFL	1	12.50	1.031	1.706	21.992	0.084	1.084	-3.516	0.000
Shaft below HFL	1	12.50	1.131	3.250	45.958	0.034	1.034	-3.566	0.000
Solid Return Wall	1	5.00	0.500	9.058	22.646	-3.100	-2.100	-6.700	6.000
Cantilever Return wall(Rectangular portion)	1	0.00	0.000	0.000	0.000	-0.600	0.400	-4.200	6.000
Cantilever Return wall(Traingular portion)	1	0.00	0.000	0.000	0.000	-0.600	0.400	-4.200	6.000
Footing									
Heel Slab	1	12.50	5.000	0.875	54.688		-1.743	-6.343	0.000
Toe Slab	1	12.50	3.000	0.875	32.813		2.886	-1.714	0.000
Portion between Heel and Toe	1	12.50	1.200	1.250	18.750		1.000	-3.600	0.000
Back filling above HFL over Heel Slab	1	12.50	5.000	4.791	299.437		-2.100	-6.700	0.000
Back filling below HFL over Heel Slab	1	12.50	5.000	4.125	257.813		-2.176	-6.776	0.000
Backfill above Heel slab	1	12.50	5.000	8.987	561.703		-2.135	-6.735	0.000
Front Filling over Toe Slab	1	12.50	3.000	2.125	79.688		3.012	-1.588	0.000
Front Filling over Toe Slab in HFL Case	1	12.50	3.000	1.125	42.188		1.933	-2.667	0.000
Side filling between heel and toe	1	0.00	1.200	2.125	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-1.100	-0.100	-4.700	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.063	4.791	3.745		0.485	-4.115	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.137	4.125	7.088		0.446	-4.154	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.800	0.200	-4.400

SECTIONAL PROPERTIES

Width of Footing (B) = 9.200 m
 Length of Footing (L) = 12.500 m

A = 9.200 x 12.500 = 115.000 m²
 ZL = 12.500 x 14.107 = 176.333 m³
 ZT = IT1 + IT2

distance of extreme point from centre

IT1 = 9.200 x 162.760 = 1497.40 m⁴
 IT2 (moment of inertia of triangle) = 9.200 x 0.000 + 0.500 x 9.200 x 0.000 x 39.063
 from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1497.40 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 239.583 m³

Load Factors (As per IRC:6-2017)**Table B.1 Partial Safety Factor For Verification of Equilibrium**

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.000	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.00	1.00	1.00
wearing course	1.20	1.20	1.20
Back Filling Weight	1.00	1.00	1.00
Shrinkage Creep Effect	1.00	1.00	1.00
Earth Pressure due to back filling	1.00	1.00	1.00
CWLL and Associate load and FPLL	1.00	0.75	0.00
Live Load Surcharge	0.80	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation**(As Per IRC:6-2017 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 7.706 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 9.363 m

Abutment Cap Top Level - Foundation Level

= 7.306 m

Dimensions of Abutment Shaft

Length = 12.50 m

Width = 1.10 m

Moment of Inertia , $I_{longitudinal}$ = 1.040 m^4

Moment of Inertia , $I_{transverse}$ = 179.036 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force	=	238.829	KN
D	=	2636.19	KN
T	=	0.2101	sec

Transverse Direction

Force	=	31286.680	KN
D	=	2906.195	KN
T	=	0.0193	sec

For Hard or Rocky Strata, with $N > 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.289$$

For Medium Strata, with $N > 10 \& N < 30$

$$\frac{S_a}{g} = 2.500$$

$$\frac{S_a}{g} = 1.289$$

For Soft Soil Strata, with $N < 10$

$$\frac{S_a}{g} = 2.5$$

$$\frac{S_a}{g} = 1.289$$

Medium Soil Strata

$$S_a/g = 2.5$$

$$S_a/g = 1.289$$

Seismic Coeff. In Longitudinal Direction = 0.18

Seismic Coeff. In Transverse Direction = 0.278

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.180	In Longitudinal direction
Ah	=	0.278	In Transverse direction
Av	=	0.186	In Vertical direction

For Design of Foundation

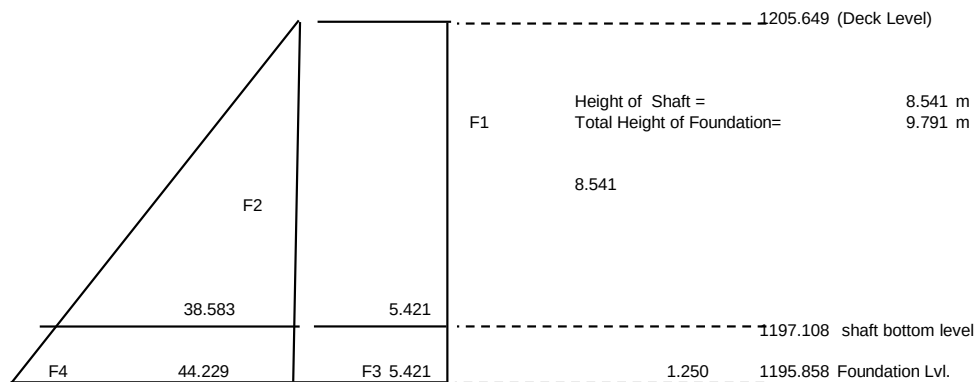
(35% increment in Seismic Coeff for Foundation as per IRC:6-2017, Clause No. 219.8)

Ah	=	0.243	In Longitudinal direction
Ah	=	0.278	In Transverse direction
Av	=	0.186	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	22.5 degree	0.393 radians
	Kah	=	0.226 active component	
	Kph	=	5.249 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1197.108 m (at Shaft Base)			
@ RL					1195.858 m (at Foundation Level)			
Due to Live Load Surcharge								
Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421 kN/m ²
F1	=	5.421	x	8.541	x	12.500	=	578.739 kN
M1	=	578.74	x	4.27	=	2471.504	kN.m	at Shaft Bottom
F3	=	5.421	x	9.791	x	12.500	=	663.439 kN
M3	=	663.439	x	4.895	=	3247.866	kN.m	at Foundation
Due to Active Earth Pressure								
Intensity for triangular portion (At Shaft bottom level)								
	=	0.226	x	20	x	8.541	=	38.583 kN/m ²
F2	=	0.5	x	38.58	x	8.541	x	12.50
	=	2059.587 kN						
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)								
M2	=	2059.59	x	3.59	=	7388.192	kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)								
	=	0.226	x	20	x	9.791	=	44.229 kN/m ²
F4	=	0.5	x	44.23	x	9.791	x	12.50
	=	2706.555 kN						
M4	=	2706.55	x	4.11	=	11129.948	kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
 = 4.800 x 8.541 = 40.997 kN/m²

F = 0.5 x 40.997 x 12.500
 = 2188.460 kN

M = 2188.46 x 2.847 = 6230.547 kN.m at Shaft Bottom

Intensity for triangular portion (At Foundation level)
 = 4.800 x 9.791 = 47.00 kN/m²

F = 0.5 x 46.997 x 12.500
 = 2875.910 kN

M = 2875.91 x 3.264 = 9386.013 kN.m at Foundation

Intensity of Passive pressure
 = 5.249 x 20 x 0.000 = 0.000 kN/m²

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 12.500
 = 0.000 kN

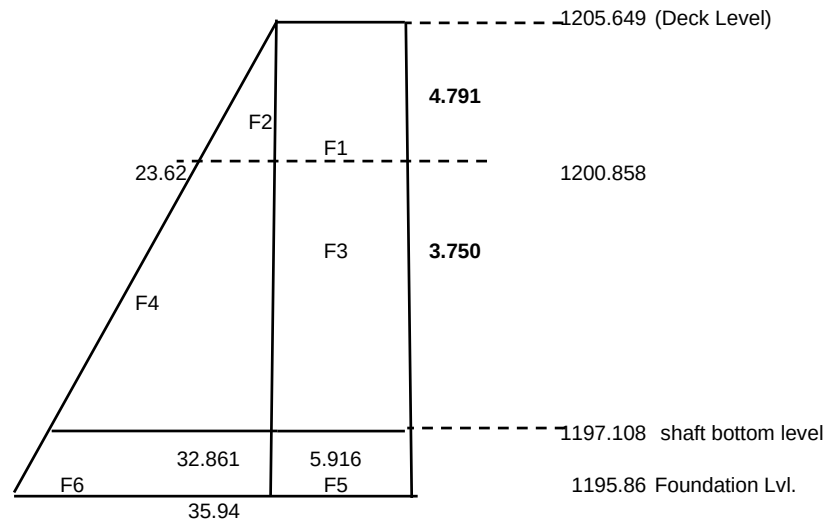
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = 0.000 kN.m at Foundation

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	7388.192	11129.948	2059.587	2706.555
Due to Minimum Fluid Pressure	6230.547	9386.013	2188.460	2875.910
Governing of Two	7388.192	11129.948	2188.460	2875.910
Due to Live Load Surcharge	2471.504	3247.866	578.739	663.439
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	35 degree	0.611 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	11.3 degree	0.196 radians
	Ka'	=	0.246 active component	
	Kp'	=	5.249 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1197.1 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.246	x	20	x	1.200	=	5.916 kN/m ²
F1	=	5.916	x	8.541	x	12.500	=	631.556 kN
M1	=	631.56	x	4.27	=	2697.061 kN.m		at Shaft Bottom
F3	=	5.916	x	9.791	x	12.500	=	723.986 kN
M3	=	723.99	x	4.90	=	3544.276 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.246	x	20	x	4.791	=	23.618 kN/m ²
(At Shaft bottom level) Below HFL	=	0.246	x	10	x	3.750	=	9.243 kN/m ²
F2	=	0.5	x	23.62	x	4.791	x	12.50
	=	707.204 kN						
F4	=	$\frac{(23.62 + 32.86)}{2}$	x	3.75	x	12.50		
	=	1323.715 kN						
Total Force	=	2030.918 kN						
M2	=	707.20	x	5.76	=	4075.063 kN.m		
M4	=	1323.71	x	1.77	=	2346.569 kN.m		
Total Moment	=	6421.63 kN.m						at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.246 \times 20 \times 4.791 = 23.618 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.246 \times 10 \times 5.000 = 12.324 \text{ kN/m}^2$$

$$F2 = 0.5 \times 23.62 \times 4.791 \times 12.50 = 707.204 \text{ kN}$$

$$F6 = \frac{(23.62 + 35.94)}{2} \times 5.00 \times 12.50 = 1861.234 \text{ kN}$$

$$\text{Total Force} = 2568.438 \text{ kN}$$

$$M2 = 707.20 \times 7.01 = 4959.068 \text{ kN.m}$$

$$M6 = 1861.23 \times 2.33 = 4332.147 \text{ kN.m}$$

$$\text{Total Moment} = 9291.21 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 5.249 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 0.00 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	6421.632	9291.215	2030.918	2568.438
Due to Minimum Fluid Pressure	6230.547	9386.013	2188.460	2875.910
Governing of Two	6421.632	9386.013	2188.460	2875.910
Due to Live Load Surcharge	2697.061	3544.276	631.556	723.986
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta (1 \pm \alpha v)}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2}$$

αh	=	0.180	
αv	=	0.186	
ϕ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

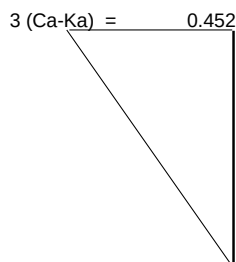
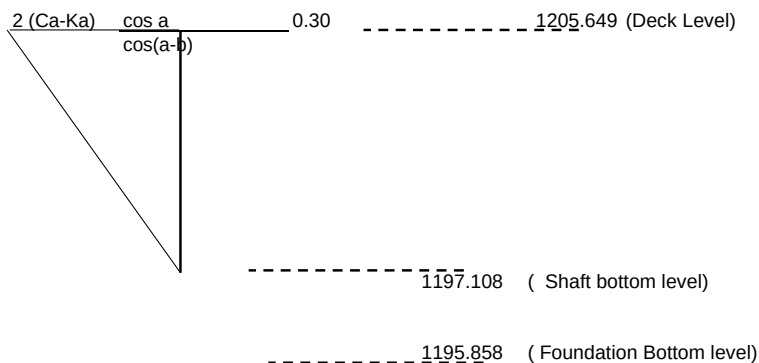
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.151 \\ 0.218 \end{matrix}$$

$$C_a = \frac{1}{0.376} \frac{2}{0.303} = 0.376 \quad 0.303$$

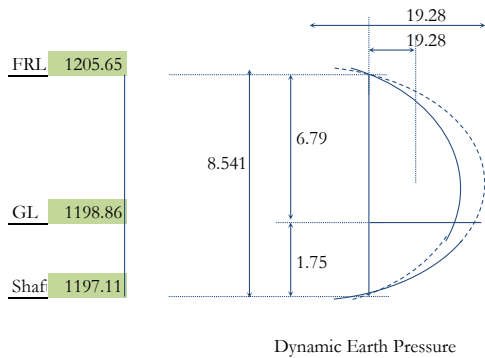
Ca	=	0.376	
Ka	=	0.226	
Dynamic Increment	=	0.376	-0.226 0.151

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

Active Earth Pressure**Surcharge Earth Pressure****Earth Pressure Diagram for Dynamic Increment****Due to Dynamic Live Load Surcharge**

	=	0.301	x	20.00	x	1.2	=	7.225 kN/m ²
at Shaft Bottom Level								
E1	=	0.50	x	7.225	x	8.541	x	12.500
	=	385.665	kN					
M1	=	385.665	x	5.722			=	2206.959 kN.m
at Foundation Bottom Level								
E2	=	0.50	x	7.225	x	8.541	x	12.500
	=	385.665	kN					
M2	=	385.665	x	6.972			=	2689.040 kN.m

Due to Dynamic Active Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height	=	19.28 t/m ²
h	=	8.541 m
y	=	2.5205 m
L	=	12.500 m

Parabola below Water Level

p_mid_height	=	19.28 t/m ²
h	=	8.541 m
y	=	-2.5205 m
L	=	12.500 m

Dyanmic Earth Pressure	Pa	cy
	T	m
Parabola above Water Level	1223.2	4.7
Parabola below Water Level	149.2	1.1
Total Dynamic Earth Pressure	1372.5	4.3

$$E3 = 1372.487 \text{ kN}$$

$$E4 = 1372.487 \text{ kN}$$

$$M3 = 1372.49 \times 4.27 = 5861.205 \text{ kN.m (Shaft bottom level)}$$

$$M4 = 1372.49 \times 5.52 = 7576.813 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	7388.192	11129.948	2059.587	2706.555
Due to active Earth Pressure (dynamic Increment)	5861.205	7576.813	1372.487	1372.487
Total Earth Pressure	13249.397	18706.762	3432.074	4079.041
Due to Minimum Fluid Pressure	6230.547	9386.013	2188.460	2875.910
Governing of Two	7388.192	18706.762	3432.074	4079.041
Due to Live Load Surcharge (Static)	2471.504	3247.866	578.739	663.439
Due to Live Load Surcharge(Dynamic)	2206.959	2689.040	385.665	385.665
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

αh	=	0.180			
αv	=	0.186			
ϕ	=	35.00		0.611	
δ	=	11.25		0.196	
α	=	0.00		0.000	
β	=	0.00		0.000	
Ws	=	20.00	Kn/m3	2.00	gm/cm3
λ	=	$\tan^{-1} \frac{Ws}{Ws-1}$		$\frac{\alpha h}{(1 \pm \alpha v)}$	=
					0.295
					0.416
C_a'	=	1		2	
		0.550		0.514	
Ca'	=			0.550	
Ka'	=			0.246	
Dynamic Increment	=	0.550		-0.246	0.303
Dynamic Increment	=			0.303	
γ_d	=			20	kN/m ³
γ_{sat}	=			10	kN/m ³
γ_{water}	=			10	kN/m ³
Equivalent Live Load Surcharge height	=			1.2	m
Foundation	=			9.20	m
Dynamic Active earth pressure Variation					
3 (ca'-ka')					
Dynamic Surcharge earth pressure Variation					
2 (Ca'-Ka')					
$\cos a$					1205.649 (Deck Level)
$\cos(a-b)$					
				4.791	
					1200.858 HFL
				3.750	
					5.000
					1197.108 shaft bottom level
					1195.858 Foundation Bottom Lvl.

Earth Pressure Diagram

h'	=	3.750
h	=	8.541

Dynamic active earth pressure

3 (ca-ka)	=	0.452 at deck level
3 (ca'-ka')	=	0.910 at deck level
3 (ca'-ka')h'/h	=	0.400 at HFL level

Dynamic Surcharge earth pressure

2 (Ca'-Ka')	$\frac{\cos a}{\cos(a-b)}$	=	0.607 at deck level	Pressure	=	14.57 kN/m ²
		=	0.266 at HFL level	Pressure	=	6.40 kN/m ²

Due to Live Load Surcharge

Dynamic surcharge pressure in dry condition at deck level = 7.225 kN/m²
 Dynamic surcharge pressure in Submerge condition at HFL level = 6.40 kN/m²

at Shaft Bottom Level

F1 = 6.810 x 4.791 x 12.500 = **407.843 kN**

M1 = 407.84 x 6.15 = **2506.401 kN.m**

F2 = 0.50 x 6.396 x 3.750 x 12.500

= **149.896 kN**

M2 = 149.90 x 2.51 = **376.615 kN.m**

Total Force at Abutment shaft level = 557.740 **kN**

Total Moment at Abutment shaft level = 2883.016 **kN.m**

at Foundation Bottom Level

F3 = 6.810 x 4.791 x 12.500 = **407.843 kN**

M3 = 407.84 x 7.40 = **3016.205 kN.m**

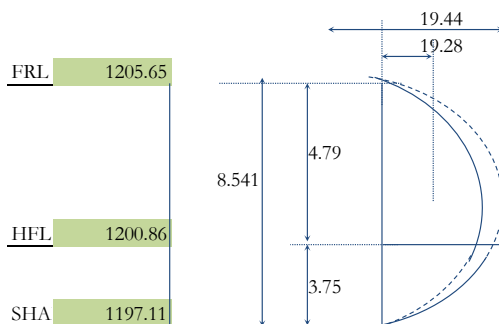
F4 = 0.500 x 6.396 x 3.750 x 12.500

= **149.896 kN**

M4 = 149.90 x 3.76 = **563.985 kN.m**

Total Force at Founding level = 557.740 **kN**

Total Moment at Founding level = 3580.191 **kN.m**

Due to Dynamic Active Earth Pressure

Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation**Parabola above Water Level**

p_{mid_height} = 19.28 t/m²
 h = 8.541 m
 y = 0.5205 m
 L = 12.500 m

Parabola below Water Level

p_{mid_height} = 19.44 t/m²
 h = 8.541 m
 y = -0.5205 m
 L = 12.500 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	811.1	5.6
Parabola below Water Level	566.0	2.4
Total Dynamic Earth Pressure	1377.0	4.3

Total Force (F1 + F2)	=	1377.037 kN	at Shaft Bottom Level
Total Force (F1 + F2)	=	1377.037 kN	at Foundation Bottom Level

M1 = 1377.04 x 4.26 = **5871.991 kN.m**

Total Mome = **5871.991 kN.m** at Shaft Bottom

M1 = 1377.04 x 5.51 = **7593.287 kN.m**

Total Mome = **7593.287 kN.m** at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Bottom	At Shaft Bottom Lvl	At Foundation Bottom Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure(Static)	6421.632	9291.215	2030.918	2568.438
Due to active Earth Pressure (Dynamic Increment)	5871.991	7593.287	1377.037	1377.037
Total Earth Pressure	12293.623	16884.502	3407.955	3945.474
Due to Minimum Fluid Pressure	6230.547	9386.013	2188.460	2875.910
Governing of Two	12293.623	16884.502	3407.955	3945.474
Due to Live Load Surcharge(Static)	2697.061	3544.276	631.556	723.986
Due to Live Load Surcharge (Dynamic Increment)	2883.016	3580.191	557.740	557.740
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	2134.30	1.35	1.35	2881.30	2881.30	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	301.90	1.75	1.75	528.32	528.32	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1059.33	1.5	0.20	1589.00	211.87	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1926.19	1	0.20	1926.19	385.24	SV Loading
CWLLmin	=	290.67	1.5	0.20	436.00	58.13	(1-70RW + 1-CLASS A)
CWLLmin	=	1493.81	1	0.20	1493.81	298.76	SV Loading
CWLLmax-Transv. Moment Case		809.52	1.5	0.20	1214.29	161.90	(1-70RW)

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 554 = 227.7 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	3679.62	0	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.55	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.55	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.55	244.695	415.470	96.855	415.470	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	$Fh/2 + \mu R$	$Fh - \mu R$	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1423.55	183.981	895.754	1239.564	1423.545	
DL+SIDL+LL-Max Reaction case		3737.75	1469.09	186.888	921.430	1282.197	1469.085	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	1469.09	194.574	929.117	1274.511	1469.085	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	1469.09	192.076	926.619	1277.009	1469.085	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	427.064	183.981	397.513	243.082	427.064	
DL+SIDL+LL-Max Reaction case		3737.75	472.604	186.888	423.189	285.716	472.604	Dry Case
DL+SIDL+LL-Min Reaction case		3891.49	472.604	194.574	430.876	278.029	472.604	HFL Case
DL+SIDL+LL-Max Transv. Moment case		3841.53	472.604	192.076	428.378	280.527	472.604	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.35	1.35	2881.30	2881.30
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	301.90	1.75	1.75	528.32	528.32
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.75	1589.00	794.50
CWLLmax- Transv. Moment Case	=	809.52	1.5	0.75	1214.29	607.14
CWLLmin	=	290.67	1.5	0.75	436.00	218.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	3679.62	0.000	183.981	183.981	-183.981	183.981	
DL+SIDL+LL-Max Reaction case	4115.62	341.550	205.781	376.556	135.769	376.556	(1-70RW + 1-CLASS A)
	5609.43	0.000	280.472	280.472	-280.472	280.472	SV Loading
DL+SIDL+LL-Min Reaction case	5268.62	341.550	263.431	434.206	78.119	434.206	(1-70RW + 1-CLASS A)
	5605.81	0.000	280.291	280.291	-280.291	280.291	SV Loading
DL+SIDL+LL-Max Transv. Moment case	4893.91	341.550	244.695	415.470	96.855	415.470	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	1921.79	183.981	1144.874	1737.805	1921.786	
DL+SIDL+LL-Max Reaction case		3897.62	1967.33	194.881	1178.544	1772.445	1967.326	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	1967.33	223.706	1207.369	1743.620	1967.326	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	1967.33	214.338	1198.001	1752.988	1967.326	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	3679.62	576.536	183.981	472.249	392.555	576.536	
DL+SIDL+LL-Max Reaction case		3897.62	622.076	194.881	505.919	427.195	622.076	Dry Case
DL+SIDL+LL-Min Reaction case		4474.12	622.076	223.706	534.744	398.370	622.076	HFL Case
DL+SIDL+LL-Max Transv. Moment case		4286.76	622.076	214.338	525.376	407.738	622.076	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1	1.00	2134.30	2134.30
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	301.90	1	1.00	301.90	301.90
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1	0.20	1059.33	211.87
CWLLmax- Transv. Moment Case		809.52	1	0.20	809.52	161.90
CWLLmin	=	290.67	1	0.20	290.67	58.13

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	0.000	131.810	131.810	-131.810	131.810	
DL+SIDL+LL-Max Reaction case	2926.86	227.700	146.343	260.193	81.357	260.193	(1-70RW + 1-CLASS A)
	4130.01	0.000	206.500	206.500	-206.500	206.500	SV Loading
DL+SIDL+LL-Min Reaction case	3695.53	227.700	184.776	298.626	42.924	298.626	(1-70RW + 1-CLASS A)
	4562.38	0.000	228.119	228.119	-228.119	228.119	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3445.72	227.700	172.286	286.136	55.414	286.136	

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	1281.191	131.810	772.405	1149.381	1281.191	
DL+SIDL+LL-Max Reaction case	2694.33	1326.731	134.716	798.082	1192.014	1326.731	Dry Case
DL+SIDL+LL-Min Reaction case	2848.06	1326.731	142.403	805.768	1184.328	1326.731	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2798.10	1326.731	139.905	803.270	1186.826	1326.731	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)
DL+SIDL	2636.19	384.357	131.810	323.988	252.547	384.357
DL+SIDL+LL-Max Reaction case	2694.33	429.897	134.716	349.665	295.181	429.897
DL+SIDL+LL-Min Reaction case	2848.06	429.897	142.403	357.352	287.494	429.897
DL+SIDL+LL-Max Transv. Moment case	2798.10	429.897	139.905	354.854	289.992	429.897

Dry Case

HFL Case

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - SPHERICAL BEARING

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	2134.30	1.1	1.10	2347.73	2347.73
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	301.90	1.35	1.35	407.56	407.56
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	1059.33	1.5	0.00	1589.00	0.00
CWLLmax- Transv. Moment Case		809.52	1.5	0.00	1214.29	0.00
CWLLmin	=	290.67	1.5	0.00	436.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)
DL+SIDL	2975.29	0.000	148.764	148.764	-148.764	148.764
DL+SIDL+LL-Max Reaction case	3411.29	341.550	170.564	341.339	170.986	341.339
	4469.10	0.000	223.455	223.455	-223.455	223.455
DL+SIDL+LL-Min Reaction case	4564.29	341.550	228.214	398.989	113.336	398.989
	4901.48	0.000	245.074	245.074	-245.074	245.074
DL+SIDL+LL-Max Transv. Moment case	4189.57	341.550	209.479	380.254	132.071	380.254

(1-70RW + 1-CLASS A)

Dry Case

SV Loading

(1-70RW + 1-CLASS A)

HFL Case

SV Loading

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh- μR	Governing Long. Force (kN)
DL+SIDL	2636.19	2975.29	1921.79	148.764	1109.657	1773.021	1921.786
DL+SIDL+LL-Max Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786
DL+SIDL+LL-Min Reaction case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786
DL+SIDL+LL-Max Transv. Moment case		2975.29	1921.79	148.764	1109.657	1773.021	1921.786

Dry Case

HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2636.19	2975.29	576.536	148.764	437.032	427.771	576.536	
DL+SIDL+LL-Max Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	Dry Case
DL+SIDL+LL-Min Reaction case		2975.29	576.536	148.764	437.032	427.771	576.536	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2975.29	576.536	148.764	437.032	427.771	576.536	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	2134.30	1	1	1	2134.30	2134.30	2134.30
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	301.90	1.20	1.20	1.20	362.27	362.27	362.27
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	1059.33	1	0.75	0	1059.33	794.50	0.00
CWLLmax-Transv. Moment Case	=	809.52	1	0.75	0	809.52	607.14	0.00
CWLLmin	=	290.67	1	0.75	0	290.67	218.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2987.24	227.700	149.362	263.212	78.338	263.212	(1-70RW + 1-CLASS A) Dry Case
	4190.38	0.000	209.519	209.519	-209.519	209.519	SV Loading
DL+SIDL+LL-Min Reaction case	3755.91	227.700	187.795	301.645	39.905	301.645	(1-70RW + 1-CLASS A) HFL Case
	4622.76	0.000	231.138	231.138	-231.138	231.138	SV Loading
DL+SIDL+LL-Max Transv. Moment case	3506.10	227.700	175.305	289.155	52.395	289.155	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2914.57	170.775	145.729	231.116	25.046	231.116	Dry Case
DL+SIDL+LL-Min Reaction case	3491.07	170.775	174.554	259.941	-3.779	259.941	HFL Case
DL+SIDL+LL-Max Transv. Moment case	3303.72	170.775	165.186	250.573	5.589	250.573	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Fh/2 + μR	Fh - μR	Governing Long. Force (kN)	
DL+SIDL	2696.57	0.000	134.829	134.829	-134.829	134.829	
DL+SIDL+LL-Max Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	Dry Case
DL+SIDL+LL-Min Reaction case	2696.57	0.000	134.829	134.829	-134.829	134.829	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2696.57	0.000	134.829	134.829	-134.829	134.829	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	1059.33	kN	1059.33	kN
Radius of Curvature	R	=	78.00	m	78.00	m
CENTRIFUGAL FORCE	C	=	171.10	kN	171.10	kN

Possible Load Combination

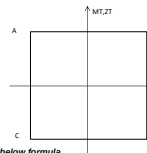
Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1195.858 m

Properties of Footing Base:

A	=	115.000	m ²
ZL	=	176.333	m ³
ZT	=	239.583	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		2668.995		-18.000
Dead Load	1			2134.300	1.000	2134.300	0.000	0.000
SIDL except Wearing Course	1			200.000	1.000	200.000	0.000	0.000
Wearing Course	1			301.895	1.000	301.895	0.000	0.000
Bearing Pedestal	1	25	1.312	32.800	1.000	32.800	-0.549	-18.000
				2668.995		2668.995		-18.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	3.750	93.750	0.200	18.750	0.000	0.000
Dirt Wall-Tapered portion	1	25	5.896	145.896	0.200	29.180	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.100	-2.813	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	-0.050	-0.703	0.000	0.000
Cap - (uniform portion)	1	25	7.313	182.813	1.025	187.383	0.000	0.000
Cap - (corbel portion)	25	5.433	135.826	1.025	139.221	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.400	0.000	6.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.400	0.000	6.000	0.000
RCC Railing or Crash Barrier	1	25	0.000	28.000	0.200	5.600	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.100	-16.406	0.000	0.000
				792.537		360.212		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	22.646	566.156	-2.100	-1188.928	6.000	3396.937
Abutment Shaft	1	25	67.950	1698.739	1.034	1755.936	0.000	0.000
Back filling over heel slab	1	20	561.703	11234.062	-2.135	-23982.156	0.000	0.000
Front Filling over toe slab	1	20	79.688	1593.750	3.012	4800.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	54.688	1367.188	-1.743	-2382.813	0.000	0.000
Toe slab	1	25	32.813	820.313	2.886	2367.188	0.000	0.000
Portion between heel & toe	1	25	18.750	468.750	1.000	468.750	0.000	0.000
Vertical Components of active earth pressure	1			1191.241		-5479.709		0.000
				19156.862		-23540.860		3396.937
Total				22618.393		-20511.653		3378.937

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.900	1920.870	-3.600	-6915.131
0.900	180.000	-3.600	-648.000
0.900	301.895	-3.600	-1086.822
0.900	29.520	-3.600	-106.272
	2432.285		-8756.225
0.900	84.375	-4.400	-371.250
0.900	131.309	-4.400	-577.758
0.900	25.313	-4.700	-118.969
0.900	12.656	-4.650	-58.852
0.900	164.533	-3.575	-588.199
0.900	122.243	-3.575	-437.019
0.900	0.000	-4.200	0.000
0.900	0.000	-4.200	0.000
0.900	25.200	-4.400	-110.880
0.900	147.656	-4.700	-693.984
	713.283		-2956.911
0.900	509.541	-6.700	-3413.922
0.900	1528.865	-3.566	-5402.439
0.900	10110.656	-6.735	-68092.959
0.900	1434.375	-1.588	-2276.125
0.900	0.000	0.000	0.000
0.900	1230.469	-6.343	-7804.688
0.900	738.281	-1.714	-1265.625
0.900	421.875	-3.600	-1518.750
0.900	1072.117	-9.200	-9863.476
	17241.175		-100492.329
	20386.743		-112205.464

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1203.764	1042.088
due to Earth pressure	1	2875.910		11129.948

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
FL Sinθ	ML Sinθ
131.81	1042.08
2875.91	11129.95
3007.720	12172.036
0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1203.764	1176.131
due to Earth pressure	1.5	4313.866		16694.923
		4462.630		17871.054

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
FL Sinθ	ML Sinθ
148.76	1176.13
4313.87	16694.92
4462.630	17871.054
0.000	0.000

Summary of Forces For SBC

P	22618.393 kN
ML	-6339.617 kNm
MT	3378.937 kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case DL+SIDL		22618.393		-20511.653		3378.937
CWLL-Max. Reaction case	1	1059.332	1.000	1059.332	0.950	1006.366
Vertical Components of LL Surcharge	1	274.805	-4.600	-1264.105	0.000	0.000
Total		23952.530		-20716.426		4385.303

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.000	20386.74302	-3.600	-112205.46
0.900	-9.200	-9.200	-2275.39
	20386.743		-114480.85

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	260.193	1203.764	2057.087
due to Earth pressure	1	2875.910		11129.948
due to Live load surcharge	1	863.439		3247.866

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
FL Sinθ	ML Sinθ
260.19	2057.09
2875.91	11129.95
863.439	3247.866
3799.54	16434.90
0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		341.339	1203.764	2698.630
due to Earth pressure	1.5	4313.866		16694.923
due to Live load surcharge	1.2	796.127		3897.439
		5451.332		23290.991

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
FL Sinθ	ML Sinθ
341.34	2698.63
4313.87	16694.92
796.13	3897.44
5451.332	23290.991
0.000	0.000

Summary of Forces For SBC

P	23952.530 kN
ML	-4291.625 kNm
MT	4385.303 kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2668.995		2668.995		-18.000
Substructure & Foundation -Portion 1								
				792.537		360.212		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	22.646	566.156	-2.100	-1188.928	6.000	3396.937
Shaft above HFL	1	25	21.992	549.795	1.084	596.092	0.000	0.000
Shaft below HFL	1	15	45.958	689.367	1.034	712.578	0.000	0.000
Back filling above HFL over heel slab	1	20	299.437	5988.750	-2.100	-12576.375	0.000	0.000
Back filling below HFL over heel slab	1	10	257.813	2578.125	-2.176	-5600.375	0.000	0.000
Front Filling over toe slab	1	10	79.688	796.875	1.933	1540.625	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	54.688	820.313	-1.743	-1429.688	0.000	0.000
Toe slab	1	15	32.813	492.188	2.886	1420.313	0.000	0.000
Portion between Heel & Toe	1	15	18.750	281.250	1.000	281.250	0.000	0.000
Vertical Components of active earth pressure	1			1191.241		-5479.709		0.000
				14099.842		-21665.265		3396.937
Total				17561.373		-18636.059		3378.937

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load (P) (kN)	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	2432.285		-8756.225
	713.283		-2956.911
0.900	509.541	-6.700	-3413.922
0.900	494.815	-3.516	-1739.668
0.900	620.430	-3.566	-2212.658
0.900	5389.875	-6.700	-36112.162
0.900	2320.313	-6.776	-15721.875
0.900	717.188	-2.667	-1912.500
0.900	0.000	0.000	0.000
0.900	738.281	-6.343	-4682.913
0.900	442.969	-1.714	-759.375
0.900	253.125	-3.600	-911.250
0.900	1072.117	-9.200	-9863.476
	12689.858		-77872.083
	15836.425		-89585.219

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	131.810	1203.764	1042.088
due to Earth pressure	1	2875.910		9386.013

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
FL Sinθ	ML Sinθ
131.81	1042.09
2875.91	9386.01
3007.72	10428.10
0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		148.764	1203.764	1176.131
due to Earth pressure	1.5	4313.866		14079.020
		4462.630		15255.151

Forces along Long. Axis	Forces along Trans. Axis
FL Cosθ	ML Cosθ
FL Sinθ	ML Sinθ
148.76	1176.13
4313.87	14079.02
4462.63	15255.15
0.00	0.00

Summary of Forces For SBC

P	17561.373 kN
ML	-6207.998 kNm
MT	3378.937 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	133.812	0.000	-8756.22	-481.722
Forces from Substructure				18466.111	108.097	0.000	-107978.62	-484.586
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.600	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-9.200	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.200	0.00	
Total =				20898.395	241.909		-116734.85	-966.308
					-241.909			966.308

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	240.656	1203.764	10489.132	2238.420
due to Substructure	1	540.273	185.730		3064.628	1053.527
due to Earth pressure	1	4079.041			18706.762	
due to Live load surcharge	0.20	209.821			1187.381	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1326.73	10489.13	0.00	0.00	0.00	0.00	240.66	2238.42
540.27	3064.63	0.00	0.00	0.00	0.00	185.73	1053.53
4079.04	18706.76						
209.82	1187.38						
6155.87	33447.90	0.00	0.00	0.00	0.00	426.39	3291.95

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1203.764	15193.639
due to Substructure	1.5	786.116		4479.046
due to Active Earth pressure	1	2706.555		11129.948
due to dynamic Earth pressure	1.5	2058.730		11365.22
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		7473.187		42167.853

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	15193.64	0.00	0.00
786.12	4479.05	0.00	0.00
2706.555	11129.948		
2058.730	11365.220		
0.000	0.000		
0.000	0.000		
7473.19	42167.85	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	23699.780	23131.266 kN
ML	10634.244	10277.560 kNm
MT	6872.158	6872.158 kNm

Summary of Restoring Forces

Vertical Load	20956.487 kN
Moment	-117701.153 kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		222.957	148.638		2668.995	148.638				-18.000	2043.896
Substructure & Foundation -Portion 1				792.537	135.664	46.637	31.091		360.212	20.858		1039.925		0.000	357.495
Substructure & Foundation -Portion 2															
Solid Return wall	1		22.65	566.16	137.576	47.294	31.530	-2.10	-1188.928	-66.212	1201.16	728.791	6.00	3396.937	250.537
Shall above HFL	1	25	21.992	549.795	133.600	45.928	30.618	1.084	596.092	33.197	1201.711	781.962	0.000	0.000	268.815
Shall below HFL	1	15	45.958	689.367	133.433	45.870	30.580	1.034	712.578	31.610	1199.858	533.732	0.000	0.000	183.481
Back filling above HFL over heel slab	1	20	299.437	5988.750	0.000	0.000	0.000	-2.100	-12576.375	0.000	1203.254	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	257.813	2578.125	0.000	0.000	0.000	-2.176	-5609.375	0.000	1198.671	0.00	0.000	0.000	0.00
Front Filling over toe	1	10	79.688	796.875	1.933	1540.625							0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000							0.000	0.000	
Heel slab	1	15	54.688	820.313	0.000	-6.700		-1.743	-1429.688	0.000	0.000		0.000	0.000	
Toe slab	1	15	32.813	492.188	0.000	-6.700		2.886	1420.313	0.000	0.000		0.000	0.000	
portion between heel & toe	1	15	18.750	281.250	0.000	-6.700		1.000	281.250	0.000	0.000		0.000	0.000	
Vertical component of active earth pressure	1			1063.882		-4.600		-4.600	-4893.856	0.000	0.000		0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			570.387		-4.600		-4.600	-2623.781	0.000	0.000		0.000	0.000	
				14542.870	440.034	151.271	100.847		-23771.146	-1.406		2199.460		3396.937	756.108
Total =				18004.401	575.698	420.865	280.577		-20741.938	168.091		3239.385		3378.937	3157.499
							-280.577			-168.091					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	133.812				-8756.225	-481.722
Substructure & Foundation -Portion 1				713.283	27.982				-2779.091	-109.946
Substructure & Foundation -Portion 2										
Solid Return wall	0.9	25	22.64625	509.541	28.377	-6.70	-3413.922	-190.124		
Shall above HFL	0.9	25	21.992	494.815	27.557	-3.516	-1739.668	-96.883		
Shall below HFL	0.9	15	45.958	620.430	24.182	-3.566	-2212.658	-86.240		
Back filling above HFL over heel slab	0.9	20	299.437	5389.875	0.000	0.000	-36112.162	0.000		
Back filling below HFL over heel slab	0.9	10	257.813	2320.313	0.000	-6.776	-15721.875	0.000		
Front Filling over toe	0.9	10	79.688	717.188		-2.667	-1912.500			
Side filling between heel and toe	0.9	10	0.000	0.000		0.000				
Heel slab	0.9	15	54.688	738.281		-6.343	-4682.813			
Toe slab	0.9	15	32.813	442.969		-1.714	-759.375			
portion between heel & toe	0.9	15	18.750	253.125		-3.600	-911.250			
Vertical component of active earth pressure	0.9			957.494		-9.200	-8808.941			
Vertical component of dynamic increment of earth pressure	0.9			513.349		-9.200	-4722.806			
				13088.583	87.422		-81540.35		-403.453	
Total =				16234.150	249.216		-93075.67		-995.121	
							-249.216			995.121

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	135.664		1039.925
1.0	137.576	1201.155	728.791
1.0	133.600	1201.711	781.962
1.0	117.237	1199.858	468.950
1.0	0.000	1203.254	0.000
1.0	0.000	1198.671	0.000
	388.414		1979.703
	524.077		3019.627

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1281.191	222.957	1203.764	10129.093	2043.896
due to Substructure	1	575.698	197.908		3239.385	1113.603
due to Earth pressure	1	3945.474			16884.502	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1281.19	10129.09	0.00	0.00	0.00	0.00	222.96	2043.90
575.70	3239.38	0.00	0.00	0.00	0.00	197.91	1113.60
3945.47	16884.50						
5802.36	30252.98	0.00	0.00	0.00	0.00	420.87	3157.50

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1203.764	15193.639
due to Substructure	1.5	786.116		4529.444
due to Active Earth pressure	0.9	2568.438		9291.215
due to dynamic Earth pressure	1.5	2065.555		11389.930
		7341.894		40404.225

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1921.79	15193.64	0.00	0.00
786.12	4529.44	0.00	0.00
2568.438	9291.215		
2065.555	11389.930		
7341.89	40404.22	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	18284.978	17723.824 kN
ML	9679.130	9342.949 kNm
MT	6536.437	6536.437 kNm

Summary of Restoring Forces

Vertical Load	15984.935 kN
Moment	-94070.790 kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long, Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x av ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2668.995		222.957	148.638		2668.995	148.638				-18.000	2043.896
Forces from Substructure				15335.406	575.698	197.908	131.938		-23410.934	19.452		3239.385		3396.937	1113.603
CWLL-Max. Reaction case	0.20			58.13		4.856	3.237	1.000	58.134	3.237	1206.849		0.950	55.227	53.375
Vertical component of LL Surcharge	0.20			59.98				-4.600	-275.894				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			46.20				-4.600	-212.542				0.000	0.000	
Total =				18168.716	575.698	425.721	283.814		-21172.241	171.328		3239.385		3434.164	3210.874
							-283.814			-171.328					

Vertical Forces For Restoring or Resisting Effect

Table 1: Forces For Response on Retaining Wall								
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2432.285	133.812		-8756.225	-481.722
Forces from Substructure				13801.866	115.404		-84319.44	-513.399
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.60	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.600	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.200	0.000	0.000
Total =				16234.150	-249.216		-93709.27	-995.121
								995.121

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1326.731	227.814	1203.764	10489.132	2097.271
due to Substructure	1	575.698	197.908		3239.385	1113.603
due to Earth pressure	1	3945.474			16884.502	
due to Live load surcharge	0.20	256.345			1424.893	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1921.786	1203.764	15193.639
due to Substructure	1.5	786.116		4529.4412
due to Active Earth pressure	1	2568.438		9291.215
due to dynamic Earth pressure	1.5	2065.555		11389.93
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		7341.894		40404.225

Summary of Forces For SBC

	Downward	Upward
P	18452.530	17884.902 kN
ML	11036.998	10694.342 kNm
MT	6645.039	6645.039 kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN.	FL = 0.3 x ah x P (kN)	FT = 0.3 x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2668.995		743.191	148.638		2668.995	148.638				-18.000	6812.988
Substructure & Foundation -Portion 1				792.537	40.699	155.457	31.091		360.212	20.858		311.977		0.000	1191.649
Substructure & Foundation -Portion 2				19655.215	121.383	463.641	92.728		-25833.285	-2.953		607.411		3396.937	2320.107
Total =				23116.746	162.082	1362.290	272.458		-22804.078	-166.543		919.388		3378.937	10324.744
							-272.458			-166.543					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kNm ⁻³)	Volume (m ³)	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				2432.285	133.812		-8756.22	-481.722
Substructure & Foundation -Portion 1				713.283	27.982		-2779.09	-109.946
Substructure & Foundation -Portion 2				17752.828	80.115		-105199.53	-374.639
Total =				20898.395	241.909		-116734.85	-966.308
							-241.909	-966.308

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	135.664		1039.925
	388.414		1946.106
	524.077		2986.031

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.357	743.191	1203.764	3038.728	6812.988
due to Substructure	1	162.082	619.098		919.388	3511.76
due to Earth pressure	1	4079.041			18706.762	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1203.764	4558.092
due to Substructure	1.5	786.116		4479.0462
due to Active Earth pressure	1	2706.555		11129.948
due to dynamic Earth pressure	1.5	617.619		3409.566
due to dynamic increment of live load surcharge		4686.832		23576.652

Summary of Forces For SBC

	Downward	Upward
P	23389.204	22844.288 kN
ML	27.343	-305.743 kNm
MT	13703.682	13703.682 kNm

Summary of Restoring Forces

Vertical Load	20856.487 kN
Moment	-117701.153 kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	23415.523	284.257	-22992.00	178.342	3580.211
		-284.257		-178.342	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	802.186	1203.764	3398.767	7461.402
due to Substructure	1	162.082	619.098		919.388	3511.756
due to Earth pressure	1	4079.041			18706.762	
due to Live load surcharge	0.2	209.821			1187.381	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1203.764	4558.092
due to Substructure	1.5	786.116		4479.0462
due to Active Earth pressure	1	2706.55		11129.948
due to dynamic Earth pressure	1.5	617.62		3409.566
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		4136.54		20441.320

Summary of Forces For SBC

	Downward	Upward
P	23699.780	23131.266 kN
ML	1398.640	1041.955 kNm
MT	14553.368	14553.368 kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	2668.995	148.638	2668.995	148.638	-18.000
Substructure & Foundation -Portion 1	792.537	31.091	360.212	20.858	0.000
Substructure & Foundation -Portion 2	14542.870	100.847	-23771.146	-1.406	3396.937
Total =	18004.401	280.577	-20741.939	168.091	3378.937
		-280.577		-168.091	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	384.36	743.19	1203.76	3038.73	6812.99
due to Substructure	1	172.71	699.69		971.82	3712.01
due to Earth pressure	1	3945.47			16884.50	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.536	1203.764	4558.09
due to Substructure	1.5	786.116		4479.0462
due to Active Earth pressure	1	2568.438		9291.215
due to dynamic Earth pressure	1.5	617.619		3409.566
due to dynamic increment of live load surcharge		4000.475		18625.12

Summary of Forces For SBC

	Downward	Upward
P	18284.978	17723.824 kN
ML	321.196	-14.985 kNm
MT	13903.935	13903.935 kNm

Summary of Restoring Forces

Vertical Load	15984.935 kN
Moment	-94070.790 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
1326.73	10489.13	0.00	0.00	0.00	0.00	227.81	2097.27
575.70	3239.38	0.00	0.00	0.00	0.00	197.91	1113.60
3945.47	16884.50						
256.35	1424.89						
6104.25	32037.91	0.00	0.00	0.00	0.00	425.72	3210.87

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
1921.79	15193.64	0.00	0.00
786.12	4529.44	0.00	0.00
2568.438	9291.215		
2065.555	11389.930		
0.000	0.000		
0.000	0.000		
7341.89	40404.22	0.00	0.00

Summary of Restoring Forces

Vertical Load	15984.935 kN
Moment	-94074.390 kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	3038.73	0.00	0.00	0.00	0.00	743.19	6812.99
162.08	919.39	0.00	0.00	0.00	0.00	619.10	3511.76
4079.04	18706.76						
462.48	22664.88	0.00	0.00	0.00	0.00	1362.29	10324.74

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	4558.09	0.00	0.00
786.12	4479.05	0.00	0.00
2706.555	11129.948		
617.619	3409.566		
4686.83	23576.65	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL2	MLs due to Fv
Total =	20898.395	241.909	-116734.85	-966.308
		-241.909		966.308

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
429.90	3398.77	0.00	0.00	0.00	0.00	802.19	7461.40
162.08	919.39	0.00	0.00	0.00	0.00	619.10	3511.76
4079.04	18706.76						
209.82	1187.38						
4880.84	24212.30	0.00	0.00	0.00	0.00	1421.28	10973.16

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	4558.09	0.00	0.00
786.12	4479.05	0.00	0.00
2706.555	11129.948		
617.619	3409.566		
0.000	0.000		
0.000	0.000		
4136.54	20441.32	0.00	0.00

Summary of Restoring Forces

Vertical Load	20856.487 kN
Moment	-117701.153 kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	2432.285	133.812		-8756.225	-481.722
Substructure & Foundation	713.283	27.982		-2779.091	-109.946
Substructure & Foundation	13088.583	87.422		-81540.354	-403.453
Total =	16234.150	249.216		-93075.670	-995.121
		-249.216			995.121

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
384.36	3038.73	0.00	0.00	0.00	0.00	743.19	6812.99
172.71	971.82	0.00	0.00	0.00	0.00	659.69	3712.01
3945.47	16884.50						
4502.54	20895.04	0.00	0.00	0.00	0.00	1402.88	10525.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sinθ
576.54	4558.09	0.00	0.00
786.12	4479.05	0.00	0.00
2568.438	9291.215		
617.619	3409.566		
4000.47	18625.12	0.00	0.00

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN	$F_v = 0.3 \times w \times P$ (kN)	$M_L = P \times e_{L1}$	M_L due to F_v	$M_T = P \times e_T$
Total =	18168.716	283.814	-21172.24	171.328	3434.164
		-283.814		-171.328	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	429.897	759.3787	1203.764	3398.767	6990.9046
due to Substructure	1	172.709	659.69219	971.815	3712.0101	
due to Earth pressure	1	3945.474		16884.502		
due to Live load surcharge	0.2	256.345			1424.893	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		576.54	1203.764	4558.09
due to Substructure	1.5	235.83		1358.83
due to Active Earth pressure	1	2568.44		9291.21
due to dynamic Earth pressure	1.5	619.67		3416.98
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
				4000.47
				18625.12

Summary of Forces For SBC

	Downward	Upward
P	18452.530	17884.902 kN
M_L	1679.064	1336.408 kNm
M_T	14137.079	14137.079 kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	171.10
Transverse Moment due to C.F.	=	171.102	x (	1206.992 -
				1195.858)

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	171.10
Transverse Moment due to C.F.	=	34.220	x (	1206.992 -
				1195.858)

Base pressure on corner A	=	σ_A	=	$P/A - M_L/Z_L + M_T/Z_T$
Base pressure on corner B	=	σ_B	=	$P/A + M_L/Z_L + M_T/Z_T$
Base pressure on corner C	=	σ_C	=	$P/A - M_L/Z_L - M_T/Z_T$
Base pressure on corner D	=	σ_D	=	$P/A + M_L/Z_L - M_T/Z_T$

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN	$F_v = 0.3 \times w \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$M_L = P \times e_{L2}$	M_L due to F_v
Total =	16234.160	249.216		-93079.27	-995.121
		-249.216			995.121

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
429.90	3398.77	0.00	0.00	0.00	0.00	759.38	6990.90
172.71	971.82	0.00	0.00	0.00	0.00	659.69	3712.01
3945.47	16884.50						
256.35	1424.89						
4804.43	22679.98	0.00	0.00	0.00	0.00	1419.07	10702.91

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
576.54	4558.09	0.00	0.00
235.83	1358.83	0.00	0.00
2568.438	9291.215		
619.666	3416.979		
0.000	0.000		
4000.47	18625.12	0.00	0.00

Summary of Restoring Forces

Vertical Load	15984.935 kN
Moment	-94074.390 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
171.10	1904.96	0.00	0.00

34.22	380.99	0.00	0.00

	SAFE BEARING CAPACITY CHECK								SLIDING CHECK		OVERTURNING CHECK				
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + cA + F_p$	FOS	Overturning moment	Restoring Moment = $\sum P \times e_{Toe} + M_B$	FOS
Normal Dry Case	kN	kNm	kNm	kNm ²	kNm ²	kNm ²	kNm ²	kNm ²	kNm ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	22618.393	-8339.617	3378.937	258.080	163.490	229.873	135.284	258.080	135.284	4462.630	14270.720	3.20	17871.054	112205.46	6.28
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	23952.530	-2376.567	4385.303	240.064	213.109	203.457	176.501	240.064	176.501	5451.332	14270.720	2.62	23290.991	114480.85	4.92
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	17561.373	-8207.958	3378.937	213.359	120.263	185.152	92.056	213.359	92.056	4462.630	11084.798	2.48	15255.151	89585.22	5.87
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	18151.926	-2528.675	3655.072	187.439	158.758	156.927	128.247	187.439	128.247	5581.639	11273.725	2.02	21486.560	92068.27	4.28
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	23389.204	9262.947	6476.361	177.885	282.947	123.822	228.884	282.947	123.822	7473.187	14459.541	1.93	42167.853	117701.15	2.79
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	23699.780	11015.236	6872.158	172.301	297.237	114.933	239.870	297.237	114.933	7473.187	14459.541	1.93	42167.853	117701.15	2.79
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	18284.978	9679.130	6536.437	131.391	241.173	76.826	186.608	241.173	76.826	7341.894	11189.454	1.52	40404.225	94070.79	2.33
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	18452.530	11417.990	6645.039	123.440	252.945	67.969	197.473	252.945	67.969	7341.894	11189.454	1.52	40404.225	94074.39	2.33
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	23389.204	27.343	13703.682	260.427	260.737	146.031	146.341	260.737	146.031	4686.825	14459.541	3.09	23576.652	117701.15	4.99
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	23699.780	1398.640	14934.360	260.488	276.352	135.819	151.682	276.352	135.819	4136.544	14459.541	3.50	20441.320	117701.15	5.76
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	18284.978	321.196	13903.935	215.212	218.855	99.144	102.788	218.855	99.144	4000.475	11189.454	2.80	18625.118	94070.79	5.05
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	18452.530	1679.064	14518.071	211.532	230.576	90.338	109.382	230.576	90.338	4000.475	11189.454	2.80	18625.118	94074.39	5.05
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A1 for Minor Bridge at Ch. 90+038**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.123m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Design Calculation

RODIC

INPUT

Abutment Cap

Width of Abutment cap of Uniform portion	=	0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	=	0.720m	0.720m
Projection of Abutment Cap (Span Side)	=	0.000m	0.000m
Projection of Abutment Cap Back Side	=	0.000m	0.000m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.000m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.814m	0.814m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	3.200m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	6.300m	
abutment pedestal width	=	1.000m	
abutment pedestal Height	=	1.000m	
Width of Toe Slab	=	2.100m	
Width of Heel Slab	=	3.200m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.000m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.000m	
Width of backfill on heel slab	=	3.200m	
Thickness of heel slab at back fill edge	=	1.000m	
Height of back fill at bottom edge of heel slab	=	6.044m	
Height of back fill at back fill edge of heel slab	=	5.544m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m	(skew dimension)
Width of foundation -Tapering portion	=	12.500m	(skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
1	Minor Bridge	90+038	1211.856	1208.169	1205.169	6.687

Levels

Deck Level at Median Edge=	1211.856m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1211.571m	Height of Superstructure	=	0.800m
Deck level at center line =	1211.856m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1210.991m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1210.990m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lvl (uniform portion ends)	1210.690m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1210.690m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1210.690m	Height (Avg.) of Dirt Wall	=	0.723m
Ground level/LBL =	1208.169m	Abutment shaft Above G.L	=	2.521m
Abutment shaft bottom level =	1206.169m	Abutment Shaft below G.L	=	2.000m
Foundation level =	1205.169m	Height of abutment shaft	=	4.521m
HFL	1209.169m	MSL	=	1208.169m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f _{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f _{cd}	=	15.63 Mpa at 28 (0.67/1.5 * f _{ck})	
Tensile strength of concrete , f _{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ε _{sc2}	=	0.02	
Ultimate Strain, ε _{cu2}	=	0.035	
E _{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D (HYSD Steel)	
Yield Strength of Reinforcement, f _y or f _{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f _{yd}	=	434.78 Mpa (1/1.15 * f _y)	
Modulus of Elasticity of Steel (E _s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f _{ck}	
	=	16.8 N/mm ²	
Maximum tensile stress in steel under rare combination	=	300 N/mm ²	

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
φ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft = 0.160m in longitudinal direction
 Dist between c.g of superstructure and c.g. of abutment shaft = 0.000m in Transverse direction
 C.G. of crash barrier above deck level = 0.449m

From Superstructure analysis

Dead Load

Self weight of Slab = 0.80 x 10.00 x 12.50 x 25.00
 = 2500.00 KN
 Reaction at one end = 1250.00 KN
 Transverse Eccentricity = 0.000 m

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier = 2 x 8.00 x 10.00
 = 160.00 KN
 Reaction at one end = 80.00 KN
 Transverse Eccentricity = 0.00 m

Reaction Due to Wearing Course only

Weight due to Wearing Coat = 2.2 x 10 x 12.5
 = 275 KN
 Reaction at one end = 137.5 KN
 Transverse Eccentricity = 0.00 m

Carriageway Live Load Reactions

Reduction Factor =

0.9 (for 3 Lane)

MAXIMUM REACTION CASE:

Congestion factor =

1 (As per Table 3 of IRC :112-2014)

1- 70RW + 2-CLASS A**Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transverse ecc
2561.34	0.30

Min CWLL

Vertical	Transverse ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

VOLUME CALCULATION

C.G. Of Footing	=	3.150 m
C.G. Of shaft from toe tip	=	2.600 m
Distance between c.g. of shaft and footing	=	0.550 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m^3	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.340	-2.810	0.000
-Trapering portion	1	12.50	0.300	0.123	0.463	-0.210	0.340	-2.810	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.040	-3.110	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-0.460	0.090	-3.060	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.550	-2.600	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.550	-2.600	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.767	1.521	14.584	0.116	0.666	-2.484	0.000
Shaft below HFL	1	12.50	0.907	2.500	28.347	0.045	0.595	-2.555	0.000
Solid Return Wall	2	3.20	0.500	5.937	18.998	-2.100	-1.550	-4.700	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.050	-3.100	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.050	-3.100	0.000
Footing									
Heel Slab	1	12.50	3.200	0.750	30.000		-1.372	-4.522	0.000
Toe Slab	1	12.50	2.100	0.750	19.688		1.983	-1.167	0.000
Portion between Heel and Toe	1	12.50	1.000	1.000	12.500		0.550	-2.600	0.000
Back filling above HFL over Heel Slab	1	12.50	3.200	2.687	107.480		-1.550	-4.700	0.000
Back filling below HFL over Heel Slab	1	12.50	3.200	3.250	130.000		-1.591	-4.741	0.000
Backfill above Heel slab	1	12.50	3.200	5.794	231.780		-1.573	-4.723	0.000
Front Filling over Toe Slab	1	12.50	2.100	2.250	59.063		2.061	-1.089	0.000
Side filling between heel and toe	1	0.00	1.000	2.250	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.040	-3.110	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.094	2.687	3.164		0.168	-2.982	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.186	3.250	7.548		0.112	-3.038	0.000

		L	eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN	-0.210 0.340 -2.810

SECTIONAL PROPERTIES

[illegible]

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviciilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case
	Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
	Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case
	Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
	Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case
	Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case
	Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case
	Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case
	Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone 5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

$$= 5.821 \text{ m}$$

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

$$= 6.398 \text{ m}$$

Abutment Cap Top Level - Foundation Level

$$= 5.821 \text{ m}$$

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.86	m
Moment of Inertia , $I_{\text{longitudinal}}$	=	0.663	m^4
Moment of Inertia , $I_{\text{transverse}}$	=	139.974	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction

Force	=	162.793	KN
D	=	1467.50	KN
T	=	0.1899	sec

Transverse Direction

Force	=	29938.181	KN
D	=	1747.220	KN
T	=	0.0153	sec

Hard or Rocky Strata

$$S_a/g = 2.5$$

$$S_a/g = 2.5$$

$$\text{Seismic Coeff. In Longitudinal Direction} = 0$$

$$\text{Seismic Coeff. In Transverse Direction} = 0$$

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

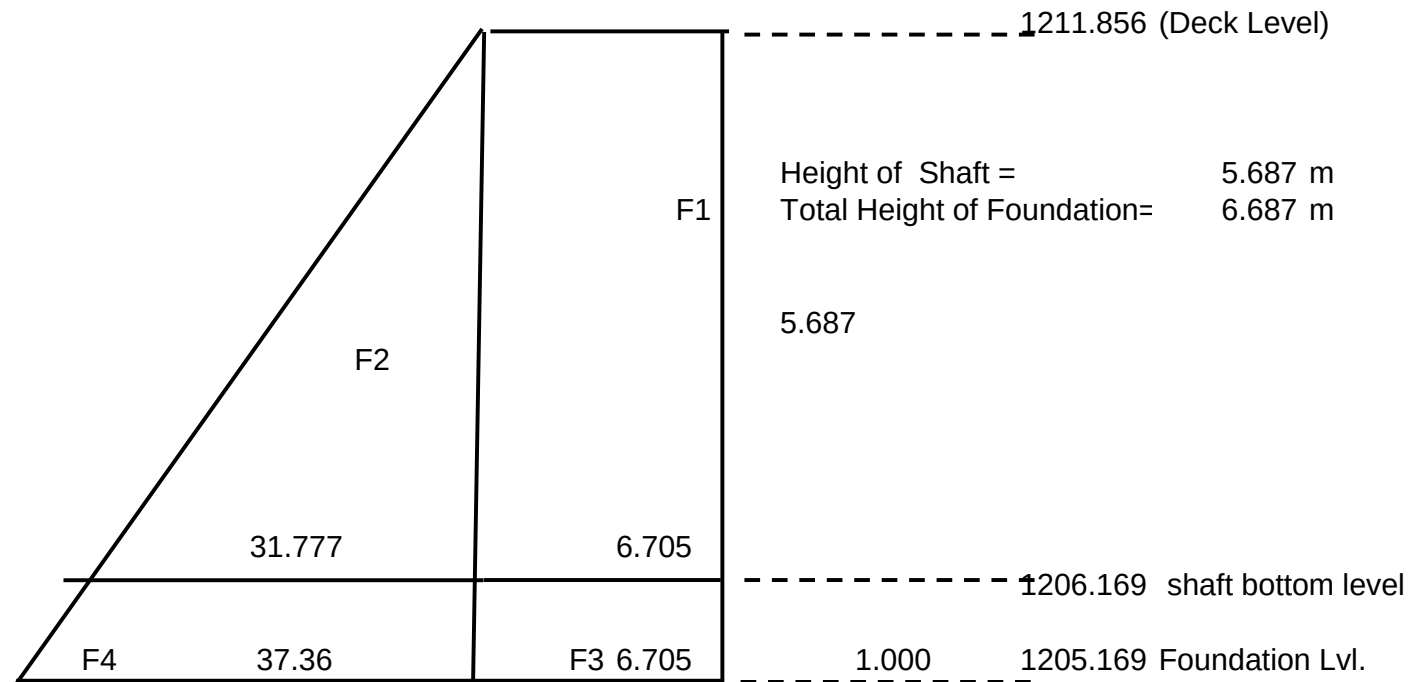
(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL					1206.169 m (at Shaft Base)			
@ RL					1205.169 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m^2
F1	=	6.705	x	5.687	x	12.500	=	476.656 kN
M1	=	476.66	x	2.84	=	1355.373 kN.m	at Shaft Bottom	
F3	=	6.705	x	6.687	x	12.500	=	560.472 kN
M3	=	560.472	x	3.343	=	1873.937 kN.m	at Foundation	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
	=	0.279	x	20	x	5.687	= 31.777 kN/m ²
F2	=	0.5	x	31.78	x	5.687	x 12.50
	=	1129.477 kN					

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2	=	1129.48	x	2.39	=	2697.801 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.279	x	20	x	6.687	= 37.365 kN/m ²
F4	=	0.5	x	37.36	x	6.687	x 12.50
	=	1561.614 kN					
M4	=	1561.61	x	2.81	=	4385.855 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ_{fluid} = **4.8 kN/m³**

Intensity for triangular portion (At Shaft bottom level)

$$= 4.800 \times 5.687 = 27.298 \text{ kN/m}^2$$

F = 0.5 x 27.298 x 5.687 x 12.500

$$= \mathbf{970.259 \text{ kN}}$$

M = 970.26 x **1.896** = **1839.288 kN.m** **at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 6.687 = 32.10 \text{ kN/m}^2$$

F = 0.5 x 32.098 x 6.69 x 12.500

$$= \mathbf{1341.479 \text{ kN}}$$

M = 1341.48 x **2.229** = **2990.157 kN.m** **at Foundation**

Intensity of Passive pressure

$$= 3.766 \times 20 \times \mathbf{0.000} = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50$$

$$= \mathbf{0.000 \text{ kN}}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = \mathbf{0.000 \text{ kN.m}} \quad \mathbf{\text{at Foundation}}$$

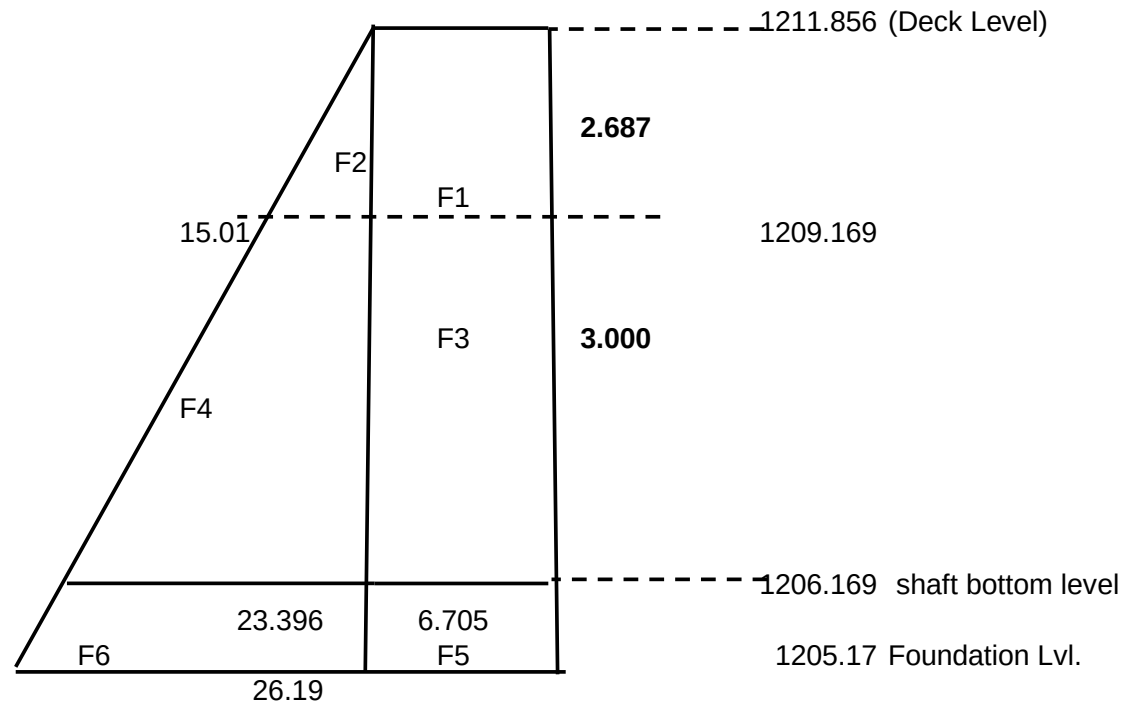
Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl kN	At Foundation Lvl kN
Due to active Earth Pressure	2697.801	4385.855	1129.477	1561.614
Due to Minimum Fluid Pressure	1839.288	2990.157	970.259	1341.479
Governing of Two	2697.801	4385.855	1129.477	1561.614
Due to Live Load Surcharge	1355.373	1873.937	476.656	560.472
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	

Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL**1206.2 m (at Shaft Base)****Due to Live Load Surcharge**

$$\text{Intensity for rectangular portion} = 0.279 \times 20 \times 1.200 = 6.705 \text{ kN/m}^2$$

$$F1 = 6.705 \times 5.687 \times 12.500 = 476.656 \text{ kN}$$

$$M1 = 476.66 \times 2.84 = 1355.373 \text{ kN.m at Shaft Bottom}$$

$$F3 = 6.705 \times 6.687 \times 12.500 = 560.472 \text{ kN}$$

$$M3 = 560.47 \times 3.34 = 1873.937 \text{ kN.m at Foundation Level}$$

Due to Active Earth PressureIntensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 2.687 = 15.014 \text{ kN/m}^2$$

$$(\text{At Shaft bottom level}) \text{ Below HFL} = 0.279 \times 10 \times 3.000 = 8.382 \text{ kN/m}^2$$

$$F2 = 0.5 \times 15.01 \times 2.687 \times 12.50 = 252.143 \text{ kN}$$

$$F4 = \left(\frac{15.01 + 23.40}{2} \right) \times 3.00 \times 12.50$$

$$= 720.181 \text{ kN}$$

$$\text{Total Force} = 972.324 \text{ kN}$$

$$M2 = 252.14 \times 4.13 = 1040.981 \text{ kN.m}$$

$$M4 = 720.18 \times 1.39 = 1001.695 \text{ kN.m}$$

$$\text{Total Mome} = 2042.68 \text{ kN.m at Shaft Bottom}$$

Intensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 2.687 = 15.014 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$\begin{aligned} F2 &= 0.5 \times 15.01 \times 2.687 \times 12.50 \\ &= 252.143 \text{ kN} \end{aligned}$$

$$\begin{aligned} F6 &= \left(\frac{15.01 + 26.19}{2} \right) \times 4.00 \times 12.50 \\ &= 1030.087 \text{ kN} \end{aligned}$$

$$\text{Total Force} = 1282.230 \text{ kN}$$

$$M2 = 252.14 \times 5.13 = 1293.124 \text{ kN.m}$$

$$M6 = 1030.09 \times 1.82 = 1873.919 \text{ kN.m}$$

$$\text{Total Mome} = 3167.04 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$\begin{aligned} &= 0.5 \times 0.000 \times 0.00 \times 12.50 \\ &= 0.000 \text{ kN} \end{aligned}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	2042.676	3167.043	972.324	1282.230
Due to Minimum Fluid Pressure	1839.288	2990.157	970.259	1341.479
Governing of Two	2042.676	3167.043	972.324	1341.479
Due to Live Load Surcharge	1355.373	1873.937	476.656	560.472
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone =	5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{(\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta)))^2}} (1 \pm \alpha v)$$

αh	=	0.000	
αv	=	0.000	
ϕ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COFFICIENT
αv	=	VERTICAL SEISMIC COFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

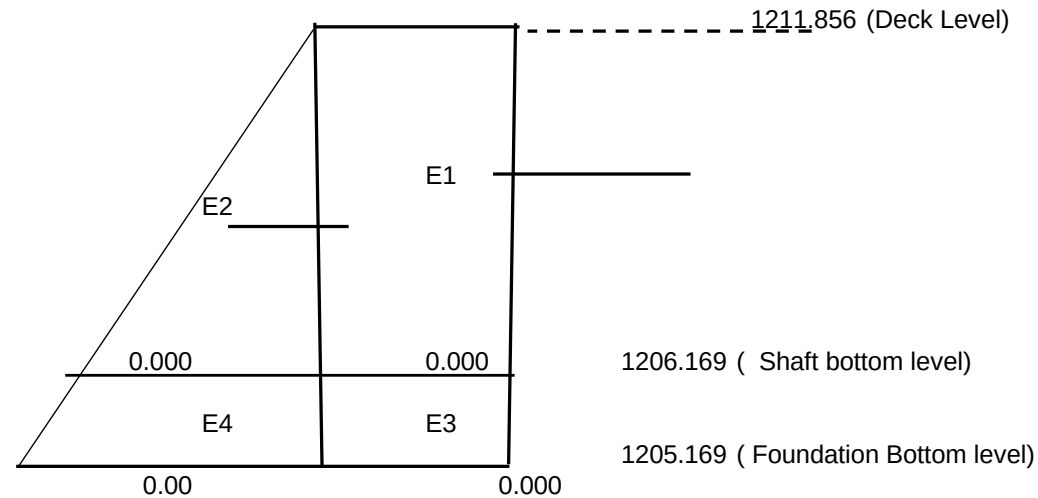
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.000 \\ 0.000 \end{matrix}$$

$$C_a = \begin{matrix} 1 & 2 \\ 0.279 & 0.279 \end{matrix}$$

Ca	=	0.279	
Ka	=	0.279	
Dynamic Increment	=	0.279	-0.279 0.000

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m	
Assuming			
γ_{dry}	=	20 kN/m ³	
γ_{water}	=	10.00 kN/m ³	



Earth Pressure Diagram for Dynamic Increment

Horizontal Forces and Moments @ RL

Due to Dynamic Live Load Surcharge

	=	0.000	x	20	x	1.2	=	0.000 kN/m ²
<u>at Shaft Bottom Level</u>								
E1	=	0.000	x	5.687	x	12.500	=	0.000 kN
M1	=	0.000	x	3.810			=	0.000 kN.m
<u>at Foundation Bottom Level</u>								
E3	=	0.000	x	6.687	x	12.500	=	0.000 kN
M3	=	0.000	x	4.480			=	0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 5.687 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 6.687 = 0.000 \text{ kN/m}^2$$

$$\begin{aligned} E2 &= 0.50 \times 0.00 \times 5.69 \times 12.500 \\ &= \mathbf{0.000} \text{ kN} \end{aligned}$$

$$\begin{aligned} E4 &= 0.50 \times 0.00 \times 6.69 \times 12.500 \\ &= \mathbf{0.000} \text{ kN} \end{aligned}$$

$$M2 = 0.00 \times \mathbf{2.84} = \mathbf{0.000} \text{ kN.m (Shaft bottom level)}$$

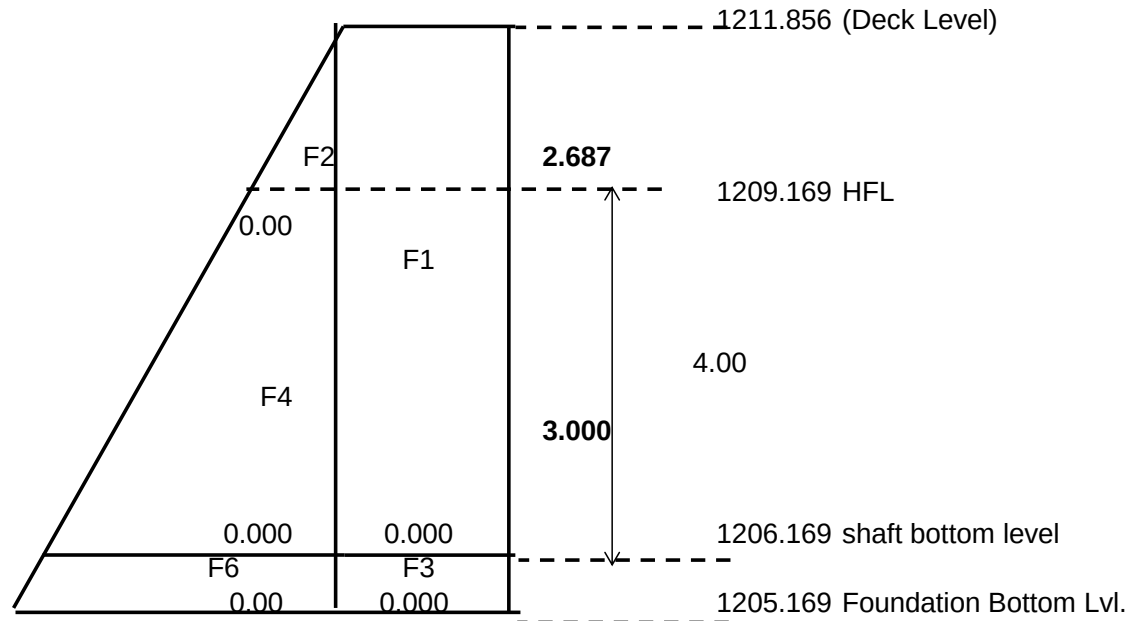
$$M4 = 0.00 \times 3.34 = \mathbf{0.000} \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	2697.801	4385.855	1129.477	1561.614
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	2697.801	4385.855	1129.477	1561.614
Due to Minimum Fluid Pressure	1839.288	2990.157	970.259	1341.479
Governing of Two	2697.801	4385.855	1129.477	1561.614
Due to Live Load Surcharge (Static)	1355.373	1873.937	476.656	560.472
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1206.169 m (at Shaft Base)****1205.169 m (at Foundation Bottom Level)**

Due to Live Load Surcharge

Intensity for rectangular portion = 0.000 x 20 x 1.200 = 0.000 kN/m²

at Shaft Bottom Level

F1 = 0.000 x 5.687 x 12.500 = **0.000 kN**

M1 = 0.00 x 3.75 = **0.000 kN.m**

at Foundation Bottom Level

F3 = 0.000 x 6.687 x 12.500 = **0.000 kN**

M3 = 0.00 x 4.41 = **0.000 kN.m**

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL = 0.000 x 20 x 2.687 = 0.000 kN/m²

(At Shaft bottom level) Below HFL = 0.000 x 10 x 3.000 = 0.000 kN/m²

(At Foundation bottom level) Below HFL = 0.000 x 10 x 4.000 = 0.000 kN/m²

F2 = 0.5 x 0.00 x 2.69 x 12.50
= **0.000 kN**

F4 = $\frac{(0.00 + 0.00)}{2} \times 3.00 \times 12.50$
= **0.000 kN**

F6 = $\frac{(0.00 + 0.00)}{2} \times 4.00 \times 12.50$
= **0.000 kN**

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

$$M2 = 0.00 \times 4.34 = 0.000 \text{ kN.m}$$

$$M4 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Shaft Bottom

$$M2 = 0.00 \times 5.34 = 0.000 \text{ kN.m}$$

$$M6 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	2042.676	3167.043	972.324	1282.230
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	2042.676	3167.043	972.324	1282.230
Due to Minimum Fluid Pressure	1839.288	2990.157	970.259	1341.479
Governing of Two	2042.676	3167.043	972.324	1341.479
Due to Live Load Surcharge(Static)	1355.373	1873.937	476.656	560.472
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing

Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case:

Seismic effect

=

1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:		Seismic effect = 1.50			
	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063

Dry Case

HFL Case

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case:		Seismic effect = 1.50			
	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063

Dry Case

HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A Dry Case
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A HFL Case
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case

Design Speed	V	=	40.00	kmph
Live Load	W	=	932.33	kN
Radius of Curvature	R	=	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN

Seismic Case

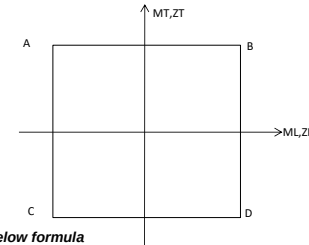
40.00	kmph
932.33	kN
0.00	m
0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1205.169 m

Properties of Footing Base:

A	=	78.750	m ²
ZL	=	82.688	m ³
ZT	=	164.063	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	0.710	887.500	0.000	0.000
SIDL except Wearing Course	1			80.000	0.710	56.800	0.000	0.000
Wearing Course	1			137.500	0.710	97.625	0.000	0.000
				1467.500		1041.925		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.340	19.125	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.340	3.937	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.040	1.125	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.090	1.266	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.550	37.125	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.550	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.050	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.050	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.340	9.520	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.040	6.562	0.000	0.000
				369.578		78.660		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	18.998	474.960	-1.550	-736.188	0.000	0.000
Abutment Shaft	1	25	42.931	1073.284	0.595	638.458	0.000	0.000
Back filling over heel slab	1	20	231.780	4635.600	-1.573	-7291.847	0.000	0.000
Front Filling over toe slab	1	20	59.063	1181.250	2.061	2434.688	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	30.000	750.000	-1.372	-1029.167	0.000	0.000
Toe slab	1	25	19.688	492.188	1.983	976.172	0.000	0.000
portion between heel & toe	1	25	12.500	312.500	0.550	171.875	0.000	0.000
Vertical Components of active earth pressure	1			568.381	-3.150	-1790.400	0.000	0.000
				9702.404		-6596.418		0.000
Total				11539.482		-5475.833		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-2.440	-2897.500
0.950	76.000	-2.440	-185.440
1.000	137.500	-2.440	-335.500
	1401.000		-3418.440
0.950	53.438	-2.810	-150.159
0.950	10.999	-2.810	-30.908
0.950	26.719	-3.110	-83.095
0.950	13.359	-3.060	-40.880
0.950	64.125	-2.600	-166.725
0.950	0.000	-2.600	0.000
0.950	0.000	-3.100	0.000
0.950	0.000	-3.100	0.000
0.950	26.600	-2.810	-74.746
0.950	155.859	-3.110	-484.723
	351.099		-1031.236
0.950	451.212	-4.700	-2120.696
0.950	1019.620	-2.555	-2605.268
0.950	4403.820	-4.723	-20799.287
0.950	1122.188	-1.089	-1221.938
0.950	0.000	0.000	0.000
0.950	712.500	-4.522	-3222.083
0.950	467.578	-1.167	-545.508
0.950	296.875	-2.600	-771.875
0.950	539.962	-6.300	-3401.760
	9217.284		-35295.332
	10969.383		-39745.007

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1210.991	4271.892
due to Earth pressure	1	1561.614		4385.855

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4271.89	0.00	0.00
1561.61	4385.85	0.00	0.00
2295.364	8657.747	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Earth pressure	1.5	2342.421		6578.782
		3133.483		11184.348

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
2342.42	6578.78	0.00	0.00
3133.483	11184.348	0.000	0.000

Summary of Forces For SBC

Design Calculation

P	11539.482	kN
ML	3181.914	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		11539.482		-5475.833		0.000
CWLL-Max. Reaction case	1	932.327	0.710	661.952	2.411	2248.220
Vertical Components of LL Surcharge	1	203.995	-3.150	-642.584	0.000	0.000
Total		12675.804		-5456.465		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1210.991	4271.892
due to Earth pressure	1	1561.614		4385.855
due to Live load surcharge	1	560.472		1873.937

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Earth pressure	1.5	2342.421		6578.782
due to Live load surcharge	1.2	672.566		2248.724
		3806.049		13433.072

Summary of Forces For SBC

P	12675.804	kN
ML	5075.218	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		11539.482		-5475.833		0.000
CWLL-Max. Reaction case	1	2561.336	0.710	1818.549	0.300	768.401
Vertical Components of LL Surcharge	1	203.995	-3.150	-642.584	0.000	0.000
Total		14304.813		-4299.869		768.401

RODIC

Stability of Foundation

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	10969.383		-39745.01
0.000		-2.440	0.00
0.950		-6.300	-1220.91
	10969.383		-40965.92

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4271.89	0.00	0.00
1561.61	4385.85	0.00	0.00
560.472	1873.937	0.000	0.000
2855.84	10531.68	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
2342.42	6578.78	0.00	0.00
672.57	2248.72	0.00	0.00
3806.049	13433.072	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	10969.38308		-39745.007
0.000		-2.440	0.00
0.950		-6.300	-1220.91
	10969.383		-40965.92

Design Calculation

Stability of Foundation

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1210.991	4271.892
due to Earth pressure	1	1561.614		4385.855
due to Live load surcharge	1	560.472		1873.937

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Earth pressure	1.5	2342.421		6578.782
due to Live load surcharge	1.2	672.566		2248.724
		3806.049		13433.072

Summary of Forces For SBC

P	14304.813	KN
ML	6231.815	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		1041.925		0.000
Substructure & Foundation -Portion 1				369.578		78.660		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	18.998	474.960	-1.550	-736.188	0.000	0.000
Shaft above HFL	1	25	14.584	364.612	0.666	242.820	0.000	0.000
Shaft below HFL	1	15	28.347	425.203	0.595	252.938	0.000	0.000
Back filling above HFL over heel slab	1	20	107.480	2149.600	-1.550	-3331.880	0.000	0.000
Back filling below HFL over heel slab	1	10	130.000	1300.000	-1.591	-2068.333	0.000	0.000
Front Filling over toe slab	1	10	59.063	590.625	2.061	1217.344	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	30.000	450.000	-1.372	-617.500	0.000	0.000
Toe slab	1	15	19.688	295.313	1.983	585.703	0.000	0.000
Portion between Heel & Toe	1	15	12.500	187.500	0.550	103.125	0.000	0.000
Vertical Components of active earth pressure	1			488.258	-3.150	-1538.014	0.000	0.000
				6864.832		-5870.903		0.000
Total				8701.910		-4750.319		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1210.991	4271.892
due to Earth pressure	1	1341.479		3167.043

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Earth pressure	1.5	2012.219		4750.564
		2803.281		9356.130

Summary of Forces For SBC

P	8701.910	KN
ML	2688.617	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation

RODIC

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4271.89	0.00	0.00
1561.61	4385.85	0.00	0.00
560.472	1873.937	0.000	0.000
2855.84	10531.68	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
2342.42	6578.78	0.00	0.00
672.57	2248.72	0.00	0.00
3806.049	13433.072	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-3418.440
	351.099		-1031.236
0.950	451.212	-4.700	-2120.696
0.950	346.382	-2.484	-860.423
0.950	403.943	-2.555	-1032.129
0.950	2042.120	-4.700	-9597.964
0.950	1235.000	-4.741	-5855.167
0.950	561.094	-1.089	-610.969
0.950	0.000	0.000	0.000
0.950	427.500	-4.522	-1933.250
0.950	280.547	-1.167	-327.305
0.950	178.125	-2.600	-463.125
0.950	463.846	-6.300	-2922.227
	6521.590		-26120.367
	8273.689		-30570.043

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4271.89	0.00	0.00
1341.48	3167.04	0.00	0.00
2075.23	7438.94	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
2012.22	4750.56	0.00	0.00
2803.28	9356.13	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Design Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		8701.910		-4750.319		0.000
CWLL-Min. Reaction case	1	466.273	0.710	331.054	3.109	1449.594
Vertical Components of LL Surcharge	1	203.995	-3.150	-642.584	0.000	0.000
Total		9372.178		-5061.849		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1210.991	4271.892
due to Earth pressure	1	1341.479		3167.043
due to Live load surcharge	1	560.472		1873.937

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Earth pressure	1.5	2012.219		4750.564
due to live load surcharge	1.2	672.566		2248.724
		3475.847		11604.854

Summary of Forces For SBC

P	9372.178	kN
ML	4251.023	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		8701.910		-4750.319		0.000
CWLL-Min. Reaction case	1	858.664	0.710	609.651	0.300	257.599
Vertical Components of LL Surcharge	1	203.995	-3.150	-642.584	0.000	0.000
Total		9764.569		-4783.251		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1210.991	4271.892
due to Earth pressure	1	1341.479		3167.043
due to Live load surcharge	1	560.472		1873.937

RODIC

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8273.689		-30570.043
0.000	0.000	-2.440	0.000
0.950	193.795	-6.300	-1220.910
	8467.485		-31790.952

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4271.89	0.00	0.00
1341.48	3167.04	0.00	0.00
560.472	1873.937	0.000	0.000
2635.70	9312.87	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
2012.22	4750.56	0.00	0.00
672.566	2248.724	0.000	0.000
3475.85	11604.85	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8273.689		-30570.043
0.000	0.000	-2.440	0.000
0.950	193.795	-6.300	-1220.910
	8467.485		-31790.952

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4271.89	0.00	0.00
1341.48	3167.04	0.00	0.00
560.472	1873.937	0.000	0.000
2635.70	9312.87	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Earth pressure	1.5	2012.219		4750.564
due to live load surcharge	1.2	672.566		2248.724
		3475.847		11604.854

Summary of Forces For SBC

P	9764.569	kN
ML	4529.621	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.840 kN
		ah=	0.000	In Transverse direction	Weight of back fill below Ground level	=	1600.000 kN
		av=	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	0.710	887.500	0.000	1211.524		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	0.710	56.800	0.000	1212.305		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	0.710	97.625	0.000	1211.856		0.000	0.000	0.000
				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.340	19.125	0.000	1211.556	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.000	0.000	0.000	0.340	3.937	0.000	1211.194	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.040	1.125						
Bracket - Tapered portion	1	25	0.563	14.063				0.090	1.266						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.550	37.125	0.000	1210.840	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.550	0.000	0.000	1210.690	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	1211.856	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	1211.856	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.340	9.520				0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063				0.040	6.562				0.000	0.000	0.000
				369.578	0.000	0.000	0.000		78.660	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	18.998	474.960	0.000	0.000	0.000	-1.550	-736.188	0.000	1208.959	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	42.931	1073.284	0.000	0.000	0.000	0.595	638.458	0.000	1209.430	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	231.780	4635.600	0.000	0.000	0.000	-1.573	-7291.847	0.000	1208.959	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	59.063	1181.250				2.061	2434.688				0.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	0.000
Heel slab	1	25	30.000	750.000				-1.372	-1029.167				0.000	0.000	0.000
Toe slab	1	25	19.688	492.188				1.983	976.172				0.000	0.000	0.000
portion between heel & toe	1	25	12.500	312.500				0.550	171.875				0.000	0.000	0.000
Vertical component of active earth pressure	1			568.381				-3.150	-1790.400				0.000	0.000	0.000
Vertical component of dynamic increment of earth pressure	1			0.000				-3.150	0.000				0.000	0.000	0.000
				9702.404	0.000	0.000	0.000		-6596.418	0.000		0.000		0.000	0.000
Total =				11539.482	0.000	0.000	0.000		-5475.833	0.000		0.000		0.000	0.000
							0.000								0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-2.440	-2897.500	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-2.440	-185.440	0.000
Wearing Course	1.00			137.500	0.000	-2.440	-335.500	0.000
				1401.000	0.000		-3418.440	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-2.810	-150.159	0.000
Dirt Wall-Tapered portion	0.95	25	0.463	10.999	0.000	-2.810	-30.908	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-2.600	-166.725	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-2.600	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-3.100	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-3.100	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-2.810	-74.746	0.000
Approach Slab	0.95	25	6.563	155.859		-3.110	-484.723	
				351.099	0.000		-907.261	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	42.931	1019.620	0.000	-2.555	-2605.268	0.000
Solid Return wall	0.95	25	18.998	451.212	0.000	-4.700	-2120.696	0.000
Back filling over heel slab	0.95	20	231.780	4403.820	0.000	-4.723	-20799.287	0.000
Front Filling over Pile Cap	0.95	20	59.063	1122.188		-1.089	-1221.938	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	30.000	712.500		-4.522	-3222.083	
Toe slab	0.95	25	19.688	467.578		-1.167	-545.508	
portion between heel & toe	0.95	25	12.500	296.875		-2.600	-771.875	
Vertical component of active earth pressure	0.95			539.962		-6.300	-3401.760	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-6.300	0.000	
				9217.284	0.000		-35295.33	0.000
Total =				10969.383	0.000		-39621.03	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1210.991	4271.892	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1561.614			4385.855	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.57
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	2342.421		6578.78
due to dynamic Earth pressure	1.5	0.000		0.00
		3133.483		11184.348

Summary of Forces For SBC

	Downward	Upward	
P	11539.482	11539.482	kN
ML	3181.914	3181.914	kNm
MT	0.000	0.000	kNm

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	0.000	1211.556	0.000
1.0	0.000	1211.194	0.000
1.0	0.000	1210.840	0.000
1.0	0.000	1210.690	0.000
1.0	0.000	1211.856	0.000
1.0	0.000	1211.856	0.000
	0.000		0.000
1.0	0.000	1209.430	0.000
1.0	0.000	1208.959	0.000
1.0	0.000	1208.959	0.000
	0.000		0.000
	0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1561.61	4385.85						
2295.36	8657.75	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
2342.421	6578.782	0.000	0.000
0.000	0.000	0.000	0.000
3133.48	11184.35	0.00	0.00

Summary of Restoring Forces

Vertical Load	10969.383	kN
Moment	-39621.032	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Forces from Substructure				10071.982	0.000	0.000	0.000		-6517.758	0.000				0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	0.710	132.390	0.000	1213.056	0.000	2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			40.80				-3.150	-128.517				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-3.150	0.000				0.000	0.000	
Total =				11766.747	0.000	0.000	0.000		-5471.960	0.000		0.000		449.644	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-3418.44	0.000
Forces from Substructure				9568.383	0.000	0.000	-36202.59	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-2.440	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-6.300	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-6.300	0.00	
Total =				10969.383	0.000		-39621.03	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1210.991	4271.892	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1561.614			4385.855	
due to Live load surcharge	0.20	112.094			374.787	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1561.61	4385.85						
112.09	374.79						
2407.46	9032.53	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	2342.421		6578.782
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0

3133.483

11184.348

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
2342.421	6578.782		
0.000	0.000		
0.000	0.000		
0.000	0.000		
3133.48	11184.35	0.00	0.00

Summary of Forces For SBC

	Downward	Upward
P	11766.747	11766.747 kN
ML	3560.575	3560.575 kNm
MT	449.644	449.644 kNm

Summary of Restoring Forces

Vertical Load	10969.383 kN
Moment	-39621.032 kNm

Case 7 : DL+SIDL-Long, Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		78.660	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		19.00	474.96	0.000	0.000	0.000	-1.55	-736.188	0.000	1208.96	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	14.584	364.612	0.000	0.000	0.000	0.666	242.820	0.000	1209.930	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	28.347	425.203	0.000	0.000	0.000	0.595	252.938	0.000	1208.669	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	107.480	2149.600	0.000	0.000	0.000	-1.550	-3331.880	0.000	1210.513	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	130.000	1300.000	0.000	0.000	0.000	-1.591	-2068.333	0.000	1207.419	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	59.063	590.625				2.061	1217.344				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	30.000	450.000				-1.372	-617.500				0.000	0.000	
Toe slab	1	15	19.688	295.313				1.983	585.703				0.000	0.000	
portion between heel & toe	1	15	12.500	187.500				0.550	103.125				0.000	0.000	
Vertical component of active earth pressure	1			466.694				-3.150	-1470.085				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-3.150	0.000				0.000	0.000	
				6843.267	0.000	0.000	0.000		-5822.056	0.000		0.000		0.000	0.000
Total =				8680.345	0.000	0.000	0.000		-4701.471	0.000		0.000		0.000	0.000
0.000															

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Superstructure				1401.000	0.000		-3418.440	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-907.261	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	18.9984	451.212	0.000	-4.70	-2120.696	0.000
Shaft above HFL	0.95	25	14.584	346.382	0.000	-2.484	-860.423	0.000
Shaft below HFL	0.95	15	28.347	403.943	0.000	-2.555	-1032.129	0.000
Back filling above HFL over heel slab	0.95	20	107.480	2042.120	0.000	-4.700	-9597.964	0.000
Back filling below HFL over heel slab	0.95	10	130.000	1235.000	0.000	-4.741	-5855.167	0.000
Front Filling over Pile Cap	0.95	10	59.063	561.094		-1.089	-610.969	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	30.000	427.500		-4.522	-1933.250	
Toe slab	0.95	15	19.688	280.547		-1.167	-327.305	
portion between heel & toe	0.95	15	12.500	178.125		-2.600	-463.125	
Vertical component of active earth pressure	0.95			443.359		-6.300	-2793.161	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-6.300	0.000	
				6501.103	0.000		-25991.301	0.000
Total =				8253.203	0.000		-30317.00	0.000
0.000								

For Overturning or Sliding Effect

Load Factor	FL = $\alpha h \times P$ (kN)	C.g. of Force (m)	MLS due to FL
	0.000		0.000
1.0	0.000	1208.959	0.000
1.0	0.000	1209.930	0.000
1.0	0.000	1208.669	0.000
1.0	0.000	1210.513	0.000
1.0	0.000	1207.419	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1210.991	4271.892	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1341.479			3167.043	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1341.48	3167.04						
2075.23	7438.94	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	1923.345		4750.564
due to dynamic Earth pressure	1.5	0.000		0.000
		2714.408		9356.130

Summary of Forces For SBC

	Downward	Upward	
P	8680.345	8680.345	kN
ML	2737.464	2737.464	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
1923.345	4750.564		
0.000	0.000		
2714.41	9356.13	0.00	0.00

Summary of Restoring Forces

Vertical Load	8253.203	kN
Moment	-30317.002	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Forces from Substructure				7212.845	0.000	0.000	0.000		-5743.396	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	0.710	66.211	0.000	1213.056		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			40.80				-3.150	-128.517				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-3.150	0.000				0.000	0.000	
Total =				8814.399	0.000	0.000	0.000		-4763.777	0.000		0.000		289.919	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-3418.440	0.000
Forces from Substructure				6852.203	0.000		-26898.562	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-2.44	0.00
Vertical component of LL Surcharge	0.00			0.00		-2.440	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-6.300	0.000	0.000
Total =				8253.203	0.000		-30319.44	0.000
					0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1210.991	4271.892	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1341.479			3167.043	
due to Live load surcharge	0.20	112.094			374.787	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	1923.345		4750.564
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		2714.408		9356.130

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1341.48	3167.04						
112.09	374.79						
2187.32	7813.72	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
1923.345	4750.564		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2714.41	9356.13	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	8814.399	8814.399	kN
ML	3049.945	3049.945	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	8253.203	kN
Moment	-30319.442	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxL1	MTs due to FT
Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		78.660	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				9702.404	0.000	0.000	0.000		-6596.418	0.000		0.000		0.000	0.000
Total =				11539.482	0.000	0.000	0.000		-5475.833	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxL2	MLs due to Fv
Superstructure				1401.000	0.000		-3418.44	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-907.26	0.000
Substructure & Foundation -Portion 2				9217.284	0.000		-35295.33	0.000
Total =				10969.383	0.000		-39621.03	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1210.991	4271.892	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1561.614			4385.855	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1561.61	4385.85						
2295.36	8657.75	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.566
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	2342.421		6578.78206
due to dynamic Earth pressure	1.5	0.000		0
		3133.483		11184.348

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
2342.421	6578.782		
0.000	0.000		
3133.48	11184.35	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	11539.482	11539.482	kN
ML	3181.914	3181.914	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	10969.383	kN
Moment	-39621.032	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxL1	MLs due to Fv	MT = PxL1
Total =	11766.747	0.000	-5471.96	0.000	449.644
		0.000		0.000	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxL2	MLs due to Fv
Total =	10969.383	0.000	-39621.03	0.000
		0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1210.991	4271.892	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1561.614			4385.855	
due to Live load surcharge	0.2	112.094			374.787	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1210.991	4605.566
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	2342.42		6578.782
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		3133.48		11184.348

Summary of Forces For SBC

	Downward	Upward	
P	11766.747	11766.747	kN
ML	3560.575	3560.575	kNm
MT	449.644	449.644	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load (P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	1467.500	0.000	1041.925	0.000	0.000
Substructure & Foundation -Portion 1	369.578	0.000	78.660	0.000	0.000
Substructure & Foundation -Portion 2	6843.267	0.000	-5822.056	0.000	0.000
Total =	8680.345	0.000	-4701.471	0.000	0.000
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1210.99	4271.89	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	1341.48			3167.04	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1210.991	4605.57
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	1923.345		4750.56
due to dynamic Earth pressure	1.5	0.000		0.00
		2714.408		9356.13

Summary of Forces For SBC

	Downward	Upward	
P	8680.345	8680.345	kN
ML	2737.464	2737.464	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1561.61	4385.85						
112.09	374.79						
2407.46	9032.53	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
2342.421	6578.782		
0.000	0.000		
0.000	0.000		
0.000	0.000		
3133.48	11184.35	0.00	0.00

Summary of Restoring Forces

Vertical Load	10969.383	kN
Moment	-39621.032	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	1401.000	0.000		-3418.440	0.000
Substructure & Foundation	351.099	0.000		-907.261	0.000
Substructure & Foundation	6501.103	0.000		-25991.301	0.000
Total =	8253.203	0.000		-30317.002	0.000
		0.000			0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1341.48	3167.04						
2075.23	7438.94	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
1923.345	4750.564		
0.000	0.000		
2714.41	9356.13	0.00	0.00

Summary of Restoring Forces

Vertical Load	8253.203	kN
Moment	-30317.002	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	8814.399	0.000	-4763.78	0.000	289.919
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1210.991	4271.892	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	1341.479			3167.043	
due to Live load surcharge	0.2	112.094			374.787	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1210.991	4605.57
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	1923.35		4750.56
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		2714.41		9356.13

Summary of Forces For SBC

	Downward	Upward	
P	8814.399	8814.399	kN
ML	3049.945	3049.945	kNm
MT	289.919	289.919	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000 kN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1213.056 -	1205.169)	=	0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000 kN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1213.056 -	1205.169)	=	0.000 kNm

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Total =	8253.203	0.000		-30319.44	0.000
		0.000			0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	4271.89	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1341.48	3167.04						
112.09	374.79						
2187.32	7813.72	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	4605.57	0.00	0.00
0.00	0.00	0.00	0.00
1923.345	4750.564		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2714.41	9356.13	0.00	0.00

Summary of Restoring Forces

Vertical Load	8253.203	kN
Moment	-30319.442	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ _A	σ _B	σ _C	σ _D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= μP + c.A + F _p	FOS	Overturning moment	Restoring Moment = ΣP.e _{Toe} +M _D	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	11539.482	3181.914	0.000	108.052	185.014	108.052	185.014	185.014	108.052	3133.483	7678.568	2.45	11184.348	39745.01	3.55
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	12675.804	5075.218	2248.220	113.288	236.044	85.881	208.637	236.044	85.881	3806.049	7678.568	2.02	13433.072	40965.92	3.05
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	14304.813	6231.815	768.401	110.966	261.698	101.599	252.331	261.698	101.599	3806.049	7678.568	2.02	13433.072	40965.92	3.05
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	8701.910	2688.617	0.000	77.985	143.016	77.985	143.016	143.016	77.985	2803.281	5791.583	2.07	9356.130	30570.04	3.27
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	9372.178	4251.023	1449.594	76.437	179.258	58.765	161.587	179.258	58.765	3475.847	5927.239	1.71	11604.854	31790.95	2.74
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	9764.569	4529.621	257.599	70.785	180.345	67.644	177.204	180.345	67.644	3475.847	5927.239	1.71	11604.854	31790.95	2.74
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	11539.482	3181.914	0.000	108.052	185.014	108.052	185.014	185.014	108.052	3133.483	7678.568	2.45	11184.348	39621.03	3.54
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	11766.747	3560.575	449.644	109.099	195.220	103.618	189.739	195.220	103.618	3133.483	7678.568	2.45	11184.348	39621.03	3.54
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	8680.345	2737.464	0.000	77.120	143.333	77.120	143.333	143.333	77.120	2714.408	5777.242	2.13	9356.130	30317.00	3.24
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	8814.399	3049.945	289.919	76.811	150.581	73.277	147.047	150.581	73.277	2714.408	5777.242	2.13	9356.130	30319.44	3.24
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	11539.482	3181.914	0.000	108.052	185.014	108.052	185.014	185.014	108.052	3133.483	7678.568	2.45	11184.348	39621.03	3.54
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	11766.747	3560.575	449.644	109.099	195.220	103.618	189.739	195.220	103.618	3133.483	7678.568	2.45	11184.348	39621.03	3.54
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	8680.345	2737.464	0.000	77.120	143.333	77.120	143.333	143.333	77.120	2714.408	5777.242	2.13	9356.130	30317.00	3.24

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	8814.399	3049.945	289.919	76.811	150.581	73.277	147.047	150.581	73.277	2714.408	5777.242	2.13	9356.130	30319.44	3.24
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A2 for Minor Bridge at Ch. 90+038**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case
Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.123m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	= 0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	= 0.720m	0.720m
Projection of Abutment Cap (Span Side)	= 0.000m	0.000m
Projection of Abutment Cap Back Side	= 0.000m	0.000m
Abutmentcap thickness (Uniform portion)	= 0.300m	
Abutmentcap thickness (Tapering Portion)	= 0.000m	
Length of Abutment Cap at top (Uniform portion)	= 12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.822m	0.822m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	3.200m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	6.300m	
abutment pedestal width	=	1.000m	
abutment pedestal Height	=	1.000m	
Width of Toe Slab	=	2.100m	
Width of Heel Slab	=	3.200m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.000m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.000m	
Width of backfill on heel slab	=	3.200m	
Thickness of heel slab at back fill edge	=	1.000m	
Height of back fill at bottom edge of heel slab	=	6.237m	
Height of back fill at back fill edge of heel slab	=	5.737m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m	(skew dimension)
Width of foundation -Tapering portion	=	12.500m	(skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
1	Minor Bridge	90+038	1212.049	1208.169	1205.169	6.88

Levels

Deck Level at Median Edge=	1212.049m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1211.764m	Height of Superstructure	=	0.800m
Deck level at center line =	1212.049m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1211.184m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1211.183m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lvl (uniform portion ends)	1210.883m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1210.883m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1210.883m	Height (Avg.) of Dirt Wall	=	0.723m
Ground level/LBL =	1208.169m	Abutment shaft Above G.L	=	2.714m
Abutment shaft bottom level =	1206.169m	Abutment Shaft below G.L	=	2.000m
Foundation level =	1205.169m	Height of abutment shaft	=	4.714m
HFL	1209.169m	MSL	=	1208.169m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28, (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8 N/mm ²	
Maximum tensile stress in steel under rare combination	=	300 N/mm ²	

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft = 0.160m in longitudinal direction
 Dist between c.g of superstructure and c.g. of abutment shaft = 0.000m in Transverse direction
 C.G. of crash barrier above deck level = 0.449m

From Superstructure analysis

Dead Load

Self weight of Slab = 0.80 x 10.00 x 12.50 x 25.00
 = 2500.00 KN
 Reaction at one end = 1250.00 KN
 Transverse Eccentricity = 0.000 m

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier = 2 x 8.00 x 10.00
 = 160.00 KN
 Reaction at one end = 80.00 KN
 Transverse Eccentricity = 0.00 m

Reaction Due to Wearing Course only

Weight due to Wearing Coat = 2.2 x 10 x 12.5
 = 275 KN
 Reaction at one end = 137.5 KN
 Transverse Eccentricity = 0.00 m

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transvers e ecc
2561.34	0.30

Min CWLL

Vertical	Transvers e ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

VOLUME CALCULATION

C.G. Of Footing	=	3.150 m
C.G. Of shaft from toe tip	=	2.600 m
Distance between c.g. of shaft and footing	=	0.550 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m^3	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.340	-2.810	0.000
-Trapering portion	1	12.50	0.300	0.123	0.463	-0.210	0.340	-2.810	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.040	-3.110	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-0.460	0.090	-3.060	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.550	-2.600	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.550	-2.600	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.771	1.714	16.517	0.114	0.664	-2.486	0.000
Shaft below HFL	1	12.50	0.911	2.500	28.466	0.043	0.593	-2.557	0.000
Solid Return Wall	2	3.20	0.500	6.130	19.616	-2.100	-1.550	-4.700	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.050	-3.100	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	0.050	-3.100	0.000
Footing									
Heel Slab	1	12.50	3.200	0.750	30.000		-1.372	-4.522	0.000
Toe Slab	1	12.50	2.100	0.750	19.688		1.983	-1.167	0.000
Portion between Heel and Toe	1	12.50	1.000	1.000	12.500		0.550	-2.600	0.000
Back filling above HFL over Heel Slab	1	12.50	3.200	2.880	115.200		-1.550	-4.700	0.000
Back filling below HFL over Heel Slab	1	12.50	3.200	3.250	130.000		-1.591	-4.741	0.000
Backfill above Heel slab	1	12.50	3.200	5.987	239.500		-1.572	-4.722	0.000
Front Filling over Toe Slab	1	12.50	2.100	2.250	59.063		2.061	-1.089	0.000
Side filling between heel and toe	1	0.00	1.000	2.250	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.040	-3.110	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.102	2.880	3.665		0.166	-2.984	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.178	3.250	7.239		0.109	-3.041	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN		-0.210	0.340	-2.810

SECTIONAL PROPERTIES

[illegible]

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviciilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case
	Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
	Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case
	Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
	Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case
	Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case
	Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case
	Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case
	Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone 5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

$$= 6.014 \text{ m}$$

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

$$= 6.591 \text{ m}$$

Abutment Cap Top Level - Foundation Level

$$= 6.014 \text{ m}$$

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.86	m
Moment of Inertia , $I_{\text{longitudinal}}$	=	0.663	m^4
Moment of Inertia , $I_{\text{transverse}}$	=	139.974	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction

Force	=	147.618	KN
D	=	1467.50	KN
T	=	0.1994	sec

Transverse Direction

Force	=	27260.678	KN
D	=	1747.220	KN
T	=	0.0160	sec

Hard or Rocky Strata

$$S_a/g = 2.5$$

$$S_a/g = 2.5$$

$$\text{Seismic Coeff. In Longitudinal Direction} = 0$$

$$\text{Seismic Coeff. In Transverse Direction} = 0$$

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

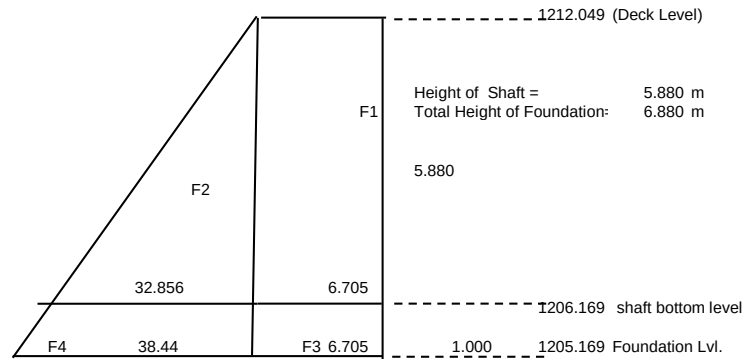
(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279	active component
	Kph	=	3.766	Passive component
	γ	=	20	kN/m ³

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1206.169 m (at Shaft Base)		
@ RL					1205.169 m (at Foundation Level)		
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.279	x	20	x	1.2	= 6.705 kN/m²
F1	=	6.705	x	5.880	x	12.500	= 492.833 kN
M1	=	492.83	x	2.94	=	1448.928 kN.m	at Shaft Bottom
F3	=	6.705	x	6.880	x	12.500	= 576.648 kN
M3	=	576.648	x	3.440	=	1983.669 kN.m	at Foundation

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
	=	0.279	x	20	x	5.880	= 32.856 kN/m^2
F2	=	0.5	x	32.86	x	5.880	x 12.50
	=	1207.440 kN					
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)							
M2	=	1207.44	x	2.47	=	2981.894 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.279	x	20	x	6.880	= 38.443 kN/m^2
F4	=	0.5	x	38.44	x	6.880	x 12.50
	=	1653.057 kN					
M4	=	1653.06	x	2.89	=	4776.674 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
 = 4.800 x 5.880 = 28.224 kN/m²

F = 0.5 x 28.224 x 5.880 x 12.500
 = **1037.232 kN**

M = 1037.23 x 1.960 = **2032.975 kN.m at Shaft Bottom**

Intensity for triangular portion (At Foundation level)
 = 4.800 x 6.880 = 33.02 kN/m²

F = 0.5 x 33.024 x 6.88 x 12.500
 = **1420.032 kN**

M = 1420.03 x 2.293 = **3256.607 kN.m at Foundation**

Intensity of Passive pressure
 = 3.766 x 20 x 0.000 = 0.000 kN/m²

Force due to passive @ Foundation, F
 = 0.5 x 0.000 x 12.50
 = **0.000 kN**

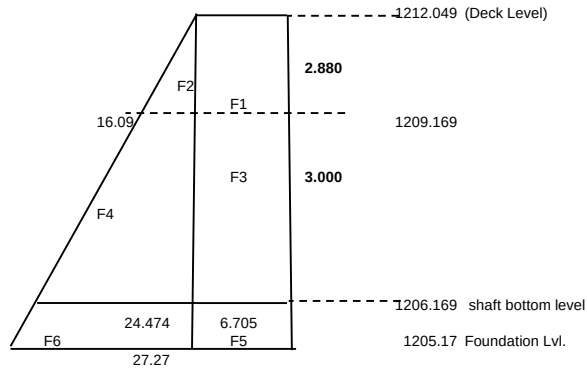
Moment due to passive @ Foundation, M
 = 0.000 x 0.000 = **0.000 kN.m at Foundation**

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl kN	At Foundation Lvl kN
Due to active Earth Pressure	2981.894	4776.674	1207.440	1653.057
Due to Minimum Fluid Pressure	2032.975	3256.607	1037.232	1420.032
Governing of Two	2981.894	4776.674	1207.440	1653.057
Due to Live Load Surcharge	1448.928	1983.669	492.833	576.648
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279	active component
	Kph	=	3.766	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL 1206.2 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	5.880	x	12.500	=	492.833 kN
M1	=	492.83	x	2.94	=	1448.928 kN.m		at Shaft Bottom
F3	=	6.705	x	6.880	x	12.500	=	576.648 kN
M3	=	576.65	x	3.44	=	1983.669 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	2.880	=	16.092 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	3.000	=	8.382 kN/m ²
F2	=	0.5	x	16.09	x	2.880	x	12.50
	=	289.665 kN						
F4	=	(16.09 + 24.47)	x	3.00	x	12.50		
	=	760.622 kN						
Total Force	=	1050.287 kN						
M2	=	289.66	x	4.21	=	1219.374 kN.m		
M4	=	760.62	x	1.40	=	1062.356 kN.m		
Total Mome	=	2281.73 kN.m						at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 2.880 = 16.092 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 16.09 \times 2.880 \times 12.50 = 289.665 \text{ kN}$$

$$F6 = \left(\frac{16.09 + 27.27}{2} \right) \times 4.00 \times 12.50 = 1084.009 \text{ kN}$$

$$\text{Total Force} = 1373.673 \text{ kN}$$

$$M2 = 289.66 \times 5.21 = 1509.039 \text{ kN.m}$$

$$M6 = 1084.01 \times 1.83 = 1981.761 \text{ kN.m}$$

$$\text{Total Mome} = 3490.80 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

$$\text{Force due to passive @ Foundation, F} = 0.5 \times 0.000 \times 0.00 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	2281.730	3490.800	1050.287	1373.673
Due to Minimum Fluid Pressure	2032.975	3256.607	1037.232	1420.032
Governing of Two	2281.730	3490.800	1050.287	1420.032
Due to Live Load Surcharge	1448.928	1983.669	492.833	576.648
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case**As per Clause 219.5.4 , IRC:6-2014****Seismic Zone = 5.0****Dynamic increment due to seismic force**

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000	
αv	=	0.000	
ϕ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.000 \\ 0.000 \end{matrix}$$

$$C_a = \begin{matrix} 1 & 2 \\ 0.279 & 0.279 \end{matrix}$$

Ca	=	0.279	0.279	
Ka	=	0.279		
Dynamic Increment	=	0.279	-0.279	0.000

3 Earth Pressure :**DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height

=

1.2 m

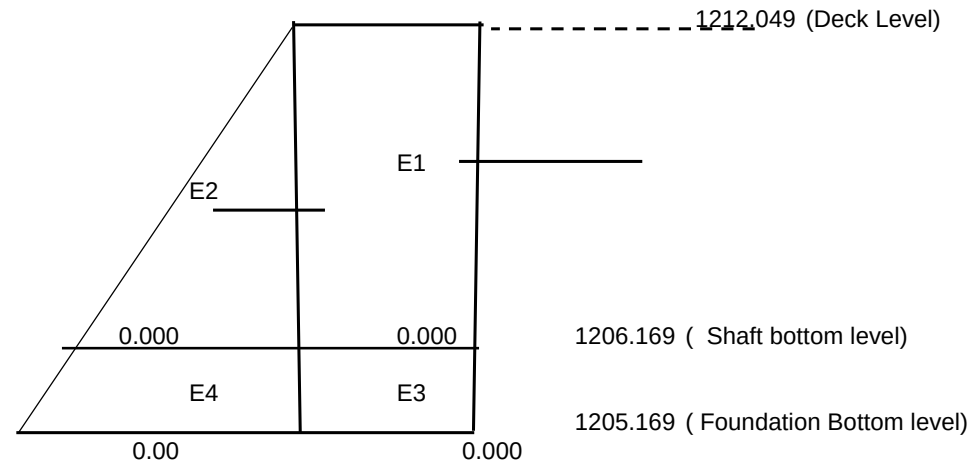
Assuming

 γ_{dry}

=

20 kN/m³ γ_{water}

=

10.00 kN/m³**Earth Pressure Diagram for Dynamic Increment****Horizontal Forces and Moments @ RL****1206.2 m (at Shaft Base)****1205.2 m (at Foundation Bottom Level)****Due to Dynamic Live Load Surcharge**

	=	0.000	x	20	x	1.2	=	0.000 kN/m ²
<u>at Shaft Bottom Level</u>								
E1	=	0.000	x	5.880	x	12.500	=	0.000 kN
M1	=	0.000	x	3.940			=	0.000 kN.m
<u>at Foundation Bottom Level</u>								
E3	=	0.000	x	6.880	x	12.500	=	0.000 kN
M3	=	0.000	x	4.610			=	0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 5.880 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 6.880 = 0.000 \text{ kN/m}^2$$

$$\begin{aligned} E2 &= 0.50 \times 0.00 \times 5.88 \times 12.500 \\ &= \mathbf{0.000} \text{ kN} \end{aligned}$$

$$\begin{aligned} E4 &= 0.50 \times 0.00 \times 6.88 \times 12.500 \\ &= \mathbf{0.000} \text{ kN} \end{aligned}$$

$$M2 = 0.00 \times \mathbf{2.94} = \mathbf{0.000} \text{ kN.m} \quad (\text{ Shaft bottom level})$$

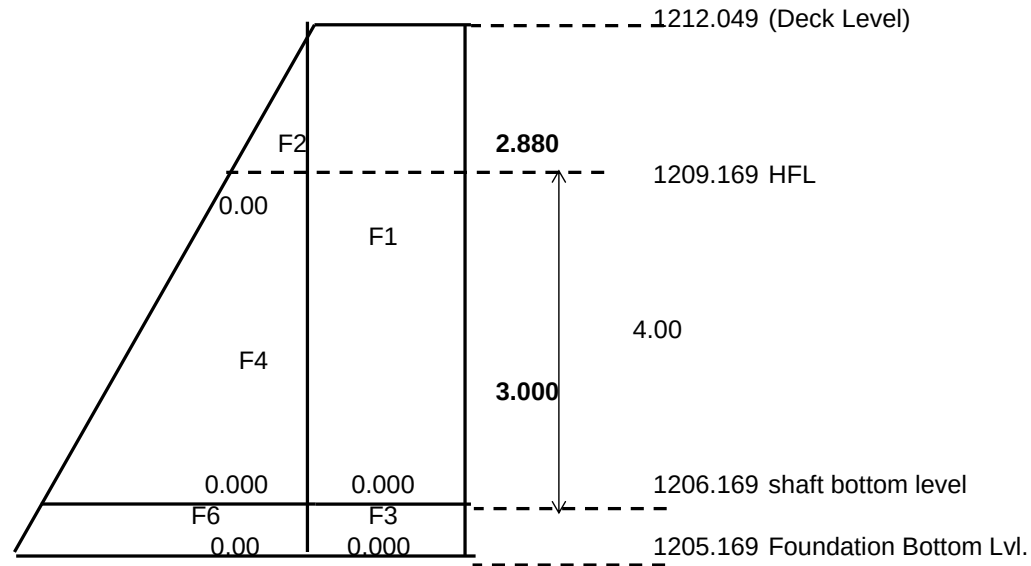
$$M4 = 0.00 \times 3.44 = \mathbf{0.000} \text{ kN.m} \quad (\text{ Foundation Bottom level})$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	2981.894	4776.674	1207.440	1653.057
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	2981.894	4776.674	1207.440	1653.057
Due to Minimum Fluid Pressure	2032.975	3256.607	1037.232	1420.032
Governing of Two	2981.894	4776.674	1207.440	1653.057
Due to Live Load Surcharge (Static)	1448.928	1983.669	492.833	576.648
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1206.169 m (at Shaft Base)****1205.169 m (at Foundation Bottom Level)**

Due to Live Load Surcharge

Intensity for rectangular portion = 0.000 x 20 x 1.200 = 0.000 kN/m²

at Shaft Bottom Level

F1 = 0.000 x 5.880 x 12.500 = **0.000 kN**

M1 = 0.00 x 3.88 = **0.000 kN.m**

at Foundation Bottom Level

F3 = 0.000 x 6.880 x 12.500 = **0.000 kN**

M3 = 0.00 x 4.54 = **0.000 kN.m**

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL = 0.000 x 20 x 2.880 = 0.000 kN/m²

(At Shaft bottom level) Below HFL = 0.000 x 10 x 3.000 = 0.000 kN/m²

(At Foundation bottom level) Below HFL = 0.000 x 10 x 4.000 = 0.000 kN/m²

F2 = 0.5 x 0.00 x 2.88 x 12.50
= **0.000 kN**

F4 = $\frac{(0.00 + 0.00)}{2} \times 3.00 \times 12.50$

= **0.000 kN**

F6 = $\frac{(0.00 + 0.00)}{2} \times 4.00 \times 12.50$

= **0.000 kN**

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

$$M2 = 0.00 \times 4.44 = 0.000 \text{ kN.m}$$

$$M4 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Shaft Bottom

$$M2 = 0.00 \times 5.44 = 0.000 \text{ kN.m}$$

$$M6 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	2281.730	3490.800	1050.287	1373.673
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	2281.730	3490.800	1050.287	1373.673
Due to Minimum Fluid Pressure	2032.975	3256.607	1037.232	1420.032
Governing of Two	2281.730	3490.800	1050.287	1420.032
Due to Live Load Surcharge(Static)	1448.928	1983.669	492.833	576.648
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing

-

Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case:

Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:		Seismic effect = 1.50			
	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063

Dry Case

HFL Case

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:		Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)
DL+SIDL		2036.13	0.000	1018.063	1018.063
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A SV Loading
	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A SV Loading
	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Longitudinal Seismic Case:		Seismic effect = 1.50				
	Unfactored Vertical Force	Vertical Force	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	HFL Case

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A Dry Case
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A HFL Case
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A Dry Case
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A HFL Case
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Longitudinal Seismic Case:

Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case

Design Speed	V	=	40.00	kmph
Live Load	W	=	932.33	kN
Radius of Curvature	R	=	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN

Seismic Case

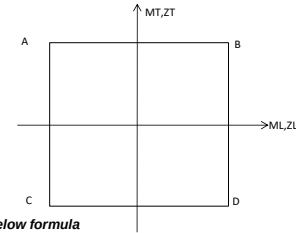
40.00	kmph
932.33	kN
0.00	m
0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1205.169 m

Properties of Footing Base:

A	=	78.750	m ²
ZL	=	82.688	m ³
ZT	=	164.063	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	0.710	887.500	0.000	0.000
SIDL except Wearing Course	1			80.000	0.710	56.800	0.000	0.000
Wearing Course	1			137.500	0.710	97.625	0.000	0.000
				1467.500		1041.925		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.340	19.125	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.340	3.937	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.040	1.125	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.090	1.266	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.550	37.125	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.550	0.000	0.000	0.000
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.050	0.000	0.000	0.000
Cantilever Return Wall-Triangle por	1	25	0.000	0.000	0.050	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.340	9.520	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.040	6.562	0.000	0.000
				369.578		78.660		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	19.616	490.400	-1.550	-760.120	0.000	0.000
Abutment Shaft	1	25	44.982	1124.559	0.593	666.971	0.000	0.000
Back filling over heel slab	1	20	239.500	4790.000	-1.572	-7531.167	0.000	0.000
Front Filling over toe slab	1	20	59.063	1181.250	2.061	2434.688	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	30.000	750.000	-1.372	-1029.167	0.000	0.000
Toe slab	1	25	19.688	492.188	1.983	976.172	0.000	0.000
portion between heel & toe	1	25	12.500	312.500	0.550	171.875	0.000	0.000
Vertical Components of active earth pressure	1			601.664	-3.150	-1895.240	0.000	0.000
				9960.643		-6935.911		0.000
Total				11797.721		-5815.327		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-2.440	-2897.500
0.950	76.000	-2.440	-185.440
1.000	137.500	-2.440	-335.500
	1401.000		-3418.440
0.950	53.438	-2.810	-150.159
0.950	10.999	-2.810	-30.908
0.950	26.719	-3.110	-83.095
0.950	13.359	-3.060	-40.880
0.950	64.125	-2.600	-166.725
0.950	0.000	-2.600	0.000
0.950	0.000	-3.100	0.000
0.950	0.000	-3.100	0.000
0.950	26.600	-2.810	-74.746
0.950	155.859	-3.110	-484.723
	351.099		-1031.236
0.950	465.880	-4.700	-2189.636
0.950	1068.331	-2.557	-2731.620
0.950	4550.500	-4.722	-21488.683
0.950	1122.188	-1.089	-1221.938
0.950	0.000	0.000	0.000
0.950	712.500	-4.522	-3222.083
0.950	467.578	-1.167	-545.508
0.950	296.875	-2.600	-771.875
0.950	571.580	-6.300	-3600.957
	9462.611		-36390.431
	11214.710		-40840.107

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1211.184	4413.506
due to Earth pressure	1	1653.057		4776.674

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4413.51	0.00	0.00
1653.06	4776.67	0.00	0.00
2386.807	9190.180	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Earth pressure	1.5	2479.586		7165.011
		3270.648		11923.252

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
2479.59	7165.01	0.00	0.00
3270.648	11923.252	0.000	0.000

Summary of Forces For SBC

P	11797.721	kN
ML	3374.854	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		11797.721		-5815.327		0.000
CWLL-Max. Reaction case	1	932.327	0.710	661.952	2.411	2248.220
Vertical Components of LL Surcharge	1	209.883	-3.150	-661.130	0.000	0.000
Total		12939.930		-5814.505		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1211.184	4413.506
due to Earth pressure	1	1653.057		4776.674
due to Live load surcharge	1	576.648		1983.669

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Earth pressure	1.5	2479.586		7165.011
due to Live load surcharge	1.2	691.977		2380.402
		3962.626		14303.654

Summary of Forces For SBC

P	12939.930	kN
ML	5359.344	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		11797.721		-5815.327		0.000
CWLL-Max. Reaction case	1	2561.336	0.710	1818.549	0.300	768.401
Vertical Components of LL Surcharge	1	209.883	-3.150	-661.130	0.000	0.000
Total		14568.940		-4657.908		768.401

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	11214.710		-40840.11
0.000		-2.440	0.00
0.950		-6.300	-1256.15
	11214.710		-42096.25

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4413.51	0.00	0.00
1653.06	4776.67	0.00	0.00
576.648	1983.669	0.000	0.000
2963.45	11173.85	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
2479.59	7165.01	0.00	0.00
691.98	2380.40	0.00	0.00
3962.626	14303.654	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	11214.70978		-40840.107
0.000		-2.440	0.00
0.950		-6.300	-1256.15
	11214.710		-42096.25

Design Calculation

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1211.184	4413.506
due to Earth pressure	1	1653.057		4776.674
due to Live load surcharge	1	576.648		1983.669

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Earth pressure	1.5	2479.586		7165.011
due to Live load surcharge	1.2	691.977		2380.402
		3962.626		14303.654

Summary of Forces For SBC		
P	14568.940	kN
ML	6515.940	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = Px eL1 (kNm)	Trans. Ecc (eT) (m)	MT = Px eT (kNm)
Superstructure				1467.500		1041.925		0.000
Substructure & Foundation -Portion 1				369.578		78.660		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	19.616	490.400	-1.550	-760.120	0.000	0.000
Shaft above HFL	1	25	16.517	412.915	0.664	274.171	0.000	0.000
Shaft below HFL	1	15	28.466	426.986	0.593	253.244	0.000	0.000
Back filling above HFL over heel slab	1	20	115.200	2304.000	-1.550	-3571.200	0.000	0.000
Back filling below HFL over heel slab	1	10	130.000	1300.000	-1.591	-2068.333	0.000	0.000
Front Filling over toe slab	1	10	59.063	590.625	2.061	1217.344	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	30.000	450.000	-1.372	-617.500	0.000	0.000
Toe slab	1	15	19.688	295.313	1.983	585.703	0.000	0.000
Portion between Heel & Toe	1	15	12.500	187.500	0.550	103.125	0.000	0.000
Vertical Components of active earth pressure	1			516.849	-3.150	-1628.076	0.000	0.000
				7120.280		-6191.523		0.000
Total				8957.358		-5070.939		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1211.184	4413.506
due to Earth pressure	1	1420.032		3490.800

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Earth pressure	1.5	2130.048		5236.200
		2921.110		9994.441

Summary of Forces For SBC		
P	8957.358	kN
ML	2833.367	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = Px eL1 (kNm)	Trans. Ecc (eT) (m)	MT = Px eT (kNm)
Forces from Case : DL+SIDL		8957.358		-5070.939		0.000

RODIC

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4413.51	0.00	0.00
1653.06	4776.67	0.00	0.00
576.648	1983.669	0.000	0.000
2963.45	11173.85	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
2479.59	7165.01	0.00	0.00
691.98	2380.40	0.00	0.00
3962.626	14303.654	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = Px eL2 (kNm)
	1401.000		-3418.440
	351.099		-1031.236
0.950	465.880	-4.700	-2189.636
0.950	392.270	-2.486	-975.187
0.950	405.637	-2.557	-1037.174
0.950	2188.800	-4.700	-10287.360
0.950	1235.000	-4.741	-5855.167
0.950	561.094	-1.089	-610.969
0.950	0.000	0.000	0.000
0.950	427.500	-4.522	-1933.250
0.950	280.547	-1.167	-327.305
0.950	178.125	-2.600	-463.125
0.950	491.007	-6.300	-3093.344
	6764.266		-27189.386
	8516.366		-31639.062

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4413.51	0.00	0.00
1420.03	3490.80	0.00	0.00
2153.78	7904.31	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
2130.05	5236.20	0.00	0.00
2921.11	9994.44	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = Px eL2 (kNm)
	8516.366		-31639.062

Design Calculation

CWLL-Min. Reaction case	1	466.273	0.710	331.054	3.109	1449.594
Vertical Components of LL Surcharge	1	209.883	-3.150	-661.130	0.000	0.000
Total		9633.514		-5401.015		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1211.184	4413.506
due to Earth pressure	1	1420.032		3490.800
due to Live load surcharge	1	576.648		1983.669

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Earth pressure	1.5	2130.048		5236.200
due to live load surcharge	1.2	691.977		2380.402
		3613.088		12374.843

Summary of Forces For SBC		
P	9633.514	KN
ML	4486.960	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		8957.358		-5070.939		0.000
CWLL-Min. Reaction case	1	858.664	0.710	609.651	0.300	257.599
Vertical Components of LL Surcharge	1	209.883	-3.150	-661.130	0.000	0.000
Total		10025.905		-5122.418		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1211.184	4413.506
due to Earth pressure	1	1420.032		3490.800
due to Live load surcharge	1	576.648		1983.669

RODIC

0.000	0.000	-2.440	0
0.950	199.389	-6.300	-1256.148
	8715.754		-32895.210

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4413.51	0.00	0.00
1420.03	3490.80	0.00	0.00
576.648	1983.669	0.000	0.000
2730.43	9887.97	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
2130.05	5236.20	0.00	0.00
691.977	2380.402	0.000	0.000
3613.09	12374.84	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8516.366		-31639.062
0.000	0.000	-2.440	0.00
0.950	199.389	-6.300	-1256.148
	8715.754		-32895.210

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	4413.51	0.00	0.00
1420.03	3490.80	0.00	0.00
576.648	1983.669	0.000	0.000
2730.43	9887.97	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Earth pressure	1.5	2130.048		5236.200
due to live load surcharge	1.2	691.977		2380.402
		3613.088		12374.843

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
2130.05	5236.20	0.00	0.00
691.977	2380.402	0.000	0.000
3613.09	12374.84	0.00	0.00

Summary of Forces For SBC

P	10025.905	kN
ML	4765.557	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.725 kN
		ah=	0.000	In Transverse direction	Weight of back fill below Ground level	=	1600.000 kN
		av=	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	0.710	887.500	0.000	1211.717		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	0.710	56.800	0.000	1212.498		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	0.710	97.625	0.000	1212.049		0.000	0.000	0.000
				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.340	19.125	0.000	1211.749	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.000	0.000	0.000	0.340	3.937	0.000	1211.387	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.040	1.125						
Bracket - Tapered portion	1	25	0.563	14.063				0.090	1.266						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.550	37.125	0.000	1211.033	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.550	0.000	0.000	1210.883	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	1212.049	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle por	1	25	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	1212.049	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.340	9.520						
Approach Slab	1	25	6.563	164.063				0.040	6.562						
				369.578	0.000	0.000	0.000		78.660	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	19.616	490.400	0.000	0.000	0.000	-1.550	-760.120	0.000	1209.055	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	44.982	1124.559	0.000	0.000	0.000	0.593	666.971	0.000	1209.526	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	239.500	4790.000	0.000	0.000	0.000	-1.572	-7531.167	0.000	1209.055	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	59.063	1181.250				2.061	2434.688						
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000						
Heel slab	1	25	30.000	750.000				-1.372	-1029.167						
Toe slab	1	25	19.688	492.188				1.983	976.172						
portion between heel & toe	1	25	12.500	312.500				0.550	171.875						
Vertical component of active earth pressure	1			601.664				-3.150	-1895.240				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-3.150	0.000				0.000	0.000	
				9960.643	0.000	0.000	0.000		-6935.911	0.000		0.000		0.000	0.000
Total =				11797.721	0.000	0.000	0.000		-5815.327	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-2.440	-2897.500	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-2.440	-185.440	0.000
Wearing Course	1.00			137.500	0.000	-2.440	-335.500	0.000
				1401.000	0.000		-3418.440	0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL

Design Calculation

RODIC

Stability of Foundation

Substructure & Foundation -Portion 1												
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-2.810	-150.159	0.000	1.0	0.000	1211.749	0.000
Dirt Wall-Tapered portion	0.95	25	0.463	10.999	0.000	-2.810	-30.908	0.000	1.0	0.000	1211.387	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719								
Bracket - Tapered portion	0.95	25	0.563	13.359								
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-2.600	-166.725	0.000	1.0	0.000	1211.033	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-2.600	0.000	0.000	1.0	0.000	1210.883	0.000
Cantilever Return Wall-Rectangle p	0.95	25	0.000	0.000	0.000	-3.100	0.000	0.000	1.0	0.000	1212.049	0.000
Cantilever Return Wall-Traingle por	0.95	25	0.000	0.000	0.000	-3.100	0.000	0.000	1.0	0.000	1212.049	0.000
RCC Railing or Crash Barrier	0.95			26.600		-2.810	-74.746					
Approach Slab	0.95	25	6.563	155.859		-3.110	-484.723					
				351.099	0.000		-907.261	0.000		0.000		0.000
Substructure & Foundation -Portion 2												
Abutment Shaft	0.95	25	44.982	1068.331	0.000	-2.557	-2731.620	0.000	1.0	0.000	1209.526	0.000
Solid Return wall	0.95	25	19.616	465.880	0.000	-4.700	-2189.636	0.000	1.0	0.000	1209.055	0.000
Back filling over heel slab	0.95	20	239.500	4550.500	0.000	-4.722	-21488.683	0.000	1.0	0.000	1209.055	0.000
Front Filling over Pile Cap	0.95	20	59.063	1122.188		-1.089	-1221.938					
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000					
Heel slab	0.95	25	30.000	712.500		-4.522	-3222.083					
Toe slab	0.95	25	19.688	467.578		-1.167	-545.508					
portion between heel & toe	0.95	25	12.500	296.875		-2.600	-771.875					
Vertical component of active earth pressure	0.95			571.580		-6.300	-3600.957					
Vertical component of dynamic increment of earth pressure	0.95			0.000		-6.300	0.000					
				9462.611	0.000		-36390.43	0.000		0.000		0.000
Total =				11214.710	0.000		-40716.13	0.000		0.000		0.000
				0.000		0.000						

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1211.184	4413.506	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1653.057			4776.674	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.24
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	2479.586		7165.01
due to dynamic Earth pressure	1.5	0.000		0.00
		3270.648		11923.252

Summary of Forces For SBC

	Downward	Upward	
P	11797.721	11797.721	KN
ML	3374.854	3374.854	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	11214.710	kN
Moment	-40716.132	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1653.06	4776.67						
2386.81	9190.18	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2479.586	7165.011	0.000	0.000
0.000	0.000	0.000	0.000
3270.65	11923.25	0.00	0.00

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Forces from Substructure				10330.221	0.000	0.000	0.000		-6857.252	0.000				0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	0.710	132.390	0.000	1213.249		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			41.98				-3.150	-132.226				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-3.150	0.000				0.000	0.000	
Total =				12026.163	0.000	0.000	0.000		-5815.162	0.000		0.000		449.644	0.000
0.000										0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-3418.44	0.000
Forces from Substructure				9813.710	0.000	0.000	-37297.69	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-2.440	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-6.300	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-6.300	0.00	
Total =				11214.710	0.000		-40716.13	0.000
					0.000	0.000		

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1211.184	4413.506	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1653.057			4776.674	
due to Live load surcharge	0.20	115.330			396.734	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1653.06	4776.67						
115.33	396.73						
2502.14	9586.91	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	2479.586		7165.011
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		3270.648		11923.252

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2479.586	7165.011		
0.000	0.000		
0.000	0.000		
0.000	0.000		
3270.65	11923.25	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	12026.163	12026.163	kN
ML	3771.752	3771.752	kNm
MT	449.644	449.644	kNm

Summary of Restoring Forces

Vertical Load	11214.710	kN
Moment	-40716.132	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		78.660	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		19.62	490.40	0.000	0.000	0.000	-1.55	-760.120	0.000	1209.06	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	16.517	412.915	0.000	0.000	0.000	0.664	274.171	0.000	1210.026	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	28.466	426.986	0.000	0.000	0.000	0.593	253.244	0.000	1208.669	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	115.200	2304.000	0.000	0.000	0.000	-1.550	-3571.200	0.000	1210.609	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	130.000	1300.000	0.000	0.000	0.000	-1.591	-2068.333	0.000	1207.419	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	59.063	590.625				2.061	1217.344				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	30.000	450.000				-1.372	-617.500				0.000	0.000	
Toe slab	1	15	19.688	295.313				1.983	585.703				0.000	0.000	
portion between heel & toe	1	15	12.500	187.500				0.550	103.125				0.000	0.000	
Vertical component of active earth pressure	1			499.976				-3.150	-1574.925				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-3.150	0.000				0.000	0.000	
				7103.407	0.000	0.000	0.000		-6158.492	0.000		0.000		0.000	0.000
Total =				8940.485	0.000	0.000	0.000		-5037.908	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-3418.440	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-907.261	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	19.616	465.880	0.000	-4.70	-2189.636	0.000
Shaft above HFL	0.95	25	16.517	392.270	0.000	-2.486	-975.187	0.000
Shaft below HFL	0.95	15	28.466	405.637	0.000	-2.557	-1037.174	0.000
Back filling above HFL over heel slab	0.95	20	115.200	2188.800	0.000	-4.700	-10287.360	0.000
Back filling below HFL over heel slab	0.95	10	130.000	1235.000	0.000	-4.741	-5855.167	0.000
Front Filling over Pile Cap	0.95	10	59.063	561.094		-1.089	-610.969	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	30.000	427.500		-4.522	-1933.250	
Toe slab	0.95	15	19.688	280.547		-1.167	-327.305	
portion between heel & toe	0.95	15	12.500	178.125		-2.600	-463.125	
Vertical component of active earth pressure	0.95			474.977		-6.300	-2992.358	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-6.300	0.000	
				6748.237	0.000		-27088.401	0.000
Total =				8500.336	0.000		-31414.10	0.000

0.000

0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1209.055	0.000
1.0	0.000	1210.026	0.000
1.0	0.000	1208.669	0.000
1.0	0.000	1210.609	0.000
1.0	0.000	1207.419	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1211.184	4413.506	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1420.032			3490.800	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1420.03	3490.80						
2153.78	7904.31	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	2060.510		5236.200
due to dynamic Earth pressure	1.5	0.000		0.000
		2851.573		9994.441

Summary of Forces For SBC

	Downward	Upward	
P	8940.485	8940.485	kN
ML	2866.399	2866.399	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2060.510	5236.200		
0.000	0.000		
2851.57	9994.44	0.00	0.00

Summary of Restoring Forces

Vertical Load	8500.336	kN
Moment	-31414.101	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Forces from Substructure				7472.985	0.000	0.000	0.000		-6079.833	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	0.710	66.211	0.000	1213.249		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			41.98				-3.150	-132.226				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-3.150	0.000				0.000	0.000	
Total =				9075.717	0.000	0.000	0.000		-5103.923	0.000		0.000		289.919	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-3418.440	0.000
Forces from Substructure				7099.336	0.000		-27995.661	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-2.44	0.00
Vertical component of LL Surcharge	0.00			0.00		-2.440	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-6.300	0.000	0.000
Total =				8500.336	0.000		-31416.54	0.000
					0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1211.184	4413.506	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1420.032			3490.800	
due to Live load surcharge	0.20	115.330			396.734	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	2060.510		5236.200
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		2851.573		9994.441

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1420.03	3490.80						
115.33	396.73						
2269.11	8301.04	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2060.510	5236.200		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2851.57	9994.44	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	9075.717	9075.717	KN
ML	3197.117	3197.117	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	8500.336	kN
Moment	-31416.541	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1041.925	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		78.660	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				9960.643	0.000	0.000	0.000		-6935.911	0.000		0.000		0.000	0.000
Total =				11797.721	0.000	0.000	0.000		-5815.327	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-3418.44	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-907.26	0.000
Substructure & Foundation -Portion 2				9462.611	0.000		-36390.43	0.000
Total =				11214.710	0.000		-40716.13	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x ah x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1211.184	4413.506	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1653.057			4776.674	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1653.06	4776.67						
2386.81	9190.18	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.241
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	2479.586		7165.01073
due to dynamic Earth pressure	1.5	0.000		0
		3270.648		11923.252

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2479.586	7165.011		
0.000	0.000		
3270.65	11923.25	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	11797.721	11797.721	KN
ML	3374.854	3374.854	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	11214.710	kN
Moment	-40716.132	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = Px eL1	MLs due to Fv	MT = Px eT
Total =	12026.163	0.000	-5815.16	0.000	449.644
		0.000		0.000	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = Px eL2	MLs due to Fv
Total =	11214.710	0.000	-40716.13	0.000
		0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1211.184	4413.506	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1653.057			4776.674	
due to Live load surcharge	0.2	115.330			396.734	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1211.184	4758.241
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	2479.59		7165.011
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		3270.65		11923.252

Summary of Forces For SBC

	Downward	Upward
P	12026.163	12026.163
ML	3771.752	3771.752
MT	449.644	449.644

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Lloads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure	1467.500	0.000	1041.925	0.000	0.000
Substructure & Foundation -Portion 1	369.578	0.000	78.660	0.000	0.000
Substructure & Foundation -Portion 2	7103.407	0.000	-6158.492	0.000	0.000
Total =	8940.485	0.000	-5037.908	0.000	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1211.18	4413.51	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	1420.03			3490.80	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1211.184	4758.24
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	2060.510		5236.20
due to dynamic Earth pressure	1.5	0.000		0.00
		2851.573		9994.44

Summary of Forces For SBC

	Downward	Upward
P	8940.485	8940.485
ML	2866.399	2866.399
MT	0.000	0.000

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1653.06	4776.67						
115.33	396.73						
2502.14	9586.91	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2479.586	7165.011		
0.000	0.000		
0.000	0.000		
0.000	0.000		
3270.65	11923.25	0.00	0.00

Summary of Restoring Forces

Vertical Load	11214.710	kN
Moment	-40716.132	kNm

Vertical Forces For Restoring or Resisting Effect

Lloads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure	1401.000	0.000		-3418.440	0.000
Substructure & Foundation	351.099	0.000		-907.261	0.000
Substructure & Foundation	6748.237	0.000		-27088.401	0.000
Total =	8500.336	0.000		-31414.101	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1420.03	3490.80						
2153.78	7904.31	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2060.510	5236.200		
0.000	0.000		
2851.57	9994.44	0.00	0.00

Summary of Restoring Forces

Vertical Load	8500.336	kN
Moment	-31414.101	kNm

Vertical Forces For Restoring or Resisting Effect

Design Calculation

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	9075.717	0.000	-5103.92	0.000	289.919
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1211.184	4413.506	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	1420.032			3490.800	
due to Live load surcharge	0.2	115.330			396.734	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1211.184	4758.24
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	2060.51		5236.20
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		2851.57		9994.44

Summary of Forces For SBC

	Downward	Upward	
P	9075.717	9075.717	kN
ML	3197.117	3197.117	kNm
MT	289.919	289.919	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000 KN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1213.249 -	1205.169)	=	0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000 KN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1213.249 -	1205.169)	=	0.000 kNm

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

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Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Total =	8500.336	0.000		-31416.54	0.000
		0.000			0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	4413.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1420.03	3490.80						
115.33	396.73						
2269.11	8301.04	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	4758.24	0.00	0.00
0.00	0.00	0.00	0.00
2060.510	5236.200		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2851.57	9994.44	0.00	0.00

Summary of Restoring Forces

Vertical Load	8500.336	kN
Moment	-31416.541	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_p$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	11797.721	3374.854	0.000	108.998	190.627	108.998	190.627	190.627	108.998	3270.648	7850.297	2.40	11923.252	40840.11	3.43
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	12939.930	5359.344	2248.220	113.206	242.834	85.799	215.428	242.834	85.799	3962.626	7850.297	1.98	14303.654	42096.25	2.94
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	14568.940	6515.940	768.401	110.884	268.488	101.517	259.121	268.488	101.517	3962.626	7850.297	1.98	14303.654	42096.25	2.94
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	8957.358	2833.367	0.000	79.478	148.010	79.478	148.010	148.010	79.478	2921.110	5961.456	2.04	9994.441	31639.06	3.17
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	9633.514	4486.960	1449.594	76.902	185.430	59.231	167.759	185.430	59.231	3613.088	6101.028	1.69	12374.843	32895.21	2.66
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	10025.905	4765.557	257.599	71.250	186.517	68.110	183.376	186.517	68.110	3613.088	6101.028	1.69	12374.843	32895.21	2.66
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	11797.721	3374.854	0.000	108.998	190.627	108.998	190.627	190.627	108.998	3270.648	7850.297	2.40	11923.252	40716.13	3.41
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	12026.163	3771.752	449.644	109.839	201.068	104.358	195.587	201.068	104.358	3270.648	7850.297	2.40	11923.252	40716.13	3.41
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	8940.485	2866.399	0.000	78.865	148.195	78.865	148.195	148.195	78.865	2851.573	5950.235	2.09	9994.441	31414.10	3.14
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	9075.717	3197.117	289.919	78.349	155.679	74.815	152.145	155.679	74.815	2851.573	5950.235	2.09	9994.441	31416.54	3.14
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	11797.721	3374.854	0.000	108.998	190.627	108.998	190.627	190.627	108.998	3270.648	7850.297	2.40	11923.252	40716.13	3.41
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	12026.163	3771.752	449.644	109.839	201.068	104.358	195.587	201.068	104.358	3270.648	7850.297	2.40	11923.252	40716.13	3.41
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	8940.485	2866.399	0.000	78.865	148.195	78.865	148.195	148.195	78.865	2851.573	5950.235	2.09	9994.441	31414.10	3.14
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	9075.717	3197.117	289.919	78.349	155.679	74.815	152.145	155.679	74.815	2851.573	5950.235	2.09	9994.441	31416.54	3.14
								SAFE	SAFE			SAFE			SAFE

***DESIGN OF PIER P1 AND
ITS FOUNDATION
FOR MINOR BRIDGE AT CH- 90+520***

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle	:	0	degree	0	Radian		
		Left span		Right span		Unit	
		Right	Skew	Right	Skew		
C/C Expansion joint	=	25.000	25.000	25.000	25.00	m	
C/C Expansion joint to C.L. brg	=	0.625	0.625	0.625	0.63	m	
Expansion gap	=	50	50	50	50	mm	
C/C bearing	=	23.750	23.750	23.750	23.750	m	

SUPERSTRUCTURE DETAILS

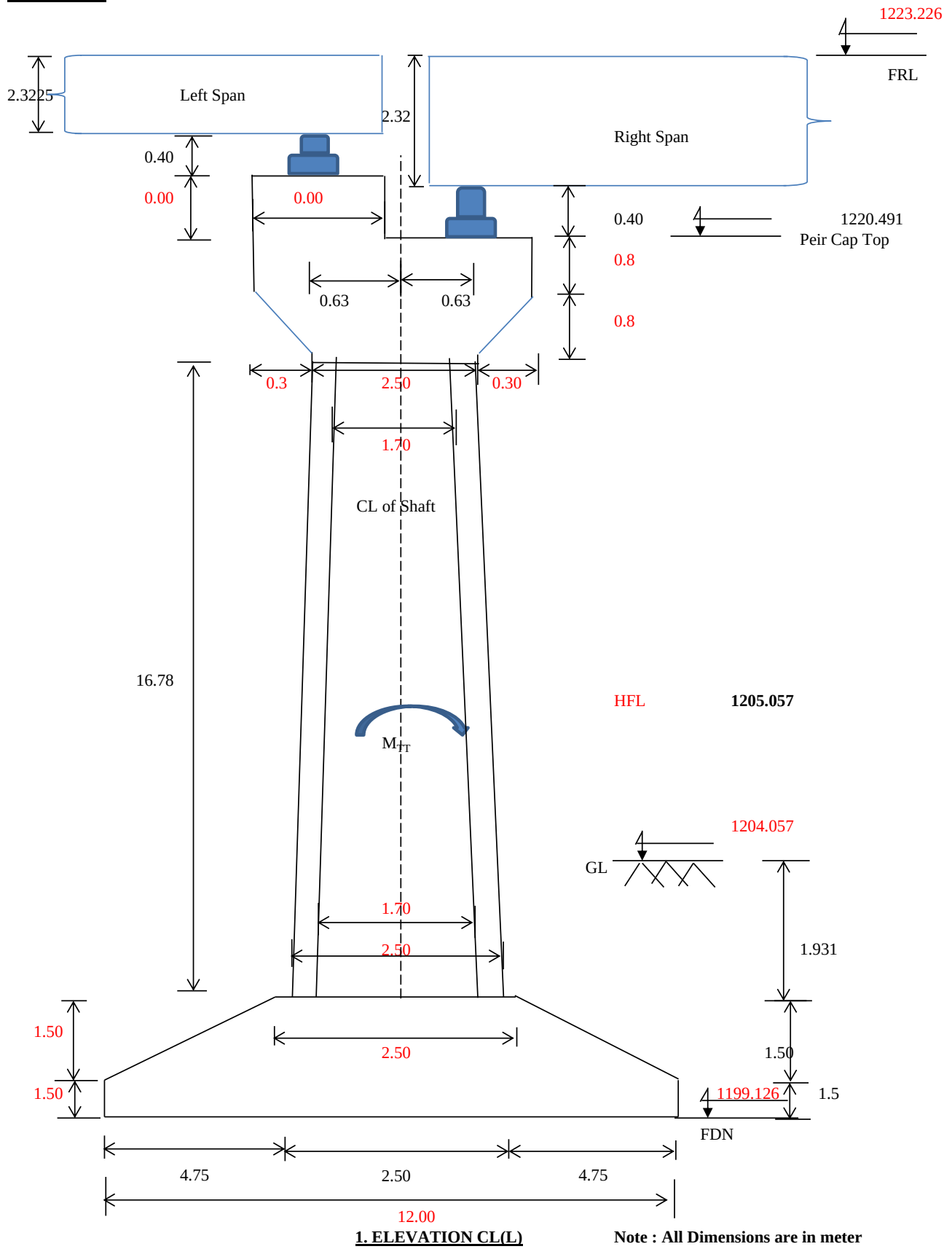
		Left Span	Right Span	
Overall deck width of bridge	=	12.50 m	12.50 m	
Carriage way width	=	11.50 m	11.50 m	
Crash barrier width	=	0.50 m	0.50 m	
Height of crash barrier	=	1.00 m	1.00 m	
C.g of Crash barrier from bottom	=	0.40 m	0.40 m	
Cross-slope	=	2.50 %	2.50 %	
Wearing coat thickness	=	65 mm	65 mm	
Nos. of Bearing	=	4	4	
Spacing of Bearing	=	3.00 m	3.00 m	
Depth of Girder	=	2.000 m	2.000 m	
Depth of slab	=	0.22 m	0.22 m	
Depth of superstructure	=	2.220 m	2.220 m	
Bearing + Pedestal height	=	0.40 m	0.40 m	
Width of main girder at top	=	1.00 m	1.00 m	
Width of cross girder	=	0.40 m	0.40 m	
Nos. of cross-girders	=	2	2	
FRL to Soffit	=	2.32 m	2.32 m	
Type of Bearing				OR SPHERICAL BR

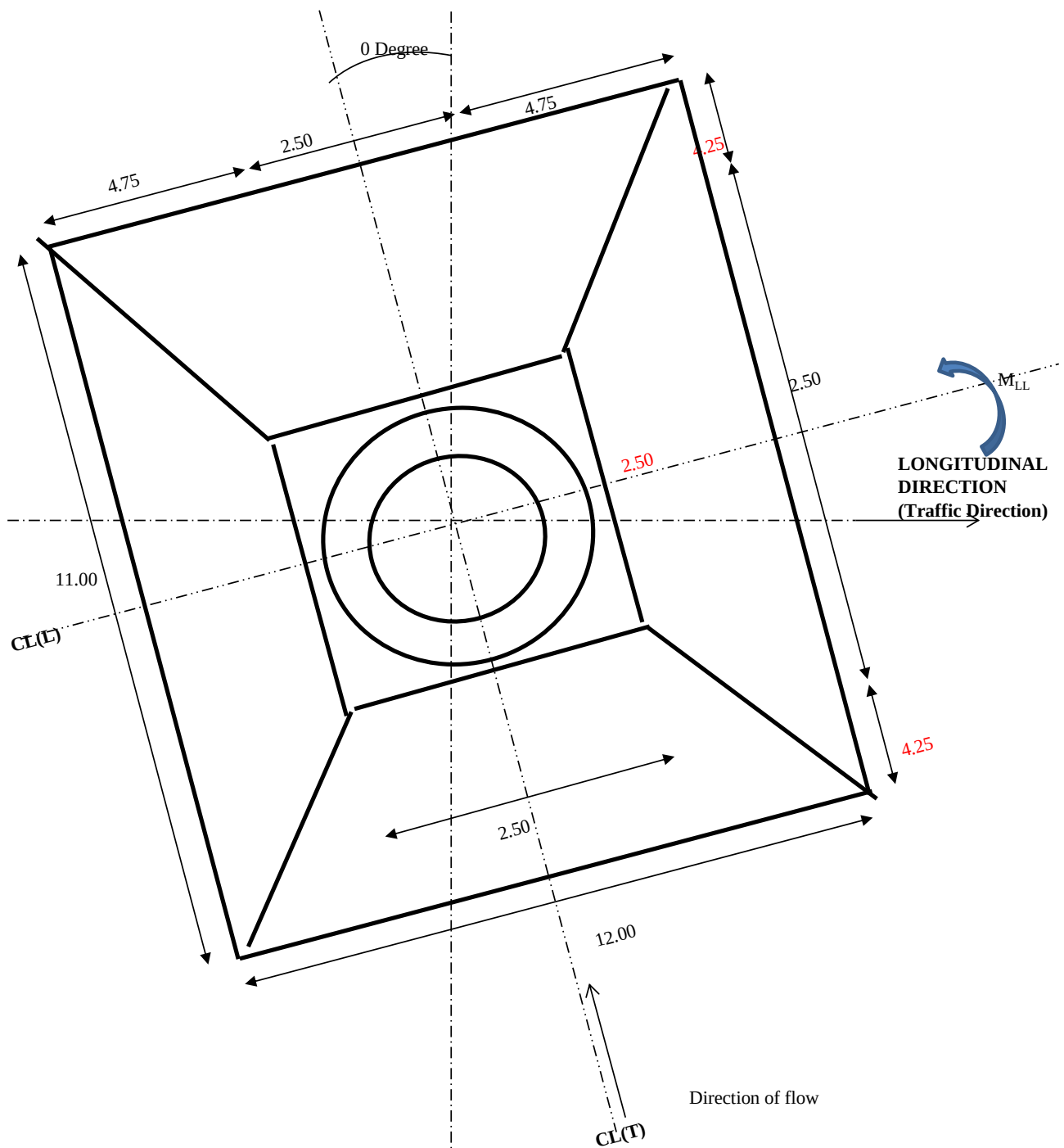
LEVEL DETAILS

Formation level	=	1223.226 m
Pier cap top level	=	1220.491 m
HFL	=	1205.057 m
Ground level	=	1204.057 m
MSL (Normal)/Rock Level	=	1204.057 m
MSL (Seismic)/Rock Level	=	1204.057 m
Pier shaft bottom/Footing top level	=	1202.114 m
Founding level	=	1199.126 m

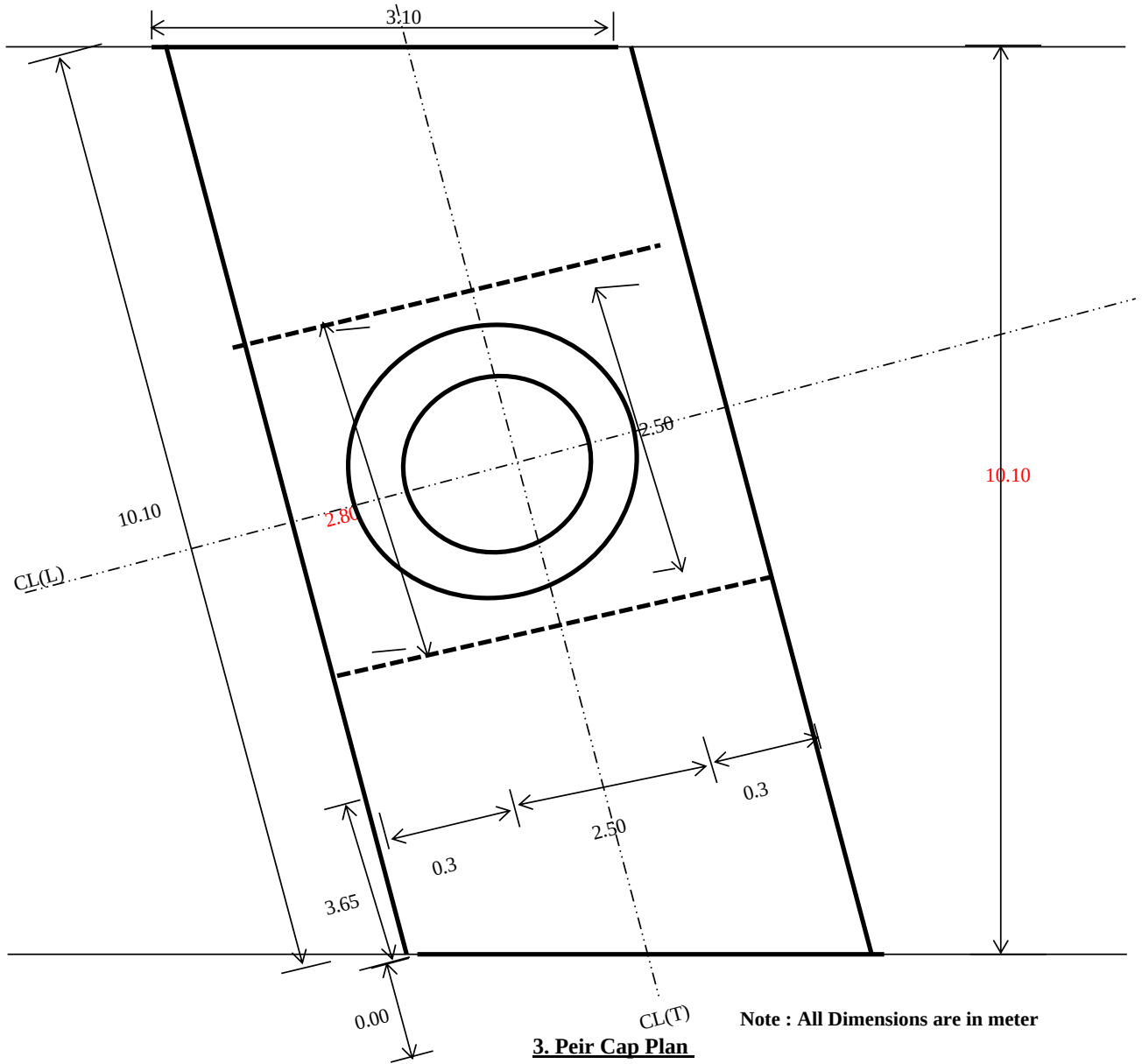
DIMENSION DETAILS

Pier cap:		Right	Skew
Width of pier cap at top	=	3.10 m	3.10 m
Width of pier cap at bottom	=	3.10 m	3.10 m
Length of pier cap at top	=	10.10 m	10.10 m
Length of pier cap at bottom	=	2.80 m	2.80 m
Thickness of uniform portion	=	0.80 m	0.80 m
Thickness of tapered portion	=	0.80 m	0.80 m
Pier shaft:			
Width of pier at top	=	2.50 m	2.50 m
Width of pier at bottom	=	2.50 m	2.50 m
Length of pier (rectangle portion)	=	0.00 m	0.00 m
Length of pier(end circular portion Top)	=	1.25 m	1.25 m
Length of pier (end circular portion Bottom)	=	1.25 m	1.25 m
Total length of pier shaft at top	=	2.50 m	2.50 m
Total length of pier shaft at bottom	=	2.50 m	2.50 m
Footing:			
Width of footing at top	=	2.50 m	2.50 m
Width of footing at bottom	=	12.00 m	12.00 m
Length of footing	=	11.00 m	11.00 m
Thickness at tip	=	1.50 m	1.50 m
Maximum thickness	=	3.00 m	3.00 m

DIAGRAMS:



2. PLAN SHOWING FOOTING & PIER SHAFT



2. MATERIALS DETAILS**CONCRETE:**

Grade of concrete	fck	=	M 35	
Mean value of concrete compressive strength, fcm		=	M 45 (28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447 x fck	(Basic and Seismic combination)
		=	15.633 Mpa	
Secant modulus of elasticity, Ecm		=	32000 Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8 Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5 t/m ³	

SOIL :

Density dry		=	2 t/m ³	
Density Saturated		=	2.3 t/m ³	
Soil density (submerged)		=	2 t/m ³	
Angle of Internal friction ϕ		=	35	
Cohesion c		=	0	
Gross bearing capacity		=	35.00 t/m ²	(Normal case)
		=	43.75 t/m ²	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	11.159 m ²	
Perimeter in contact with atmosphere, u		=	12.854 m	
Notional size, ho = 2Ac/u		=	1736 mm	
Age of concrete at the time of loading to		=	90 days	
	ta	=	25550 days	
	f(α 90)	=	1.2 (Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32 (increased by 10%)	
Creep co-efficient for foundation		=	1.0 (as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793 Mpa	Ecm' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500 Mpa	
Modulus of elasticity	Es	=	200000 Mpa	

3. PERMISSIBLE STRESSES**MAXIMUM PERMISSIBLE STRESS IN CONCRETE:**

Rare combination		=	0.48 x fck	
		=	16.8 Mpa	
Quasi permanent combination		=	0.36 x fck	
		=	12.6 Mpa	

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300 Mpa	
Permissible crack width	W _{k,max}	=	0.3 mm	

4. SEISMIC PARAMETERS

Seismic zone		=	V	
Type of soil		=	Type2(Medium)	
Zone factor	Z	=	0.36	
Importance factor	I	=	1.20	
Response Reduction Factor(Long)	R	=	3	
Response Reduction Factor(Trans)	R	=	3	

5. ENVIRONMENTAL PARAMETERS

Relative humidity		=	80%	
Condition of exposure		=	Moderate	

6.OTHER PARAMETERS

Mean velocity of water current flow		=	4.00 m/s	
Design Speed V		=	40 Kmph	
Radius of Curvature R		=	0 m	

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew = **0 °** = **0.000 Radian**
No. of Bearing = 4.00
Right
c/c of bearing in Transverse Direction = 3.000 m 3.000 m
c/c bearing on Longitudinal Direction = 1.250 m 1.250 m
Impact Factor for Design of Pier Cap = 1.15

Left Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	2255.34	200.00								
Total Load	2455.34		301.90	0.000	1048.91	349.69	0.00	0.00	1591.20	1468.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000	0.300	0.300

Right Span										
	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	2255.34	200.00								
Total Load	2455.34		301.90	0.00	1048.91	349.69	0.00	0.00	1591.20	1468.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	0.950	1.000	1.000	0.300	0.300

8. VOLUME OF SUBSTRUCTURE

PIER CAP

Uniform portion

No.		L(m)	B(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	10.100	0.000	0.000	0.000	1.550	0.000	18.3775	21.38
2	1	10.100	3.100	0.800	25.048	0.000	0.000	17.9775	20.98

Tapered portion

2a	Rectangle	2.800	3.100	0.800	6.944	0.000	0.000	17.178	20.178
	Triangle	3.650	3.100	0.800	9.052	0.000	0.000	17.311	20.311
Total Inc. 10%					45.148	0.000	0.000	16.086	18.814

PIER SHAFT

Above HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	13.847	36.540	0.000	0.000	9.854	12.854
2	0	2.500	0.000	13.847	0.000	-1.250	0.000	7.547	10.547
3	0	2.500	0.000	13.847	0.000	1.250	0.000	7.547	10.547

Cylinder/Conical Frustum portion

4	0.000	0.850	1.25	13.847	0.000	0.000	0.000	9.854	12.854
Total					36.540	0.000	0.000	9.854	12.854

Below HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	2.931	7.735	0.000	0.000	1.466	4.466
2	0	2.500	0.000	2.931	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	2.931	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.250	0.850	2.931	0.000	0.000	0.000	1.466	4.466
Total					7.735	0.000	0.000	1.465	4.465

Above LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	14.847	39.179	0.000	0.000	9.354	12.354
2	0.0	2.500	0.000	14.847	0.000	-0.850	0.000	6.880	9.880
3	0.0	2.500	0.000	14.847	0.000	0.850	0.000	6.880	9.880

Cylinder/Conical Frustum portion

4	0.000	0.850	0.850	14.847	0.000	0.000	0.000	8.942	11.942
Total					39.179	0.000	0.000	9.354	12.354

Below LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	2.500	1.700	1.931	5.096	0.000	0.000	0.966	3.966
2	0	2.500	0.000	1.931	0.000	0.000	0.000	0.000	0.000
3	0	2.500	0.000	1.931	0.000	0.000	0.000	0.000	0.000

Cylinder/Conical Frustum portion

4	0.000	1.25	0.850	1.931	0.000	0.000	0.000	0.813	3.813
Total					5.096	0.000	0.000	0.966	3.966

FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	11.000	2.500	3.00	82.500	0.000	0.000	-1.500	1.500
2	1	11.000	4.75	2.250	117.563	-3.361	0.000	-1.833	1.167
3	1	11.000	4.750	2.250	117.563	3.361	0.000	-1.833	1.167
Total					317.625	0.000	0.000	-1.747	1.253

EARTH ABOVE FOOTING

No.		L	B	H	V(m ³)	e _{LL} (m)	e _{TT} (m)	e _{VS} (m)	e _{VF} (m)
1	1	11.000	12.000	4.931	650.892	0.000	0.000	-0.534	2.466
2	-1	Shaft Below LBL			-5.096	0.000	0.000	0.966	3.966
3	-1	Footing			-317.625	0.000	0.000	-1.747	1.253
Total					328.171	0.000	0.000	0.616	3.616

9. CALCULATION OF SEISMIC FORCE

$$\text{Time Period } T = 2 \sqrt{\frac{D}{1000 F}}$$

$$\begin{aligned} D &= \text{Approximate DL of super-structure \& LL in Tonne (DL+20\% LL)} \\ &= 5514.48 \text{ KN} + 209.782 \text{ KN} \\ &= 5724 \text{ KN} \end{aligned}$$

F = Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction; and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

$$F = \frac{6 E I}{x^2(3L-x)} \quad \text{for 1 mm deflection at } x$$

$$E = 32000 \text{ N/mm}^2$$

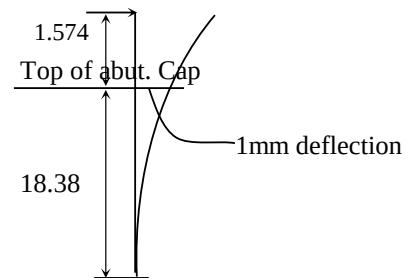
Column Cross-Section

$$D1 = 2.50 \text{ m (Average Outer Dia)}$$

$$D2 = 1.70 \text{ m (Average Inner Dia)}$$

$$I_{TT} = 1.13E+12 \text{ mm}^4 \quad 1.5E+12$$

$$I_{LL} = 1.13E+12 \text{ mm}^4$$



$$\text{Force required in Long. Dir. } F_L = 17 \text{ KN}$$

$$\text{Force required in Trans. Dir. } F_T = 15 \text{ KN}$$

$$\text{Time Period -Longitudinal Seismic Case} = 1.144 \text{ seconds}$$

$$\text{Time Period -Transverse Seismic Case} = 1.216 \text{ seconds}$$

$$S_a/g \text{ -Longitudinal Seismic Case} = 1.189$$

$$S_a/g \text{ -Transverse Seismic Case} = 1.119$$

$$\text{Seismic Zone} = V$$

$$\text{Zone Factor } Z = 0.36$$

$$\text{Importance Factor } I = 1.20$$

$$\begin{aligned} \text{Response reduction Factor } R &= 3.00 \quad \text{Longitudinal} \\ R &= 3.00 \quad \text{Transverse} \end{aligned}$$

$$\text{Avg response acceleration } S_a/g = 1.189 \quad \text{Longitudinal}$$

$$\text{Avg response acceleration } S_a/g = 1.119 \quad \text{Transverse}$$

$$\text{Elastic Seismic Coefficient} = \frac{Z}{2} \times (S_a/g) \times (I/R)$$

$$\text{In longitudinal direction} = 0.257 / R$$

$$\text{In Transverse direction} = 0.242 / R$$

		Substructure	Foundation
Enhancement factor			1.35
Design	Long. Ah	0.086	0.116

Seismic coefficient	Trans. At		0.081	0.109
	Vert. Av		0.057	0.077

CALCULATION OF SEISMIC FORCES

SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPLL :

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVF	W	eVS	eVF
	Tonnes	(m)	(m)		(m)	(m)
Total Super-Structure DL	451.07	20.33	23.33	451.07	20.33	23.33
Total Super-Structure SIDL	40.00	21.50	24.50	40.00	21.50	24.50
Total Super-Structure WC	60.38	21.13	24.13	60.38	21.13	24.13
Total Super-Structure FPLL	0.00	21.13	24.13	0.00	21.13	24.13
Total	551.45	20.50	23.50	551.45	18.94	21.72

* Bearing level	18.78	21.78		18.78	21.78

SEISMIC COMPONENT OF SUB-STRUCTURE :

Description	W	eVS	eVF
	Tonnes	(m)	(m)
Total weight of shaft and pier cap	223.56	12.28	15.14
Total weight of foundation	794.06	-1.75	1.25

SEISMIC COMPONENT OF LIVE LOAD(70R+Class A) :

Description	W	W	eVS	eVF
	Tonnes	Tonnes	(m)	(m)
	70R + Class A	70R + Class A		
Maximum Live Load	104.89	0.00	22.30	25.3
Minimum Live Load	34.97	0.00	22.30	25.3

Summary of Seismic force at shaft and foundation

Super structure

Dead load - Super structure about shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		47.19		886.111	
Seismic Transverse direction			44.42		876.00
Seismic Vertical Direction	31.46				

Dead load - Super structure about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		63.71		1387.37	
Seismic Transverse direction			59.971		1355.99
Seismic Vertical Direction	42.47				

Dead load Left span Dislodged- about foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		31.85		693.685	
Seismic Transverse direction			29.99		651.35
Seismic Vertical Direction	21.24				

Sub structure

Dead load - Sub structure Shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		19.13		234.84	
Seismic Transverse direction			18.01		221.07
Seismic Vertical Direction	12.75				

Dead load - Sub structure foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		25.8268		390.95	
Seismic Transverse direction			24.31		368.03
Seismic Vertical Direction	17.22				

Live Load - Max**70R + Class A**

Live load - Max shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.69		37.69
Seismic Vertical Direction	1.20				

Live load - Max foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.28		57.72
Seismic Vertical Direction	1.62				

70R

Live load - Max shaft	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.69		37.69
Seismic Vertical Direction	1.20				

Live load - Max foundation	V	H L	H T	M T T	M L L
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.28		57.72
Seismic Vertical Direction	1.62				

Live Load - Min**70R + Class A**

Live load - Min shaft	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.56		12.56
Seismic Vertical Direction		0.40				

Live load - Min foundation	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.76		19.24
Seismic Vertical Direction		0.54				

70R

Live load - Min shaft	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.56		12.56
Seismic Vertical Direction		0.40				

Live load - Min foundation	about	V	H L	H T	M T T	M L L
		Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction				0.76		19.24
Seismic Vertical Direction		0.54				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)**1. Normal Max Reaction on Fix End****Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (225.534 + 50.19 + 0.00) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ &+ 0.1 \times 0 + 0.05 \times 0 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (225.534 + 50.19 + 34.97) \\ &= 15.53 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 26.88 \text{ Ton} \\ F_{hr} &= 26.88 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 26.88 - 13.79 \\ &= 13.10 \text{ Ton} \end{aligned}$$

2. Normal Min Reaction on Fix End**Left Span**

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (225.534 + 50.19 + 0.00) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\ &= 0.2 \times 100 + 0.05 \times 54 \\ F_h &= 22.7 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (Rg + Rq) &= 0.05 \times (225.534 + 50.19 + 104.89) \\ &= 19.03 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Max of } (F_h/2 + \mu (Rg + Rq)) \text{ and } (F_h - \mu (Rg + Rq)) \\ &= 30.38 \text{ Ton} \\ F_{hr} &= 30.38 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 30.38 - 13.79 \\
 &= 16.59 \text{ Ton}
 \end{aligned}$$

3. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (Rg + Rq) &= 0.05 \times \left(\begin{array}{l} \text{Total DL} \\ 225.534 \end{array} + \begin{array}{l} \text{Total SIDL load} \\ 50.19 \end{array} + \begin{array}{l} \text{CWLL} \\ 0.00 \end{array} \right) \\
 &= 13.79 \text{ Ton} \\
 F_{hl} &= 13.79 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \begin{array}{l} \text{Class 70R on First two Lane} \\ 0.2 \end{array} \times \begin{array}{l} 20 \\ \end{array} + \begin{array}{l} \text{Class A on third Lane} \\ 0.05 \end{array} \times \begin{array}{l} 10.8 \\ \end{array} \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 23.595 \text{ Ton} \\
 \text{Seismic Horizontal force(foundation)} &= 31.853 \text{ Ton} \\
 \text{Total Horizontal force for Shaft}(F_h) &= 28.135 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 36.393 \text{ Ton} \\
 \mu (Rg + Rq) &= 0.05 \times \left(\begin{array}{l} \text{Total DL} \\ 225.534 \end{array} + \begin{array}{l} \text{Total SIDL load} \\ 50.19 \end{array} + \begin{array}{l} \text{CWLL} \\ 6.99 \end{array} \right) \\
 &= 14.13589 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Max of } & (F_h/2 + \mu (Rg + Rq) \text{ and } F_h - \mu (Rg + Rq)) \\
 F_{hr} \text{ for shaft} &= 30.47 \text{ Ton} \\
 F_{hr} \text{ for foundation} &= 34.60 \text{ Ton} \\
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 30.47 - 13.79 \\
 &= 16.69 \text{ Ton} \\
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 34.60 - 13.79 \\
 &= 20.82 \text{ Ton}
 \end{aligned}$$

4. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned}
 \mu (Rg + Rq) &= 0.05 \times \left(\begin{array}{l} \text{Total DL} \\ 225.534 \end{array} + \begin{array}{l} \text{Total SIDL load} \\ 50.19 \end{array} + \begin{array}{l} \text{CWLL} \\ 0.00 \end{array} \right) \\
 &= 13.79 \text{ Ton} \\
 F_{hl} &= 13.79 \text{ Ton}
 \end{aligned}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \begin{array}{l} \text{Class 70R on First two Lane} \\ 0.2 \end{array} \times \begin{array}{l} 20 \\ \end{array} + \begin{array}{l} \text{Class A on third Lane} \\ 0.05 \end{array} \times \begin{array}{l} 10.8 \\ \end{array} \\
 F_h &= 4.54 \text{ Ton} \\
 \text{Seismic Horizontal force(Shaft)} &= 23.595 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 31.853 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \%})
 \end{aligned}$$

Total Horizontal force for Shaft(Fh)	=	28.135	Ton	inc.)
Total Horizontal force for foundation(Fh)	=	36.393	Ton	
$\mu (Rg + Rq)$	=	0.05	x (	
			Total DL	Total SIDL load
			225.534	50.19
			+	CWLL
				20.98)
	=	14.83511	Ton	
Max of	(Fh/2 + $\mu (Rg + Rq)$	and	Fh - $\mu (Rg + Rq)$	)
	Fhr for shaft	=	31.17	Ton
	Fhr for foundation	=	35.30	Ton
Horizontal force for shaft	=	Fhr	-	Fhl
	=	31.17	-	13.79
	=	17.39	Ton	
Horizontal force for foundation	=	Fhr	-	Fhl
	=	35.30	-	13.79
	=	21.52	Ton	

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

$\mu (Rg + Rq)$	=	0.05	x (	Total DL	+	Total SIDL load	+	CWLL
				225.534		50.19		0.00)
	=	13.79	Ton					
Fhl	=	13.79	Ton					

Right Span

Beaking Force	=	Class 70R on First two Lane	+	Class A on third Lane
		0.2 x 100		0.05 x 0.00)

Fh	=	20 Ton

$\mu (Rg + Rq)$	=	0.05	x (	Total DL	+	Total SIDL load	+	CWLL
				225.534		50.19		34.97)
	=	15.53	Ton					

Max of	(Fh/2 + $\mu (Rg + Rq)$	and	Fh - $\mu (Rg + Rq)$	)

	=	25.53	Ton
Fhr	=	25.53	Ton

Horizontal force	=	Fhr	-	Fhl
	=	25.53	-	13.79
	=	11.75	Ton	

6. Normal Min Reaction on Fix End

Left Span

$\mu (Rg + Rq)$	=	0.05	x (	Total DL	+	Total SIDL load	+	CWLL
				225.534		50.19		0.00)
	=	13.79	Ton					

$$F_{hl} = 13.79 \text{ Ton}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 100 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 20 \text{ Ton}$$

$$\mu (R_g + R_q) = 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{104.89} \right) = 19.03 \text{ Ton}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$= 29.03 \text{ Ton}$$

$$F_{hr} = 29.03 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 29.03 - 13.79 \\ &= 15.24 \text{ Ton} \end{aligned}$$

7. Seismic Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\text{Beaking Force} = \frac{\text{Class 70R on First two Lane}}{0.2} \times 20 + \frac{\text{Class A on third Lane}}{0.05} \times 0$$

$$F_h = 4 \text{ Ton}$$

$$\text{Seismic Horizontal force (Shaft)} = 23.595 \text{ Ton}$$

$$\text{Seismic Horizontal force (foundation)} = 31.853 \text{ Ton}$$

$$\text{Total Horizontal force for Shaft (Fh)} = 27.595 \text{ Ton}$$

$$\text{Total Horizontal force for foundation (Fh)} = 35.853 \text{ Ton}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{6.99} \right) \\ &= 14.13589 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 29.93 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 34.06 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 29.93 - 13.79 \\ &= 16.15 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 34.06 - 13.79 \\ &= 20.28 \text{ Ton} \end{aligned}$$

8. Seismic Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \text{Beaking Force} &= 0.2 \times \frac{\text{Class 70R on First two Lane}}{20} + 0.05 \times \frac{\text{Class A on third Lane}}{0} \\ F_h &= 4 \text{ Ton} \\ \text{Seismic Horizontal force(Shaft)} &= 23.595 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\ \text{Seismic Horizontal force(foundation)} &= 31.853 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\ \text{Total Horizontal force for Shaft}(F_h) &= 27.595 \text{ Ton} \\ \text{Total Horizontal force for foundation}(F_h) &= 35.853 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{20.98} \right) \\ &= 14.83511 \text{ Ton} \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 30.63 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 34.76 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\ &= 30.63 - 13.79 \\ &= 16.85 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\ &= 34.76 - 13.79 \\ &= 20.98 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{0.00} \right) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \frac{\text{CWLL}}{146.80} \right) \\ &= 21.13 \text{ Ton} \end{aligned}$$

$$F_{hr} = 21.13 \text{ Ton}$$

$$\begin{aligned} \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 21.13 - 13.79 \\ &= 7.34 \text{ Ton} \end{aligned}$$

10. Normal Min Reaction on Fix End

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \text{CWLL} \right) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \text{CWLL} \right) \\ &= 21.74 \text{ Ton} \\ F_{hr} &= 21.74 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 21.74 - 13.79 \\ &= 7.96 \text{ Ton} \end{aligned}$$

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \text{CWLL} \right) \\ &= 13.79 \text{ Ton} \\ F_{hl} &= 13.79 \text{ Ton} \end{aligned}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \text{CWLL} \right) \\ &= 13.79 \text{ Ton} \\ F_{hr} &= 13.79 \text{ Ton} \\ \text{Horizontal force} &= F_{hr} - F_{hl} \\ &= 13.79 - 13.79 \\ &= 0.00 \text{ Ton} \end{aligned}$$

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned} \mu (R_g + R_q) &= 0.05 \times \left(\frac{\text{Total DL}}{225.534} + \frac{\text{Total SIDL load}}{50.19} + \text{CWLL} \right) \\ &= 13.7862 \text{ Ton} \\ F_{hr} &= 13.7862 \text{ Ton} \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force} &= F_{hr} - F_{hl} \\
 &= 13.7862 - 0.000 \\
 &= 13.7862 \text{ Ton}
 \end{aligned}$$

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

$$F_{hl} = 0 \text{ Ton}$$

Right Span

$$\begin{aligned}
 \text{Beaking Force} &= \text{Class 70R on First two Lane} + \text{Class A on third Lane} \\
 &= 0.2 \times 0 + 0.05 \times 0
 \end{aligned}$$

$$F_h = 0 \text{ Ton}$$

$$\begin{aligned}
 \text{Seismic Horizontal force(Shaft)} &= 23.595 \text{ Ton} \quad (\text{Including safty factor 1.5}) \\
 \text{Seismic Horizontal force(foundation)} &= 31.853 \text{ Ton} \quad (\text{Including safty factor 1.5 and 35 \% inc.}) \\
 \text{Total Horizontal force for Shaft}(F_h) &= 23.595 \text{ Ton} \\
 \text{Total Horizontal force for foundation}(F_h) &= 31.853 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \mu (R_g + R_q) &= 0.05 \times (225.534 + 50.19 + 0.00) \\
 &= 13.7862 \text{ Ton}
 \end{aligned}$$

$$\text{Max of } (F_h/2 + \mu (R_g + R_q) \text{ and } F_h - \mu (R_g + R_q))$$

$$F_{hr} \text{ for shaft} = 25.58 \text{ Ton}$$

$$F_{hr} \text{ for foundation} = 29.71 \text{ Ton}$$

$$\begin{aligned}
 \text{Horizontal force for shaft} &= F_{hr} - F_{hl} \\
 &= 25.58 - 0.00 \\
 &= 25.58 \text{ Ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal force for foundation} &= F_{hr} - F_{hl} \\
 &= 29.71 - 0.00 \\
 &= 29.71 \text{ Ton}
 \end{aligned}$$

Summary of forces			
Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	13.10	13.10
	2. Normal Min Reaction on Fix End	16.59	16.59
	3. Seismic Max Reaction on Fix End	16.69	20.82
	4. Seismic Min Reaction on Fix End	17.39	21.52
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.75	11.75
	6. Normal Min Reaction on Fix End	15.24	15.24
	7. Seismic Max Reaction on Fix End	16.15	20.28
	8. Seismic Min Reaction on Fix End	16.85	20.98
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	7.34	7.34
	10. Normal Min Reaction on Fix End	7.96	7.96
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	13.79	13.79
	13. Seismic Span Dislodge Condition	25.58	29.71

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$C = \frac{WV^2}{127R}$$

70R + Class A

Maxium Reaction				
Live Load	W	=	104.89	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0.00	22.30	25.30

Minimum Reaction				
Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0.00	t	

C (t)	e _{VS} (m)	e _{VF} (m)
0	22.30	25.30

70R

Maxium Reaction				
Live Load	W	=	104.89	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
0	22.30	25.30

Minimum Reaction				
Live Load	W	=	34.97	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m
C	=	0	KN	

C (t)	e _{VS} (m)	e _{VF} (m)
0	22.30	25.30

Special Vehicle

Maxium Reaction				
Live Load	W	=	159.12	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e_{VS}(m)	e_{VF}(m)
0	22.30	25.30

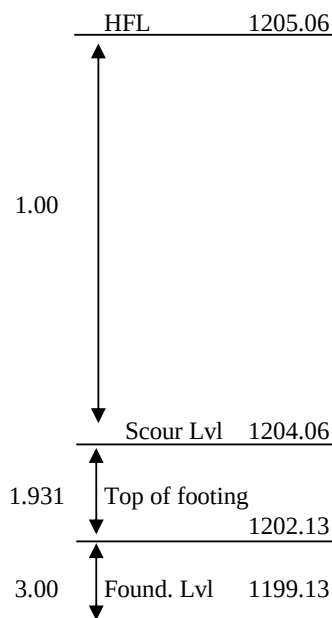
Minimum Reaction				
Live Load	W	=	146.80	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

$$C = 0 \text{ KN}$$

C (t)	e_{VS}(m)	e_{VF}(m)
0	22.30	25.30

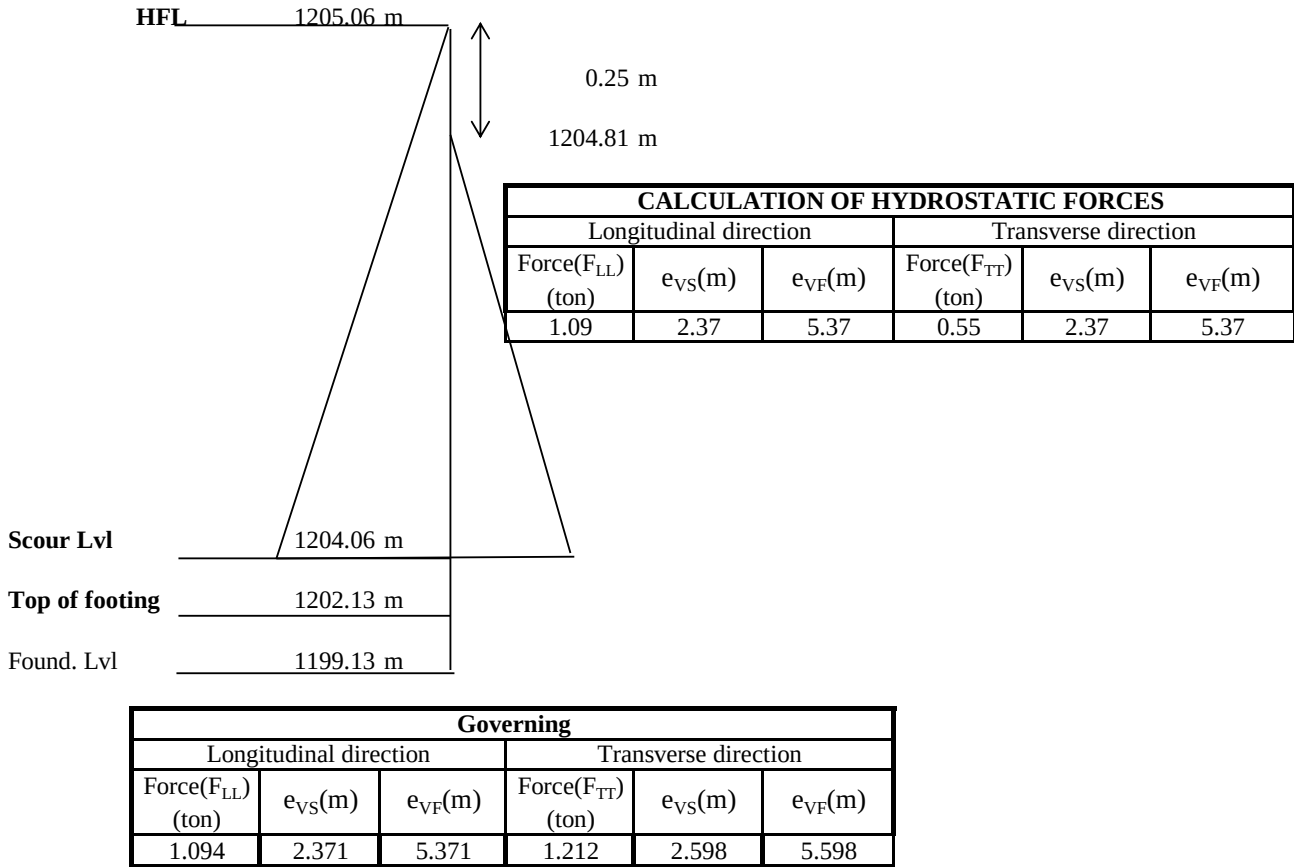
12. WATER CURRENT FORCES**NORMAL CASE****Water current forces**

HFL	=	1205.057 m	
MSL (NORMAL)	=	1204.057 m	
Water current pressure	P	=	52 KV ² Kg/m ²
For piers with square ends	K	=	1.5
For piers with semicircular ends	K	=	0.66
Mean velocity of water current	V _{mean}	=	4.00 m/s
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00
		=	5.66 m/s
Angle of variation		=	20 degree
Water current pressure at HFL (Trans direction)		=	0.97 t/m ² 52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ² 53 K (vsinq) ²

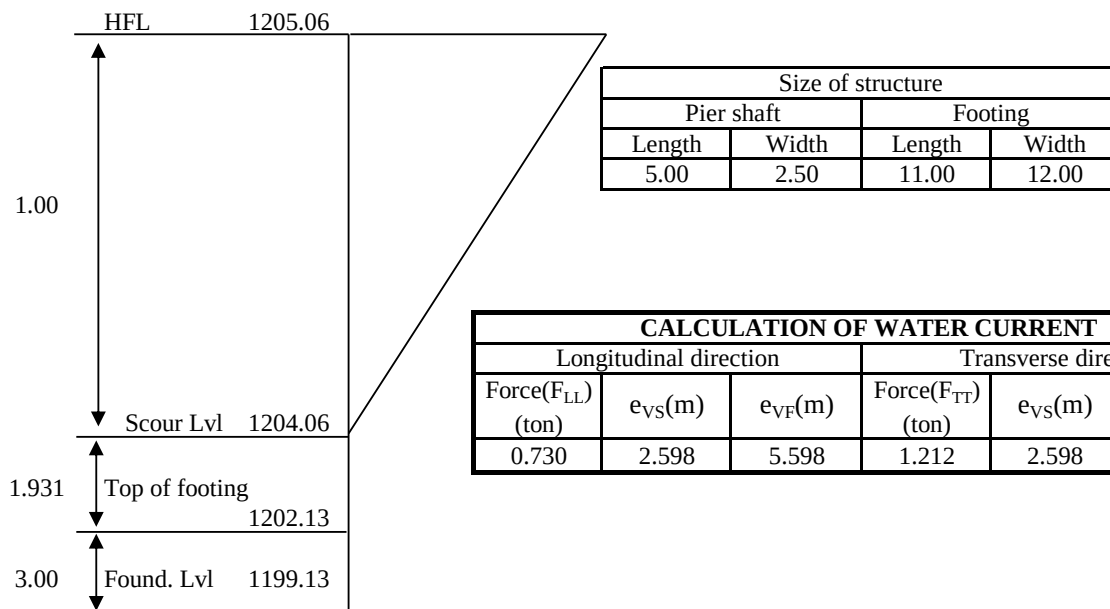
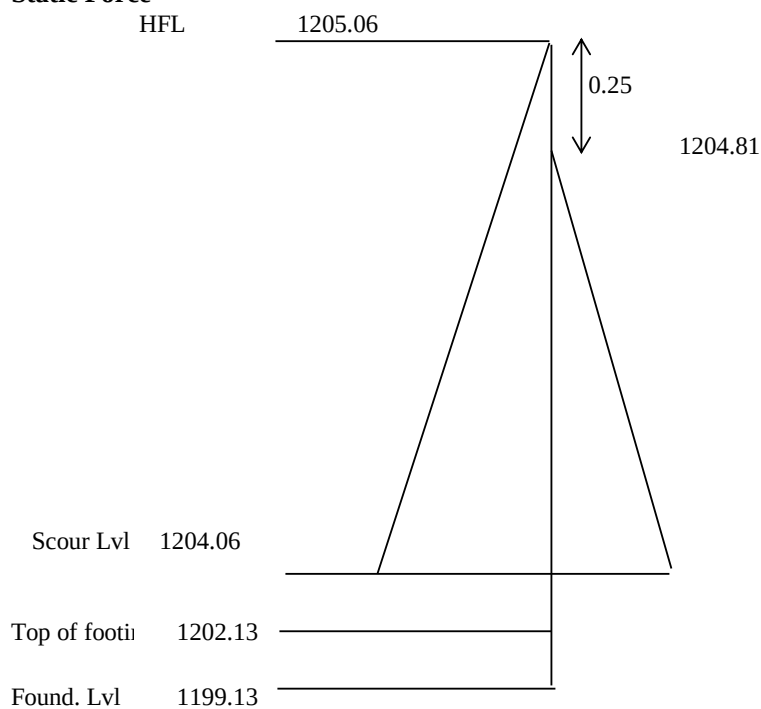


Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
5.00	2.50	11.00	12.00

CALCULATION OF WATER CURRENT FORCES					
Longitudinal direction			Transverse direction		
Force(F _{LL}) (ton)	e _{VS} (m)	e _{VF} (m)	Force(F _{TT}) (ton)	e _{VS} (m)	e _{VF} (m)
0.730	2.598	5.598	1.212	2.598	5.598

Static Force**SEISMIC CASE**

HFL	=	1205.057 m		
MSL (SEISMIC)	=	1204.06 m		
Water current pressure	P	=	52 KV ²	Kg/m ²
For piers with square ends	K	=	1.5	
For piers with semicircular ends	K	=	0.66	
Mean velocity of water current	V_{mean}	=	4.00 m/s	
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00	
		=	5.66 m/s	
Angle of variation		=	20 degree	
Water current pressure at HFL (Trans direction)		=	0.97 t/m ²	52 K (vcosq) ²
Water current pressure at HFL (Long direction)		=	0.29 t/m ²	53 K (vsinq) ²

**Pressure diagram (seismic case)****Static Force**

CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
1.09	2.37	5.37	0.55	2.37	5.37

Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$	Force(F_{TT}) (ton)	$e_{VS}(m)$	$e_{VF}(m)$
1.094	2.371	5.371	1.212	2.598	5.598

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

- LC -1 ULS NORMAL LWL MAX REACTION
 LC -2 ULS NORMAL LWL SPAN DISLOGED
- LC - 5 ULS MAX REACTION $1X + 0.3Y + 0.3Z$
 LC - 6 ULS MAX REACTION $0.3X + 1Y + 0.3Z$
- LC - 9 ULS NORMAL SV MAX REACTION

SLS

- LC -1 RARE NORMAL MAX REACTION
 LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

- LC - 1 ULS NORMAL MAX REACTION(70R +Class A)
 LC - 2 ULS NORMAL SPAN DISLOGED
- LC - 5 ULS NORMAL MAX REACTION(70R)
- LC - 7 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R + \text{Class A})$
 LC - 8 ULS SPAN DISLODGED $1X + 0.3Y + 0.3Z$
 LC - 9 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{Class A})$
 LC - 10 ULS SPAN DISLODGED $0.3X + 1Y + 0.3Z$
- LC - 15 ULS MAX REACTION $1X + 0.3Y + 0.3Z(70R)$
 LC - 16 ULS MAX REACTION $0.3X + 1Y + 0.3Z(70R)$
- LC - 19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION(70R+Class A)

LC - 2 NORMAL SPAN DISLOGED

LC - 5 0

LC - 6 SEISMIC SPAN DISLODGED $1X + 0.3Y + 0.3Z$ LC - 7 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R + \text{class A})$ LC - 8 SEISMIC LWL SPAN DISLODGED $0.3X + 1Y + 0.3Z$

LC - 13 SEISMIC NORMAL MAX REACTION(70R)

LC - 15 SEISMIC MAX REACTION $1X + 0.3Y + 0.3Z(70R)$ LC - 16 SEISMIC MAX REACTION $0.3X + 1Y + 0.3Z(70R)$

LC - 13 NORMAL LWL SV MAX REACTION

14.A DESIGN FORCES FOR PIER SHAFT(ULS CASES)**LC -1 ULS NORMAL LWL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.459	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			104.891		0.625	0.950		65.557	99.646	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			22.300	0.0	0.000	1.5	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				13.098			18.778	245.956		1.5	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1227.75	457.44	134.52

LC -2 ULS NORMAL LWL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			22.300	0.000	0.000	1.5	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				13.786			18.778	258.870		1.5	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
686.11	628.50	0.00

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			245.534		-0.63	0.000		-153.459	0.000	1.35	
2	Surfacing			30.190		-0.63	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.63	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.63	0.950		0.000	0.000	0.2	1
5	LL (Class-A)			0.000		-0.63	1.000		0.000	0.000	0.2	1
	Right Span											
6	DL (superstructure)			245.534		0.63	0.000		153.459	0.000	1.35	
7	Surfacing			30.190		0.63	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.63	0.000		0.000	0.000	0.2	
9	LL (70R)			104.891		0.63	0.950		65.557	99.6	0.2	1
10	LL (Class-A)			0.000		0.63	1.000		0.000	0.0	0.2	1
11	Centrifugal force				0.000			22.300	0.0	0.0	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				16.687			18.778	313.344		1.000	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1.000	
18	Seismic											
	Super structure											
	Longitudinal				47.190				886.11		1.5	
	Transverse				44.423					876.00434	0.45	
	Vertical			31.460							0.45	
	Sub structure											
	Longitudinal				19.131				234.84		1.5	
	Transverse				18.009					221.06709	0.45	
	Vertical			12.754							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				1.690					37.685779	0.45	
	Vertical			1.197							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1111.823	2007.88	530.57

LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.63	0.00		-153.46	0.00	1.35	
2	Surfacing			30.190		-0.63	0.00		-18.87	0.00	1.75	
3	FLL			0.000		-0.63	0.00		0.00	0.00	0.2	
4	LL (70R)			0.000		-0.63	0.95		0.00	0.00	0.2	1
5	LL (Class-A)			0.000		-0.63	1.00		0.00	0.00	0.2	1
Right Span												
6	DL (superstructure)			245.534		0.63	0.00		153.46	0.00	1.35	
7	Surfacing			30.190		0.63	0.00		18.87	0.00	1.75	
8	FLL			0.000		0.63	0.00		0.00	0.00	0.2	
9	LL (70R)			104.891		0.63	0.95		65.56	99.65	0.2	1
10	LL (Class-A)			0.000		0.63	1.00		0.00	0.00	0.2	1
11	Centrifugal force				0.000			22.300	0.0	0.000	0.2	
12	Pier cap	45.148	2.500	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.500	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.500	12.739		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F _{LL})				16.687			18.778	313.344		1.000	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1.000	
18	Seismic											
Super structure												
	Longitudinal				47.190				886.11		0.45	
	Transverse				44.423					876.004	1.5	
	Vertical			31.460							0.45	
Sub structure												
	Longitudinal				19.131				234.84		0.45	
	Transverse				18.009					221.067	1.5	
	Vertical			12.754							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				1.690					37.686	1.5	
	Vertical			1.197							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
1111.823	830.88	1722.07

LC - 9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.459	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1.35	
6	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
7	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
8	LL			159.120		0.625	0.300		99.450	47.736	1	1
9	Centrifugal force				0.000			22.300	0.000		1	
10	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
15	Horizontal Force(F _{LL})				7.340			18.778	137.827		1.5	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1.5	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1229.53	306.19	47.74

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)**LC -1 RARE NORMAL MAX REACTION**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.459	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			104.891		0.625	0.950		65.557	99.646	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			22.300	0.000	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			2.371	0.000		1	
	Water Current Force(F _{TT})				0.000			2.598		0.000	1	
17	Horizontal Force(F _{LL})				13.098			18.778	245.956		1	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
891.97	304.96	89.68

LC-2 RARE NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force(F _{LL})				0.000			22.300	0.000	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			2.371	0.000		1	
	Water Current Force(F _{TT})				0.000			2.598		0.000	1	
17	Horizontal Force(F _{LL})				13.786			18.778	258.870		1	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
505.32	434.97	0.00

LC -5 QP NORMAL

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.459	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	0	
9	LL (70R)			104.891		0.625	0.950		65.557	99.646	0	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			22.300	0.000	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			2.371	0.000		0	
	Water Current Force(F _{TT})				0.000			2.598		0.000	0	
17	Horizontal Force(F _{LL})				0.000			18.778	0.000		0	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
787.08	0.00	0.00

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.2	
8	FLL			0.000		0.625	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			22.300	0.000	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F _{LL})				0.000			2.371	0.000		0	
	Water Current Force(F _{TT})				0.000			2.598		0.000	0	
17	Horizontal Force(F _{LL})				13.786			18.778	258.870		1	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
505.32	434.97	0.00

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.459	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.2	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			245.534		0.625	0.000		153.459	0.000	1	
6	Surfacing			30.190		0.625	0.000		18.869	0.000	1.2	
7	FLL			0.000		0.625	0.000		0.000	0.000	1	
8	LL			159.120		0.625	0.300		99.450	47.736	1	1
9	Centrifugal force				0.000			22.300	0.000		1	
10	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			2.371	0.000		1	
	Water Current Force(F _{TT})				0.000			2.598		0.000	1	
15	Horizontal Force(F _{LL})				7.340			18.778	137.827		1	
	Horizontal Force(F _{TT})				0.000			18.778		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
946.20	237.28	47.74

15. DESIGN FORCES FOR FOUNDATION**LC -1 ULS NORMAL MAX REACTION(70R +Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centrifugal force				0.000			25.300	0.0	0.000	1.5	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				13.098			21.778	285.25		1.5	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1.5	
18	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
3170.06	516.38	134.52

LC -2 ULS NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1.5	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			25.300	0.000	0.000	1.5	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				13.786			21.778	300.229		1.5	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1.5	
18	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2644.15	690.53	0.00

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	1.5	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			25.300	0.0	0.000	1.5	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				11.748			21.778	255.85		1.5	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1.5	
18	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2283.997	472.28	134.52

LC - 7 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			104.891		0.625	0.950		65.557	99.646	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			25.300	0.0	0.000	0.2	
12	Pier cap	45.148	2.500	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.500	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.500	12.739		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				20.816			21.778	453.33		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.00	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				63.707				1387.4		1.5	
	Transverse				59.971					1356.0	0.45	
	Vertical			42.471							0.45	
Sub structure												
	Longitudinal				25.827				391.0		1.5	
	Transverse				24.312					368.03021	0.45	
	Vertical			17.22							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				2.281					57.72008	0.45	
	Vertical			1.616							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3077.095	3133.92	824.31

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.00	0.000	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				29.713			21.778	647.07		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				31.853				693.69		1.5	
	Transverse				29.986					651.35287	0.45	
	Vertical			21.236							0.45	
	Sub structure											
	Longitudinal				25.827				391.0		1.5	
	Transverse				24.312					368.03021	0.45	
	Vertical			17.218							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2661.457	2307.05	458.72

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			25.300	0.0	0.000	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				20.816			21.778	453.33		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				63.707				1387.4		0.45	
	Transverse				59.971					1355.994	1.5	
	Vertical			42.471							0.45	
	Sub structure											

	Longitudinal				25.827				391.0		0.45	
	Transverse				24.312					368.030	1.5	
	Vertical			17.218							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				2.281					57.720	1.5	
	Vertical			1.616							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3077.095	1266.68	2721.41

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.00	0.000	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				29.713			21.778	647.07		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				31.853			693.69			0.45	
	Transverse				29.986					651.35287	1.5	
	Vertical			21.236							0.45	
Sub structure												
	Longitudinal				25.827				391.0		0.45	
	Transverse				24.312					368.03021	1.5	
	Vertical			17.218							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
2661.457	1168.18	1529.07

LC -15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			104.891		0.625	0.950		65.557	99.646	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.0	0.000	0.2	
12	Pier cap	45.148	2.500	112.871		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	39.179	2.500	97.947		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	5.096	2.500	12.739		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				20.276			21.778	441.57		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.00	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
	Super structure											
	Longitudinal				63.707				1387.4		1.5	
	Transverse				59.971					1356.0	0.45	
	Vertical			42.471							0.45	
	Sub structure											
	Longitudinal				25.827				391.0		1.5	
	Transverse				24.312					368.03021	0.45	
	Vertical			17.22							0.45	
a)	Max Live Load											
	Longitudinal										1.5	
	Transverse				2.281					57.72	0.45	
	Vertical			1.616							0.45	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.761					19.242962	0.45	0.3
	Vertical			0.539							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	MTT (tm)	MLL(tm)
3077.095	3122.16	824.31

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VS} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
8	FLL			0.000		0.625	0.000		0.000	0.000	0.2	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.0	0.000	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				20.276			21.778	441.57		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1.35	
20	Seismic											
Super structure												
	Longitudinal				63.707				1387.4		0.45	
	Transverse				59.971					1355.994	1.5	
	Vertical			42.471							0.45	
Sub structure												
	Longitudinal				25.827				391.0		0.45	
	Transverse				24.312					368.030	1.5	
	Vertical			17.218							0.45	
a)	Max Live Load											
	Longitudinal										0.45	
	Transverse				2.281					57.720	1.5	
	Vertical			1.616							0.45	
b)	Min Live Load											
	Longitudinal										0.45	0.3

	Transverse				0.761					19.242962	1.5	1
	Vertical			0.539							0.45	0.3
SUMMARY OF FACTORED FORCES												
V(ton)		MTT (tm)		MLL(tm)								
3077.095		1254.92		2721.41								

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors (Design)	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1.35	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1.75	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
Right Span												
5	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1.35	
6	Surfacing			30.190		0.625	0.000		18.869	0.000	1.75	
7	FLL			0.000		0.625	0.000		0.000	0.000	1.5	
8	LL			159.120		0.625	0.300		99.45	47.736	1	1
9	Centrifugal force				0.000			25.300	0.0	0.000	1	
10	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
15	Horizontal Force(F _{LL})				7.340			21.778	159.85		1.5	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1.5	
16	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	MTT (tm)	MLL(tm)
3187.58	339.22	47.74

16. DESIGN FORCES FOR BASE PRESSURE**LC -1 NORMAL MAX REACTION(70R+Class A)**

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			25.300	0.0	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				13.098				21.778		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2319.81	344.25	89.68

LC -2 NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	1	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	1	0.9
11	Centrifugal force				0.000			25.300	0.000	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				13.786			21.778	300.229		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
1949.69	472.56	0.00

472.556 0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.00	0.000	0	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	

	Water Current Force(F_{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F_{LL})				29.713			21.778	647.07		1	
	Horizontal Force(F_{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				31.853				693.69		1	
	Transverse				22.212					482.48361	0.3	
	Vertical			15.730							0.3	
	Sub structure											
	Longitudinal				25.827				391.0		1	
	Transverse				24.312					368.03	0.3	
	Vertical			17.218							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M_{TT} (tm)	M_{LL} (tm)
1959.571	1750.58	255.15

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			0.000		-0.625	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.625	0.000		0.000	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0.2	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.625	0.950		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0.2	
11	Centrifugal force				0.000			25.300	0.00	0.000	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				29.713			21.778	647.07		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				0.000			0.00			0.3	
	Transverse				22.212					482.48361	1	
	Vertical			15.730							0.3	
	Sub structure											
	Longitudinal				25.827			391.0			0.3	
	Transverse				24.312					368.03021	1	
	Vertical			17.218							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
1959.571	783.23	850.51

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	0.9
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	1	0.9
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	0.9
11	Centrifugal force				0.000			25.300	0.0	0.000	1	
12	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				11.748			21.778	255.85		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M _{TT} (tm)	M _{LL} (tm)
2319.81	314.85	89.68

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			104.891		0.625	0.950		65.557	99.646	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.0	0.000	0.2	
12	Pier cap	45.148	2.500	112.871		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	39.179	2.500	97.947		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	5.096	2.500	12.739		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				20.276			21.778	441.57		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.00	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				63.707				1387.4		1	
	Transverse				59.971					1356.0	0.3	
	Vertical			42.471							0.3	
	Sub structure											
	Longitudinal				25.827				391.0		1	
	Transverse				24.312					368.03	0.3	
	Vertical			17.22							0.3	
a)	Max Live Load											
	Longitudinal										1	
	Transverse				2.281					57.72	0.3	
	Vertical			1.616							0.3	
b)	Min Live Load											
	Longitudinal										1.5	1
	Transverse				0.761					19.242962	0.45	0.3
	Vertical			0.539							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2264.853	2233.00	557.05

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	0	0
Left Span												
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.625	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.625	1.000		0.000	0.000	0	
Right Span												
6	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
7	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
8	FLL			0.000		0.625	0.000		0.000	0.000	1	
9	LL (70R)			104.891		0.625	0.950		65.5569	99.646	0.2	
10	LL (Class-A)			0.000		0.625	1.000		0.000	0.000	0	
11	Centrifugal force				0.000			25.300	0.0	0.000	0.2	
12	Pier cap	45.15	2.50	112.87		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	39.18	2.50	97.95		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	5.10	2.50	12.74		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F _{LL})				0.000			5.371	0.00		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
17	Horizontal Force(F _{LL})				20.276			21.778	441.57		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
18	Footing	317.63	2.50	794.06		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	328.17	2.00	656.34		0.00	0.00		0.00	0.00	1	
20	Seismic											
	Super structure											
	Longitudinal				63.707				1387.4		0.3	
	Transverse				59.971					1356.0	1	
	Vertical			42.471							0.3	
	Sub structure											
	Longitudinal				25.827				391.0		0.3	
	Transverse				24.312					368.03	1	
	Vertical			17.218							0.3	
a)	Max Live Load											

	Longitudinal									0.3	
	Transverse			2.281					57.72	1	
	Vertical		1.616							0.3	
b)	Min Live Load										
	Longitudinal									0.45	0.3
	Transverse			0.761					19.2	1.5	1
	Vertical		0.539							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2264.853	988.18	1830.54

LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m ³)	Unit weight (t/m ³)	Vertical Load (V in ton)	Horizontal Load(ton)	e _L (m)	e _T (m)	e _{VF} (m)	M _{TT} (tm)	M _{LL} (tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			245.534		-0.625	0.000		-153.46	0.000	1	
2	Surfacing			30.190		-0.625	0.000		-18.869	0.000	1	
3	FLL			0.000		-0.625	0.000		0.000	0.000	1	
4	LL			0.000		-0.625	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			245.534		0.625	0.000		153.46	0.000	1	
6	Surfacing			30.190		0.625	0.000		18.869	0.000	1	
7	FLL			0.000		0.625	0.000		0.000	0.000	1	
8	LL			159.120		0.625	0.300		99.45	47.736	1	1
9	Centrifugal force				0.000			25.300	0.0	0.000	1	
10	Pier cap	45.148	2.5	112.871		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	39.179	2.5	97.947		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	5.096	2.5	12.739		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F _{LL})				0.000			5.371	0.000		1	
	Water Current Force(F _{TT})				0.000			5.598		0.000	1	
15	Horizontal Force(F _{LL})				7.340			21.778	159.85		1	
	Horizontal Force(F _{TT})				0.000			21.778		0.000	1	
16	Footing	317.63	2.5	794.063		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	328.17	2	656.342		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES		
V(ton)	M _{TT} (tm)	M _{LL} (tm)
2384.53	259.30	47.74

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A1 for Minor Bridge at Ch. 90+925**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians
 COS θ = 1.000
 SIN θ = 0.000

Radius of Curvature of Superstructure = 100 m
 Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing	=	Tar Paper Bearing	
Coeff. Of Friction for Paper Tar Bearing	=	0.5	
Type of Soil	=	1 Hard or Rocky Strata	
NBC of soil -Normal Case	=	350 kN/m ²	(as per geotechnical report with ground improvement)
SBC of soil-Normal Case	=	380 kN/m ²	
SBC of soil-Seismic Case	=	475 kN/m ²	
Coeff. of friction between concrete and soil	=	0.7 for weathered rock	
Permissible FOS against Sliding	=	1 Normal Case	
	=	1 Seismic Case	
Permissible FOS against Overturning	=	1 Normal Case	
	=	1 Seismic Case	

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.409m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	=	0.720m	0.720m

Projection of Abutment Cap (Span Side)	=	0.000m	0.000m
Projection of Abutment Cap Back Side	=	0.000m	0.000m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.000m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	1.010m	1.010m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.000m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	9.200m
abutment pedestal width	=	1.200m
abutment pedestal Height	=	1.200m
Width of Toe Slab	=	3.000m
Width of Heel Slab	=	5.000m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.200m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.200m
Width of backfill on heel slab	=	5.000m
Thickness of heel slab at back fill edge	=	1.200m
Height of back fill at bottom edge of heel slab	=	9.098m
Height of back fill at back fill edge of heel slab	=	8.398m

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)
Width of foundation -Tapering portion	=	12.500m (skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
	1 Minor Bridge	90+925	1233.116	1226.66	1223.66	9.456

Levels

Deck Level at Median Edge=	1233.116m
Deck level at Outer Edge =	1233.401m
Deck level at center line =	1233.116m
Soffit Level at center of bridge =	1232.251m
Abutment cap top level =	1232.250m
Abutment cap bottom lvl (uniform portion ends	1231.950m
Abutment cap bottom lvl (corbel portion ends)	1231.950m
Abutment shaft top level =	1231.950m
Ground level/LBL =	1226.660m
Abutment shaft bottom level =	1224.860m
Foundation level =	1223.660m
HFL	1227.660m

Cross Slope (Bi-directional)	=	2.500%
Height of Superstructure	=	0.800m
Min. Height of Footpath Side Pedestal (1)	=	0.000m
Height of Pedestal (2)	=	0.000m
Height of Pedestal (3)	=	0.000m
Height of Pedestal (4)	=	0.000m
Distance of nearest girder to c.l. of deck	=	0.000m
Height (Avg.) of Dirt Wall	=	1.009m
Abutment shaft Above G.L	=	5.290m
Abutment Shaft below G.L	=	1.800m
Height of abutment shaft	=	7.090m
MSL	=	1226.660m
Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 d (0.67/1.5 * fck)
Tensile strength of concrete , fctm	=	2.77 MPa
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02
Ultimate Strain, ϵ_{cu2}	=	0.035
Ecm	=	32308.250 N/mm ²
Steel Grade	=	Fe 500D (HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa (1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa

Dry weight of Concrete	=	25	kN/m ³
Dry unit weight of soil	=	20	kN/m ³
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z = Zone factor	=	0	
I = Importance factor	=	1.2	
R = Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
φ	=	30
θ	=	90

β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.160m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.80	x	10.00	x	12.50	x	25.00
	=	2500.00	KN					
Reaction at one end	=	1250.00	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	10.00
	=	160.00	KN			
Reaction at one end	=	80.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	10	x	12.5
	=	275	KN			
Reaction at one end	=	137.5	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A**

Congestion factor =

1 (As per Table 3 of IRC :112-2014)**Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transvers e ecc
2561.34	0.30

Min CWLL

Vertical	Transvers e ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

VOLUME CALCULATION

C.G. Of Footing	=	4.600 m
C.G. Of shaft from toe tip	=	3.600 m
Distance between c.g. of shaft and footing	=	1.000 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m^3	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.790	-3.810	0.000
-Trapering portion	1	12.50	0.300	0.409	1.532	-0.210	0.790	-3.810	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.490	-4.110	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-0.460	0.540	-4.060	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	1.000	-3.600	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	1.000	-3.600	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.865	4.290	46.397	0.163	1.163	-3.437	0.000
Shaft below HFL	1	12.50	1.105	2.300	31.775	0.046	1.046	-3.554	0.000
Solid Return Wall	2	5.00	0.500	8.891	44.455	-3.100	-2.100	-6.700	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.400	-4.200	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.400	-4.200	0.000
Footing									
Heel Slab	1	12.50	5.000	0.850	53.125		-1.757	-6.357	0.000
Toe Slab	1	12.50	3.000	0.850	31.875		2.894	-1.706	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		1.000	-3.600	0.000
Back filling above HFL over Heel Slab	1	12.50	5.000	5.456	341.000		-2.100	-6.700	0.000
Back filling below HFL over Heel Slab	1	12.50	5.000	3.150	196.875		-2.193	-6.793	0.000
Backfill above Heel slab	1	12.50	5.000	8.748	546.781		-2.133	-6.733	0.000
Front Filling over Toe Slab	1	12.50	3.000	2.150	80.625		3.019	-1.581	0.000
Side filling between heel and toe	1	0.00	1.200	2.150	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.490	-4.110	0.000

Back fill above HFL on flared portion of stem	1	12.50	0.290	5.456	19.808		0.578	-4.022	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.190	3.150	7.464		0.463	-4.137	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barri	2	8 kN/m	1.750	28.00kN		-0.210	0.790	-3.810

SECTIONAL PROPERTIES

Width of Footing (B) = 9.2 m

Length of Footing (L) = 12.500 m

A = 9.200 x 12.500 = 115.000 m²

ZL = 12.500 x 14.107 = 176.333 m³

ZT = $\frac{IT1 + IT2}{\text{distance of extreme point from centre}}$

IT1 = 9.200 x 162.760 = 1497.40 m⁴

IT2 (moment of inertia of triangle) = 9.200 x 0.000 + 0.500 x 9.200 x 0.000 x 39.063
from centre of footing = 0.000 m⁴

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1497.40 m⁴

Distance of extreme point from centre of footing = 6.250 + 0.000 = 6.250 m

Total Section modulus (ZT) = 239.583 m³

Load Factors (As per IRC:6-2014)

Table 3.1 Partial Safety Factor For Verification of Equilibrium

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination

Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Servicibility Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75

Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case
	Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
	Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case
	Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
	Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case
	Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case
	Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case
	Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case
	Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone	5.0

Feq	=	Seismic forces to be resisted
Feq	=	Ah x (Dead load + Appropriate Live load)
Ah	=	horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \quad \frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 8.590 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 9.167 m

Abutment Cap Top Level - Foundation Level
= 8.590 m

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.96	m
Moment of Inertia , $I_{\text{longitudinal}}$	=	0.922	m^4
Moment of Inertia , $I_{\text{transverse}}$	=	156.250	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction

Force	=	70.464	KN
D	=	1467.50	KN
T	=	0.2886	sec

Transverse Direction

Force	=	10852.528	KN
D	=	1747.220	KN
T	=	0.0254	sec

Hard or Rocky Strata

Sa/g = 2.5

Sa/g = 2.5

Seismic Coeff. In Longitudinal Direction = 0

Seismic Coeff. In Transverse Direction = 0

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

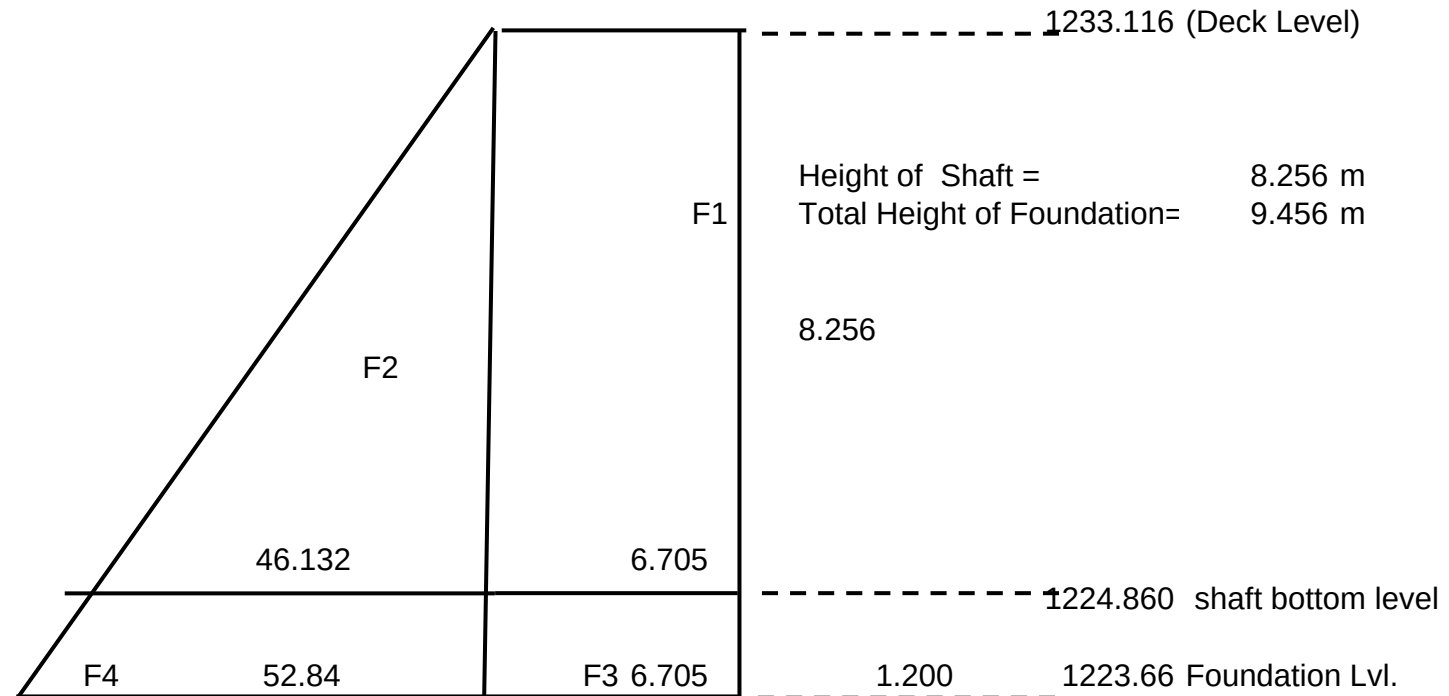
(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL					1224.860 m (at Shaft Base)			
@ RL					1223.660 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m^2
F1	=	6.705	x	8.256	x	12.500	=	691.977 kN
M1	=	691.98	x	4.13	=	2856.483 kN.m	at Shaft Bottom	
F3	=	6.705	x	9.456	x	12.500	=	792.556 kN
M3	=	792.556	x	4.728	=	3747.202 kN.m	at Foundation	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
	=	0.279	x	20	x	8.256	= 46.132 kN/m ²
F2	=	0.5	x	46.13	x	8.256	x 12.50
	=	2380.402 kN					

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2	=	2380.40	x	3.47	=	8254.092 kN.m	at Shaft Bottom

Intensity for triangular portion (At Foundation level)							
	=	0.279	x	20	x	9.456	= 52.837 kN/m ²
F4	=	0.5	x	52.84	x	9.456	x 12.50
	=	3122.669 kN					
M4	=	3122.67	x	3.97	=	12401.741 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)

$$= 4.800 \times 8.256 = 39.629 \text{ kN/m}^2$$

$$F = 0.5 \times 39.629 \times 8.256 \times 12.500 = 2044.846 \text{ kN}$$

$$M = 2044.85 \times 2.752 = 5627.416 \text{ kN.m at Shaft Bottom}$$

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 9.456 = 45.39 \text{ kN/m}^2$$

$$F = 0.5 \times 45.389 \times 9.46 \times 12.500 = 2682.478 \text{ kN}$$

$$M = 2682.48 \times 3.152 = 8455.171 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

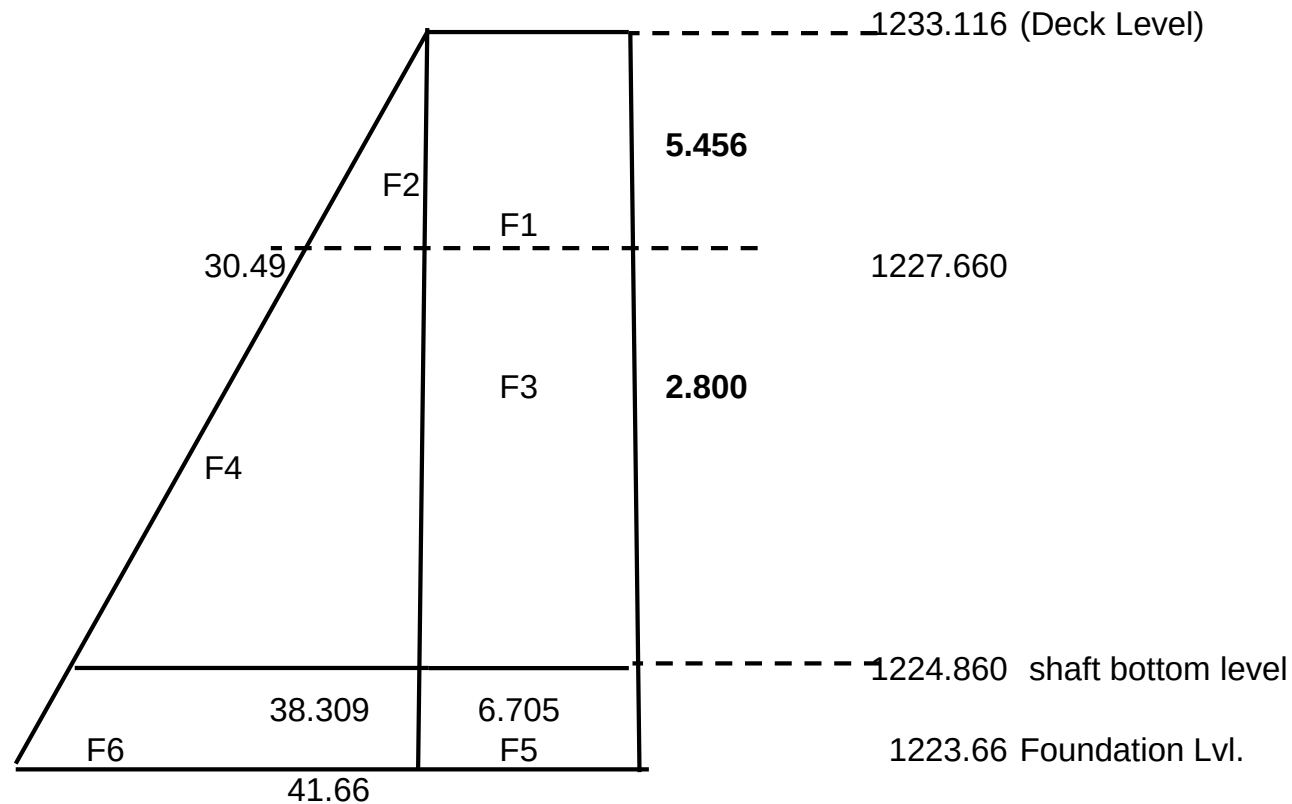
Summary of Moment and Horizontal Force

MOMENTS		HORIZONTAL FORCE		
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl

	kN-m	kN-m	kN	kN
Due to active Earth Pressure	8254.092	12401.741	2380.402	3122.669
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	8254.092	12401.741	2380.402	3122.669
Due to Live Load Surcharge	2856.483	3747.202	691.977	792.556
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				



Earth Pressure Diagram**Horizontal Forces and Moments @ RL****1224.9 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	8.256	x	12.500	=	691.977 kN
M1	=	691.98	x	4.13	=	2856.483 kN.m		at Shaft Bottom
F3	=	6.705	x	9.456	x	12.500	=	792.556 kN
M3	=	792.56	x	4.73	=	3747.202 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	5.456	=	30.486 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	2.800	=	7.823 kN/m ²
F2	=	0.5	x	30.49	x	5.456	x	12.50
	=	1039.584 kN						
F4	=	$\frac{(30.49 + 38.31)}{2}$				x	2.80	x 12.50
	=	1203.920 kN						

Total Force = 2243.504 kN

M2 = 1039.58 x 5.09 = 5293.064 kN.m

M4 = 1203.92 x 1.35 = 1621.602 kN.m

Total Mome = 6914.67 kN.m at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 5.456 = 30.486 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 30.49 \times 5.456 \times 12.50 = 1039.584 \text{ kN}$$

$$F6 = \frac{(30.49 + 41.66)}{2} \times 4.00 \times 12.50 = 1803.701 \text{ kN}$$

$$\text{Total Force} = 2843.285 \text{ kN}$$

$$M2 = 1039.58 \times 6.29 = 6540.565 \text{ kN.m}$$

$$M6 = 1803.70 \times 1.90 = 3421.146 \text{ kN.m}$$

$$\text{Total Mome} = 9961.71 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	6914.666	9961.711	2243.504	2843.285
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	6914.666	9961.711	2243.504	2843.285
Due to Live Load Surcharge	2856.483	3747.202	691.977	792.556
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone =	5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000	
αv	=	0.000	
ϕ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

λ	=	$\tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)}$	=	0.000
				0.000

C_a	=	$\frac{1}{0.279}$	$\frac{2}{0.279}$

Ca	=	0.279

Ka	=	0.279

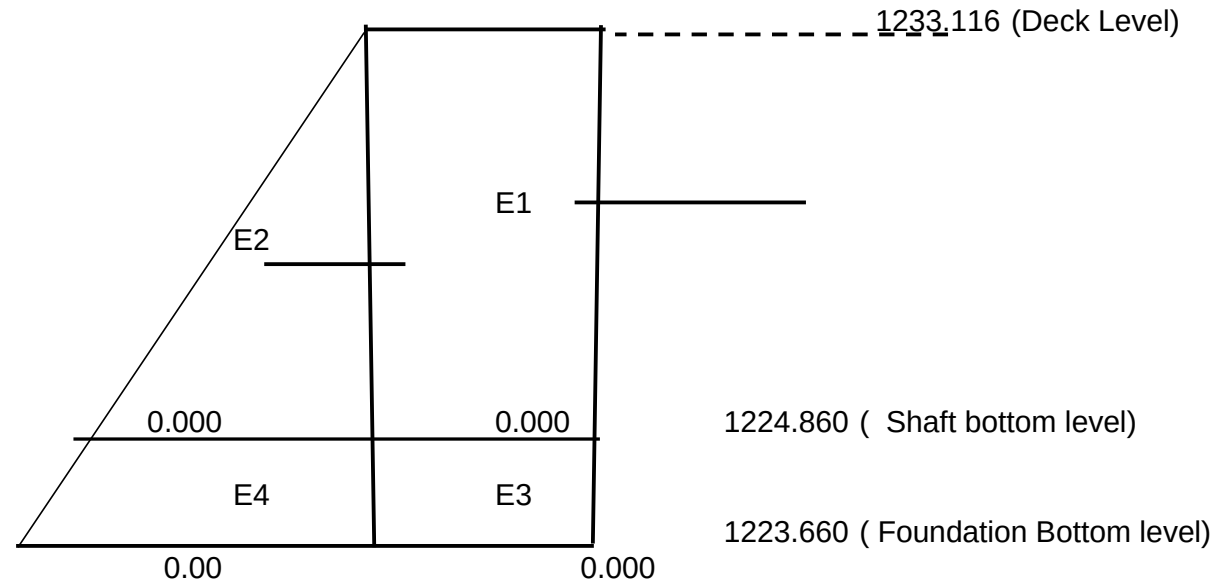
Dynamic Increment	=	0.279	-0.279	0.000

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m

Assuming γ_{dry}	=	20 kN/m ³

$$\gamma_{\text{water}} = 10.00 \text{ kN/m}^3$$



Earth Pressure Diagram for Dynamic Increment

Horizontal Forces and Moments @ RL

1224.9 m (at Shaft Base)

1223.7 m (at Foundation Bottom Level)

Due to Dynamic Live Load Surcharge

	=	0.000	x	20	x	1.2	=	0.000 kN/m ²
<u>at Shaft Bottom Level</u>								
E1	=	0.000	x	8.256	x	12.500	=	0.000 kN
M1	=	0.000	x	5.532			=	0.000 kN.m
<u>at Foundation Bottom Level</u>								
E3	=	0.000	x	9.456	x	12.500	=	0.000 kN
M3	=	0.000	x	6.336			=	0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 8.256 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 9.456 = 0.000 \text{ kN/m}^2$$

$$\begin{aligned} E2 &= 0.50 \times 0.00 \times 8.26 \times 12.500 \\ &= 0.000 \text{ kN} \end{aligned}$$

$$\begin{aligned} E4 &= 0.50 \times 0.00 \times 9.46 \times 12.500 \\ &= 0.000 \text{ kN} \end{aligned}$$

$$M2 = 0.00 \times 4.13 = 0.000 \text{ kN.m} \quad (\text{ Shaft bottom level})$$

$$M4 = 0.00 \times 4.73 = 0.000 \text{ kN.m} \quad (\text{ Foundation Bottom level})$$

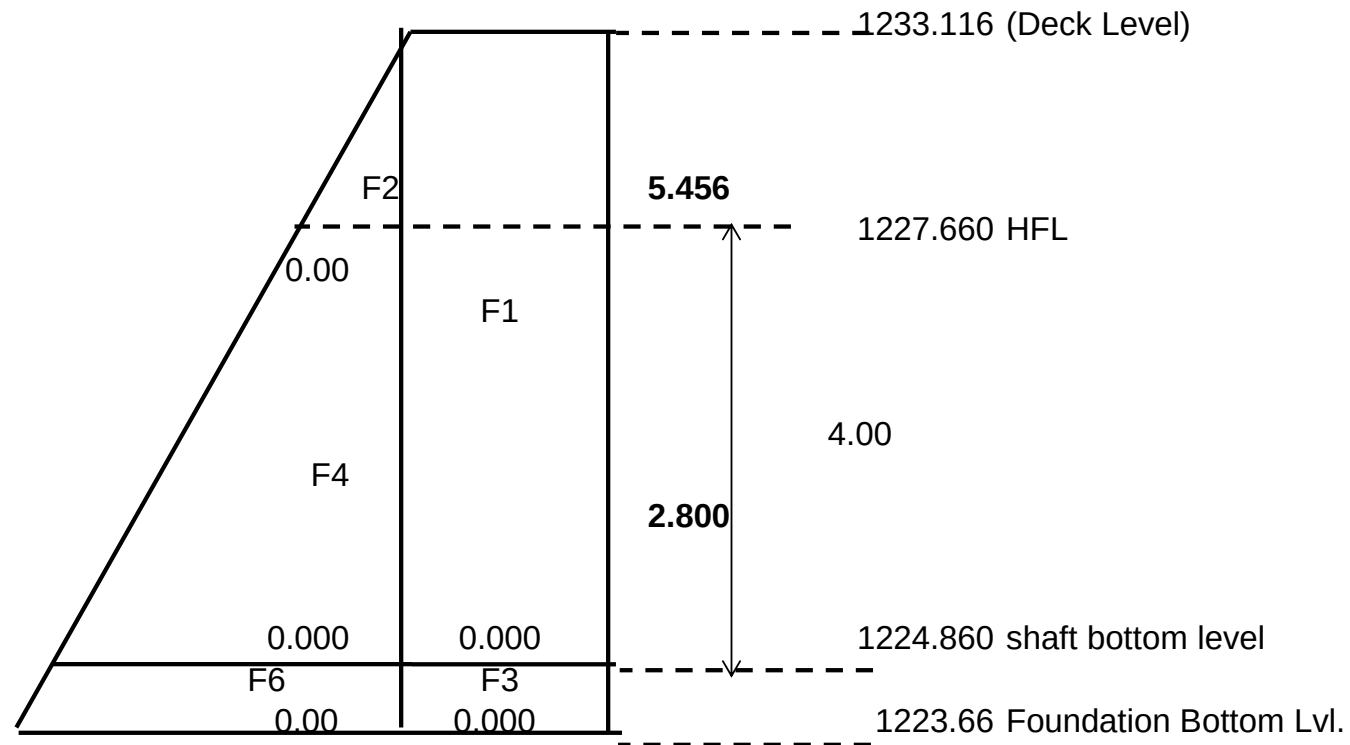
Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	8254.092	12401.741	2380.402	3122.669
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	8254.092	12401.741	2380.402	3122.669
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	8254.092	12401.741	2380.402	3122.669

Due to Live Load Surcharge (Static)	2856.483	3747.202	691.977	792.556
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		



Earth Pressure Diagram

Horizontal Forces and Moments @ RL

1224.860 m (at Shaft Base)

1223.660 m (at Foundation Bottom Level)

Due to Live Load Surcharge

Intensity for	=	0.000	x	20	x	1.200	=	0.000 kN/m ²

rectangular portion

at Shaft Bottom Level

$$F1 = 0.000 \times 8.256 \times 12.500 = 0.000 \text{ kN}$$

$$M1 = 0.00 \times 5.45 = 0.000 \text{ kN.m}$$

at Foundation Bottom Level

$$F3 = 0.000 \times 9.456 \times 12.500 = 0.000 \text{ kN}$$

$$M3 = 0.00 \times 6.24 = 0.000 \text{ kN.m}$$

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

$$\text{Upto HFL} = 0.000 \times 20 \times 5.456 = 0.000 \text{ kN/m}^2$$

$$\text{(At Shaft bottom level) Below HFL} = 0.000 \times 10 \times 2.800 = 0.000 \text{ kN/m}^2$$

$$\text{(At Foundati bottom level) Below HFL} = 0.000 \times 10 \times 4.000 = 0.000 \text{ kN/m}^2$$

$$F2 = 0.5 \times 0.00 \times 5.46 = 0.000 \text{ kN}$$

$$F4 = \frac{(0.00 + 0.00)}{2} \times 2.80 \times 12.50 = 0.000 \text{ kN}$$

$$F6 = \frac{(0.00 + 0.00)}{2} \times 4.00 \times 12.50 = 0.000 \text{ kN}$$

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

$$M2 = 0.00 \times 5.53 = 0.000 \text{ kN.m}$$

$$M4 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Shaft Bottom

$$M2 = 0.00 \times 6.73 = 0.000 \text{ kN.m}$$

$$M6 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	6914.666	9961.711	2243.504	2843.285
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	6914.666	9961.711	2243.504	2843.285
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	6914.666	9961.711	2243.504	2843.285
Due to Live Load Surcharge(Static)	2856.483	3747.202	691.977	792.556

Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax-Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A

Dry Case

Reaction case	2036.13	0	1018.063	1018.063	SV Loading	Dry Case
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2- CLASS A	HFL Case
	2036.13	0	1018.063	1018.063	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063

DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A

Dry Case

Wet Case

Reaction case	2036.13	0.000	1018.063	1018.063	SV Loading	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063		

Longitudinal Seismic Case: Seismic effect = **1.50**

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A

Dry Case

Wet Case

Reaction case	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A

Dry Case

HFL Case

Reaction case	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A
	1495.00	0.000	747.500	747.500	SV Loading

Dry Case

HFL Case

DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case

Design Speed	V	=	40.00	kmph
Live Load	W	=	932.33	kN
Radius of Curvature	R	=	100.00	m
CENTRIFUGAL FORCE	C	=	117.46	kN

Seismic Case

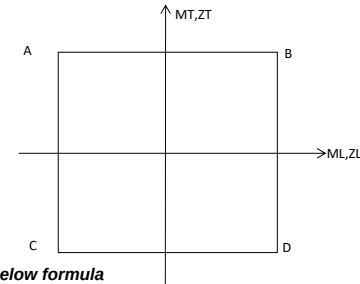
40.00	kmph
932.33	kN
100.00	m
117.46	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1223.660 m

Properties of Footing Base:

A	=	115.000	m ²
ZL	=	176.333	m ³
ZT	=	239.583	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	ML = ML Cos θ + MT Sin θ
Moment along transverse axis	MT = MT Cos θ - ML Sin θ

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	1.160	1450.000	0.000	0.000
SIDL except Wearing Course	1			80.000	1.160	92.800	0.000	0.000
Wearing Course	1			137.500	1.160	159.500	0.000	0.000
				1467.500		1702.300		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.790	44.438	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.790	30.255	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.490	13.781	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.540	7.594	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	1.000	67.500	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	1.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.400	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.400	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.790	22.120	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.490	80.391	0.000	0.000
				396.297		266.078		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	44.455	1111.375	-2.100	-2333.887	0.000	0.000
Abutment Shaft	1	25	78.172	1954.310	1.046	2044.278	0.000	0.000
Back filling over heel slab	1	20	546.781	10935.625	-2.133	-23329.396	0.000	0.000
Front Filling over toe slab	1	20	80.625	1612.500	3.019	4867.500	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	53.125	1328.125	-1.757	-2333.333	0.000	0.000
Toe slab	1	25	31.875	796.875	2.894	2306.250	0.000	0.000
portion between heel & toe	1	25	18.000	450.000	1.000	450.000	0.000	0.000
Vertical Components of active earth pressure	1			1136.558	-4.600	-5228.169	0.000	0.000
				19870.805		-23272.836		0.000
Total				21734.602		-21304.459		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-3.440	-4085.000
0.950	76.000	-3.440	-261.440
1.000	137.500	-3.440	-473.000
	1401.000		-4819.440
0.950	53.438	-3.810	-203.597
0.950	36.382	-3.810	-138.616
0.950	26.719	-4.110	-109.814
0.950	13.359	-4.060	-54.239
0.950	64.125	-3.600	-230.850
0.950	0.000	-3.600	0.000
0.950	0.000	-4.200	0.000
0.950	0.000	-4.200	0.000
0.950	26.600	-3.810	-101.346
0.950	155.859	-4.110	-640.582
	376.482		-1479.044
0.950	1055.806	-6.700	-7073.902
0.950	1856.594	-3.554	-6598.269
0.950	10388.844	-6.733	-69951.607
0.950	1531.875	-1.581	-2422.500
0.950	0.000	0.000	0.000
0.950	1261.719	-6.357	-8020.573
0.950	757.031	-1.706	-1291.406
0.950	427.500	-3.600	-1539.000
0.950	1079.731	-9.200	-9933.521
	18877.265		-108914.896
	20654.747		-115213.379

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	3122.669		12401.741

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
3122.67	12401.74	0.00	0.00

3856.419 18705.387 0.000 0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4684.003		18602.612
		5475.066		25398.630

Summary of Forces For SBC

P	21734.602	kN
ML	-2599.071	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		21734.602		-21304.459		0.000
CWLL-Max. Reaction case	1	932.327	1.160	1081.499	2.411	2248.220
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		22955.395		-21549.906		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	3122.669		12401.741
due to Live load surcharge	1	792.556		3747.202

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4684.003		18602.612
due to Live load surcharge	1.2	951.067		4496.643
		6426.132		29895.273

Summary of Forces For SBC

P	22955.395	kN
ML	902.684	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		21734.602		-21304.459		0.000
CWLL-Max. Reaction case	1	2561.336	1.160	2971.150	0.300	768.401
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		24584.405		-19660.255		768.401

Horizontal Forces For SBC Calculation

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4684.00	18602.61	0.00	0.00
5475.066	25398.630	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	20654.747		-115213.38
0.000		-3.440	0.00
0.950		-9.200	-2521.20
	20654.747		-117734.58

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
3122.67	12401.74	0.00	0.00
792.556	3747.202	0.000	0.000
4648.97	22452.59	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4684.00	18602.61	0.00	0.00
951.07	4496.64	0.00	0.00
6426.132	29895.273	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	20654.74689		-115213.379
0.000		-3.440	0.00
0.950		-9.200	-2521.20
	20654.747		-117734.58

Forces along Long. Axis		Forces along Trans. Axis	

Design Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	3122.669		12401.741
due to Live load surcharge	1	792.556		3747.202

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4684.003		18602.612
due to Live load surcharge	1.2	951.067		4496.643
		6426.132		29895.273

Summary of Forces For SBC		
P	24584.405	KN
ML	2792.334	kNm
MT	768.401	kNm

RODIC

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
3122.67	12401.74	0.00	0.00
792.556	3747.202	0.000	0.000
4648.97	22452.59	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4684.00	18602.61	0.00	0.00
951.07	4496.64	0.00	0.00
6426.132	29895.273	0.000	0.000

Stability of Foundation

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		1702.300		0.000
Substructure & Foundation -Portion 1				396.297		266.078		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	44.455	1111.375	-2.100	-2333.887	0.000	0.000
Shaft above HFL	1	25	46.397	1159.934	1.163	1349.384	0.000	0.000
Shaft below HFL	1	15	31.775	476.626	1.046	498.567	0.000	0.000
Back filling above HFL over heel slab	1	20	341.000	6820.000	-2.100	-14322.000	0.000	0.000
Back filling below HFL over heel slab	1	10	196.875	1968.750	-2.193	-4316.667	0.000	0.000
Front Filling over toe slab	1	10	80.625	806.250	3.019	2433.750	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	53.125	796.875	-1.757	-1400.000	0.000	0.000
Toe slab	1	15	31.875	478.125	2.894	1383.750	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	1.000	270.000	0.000	0.000
Vertical Components of active earth pressure	1			1034.871	-4.600	-4760.407	0.000	0.000
				15393.602		-20934.003		0.000
Total				17257.399		-18965.625		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-4819.440
	376.482		-1479.044
0.950	1055.806	-6.700	-7073.902
0.950	1101.937	-3.437	-3786.996
0.950	452.794	-3.554	-1609.214
0.950	6479.000	-6.700	-43409.300
0.950	1870.313	-6.793	-12704.271
0.950	765.938	-1.581	-1211.250
0.950	0.000	0.000	0.000
0.950	757.031	-6.357	-4812.344
0.950	454.219	-1.706	-774.844
0.950	256.500	-3.600	-923.400
0.950	983.128	-9.200	-9044.774
	14623.922		-87157.344
	16401.404		-93455.828

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	2843.285		9961.711

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
2843.29	9961.71	0.00	0.00
3577.04	16265.36	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4264.928		14942.567
		5055.990		21738.585

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4264.93	14942.57	0.00	0.00
5055.99	21738.58	0.00	0.00

Summary of Forces For SBC

P	17257.399	kN
ML	-2700.268	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		17257.399		-18965.625		0.000
CWLL-Min. Reaction case	1	466.273	1.160	540.877	3.109	1449.594
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		18012.139		-19751.695		1449.594

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16401.404		-93455.828
0.000	0.000	-3.440	0
0.950	274.043	-9.200	-2521.198
	16675.447		-95977.026

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	2843.285		9961.711
due to Live load surcharge	1	792.556		3747.202

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4264.928		14942.567
due to live load surcharge	1.2	951.067		4496.643
		6007.057		26235.227

Summary of Forces For SBC		
P	18012.139	KN
ML	260.865	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		17257.399		-18965.625		0.000
CWLL-Min. Reaction case	1	858.664	1.160	996.050	0.300	257.599
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		18404.529		-19296.522		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	2843.285		9961.711
due to Live load surcharge	1	792.556		3747.202

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
2843.29	9961.71	0.00	0.00
792.556	3747.202	0.000	0.000
4369.59	20012.56	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4264.93	14942.57	0.00	0.00
951.067	4496.643	0.000	0.000
6007.06	26235.23	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16401.404		-93455.828
0.000	0.000	-3.440	0.00
0.950	274.043	-9.200	-2521.198
	16675.447		-95977.026

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
2843.29	9961.71	0.00	0.00
792.556	3747.202	0.000	0.000
4369.59	20012.56	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4264.928		14942.567
due to live load surcharge	1.2	951.067		4496.643
		6007.057		26235.227

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4264.93	14942.57	0.00	0.00
951.067	4496.643	0.000	0.000
6007.06	26235.23	0.00	0.00

Summary of Forces For SBC

P	18404.529	kN
ML	716.038	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	α _h =	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.802 KN
		α _h =	0.000	In Transverse direction	Weight of back fill below Ground level	=	2250.000 KN
		α _v =	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = α _h x P (kN)	FT = 0.3 x α _h x P (kN)	Fv = 0.3 x α _v x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	1.160	1450.000	0.000	1232.784		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	1.160	92.800	0.000	1233.565		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	1.160	159.500	0.000	1233.116		0.000	0.000	0.000
				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.790	44.438	0.000	1232.816	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.000	0.000	0.000	0.790	30.255	0.000	1232.312	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.490	13.781						
Bracket - Tapered portion	1	25	0.563	14.063				0.540	7.594						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	1.000	67.500	0.000	1232.100	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1231.950	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1233.401	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1233.401	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.790	22.120				0.000	0.000	
Approach Slab	1	25	6.563	164.063				0.490	80.391				0.000	0.000	
				396.297	0.000	0.000	0.000		266.078	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	44.455	1111.375	0.000	0.000	0.000	-2.100	-2333.887	0.000	1228.742	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	78.172	1954.310	0.000	0.000	0.000	1.046	2044.278	0.000	1229.305	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	546.781	10935.625	0.000	0.000	0.000	-2.133	-23329.396	0.000	1228.742	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	80.625	1612.500				3.019	4867.500				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	53.125	1328.125				-1.757	-2333.333				0.000	0.000	
Toe slab	1	25	31.875	796.875				2.894	2306.250				0.000	0.000	
portion between heel & toe	1	25	18.000	450.000				1.000	450.000				0.000	0.000	
Vertical component of active earth pressure	1			1136.558				-4.600	-5228.169				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.600	0.000				0.000	0.000	
				19870.805	0.000	0.000	0.000		-23272.836	0.000		0.000		0.000	0.000
Total =				21734.602	0.000	0.000	0.000		-21304.459	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-3.440	-4085.000	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-3.440	-261.440	0.000
Wearing Course	1.00			137.500	0.000	-3.440	-473.000	0.000
				1401.000	0.000		-4819.440	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-3.810	-203.597	0.000
Dirt Wall-Tapered portion	0.95	25	1.532	36.382	0.000	-3.810	-138.616	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-3.600	-230.850	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-3.600	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-4.200	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-4.200	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-3.810	-101.346	
Approach Slab	0.95	25	6.563	155.859		-4.110	-640.582	
				376.482	0.000		-1314.990	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	78.172	1856.594	0.000	-3.554	-6598.269	0.000
Solid Return wall	0.95	25	44.455	1055.806	0.000	-6.700	-7073.902	0.000
Back filling over heel slab	0.95	20	546.781	10388.844	0.000	-6.733	-69951.607	0.000
Front Filling over Pile Cap	0.95	20	80.625	1531.875	0.000	-1.581	-2422.500	0.000
Side filling between heel and toe	0.95	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	0.95	25	53.125	1261.719		-6.357	-8020.573	
Toe slab	0.95	25	31.875	757.031		-1.706	-1291.406	
portion between heel & toe	0.95	25	18.000	427.500		-3.600	-1539.000	
Vertical component of active earth pressure	0.95			1079.731		-9.200	-9933.521	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-9.200	0.000	
				18877.265	0.000		-108914.90	0.000
Total =				20654.747	0.000		-115049.33	0.000

0.000

0.000

For Overturning or Sliding Effect

Load Factor	FL = αh x P (kN)	C.g. of Force (m)	MLs due to FL
1.0	0.000	1232.816	0.000
1.0	0.000	1232.312	0.000
1.0	0.000	1232.100	0.000
1.0	0.000	1231.950	0.000
1.0	0.000	1233.401	0.000
1.0	0.000	1233.401	0.000
	0.000		0.000
1.0	0.000	1229.305	0.000
1.0	0.000	1228.742	0.000
1.0	0.000	1228.742	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.02
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	4684.003		18602.61
due to dynamic Earth pressure	1.5	0.000		0.00
		5475.066		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21734.602	21734.602	kN
ML	-2599.071	-2599.071	kNm

Forces along Long. Axis

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
3856.42	18705.39	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Trans. Axis

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612	0.000	0.000
0.000	0.000	0.000	0.000
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

MT	0.000	0.000	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MT's due to FT
Forces from Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Forces from Substructure				20267.102	0.000	0.000	0.000		-23006.759	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	1.160	216.300	0.000	1234.316		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			57.69				-4.600	-265.389				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.600	0.000				0.000	0.000	
Total =				21978.761	0.000	0.000	0.000		-21353.548	0.000		0.000		449.644	0.000
					0.000			0.000							

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-4819.44	0.000
Forces from Substructure				19253.747	0.000	0.000	-110229.89	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.440	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-9.200	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.200	0.00	
Total =				20654.747	0.000		-115049.33	0.000
					0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	
due to Live load surcharge	0.20	158.511			749.440	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
158.51	749.44						
4014.93	19454.83	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	4684.003		18602.612
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		5475.066		25398.630

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5475.07	25398.63	0.00	0.00

Summary of Forces For SBC

Downward Upward

Summary of Restoring Forces

Vertical Load 20654.747 kN

Design Calculation

P	21978.761	21978.761	KN
ML	-1898.720	-1898.720	kNm

RODIC

Moment	-115049.326	kNm

Stability of Foundation

MT	449.644	449.644	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		266.078	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		44.45	1111.37	0.000	0.000	0.000	-2.10	-2333.887	0.000	1228.74	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	46.397	1159.934	0.000	0.000	0.000	1.163	1349.384	0.000	1229.805	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	31.775	476.626	0.000	0.000	0.000	1.046	498.567	0.000	1227.160	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	341.000	6820.000	0.000	0.000	0.000	-2.100	-14322.000	0.000	1230.388	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	196.875	1968.750	0.000	0.000	0.000	-2.193	-4316.667	0.000	1225.960	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	80.625	806.250				3.019	2433.750				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	53.125	796.875				-1.757	-1400.000				0.000	0.000	
Toe slab	1	15	31.875	478.125				2.894	1383.750				0.000	0.000	
portion between heel & toe	1	15	18.000	270.000				1.000	270.000				0.000	0.000	
Vertical component of active earth pressure	1			1034.871				-4.600	-4760.407				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.600	0.000				0.000	0.000	
				15393.602	0.000	0.000	0.000		-21197.510	0.000		0.000		0.000	0.000
Total =				17257.399	0.000	0.000	0.000		-19229.132	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Superstructure				1401.000	0.000		-4819.440	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1314.990	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	44.455	1055.806	0.000	-6.70	-7073.902	0.000
Shaft above HFL	0.95	25	46.397	1101.937	0.000	-3.437	-3786.996	0.000
Shaft below HFL	0.95	15	31.775	452.794	0.000	-3.554	-1609.214	0.000
Back filling above HFL over heel slab	0.95	20	341.000	6479.000	0.000	-6.700	-43409.300	0.000
Back filling below HFL over heel slab	0.95	10	196.875	1870.313	0.000	-6.793	-12704.271	0.000
Front Filling over Pile Cap	0.95	10	80.625	765.938		-1.581	-1211.250	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	53.125	757.031		-6.357	-4812.344	
Toe slab	0.95	15	31.875	454.219		-1.706	-774.844	
portion between heel & toe	0.95	15	18.000	256.500		-3.600	-923.400	
Vertical component of active earth pressure	0.95			983.128		-9.200	-9044.774	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-9.200	0.000	
				14623.922	0.000		-87157.344	0.000
Total =				16401.404	0.000		-93291.77	0.000

0.000

0.000

For Overturning or Sliding Effect

Load Factor	FL = $\alpha h \times P$ (kN)	C.g. of Force (m)	MLS due to FL
	0.000		0.000
1.0	0.000	1228.742	0.000
1.0	0.000	1229.805	0.000
1.0	0.000	1227.160	0.000
1.0	0.000	1230.388	0.000
1.0	0.000	1225.960	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2843.285			9961.711	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	4264.928		14942.567
due to dynamic Earth pressure	1.5	0.000		0.000
		5055.990		21738.585

Summary of Forces For SBC

	Downward	Upward	
P	17257.399	17257.399	kN
ML	-2963.775	-2963.775	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93291.774	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = $P \times eL1$	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = $P \times eT$	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Forces from Substructure				15789.899	0.000	0.000	0.000		-20931.432	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	1.160	108.175	0.000	1234.316		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			57.69				-4.600	-265.389				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.600	0.000				0.000	0.000	
Total =				17408.347	0.000	0.000	0.000		-19386.346	0.000		0.000		289.919	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = $P \times eL2$	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-4819.440	0.000
Forces from Substructure				15000.404	0.000		-88472.334	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.44	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.440	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.200	0.000	0.000
Total =				16401.404	0.000		-93295.21	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
3577.04	16265.36	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Design Calculation

RODIC

Stability of Foundation

due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2843.285			9961.711	
due to Live load surcharge	0.20	158.511			749.440	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	4264.928		14942.567
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		5055.990		21738.585

Summary of Forces For SBC

	Downward	Upward	
P	17408.347	17408.347	kN
ML	-2371.548	-2371.548	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93295.214	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		266.078	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				19870.805	0.000	0.000	0.000		-23272.836	0.000		0.000		0.000	0.000
Total =				21734.602	0.000	0.000	0.000		-21304.459	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-4819.44	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1314.99	0.000
Substructure & Foundation -Portion 2				18877.265	0.000		-108914.90	0.000
Total =				20654.747	0.000		-115049.33	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
158.51	749.44						
3735.55	17014.80	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
3856.42	18705.39	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	4684.003		18602.6117
due to dynamic Earth pressure	1.5	0.000		0
		5475.066		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21734.602	21734.602	kN
ML	-2599.071	-2599.071	kNm
MT	0.000	0.000	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Lloads	Vertical Load(P) kN.	$F_v = 0.3 \times a_v \times P$ (kN)	ML = $P \times e_{L1}$	MLs due to F_v	MT = $P \times e_T$
Total =	21978.761	0.000	-21353.55	0.000	449.644
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	
due to Live load surcharge	0.2	158.511			749.440	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1232.251	6796.018
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	4684.00		18602.612
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5475.07		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21978.761	21978.761	kN
ML	-1898.720	-1898.720	kNm
MT	449.644	449.644	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612		
0.000	0.000		
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

Vertical Forces For Restoring or Resisting Effect

Lloads	Vertical Load(P) kN.	$F_v = 0.3 \times a_v \times P$ (kN)	ML = $P \times e_{L2}$	MLs due to F_v
Total =	20654.747	0.000	-115049.33	0.000
		0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
158.51	749.44						
4014.93	19454.83	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Superstructure		1467.500	0.000	1702.300	0.000	0.000
Substructure & Foundation -Portion 1		396.297	0.000	266.078	0.000	0.000
Substructure & Foundation -Portion 2		15393.602	0.000	-21197.510	0.000	0.000
Total =		17257.399	0.000	-19229.132	0.000	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1232.25	6303.65	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	2843.29			9961.71	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.02
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	4264.928		14942.57
due to dynamic Earth pressure	1.5	0.000		0.00
		5055.990		21738.58

Summary of Forces For SBC

	Downward	Upward
P	17257.399	17257.399
ML	-2963.775	-2963.775
MT	0.000	0.000

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Total =	17408.347	0.000	-19386.35	0.000	289.919

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1232.251	6303.646	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	2843.285			9961.711	
due to Live load surcharge	0.2	158.511			749.440	

Vertical Forces For Restoring or Resisting Effect

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times e_{L2}$	MLs due to F_v
Superstructure		1401.000	0.000		-4819.440	0.000
Substructure & Foundation		376.482	0.000		-1314.990	0.000
Substructure & Foundation		14623.922	0.000		-87157.344	0.000
Total =		16401.404	0.000		-93291.774	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
3577.04	16265.36	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93291.774	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times e_{L2}$	MLs due to F_v
Total =	16401.404	0.000		-93295.21	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
158.51	749.44						
3735.55	17014.80	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1232.251	6796.02
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	4264.93		14942.57
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		5055.99		21738.58

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17408.347	17408.347	kN
ML	-2371.548	-2371.548	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93295.214	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	117.46	=	117.458 KN	Normal
Transverse Moment due to C.F.	=	117.458	x (	1234.601 -	=	1285.113 kNm	

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
117.46	1285.11	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	117.46	=	23.492 KN	Seismic
Transverse Moment due to C.F.	=	23.492	x (	1234.601 -	=	257.023 kNm	

23.49	257.02	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe+M_p}$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	21734.602	-2599.071	0.000	203.736	174.257	203.736	174.257	203.736	174.257	5475.066	14458.323	2.64	25398.630	115213.38	4.54
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	22955.395	2187.797	2248.220	196.589	221.403	177.821	202.635	221.403	177.821	6426.132	14458.323	2.25	29895.273	117734.58	3.94
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	24584.405	2792.334	768.401	201.149	232.820	194.735	226.406	232.820	194.735	6426.132	14458.323	2.25	29895.273	117734.58	3.94
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	17257.399	-2700.268	0.000	165.378	134.751	165.378	134.751	165.378	134.751	5055.990	11480.983	2.27	21738.585	93455.83	4.30

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	18012.139	1545.978	1449.594	153.910	171.445	141.809	159.344	171.445	141.809	6007.057	11672.813	1.94	26235.227	95977.03	3.66

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	18404.529	716.038	257.599	157.054	165.175	154.903	163.025	165.175	154.903	6007.057	11672.813	1.94	26235.227	95977.03	3.66
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	21734.602	-2599.071	0.000	203.736	174.257	203.736	174.257	203.736	174.257	5475.066	14458.323	2.64	25398.630	115049.33	4.53
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	21978.761	-1641.698	449.644	202.307	183.686	198.553	179.933	202.307	179.933	5475.066	14458.323	2.64	25398.630	115049.33	4.53
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	17257.399	-2963.775	0.000	166.872	133.257	166.872	133.257	166.872	133.257	5055.990	11480.983	2.27	21738.585	93291.77	4.29
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	17408.347	-2114.526	289.919	164.579	140.595	162.158	138.175	164.579	138.175	5055.990	11480.983	2.27	21738.585	93295.21	4.29
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	21734.602	-2599.071	0.000	203.736	174.257	203.736	174.257	203.736	174.257	5475.066	14458.323	2.64	25398.630	115049.33	4.53
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	21978.761	-1898.720	706.667	204.837	183.301	198.938	177.402	204.837	177.402	5475.066	14458.323	2.64	25398.630	115049.33	4.53
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	17257.399	-2963.775	0.000	166.872	133.257	166.872	133.257	166.872	133.257	5055.990	11480.983	2.27	21738.585	93291.77	4.29
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	17408.347	-2371.548	546.942	167.109	140.211	162.543	135.645	167.109	135.645	5055.990	11480.983	2.27	21738.585	93295.21	4.29
								SAFE	SAFE			SAFE			SAFE

DESIGN OF FOUNDATION

Foundation Lvl = 1223.660 m

Properties of Footing Base:

A	=	115.000	m ²
ZL	=	176.333	m ³
ZT	=	239.583	m ³

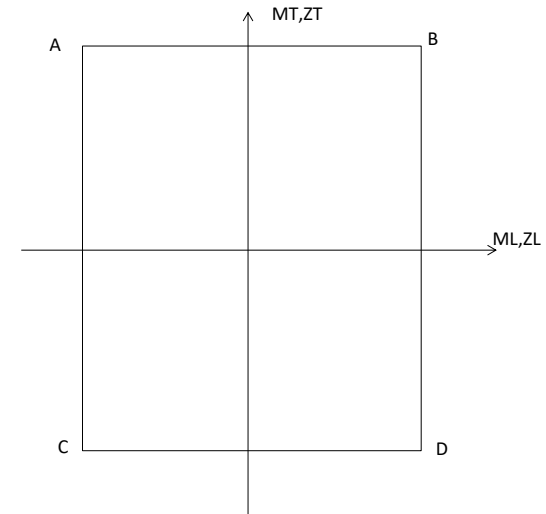
Case 1 : DL+SIDL-Normal Dry Case**Forces due to Vertical Load**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			1687.500	1.160	1957.500	0.000	0.000
SIDL except Wearing Course	1.35			108.000	1.160	125.280	0.000	0.000
Wearing Course	1.75			240.625	1.160	279.125	0.000	0.000
				2036.125		2361.905		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.35	25	2.250	75.938	0.790	59.991	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	1.532	51.701	0.790	40.844	0.000	0.000
Bracket - Uniform portion	1.35	25	1.125	37.969	0.490	18.605	0.000	0.000
Bracket - Tapered portion	1.35	25	0.563	18.984	0.540	10.252	0.000	0.000
Cap - (uniform portion)	1.35	25	2.700	91.125	1.000	91.125	0.000	0.000
Cap - (corbel portion)	1.35	25	0.000	0.000	1.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle p	1.35	25	0.000	0.000	0.400	0.000	0.000	0.000
Cantilever Return Wall-Traingle por	1.35	25	0.000	0.000	0.400	0.000	0.000	0.000
RCC Railing or Crash Barrier or	1.35			37.800	0.790	29.862	0.000	0.000
Crash Barrier	1.35	25	6.563	221.484	0.490	108.527	0.000	0.000
Approach Slab	1.35			535.001		359.205		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25	44.455	1500.356	-2.100	-3150.748	0.000	0.000
Abutment Shaft	1.35	25	78.172	2638.318	1.046	2759.776	0.000	0.000
Back filling over heel slab	1.35	20	546.781	14763.094	-2.133	-31494.684	0.000	0.000
Front Filling over toe slab	1.35	20	80.625	2176.875	3.019	6571.125	0.000	0.000
Side filling between heel and toe	1.35	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.35	25	53.125	1792.969	-1.757	-3150.000	0.000	0.000
Toe slab	1.35	25	31.875	1075.781	2.894	3113.438	0.000	0.000
portion between heel & toe	1.35	25	18.000	607.500	1.000	607.500	0.000	0.000
Vertical Components of active earth pressure	1.5			1704.838	-4.600	-7842.253	0.000	0.000
				26996.071		-32202.555		0.000
Total				29567.196		-29481.445		0.000

Forces due to Horizontal Load

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.063	1232.251	8746.175
due to Earth pressure	1.5	4684.003		18602.612

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.06	8746.17	0.00	0.00
4684.00	18602.61	0.00	0.00
5702.066	27348.787	0.000	0.000

**Summary of Forces About C.G. OF Footing**

P	29567.196	kN
ML	-2132.658	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Forces due to Vertical load**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		29567.196		-29481.445		0.000
CWLL-Max. Reaction case	1.5	1398.490	1.160	1622.248	2.411	3372.330
Vertical Components of LL Surcharge	1.2	346.160	-4.600	-1592.336	0.000	0.000
Total		31311.846		-29451.532		3372.330

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.063	1232.251	8746.175
due to Earth pressure	1.5	4684.003		18602.612
due to Live load surcharge	1.2	951.067		4496.643
		6653.132		31845.430

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.06	8746.17	0.00	0.00
4684.00	18602.61		
951.07	4496.64		
6653.132	31845.430	0.000	0.000

Summary of Forces About C.G. OF Footing

P	31311.846	kN
ML	2393.898	kNm
MT	3372.330	kNm

Case 3 : DL+SIDL-Normal HFL Case**Forces due to Vertical Load**

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2036.125		2361.905		0.000
Substructure & Foundation -Portion 1				535.001		359.205		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25	44.455	1500.356	-2.100	-3150.748	0.000	0.000
Shaft above HFL	1.35	25	46.397	1565.911	1.163	1821.668	0.000	0.000
Shaft below HFL	1.35	15	31.775	643.444	1.046	673.066	0.000	0.000
Back filling above HFL over heel slab	1.35	20	341.000	9207.000	-2.100	-19334.700	0.000	0.000
Back filling below HFL over heel slab	1.35	10	196.875	2657.813	-2.193	-5827.500	0.000	0.000
Front Filling over toe slab	1.35	10	80.625	1088.438	3.019	3285.563	0.000	0.000
Side filling between heel and toe	1.35	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.35	15	53.125	1075.781	-1.757	-1890.000	0.000	0.000
Toe slab	1.35	15	31.875	645.469	2.894	1868.063	0.000	0.000
Portion between Heel & Toe	1.35	15	18.000	364.500	1.000	364.500	0.000	0.000
Vertical Components of active earth pressure	1.5			1552.307	-4.600	-7140.611	0.000	0.000
				20936.593		-28974.965		0.000
Total				23507.719		-26253.855		0.000

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.063	1232.251	8746.175
due to Earth pressure	1.5	4264.928		14942.567

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.06	8746.17	0.00	0.00
4264.93	14942.57		
5282.990	23688.742	0.000	0.000

Summary of Forces About C.G. OF Footing

P	23507.719	KN
ML	-2565.114	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Forces due to Vertical load**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = Px eL1 (kNm)	Trans. Ecc (eT) (m)	MT = Px eT (kNm)
Forces from Case :DL+SIDL		23507.719		-26253.855		0.000
CWLL-Min. Reaction case	1.5	699.410	1.160	811.316	3.109	2174.391
Vertical Components of LL Surcharge	1.2	346.160	-4.600	-1592.336	0.000	0.000
Total		24553.289		-27034.875		2174.391

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1018.063	1232.251	8746.175
due to Earth pressure	1.5	4264.928		14942.567
due to Live load surcharge	1.2	951.067		4496.643

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1018.06	8746.17	0.00	0.00
4264.93	14942.57		
951.07	4496.64		
6234.057	28185.384	0.000	0.000

Summary of Forces About C.G. OF Footing

P	24553.289	KN
ML	1150.509	kNm
MT	2174.391	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50

α_h= 0.000 In Longitudinal direction
α_h= 0.000 In Transverse direction
α_v= 0.000 In Vertical direction

Weight of shaft below Ground level = 533.80 KN

Weight of back fill below Ground level = 2250.00 KN

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = α _h x P (kN)	FT = 0.3 x α _h x P (kN)	Fv = 0.3 x α _v x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1.35			1687.500		0.000	0.000	1.160	1957.500	0.000	1232.784		0.000	0.000	0.000
SIDL except Wearing Course	1.35			108.000		0.000	0.000	1.160	125.280	0.000	1233.565		0.000	0.000	0.000
Wearing Course	1.75			240.625		0.000	0.000	1.160	279.125	0.000	1233.116		0.000	0.000	0.000
				2036.125		0.000	0.000		2361.905	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1.35	25	2.250	75.938	0.000	0.000	0.000	0.790	59.991	0.000	1232.816	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	1.532	51.701	0.000	0.000	0.000	0.790	40.844	0.000	1232.312	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1.35	25	1.125	37.969				0.490	18.605						
Bracket - Tapered portion	1.35	25	0.563	18.984				0.540	10.252						
Cap - (uniform portion)	1.35	25	2.700	91.125	0.000	0.000	0.000	1.000	91.125	0.000	1232.100	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1.35	25	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1231.950	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle p	1.35	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1233.401	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle por	1.35	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1233.401	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1.35			37.800				0.790	29.862				0.000	0.000	
Approach Slab	1.35	25	6.563	221.484				0.490	108.527				0.000	0.000	
				535.001	0.000	0.000	0.000		359.205	0.000		0.000		0.000	0.000

Design Calculation

RODIC

FOUNDATION DESIGN

Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25	44.455	1500.356	0.000	0.000	0.000	-2.100	-3150.748	0.000	1228.742	0.000	0.000	0.000	0.000
Abutment Shaft	1.35	25	78.172	2638.318	0.000	0.000	0.000	1.046	2759.776	0.000	1229.305	0.000	0.000	0.000	0.000
Back filling over heel slab	1.35	20	546.781	14763.094	0.000	0.000	0.000	-2.133	-31494.684	0.000	1228.742	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1.35	20	80.625	2176.875				3.019	6571.125				0.000	0.000	
Side filling between heel and toe	1.35	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1.35	25	53.125	1792.969				-1.757	-3150.000				0.000	0.000	
Toe slab	1.35	25	31.875	1075.781				2.894	3113.438				0.000	0.000	
portion between heel & toe	1.35	25	18.000	607.500				1.000	607.500				0.000	0.000	
Vertical component of active earth pressure	1.00			1136.558				-4.600	-5228.169						
Vertical component of dynamic increment of earth pressure	1.50			0.000				-4.600	0.000						
				26427.791	0.000	0.000	0.000		-29588.470	0.000		0.000		0.000	0.000
Total =				28998.917	0.000	0.000	0.000		-26867.360	0.000		0.000		0.000	0.000
0.000								0.000							

Forces due to Horizontal Load

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1018.063	0.000	1232.251	8746.175	0.000
due to Substructure		0.000	0.000		0.000	0.000
due to Active Earth pressure	1.00	3122.669			12401.741	
due to dynamic increment of EP	1.50	0.000			0.000	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
0.00	0.00						
4140.73	21147.92	0.00	0.00	0.00	0.00	0.00	0.00

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	28998.917	28998.917	kN
ML	-5719.444	-5719.444	kNm
MT	0.000	0.000	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				2036.125		0.000	0.000		2361.905	0.000				0.000	0.000
Forces from Substructure				26962.792	0.000	0.000	0.000		-29229.265	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.75			699.25		0.000	0.000	1.160	811.124	0.000	1234.316		2.411	1686.165	0.000
Vertical component of LL Surcharge	0.20			57.693				-4.600	-265.389						
Vertical component of dynamic increment LL Surcharge	1.50			0.000				-4.600	0.000						
Total =				29755.856	0.000	0.000	0.000		-26321.625	0.000		0.000		1686.165	0.000
0.000								0.000							

Forces due to Horizontal Load

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1018.063	0.000	1232.251	8746.175	0.000
due to Substructure		0.000	0.000		0.000	0.000
due to Active Earth pressure	1	3122.669			12401.741	
due to dynamic increment of EP	1.50	0.000			0.000	
due to Live load surcharge	0.20	158.511			749.440	
due to dynamic increment of Surcharge	1.50	0.000			0.000	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
0.00	0.00						
158.51	749.44						
0.00	0.00						
4299.24	21897.36	0.00	0.00	0.00	0.00	0.00	0.00

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	29755.856	29755.856	kN
ML	-4424.269	-4424.269	kNm
MT	1686.165	1686.165	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Forces due to Vertical Load**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2036.125		0.000	0.000		2361.905	0.000				0.000	0.000
Substructure & Foundation -Portion 1				535.001	0.000	0.000	0.000		359.205	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25	44.455	1500.356	0.000	0.000	0.000	-2.100	-3150.748	0.000	1228.742	0.000	0.000	0.000	0.000
Shaft above HFL	1.35	25	46.397	1565.911	0.000	0.000	0.000	1.163	1821.668	0.000	1229.805	0.000	0.000	0.000	0.000
Shaft below HFL	1.35	15	31.7750353	643.444	0.000	0.000	0.000	1.046	673.066	0.000	1227.160	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1.35	20	341	9207.000	0.000	0.000	0.000	-2.100	-19334.700	0.000	1230.388	0.000	0.000	0.000	0.000
Back filling below HFL over heel slab	1.35	10	196.875	2657.813	0.000	0.000	0.000	-2.193	-5827.500	0.000	1225.960	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1.35	10	80.625	1088.438				3.019	3285.563				0.000	0.000	
Side filling between heel and toe	1.35	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1.35	15	53.125	1075.781				-1.757	-1890.000				0.000	0.000	
Toe slab	1.35	15	31.875	645.469				2.894	1868.063				0.000	0.000	
portion between heel & toe	1.35	15	18.000	364.500				1.000	364.500				0.000	0.000	
Vertical component of active earth pressure	1.00			1034.871				-4.600	-4760.407						
Vertical component of dynamic increment of earth pressure	1.50			0.000				-4.600	0.000						
				20419.158	0.000	0.000	0.000		-26594.762	0.000		0.000		0.000	0.000
Total =				22990.284	0.000	0.000	0.000		-23873.652	0.000		0.000		0.000	0.000

0.000

0.000

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1018.063	0.000	1232.251	8746.175	0.000
due to Substructure		0.000	0.000		0.000	0.000
due to Active Earth pressure	1.00	2843.285			9961.711	
due to dynamic increment of EP	1.50	0.000			0.000	

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	22990.284	22990.284	KN
ML	-5165.766	-5165.766	kNm
MT	0.000	0.000	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Forces due to Vertical Load**

Lloads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) (kN)	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2036.125		0.000	0.000		2361.905	0.000				0.000	0.000
Forces from Substructure				20954.159	0.000	0.000	0.000		-26235.557	0.000		0.000		0.000	0.000
CWLL-Min. Reaction case	0.75			349.70		0.000	0.000	1.160	405.658	0.000	1234.316		3.109	1087.196	0.000
Vertical component of LL Surcharge	0.20			57.693				-4.600	-265.389						
Vertical component of dynamic increment LL Surcharge	1.50			0.000				-4.600	0.000						
Total =				23397.682	0.000	0.000	0.000		-23733.383	0.000		0.000		1087.196	0.000

0.000

0.000

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1018.063	0.000	1232.251	8746.175	0.000
due to Substructure		0.000	0.000		0.000	0.000
due to Active Earth pressure	1	2843.285			9961.711	
due to dynamic increment of EP	1.50	0.000			0.000	
due to Live load surcharge	0.20	158.511			749.440	
due to dynamic increment of Surcharge	1.50	0.000			0.000	

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	23397.682	23397.682	KN
ML	-4276.057	-4276.057	kNm
MT	1087.196	1087.196	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
0.00	0.00						
158.51	749.44						
0.00	0.00						
4019.86	19457.33	0.00	0.00	0.00	0.00	0.00	0.00

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Forces due to Vertical Load**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2036.125		0.000	0.000		2361.905	0.000				0.000	0.000
Substructure & Foundation -Portion 1				535.001	0.000	0.000	0.000		359.205	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				26427.791	0.000	0.000	0.000		-29588.470	0.000		0.000		0.000	0.000
Total =				28998.917	0.000	0.000	0.000		-26867.360	0.000		0.000		0.000	0.000

0.000

0.000

Forces due to Horizontal Load

	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1018.063	0.000	1232.251	8746.175	0.000
due to Substructure	0.000	0.000		0.000	0.000
due to Active Earth pressure	3122.669			12401.741	
due to dynamic increment of EP	0.000			0.000	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
0.00	0.00						
4140.73	21147.92	0.00	0.00	0.00	0.00	0.00	0.00

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	28998.917	28998.917	kN
ML	-5719.444	-5719.444	kNm
MT	0.000	0.000	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Forces due to Vertical Load**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLS due to Fv	MT = PxeT
Total =				29755.856	0.000	-26321.625	0.000	1686.165

0.000

0.000

Forces due to Horizontal Load

	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1018.063	0.000	1232.251	8746.175	0
due to Substructure	0.000	0.000		0.000	0
due to Earth pressure	3122.669			12401.741	
due to dynamic increment of EP	0.000			0.000	
due to Live load surcharge	158.511			749.440	
due to dynamic increment of Surcharge	0.000			0.000	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
0.00	0.00						
158.51	749.44						
0.00	0.00						
4299.24	21897.36	0.00	0.00	0.00	0.00	0.00	0.00

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	29755.856	29755.856	kN
ML	-4424.269	-4424.269	kNm
MT	1686.165	1686.165	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Forces due to Vertical Load**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Superstructure				2036.125	0.000	2361.905	0.000	0.000
Substructure & Foundation -Portion 1				535.001	0.000	359.205	0.000	0.000
Substructure & Foundation -Portion 2				20419.158	0.000	-26594.762	0.000	0.000
Total =				22990.284	0.000	-23873.652	0.000	0.000

Forces due to Horizontal Load

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1018.063	0.000	1232.251	8746.175	0
due to Substructure		0.000	0.000		0.000	0.000
due to Active Earth pressure	1.00	2843.285			9961.711	
due to dynamic increment of EP	1.50	0.000			0.000	

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	22990.284	22990.284	kN
ML	-5165.766	-5165.766	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Forces due to Vertical Load**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Total =	23397.682	0.000	-23733.383	0.000	1087.196

Forces due to Horizontal Load

	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1018.063	0.000	1232.251	8746.175	0
due to Substructure	0.000	0.000		0.000	0
due to Earth pressure	2843.285			9961.711	
due to dynamic increment of EP	0.000			0.000	
due to Live load surcharge	158.511			749.440	
due to dynamic increment of Surcharge	0.000			0.000	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
0.00	0.00						
3861.35	18707.89	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
1018.06	8746.17	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
0.00	0.00						
158.51	749.44						
0.00	0.00						
4019.86	19457.33	0.00	0.00	0.00	0.00	0.00	0.00

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	23397.682	23397.682	kN
ML	-4276.057	-4276.057	kNm
MT	1087.196	1087.196	kNm

Centrifugal Force : Normal Case

$$\begin{aligned} \text{Centrifugal Force (C.F.)} &= 1.50 \times 117.46 = 176.188 \text{ KN} \\ \text{Transverse Moment due to C.F.} &= 176.188 \times (1234.601 - 1223.660) = 1927.670 \text{ kNm} \end{aligned}$$

Centrifugal Force : Seismic Case

$$\begin{aligned} \text{Centrifugal Force (C.F.)} &= 0.75 \times 117.46 = 88.094 \text{ KN} \\ \text{Transverse Moment due to C.F.} &= 88.094 \times (1234.601 - 1223.660) = 963.835 \text{ kNm} \end{aligned}$$

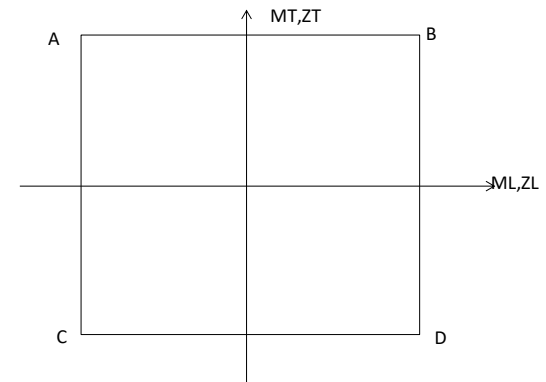
	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cos θ	MT Cos θ	FT Sin θ	MT Sin θ
Normal	176.19	1927.67	0.00	0.00

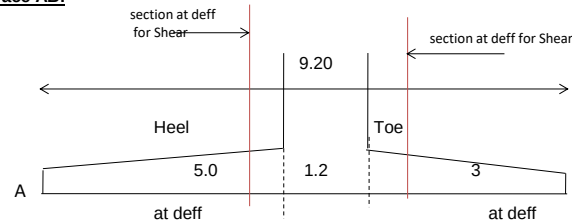
Seismic	88.09	963.83	0.00	0.00

$$\begin{aligned} \text{Base pressure on corner A} &= \sigma_A = P/A - ML/ZL + MT/ZT \\ \text{Base pressure on corner B} &= \sigma_B = P/A + ML/ZL + MT/ZT \\ \text{Base pressure on corner C} &= \sigma_C = P/A - ML/ZL - MT/ZT \\ \text{Base pressure on corner D} &= \sigma_D = P/A + ML/ZL - MT/ZT \end{aligned}$$

Summary of Design Base Pressure

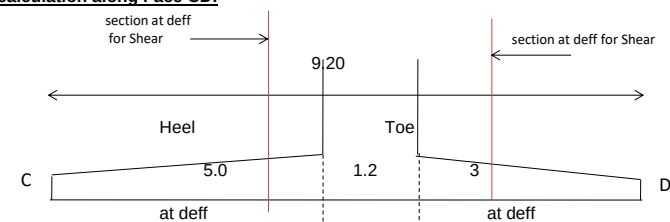
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²
Case 1 : DL+SIDL-Normal Dry Case	29567.196	-2132.658	0.000	269.201	245.012	269.201	245.012
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	31311.846	2393.898	5300.000	280.823	307.975	236.579	263.731
Normal HFLCase							
Case 3 : DL+SIDL-Normal HFL Case	23507.719	-2565.114	0.000	218.962	189.868	218.962	189.868
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	24553.289	1150.509	4102.061	224.104	237.153	189.861	202.910
Longitudinal Seismic Dry Case							
Case 5 : DL+SIDL-Long. Seismic Dry Case	28998.917	-5719.444	0.000	284.600	219.729	284.600	219.729
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	29755.856	-4424.269	2650.000	294.898	244.717	272.776	222.595
Longitudinal Seismic HFL Case							
Case 7 : DL+SIDL-Long. Seismic HFL Case	22990.284	-5165.766	0.000	229.211	170.620	229.211	170.620
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	23397.682	-4276.057	2051.031	236.269	187.769	219.147	170.647
Transverse Seismic Dry Case							
Case 9 : DL+SIDL-Trans. Seismic Dry Case	28998.917	-5719.444	0.000	284.600	219.729	284.600	219.729
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	29755.856	-4424.269	2650.000	294.898	244.717	272.776	222.595
Transverse Seismic HFL Case							
Case 11 : DL+SIDL-Trans. Seismic HFL Case	22990.284	-5165.766	0.000	229.211	170.620	229.211	170.620
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	23397.682	-4276.057	2051.031	236.269	187.769	219.147	170.647



Pressure calculation along Face AB:

	at deff		at deff			
Case : 1	269.201	258.986	256.05	252.899	249.968	245.012
Case : 2	280.823	292.288	295.58	299.121	302.411	307.975
Case : 3	218.962	206.676	203.15	199.355	195.829	189.868
Case : 4	224.104	229.614	231.20	232.898	234.479	237.153
Case : 5	284.600	257.206	249.34	240.883	233.021	219.729
Case : 6	294.898	273.707	267.63	261.080	254.999	244.717
Case : 7	229.211	204.469	197.37	189.726	182.625	170.620
Case : 8	236.269	215.788	209.91	203.584	197.706	187.769
Case : 9	284.600	257.206	249.34	240.883	233.021	219.729
Case : 10	294.898	273.707	267.63	261.080	254.999	244.717
Case : 11	229.211	204.469	197.37	189.726	182.625	170.620
Case : 12	236.269	215.788	209.91	203.584	197.706	187.769

Average MAX Base Pressure for Design of Heel Slab-along Face AB	=	288.201 kN/m ²
Average MIN Base Pressure for Design of Heel Slab-along Face AB	=	211.056 kN/m ²
Average MAX Base Pressure for Design of Toe Slab-along Face AB	=	303.548 kN/m ²
Max. Base Pressure at deff for Design of Toe Slab-along Face AB	=	302.411 kN/m ²
Max. Base Pressure at deff for Design of Heel Slab-along Face AB	=	292.288 kN/m ²

Pressure calculation along Face CD:

	at deff		at deff			
Case : 1	269.201	258.986	256.05	252.899	249.968	245.012
Case : 2	236.579	248.045	251.34	254.877	258.168	263.731
Case : 3	218.962	206.676	203.15	199.355	195.829	189.868
Case : 4	189.861	195.371	196.95	198.655	200.236	202.910
Case : 5	284.600	257.206	249.34	240.883	233.021	219.729
Case : 6	272.776	251.586	245.50	238.959	232.877	222.595
Case : 7	229.211	204.469	197.37	189.726	182.625	170.620
Case : 8	219.147	198.667	192.79	186.463	180.585	170.647
Case : 9	284.600	257.206	249.34	240.883	233.021	219.729
Case : 10	272.776	251.586	245.50	238.959	232.877	222.595
Case : 11	229.211	204.469	197.37	189.726	182.625	170.620
Case : 12	219.147	198.667	192.79	186.463	180.585	170.647

Average MAX Base Pressure for Design of Heel Slab-along Face CD	=	266.972 kN/m ²
Average MIN Base Pressure for Design of Heel Slab-along Face CD	=	193.407 kN/m ²
Average Base Pressure for Design of Toe Slab-along Face CD	=	259.304 kN/m ²
Max. Base Pressure at deff for Design of Toe Slab-along Face CD	=	258.168 kN/m ²
Max. Base Pressure at deff for Design of Heel Slab-along Face CD	=	258.986 kN/m ²

Calculation of Moment and Shear Force Along Traffic Direction:**Case 1 : Maximum Base Pressure Case (Dry Case)****Heel Slab - Maximum Moment Calculation**

Max Average Base Pressure for Design of Heel Slab	=	288.201 kN/m ²							
Upward moment due to Base pressure	=	3602.512 kNm/m							
		factor							
Downward moment due to backfill	=	1.35 x	546.781	/	12.500	x	20	x	2.500
	=	2952.619 kNm/m							
Downward moment due to self weight of Heel slab	=	1.35 x	53.125	/	12.500	x	25	x	2.157
	=	309.375 kNm/m							

Net Moment at face of shaft	=	3602.512	-2952.619	-309.375	=	340.518 kNm/m	Tension at Bottom of Heel Slab

Case 2 : Minimum Base Pressure Case (HFL Case)**Heel Slab - Maximum Moment Calculation**

Min Average Base Pressure for Design of Heel Slab	=	193.407 kN/m ²							
Upward moment due to Base pressure	=	2417.582 kNm/m							
		factor							
Downward moment due to backfill	=	1.35 x	546.781	/	12.500	x	10	x	2.500
	=	1476.309 kNm/m							
Downward moment due to self weight of Heel slab	=	1.35 x	53.125	/	12.500	x	15	x	2.157
	=	185.625 kNm/m							

Net Moment at face of shaft	=	2417.582	-1476.309	-185.625	=	755.648 kNm/m	Tension at Bottom of Heel Slab

Heel Slab - Shear Calculation at deff from face of Wall

Depth of slab at critical section	=	1.044 m							
effective depth at critical section	=	0.959 m							
Base pressure at deff from face of wall	=	292.288 kN/m ²							
Shear Force due to upward pressure at deff from face of wall	=	293.593 x	3.885 x	12.500	=	14257.617	KN		
		factor							
Downward Force due to backfill	=	1.35 x	546.781 x	20	=	14763.094	KN		
Downward Force due to self weight of Heel slab	=	1.35 x	53.125 x	25	=	1792.969	KN		
Net Shear Force	=	14257.617	-14763.094	-1792.969	=	-2298.445	KN		
Net Shear Force / unit meter	=	-2298.445	/	12.500	=	183.876	KN/m		

Toe Slab - Moment Calculation

Maximum Average Base Pressure for Design of Toe Slab	=	303.548 kN/m ²							
Upward moment due to Base pressure	=	1365.965 kNm/m							
Downward moment due to self weight of Toe slab	=	1.35 x	31.875	/	12.500	x	25	x	1.294
	=	111.3750	kNm/m						
Net Moment at face of shaft	=	1365.965	-111.375	=	1254.590 kNm/m		Tension at Bottom of Toe Slab		

Toe Slab - Shear Calculation at deff from Face of Wall

For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section	=	0.940 m							
effective depth at critical section	=	0.855 m							
Base pressure at deff from face of wall	=	302.411 kN/m ²							
upward shear force due to base pressure	=	305.193 x	1.885 x	12.500	=	7191.111	KN		
C.g. Of base pressure	=	0.847 m							
moment due to upward pressure at critical section	=	6087.490 kNm							
tanβ	=	0.233							
reduction in shear force (V _{odd})	=	$\frac{M \tan \beta}{d}$	=	1511.347	KN				
Downward force due to self weight of toe slab	=	1.35 x	0.720	x	1.885	x	12.500	x	25
	=	572.502	KN						
Net Shear Force at deff	=	7191.111	-	572.502	-	1511.347	=	5107.261	KN
Net Shear Force / unit meter	=	5107.261	/	12.500	=	408.581	KN/m		

Design Input :

Design length	=	1000 mm	
Clear Cover For Foundation	=	75 mm	
Grade of Concrete for Footing	=	M 35	
fck	=	35.00 N/mm ²	
fctm	=	2.77 N/mm ²	
Grade of Reinforcement Steel	=	Fe 500D	(HYSD Bars)
fy or fyk	=	500.00 N/mm ²	
fyd	=	434.78 N/mm ²	(fy/1.15)
Es	=	200000.00 N/mm ²	

Flexural Reinforcement Calculation:

		Along Traffic Direction	
		Heel Slab	Toe Slab
Ultimate bending moment, Mu (kNm/m)	=	755.65	1254.59
Effective depth required (dreq) (mm)	=	359.56	463.30
Effective depth provided (dpro) (mm)	=	1115.00	1115.00
Check for provided depth	=	SAFE	SAFE
R = Mu/(b d ²)	=	0.61	1.01

[illegible]

Check for Shear Reinforcement		OK, No shear reinf. Req.	OK, No shear reinf. Req.	
Balance Shear Force= $V_{Rd,s} = V_{Ed} - V_{Rd,c}$	=	0.000	0.000	KN/m
b	=	12.500	12.500	m
Total Shear Force	=	0.000	0.000	kN
$\theta = 0.5 \times \sin^{-1} [v_{Ed} / (0.18 f_{ck} (1- f_{ck}/250))]$	=	1.127	2.813	
$\cot \theta = (< 1 \cot \theta < 2.5)$	=	2.500	2.500	
$f_{ywd} = 0.8 \times f_y / 1.15$	=	347.826	347.826	N/mm ²
Provide Shear Reinforcement				
Legged	=	0	0	
Dia	=	0	0	mm
Area of Shear Reinf, Asw	=	0.000	0.000	mm ²
$z = 0.9 \times d$	=	863.010	769.350	mm
Spacing of shear Reinforcement required				
$S = Asw \times z \times f_{ywd} \times \cot \theta / V_{Rd}$	=	0.000	0.000	mm
As per Clause 10.3.3.5 of IRC:112-2011				
$Asw / (b S) = \rho_{w,min} = (0.072 f_{ck}^{0.5}) / f_{yk}$	=	0.001	0.001	
Spacing of shear Reinforcement required	=	0.000	0.000	mm
As per Clause 16.5.2 , eq. 16.6 of IRC:112-2011				
$S_{max} = 0.75 d$	=	719.175	641.125	mm
Governing Spacing of Shear Reinf.	=	0.000	0.000	mm
Provided Spacing of Shear Reinf.	=	200	150	mm

[illegible]

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A2 for Minor Bridge at Ch. 90+925**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 100 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.409m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	= 0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	= 0.720m	0.720m
Projection of Abutment Cap (Span Side)	= 0.000m	0.000m
Projection of Abutment Cap Back Side	= 0.000m	0.000m
Abutmentcap thickness (Uniform portion)	= 0.300m	
Abutmentcap thickness (Tapering Portion)	= 0.000m	
Length of Abutment Cap at top (Uniform portion)	= 12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	1.010m	1.010m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	5.000m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.000m
Thickness of Return wall at Bottom	=	0.000m

Foundation**Along Traffic Direction:**

Total Width of Footing	=	9.200m
abutment pedestal width	=	1.200m
abutment pedestal Height	=	1.200m
Width of Toe Slab	=	3.000m
Width of Heel Slab	=	5.000m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.200m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.200m
Width of backfill on heel slab	=	5.000m
Thickness of heel slab at back fill edge	=	1.200m
Height of back fill at bottom edge of heel slab	=	9.098m
Height of back fill at back fill edge of heel slab	=	8.398m

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)
Width of foundation -Tapering portion	=	12.500m (skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
	1 Minor Bridge	90+925	1233.116	1226.66	1223.66	9.456

Levels

Deck Level at Median Edge=	1233.116m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1233.401m	Height of Superstructure	=	0.800m
Deck level at center line =	1233.116m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1232.251m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1232.250m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lvl (uniform portion ends)	1231.950m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1231.950m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1231.950m	Height (Avg.) of Dirt Wall	=	1.009m
Ground level/LBL =	1226.660m	Abutment shaft Above G.L	=	5.290m
Abutment shaft bottom level =	1224.860m	Abutment Shaft below G.L	=	1.800m
Foundation level =	1223.660m	Height of abutment shaft	=	7.090m
HFL	1227.660m	MSL	=	1226.660m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²
<u>Creep Coefficient</u>			
For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days
<u>Clear Cover to Reinforcement</u>			
Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.160m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.80	x	10.00	x	12.50	x	25.00
	=	2500.00	KN					
Reaction at one end	=	1250.00	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	10.00
	=	160.00	KN			
Reaction at one end	=	80.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	10	x	12.5
	=	275	KN			
Reaction at one end	=	137.5	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transverse ecc
2561.34	0.30

Min CWLL

Vertical	Transverse ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

VOLUME CALCULATION

C.G. Of Footing	=	4.600 m
C.G. Of shaft from toe tip	=	3.600 m
Distance between c.g. of shaft and footing	=	1.000 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.790	-3.810	0.000
-Trapering portion	1	12.50	0.300	0.409	1.532	-0.210	0.790	-3.810	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.490	-4.110	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-0.460	0.540	-4.060	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	1.000	-3.600	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	1.000	-3.600	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.865	4.290	46.397	0.163	1.163	-3.437	0.000
Shaft below HFL	1	12.50	1.105	2.300	31.775	0.046	1.046	-3.554	0.000
Solid Return Wall	2	5.00	0.500	8.891	44.455	-3.100	-2.100	-6.700	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.400	-4.200	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.400	-4.200	0.000
Footing									
Heel Slab	1	12.50	5.000	0.850	53.125		-1.757	-6.357	0.000
Toe Slab	1	12.50	3.000	0.850	31.875		2.894	-1.706	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		1.000	-3.600	0.000
Back filling above HFL over Heel Slab	1	12.50	5.000	5.456	341.000		-2.100	-6.700	0.000
Back filling below HFL over Heel Slab	1	12.50	5.000	3.150	196.875		-2.193	-6.793	0.000
Backfill above Heel slab	1	12.50	5.000	8.748	546.781		-2.133	-6.733	0.000
Front Filling over Toe Slab	1	12.50	3.000	2.150	80.625		3.019	-1.581	0.000
Side filling between heel and toe	1	0.00	1.200	2.150	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.490	-4.110	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.290	5.456	19.808		0.578	-4.022	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.190	3.150	7.464		0.463	-4.137	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN	-0.210	0.790	-3.810

SECTIONAL PROPERTIES

Width of Footing (B)	=	9.2 m
Length of Footing (L)	=	12.500 m

A	=	9.200	x	12.500	=	115.000 m ²
ZL	=	12.500	x	14.107	=	176.333 m ³
ZT	=	IT1	+	IT2		

distance of extreme point from centre

IT1	=	9.200	x	162.760	=	1497.40 m ⁴
IT2 (moment of inertia of triangle)	=	9.200	x	0.000	+	0.500 x 9.200 x 0.000 x 39.063
from centre of footing	=	0.000	m ⁴			

Moment of inertia of two triangle	=	0.000 m ⁴

Total moment of inertia	=	1497.40 m ⁴

Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250 m

Total Section modulus (ZT)	=	239.583 m ³

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviceability Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation**(As Per IRC:6-2014 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 8.590 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 9.167 m

Abutment Cap Top Level - Foundation Level
= 8.590 m

Dimensions of Abutment Shaft

Length = 12.50 m
Width = 0.96 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 0.922 m^4
Moment of Inertia , $I_{\text{transverse}}$ = 156.250 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 70.464 KN
D = 1467.50 KN
T = 0.2886 sec

Transverse Direction

Force = 10852.528 KN
D = 1747.220 KN
T = 0.0254 sec

Hard or Rocky Strata

Sa/g = 2.5 Sa/g = 2.5

Seismic Coeff. In Longitudinal Direction = 0

Seismic Coeff. In Transverse Direction = 0

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

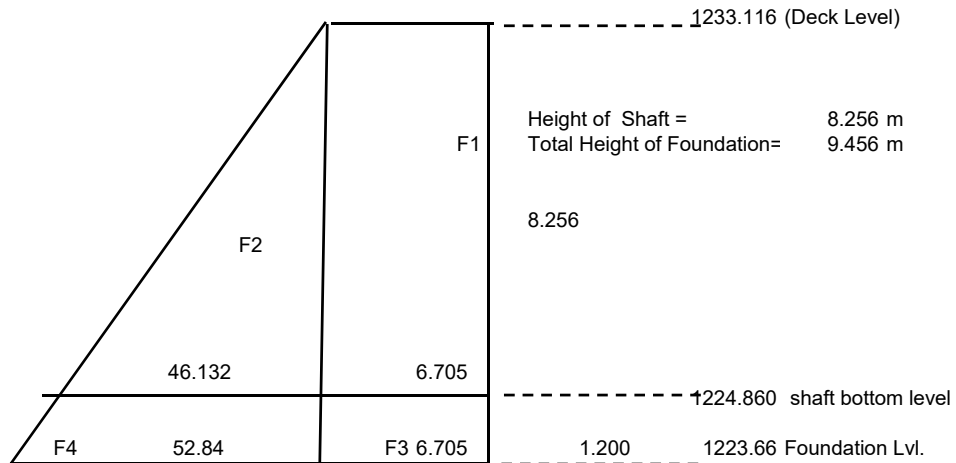
(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1224.860 m (at Shaft Base)			
@ RL					1223.660 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m^2
F1	=	6.705	x	8.256	x	12.500	=	691.977 kN
M1	=	691.98	x	4.13	=	2856.483 kN.m	at Shaft Bottom	
F3	=	6.705	x	9.456	x	12.500	=	792.556 kN
M3	=	792.556	x	4.728	=	3747.202 kN.m	at Foundation	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
=	0.279	x	20	x	8.256	=	46.132 kN/m ²
F2	=	0.5	x	46.13	x	8.256	x 12.50
	=	2380.402 kN					
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)							
M2	=	2380.40	x	3.47	=	8254.092 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
=	0.279	x	20	x	9.456	=	52.837 kN/m ²
F4	=	0.5	x	52.84	x	9.456	x 12.50
	=	3122.669 kN					
M4	=	3122.67	x	3.97	=	12401.741 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014		γ fluid	=	4.8 kN/m ³		
Intensity for triangular portion (At Shaft bottom level)						
=	4.800	x	8.256	=	39.629 kN/m^2	
F	=	0.5	x	39.629	x	8.256 x 12.500
	=	2044.846 kN				

Design Calculation

RODIC

Earth_Normal Dry

$$M = 2044.85 \times 2.752 = 5627.416 \text{ kN.m at Shaft Bottom}$$

$$\text{Intensity for triangular portion (At Foundation level)} = 4.800 \times 9.456 = 45.39 \text{ kN/m}^2$$

$$F = 0.5 \times 45.389 \times 9.46 \times 12.500 = 2682.478 \text{ kN}$$

$$M = 2682.48 \times 3.152 = 8455.171 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$\begin{aligned} &= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2 \\ \text{Force due to passive @ Foundation, F} &= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN} \end{aligned}$$

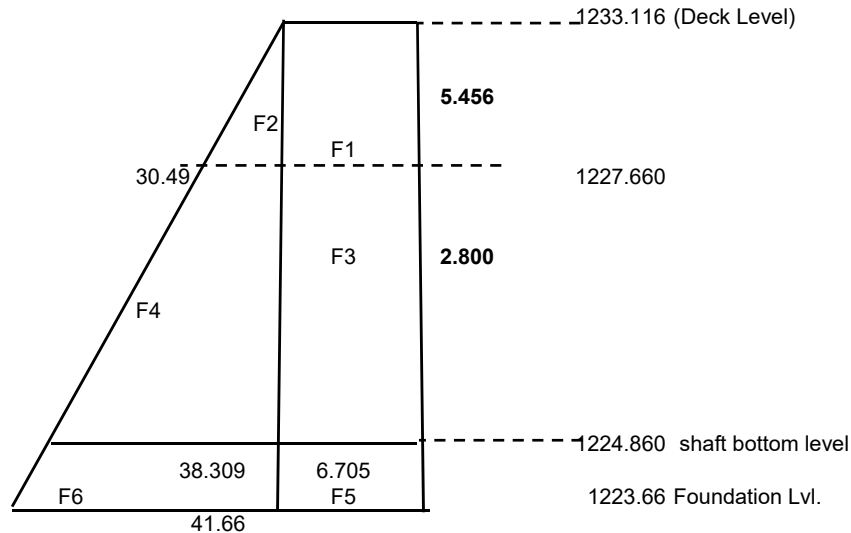
$$\text{Moment due to passive @ Foundation, M} = 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	8254.092	12401.741	2380.402	3122.669
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	8254.092	12401.741	2380.402	3122.669
Due to Live Load Surcharge	2856.483	3747.202	691.977	792.556
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Horizontal Forces and Moments @ RL****1224.9 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	8.256	x	12.500	=	691.977 kN
M1	=	691.98	x	4.13	=	2856.483 kN.m		at Shaft Bottom
F3	=	6.705	x	9.456	x	12.500	=	792.556 kN
M3	=	792.56	x	4.73	=	3747.202 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	5.456	=	30.486 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	2.800	=	7.823 kN/m ²
F2	=	0.5	x	30.49	x	5.456	x	12.50
	=	1039.584 kN						
F4	=	$\left(\frac{30.49 + 38.31}{2} \right) \times$				2.80	x	12.50
	=	1203.920 kN						
Total Force =		2243.504 kN						
M2	=	1039.58	x	5.09	=	5293.064 kN.m		
M4	=	1203.92	x	1.35	=	1621.602 kN.m		
Total Mome =		6914.67 kN.m		at Shaft Bottom				

Intensity for

triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 5.456 = 30.486 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 30.49 \times 5.456 \times 12.50 = 1039.584 \text{ kN}$$

$$F6 = \frac{(30.49 + 41.66)}{2} \times 4.00 \times 12.50 = 1803.701 \text{ kN}$$

$$\text{Total Force} = 2843.285 \text{ kN}$$

$$M2 = 1039.58 \times 6.29 = 6540.565 \text{ kN.m}$$

$$M6 = 1803.70 \times 1.90 = 3421.146 \text{ kN.m}$$

$$\text{Total Mome} = 9961.71 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	6914.666	9961.711	2243.504	2843.285
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	6914.666	9961.711	2243.504	2843.285
Due to Live Load Surcharge	2856.483	3747.202	691.977	792.556
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry CaseAs per Clause 219.5.4 , IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000
αv	=	0.000
ϕ	=	30.00
δ	=	20.00
α	=	0.00
β	=	0.00

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

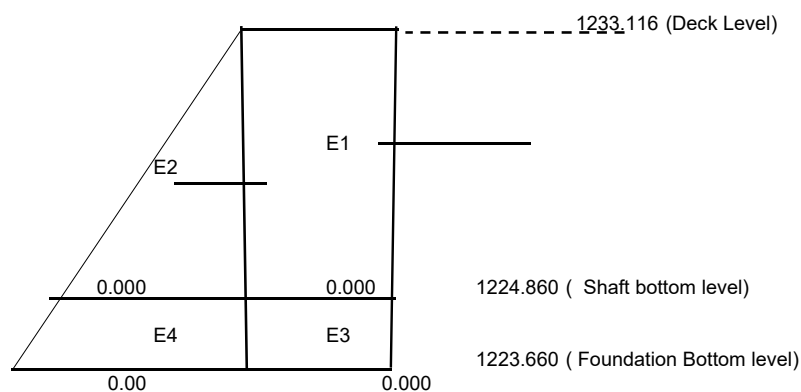
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \frac{0.000}{0.000}$$

$$C_a = \frac{1}{0.279} \frac{2}{0.279}$$

Ca	=	0.279		
Ka	=	0.279		
Dynamic Increment	=	0.279	-0.279	0.000

3 Earth Pressure :**DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

**Earth Pressure Diagram for Dynamic Increment****Horizontal Forces and Moments @ RL**

1224.9 m (at Shaft Base)

1223.7 m (at Foundation Bottom Level)

Due to Dynamic Live Load Surcharge

	=	0.000	x	20	x	1.2	=	0.000 kN/m ²
at Shaft Bottom Level								
E1	=	0.000	x	8.256	x	12.500	=	0.000 kN
M1	=	0.000	x	5.532			=	0.000 kN.m
at Foundation Bottom Level								
E3	=	0.000	x	9.456	x	12.500	=	0.000 kN
M3	=	0.000	x	6.336			=	0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 8.256 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 9.456 = 0.000 \text{ kN/m}^2$$

$$E2 = 0.50 \times 0.00 \times 8.26 \times 12.500$$

$$= 0.000 \text{ kN}$$

$$E4 = 0.50 \times 0.00 \times 9.46 \times 12.500$$

$$= 0.000 \text{ kN}$$

$$M2 = 0.00 \times 4.13 = 0.000 \text{ kN.m (Shaft bottom level)}$$

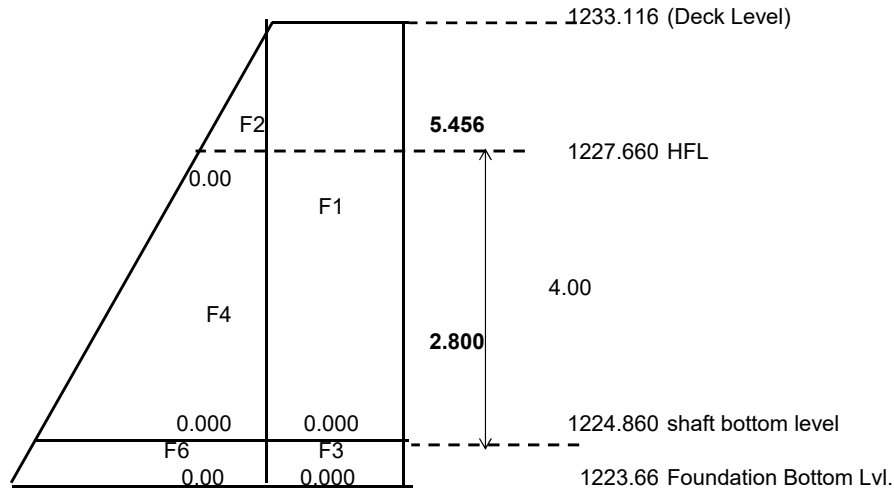
$$M4 = 0.00 \times 4.73 = 0.000 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	8254.092	12401.741	2380.402	3122.669
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	8254.092	12401.741	2380.402	3122.669
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	8254.092	12401.741	2380.402	3122.669
Due to Live Load Surcharge (Static)	2856.483	3747.202	691.977	792.556
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1224.860 m (at Shaft Base)****1223.660 m (at Foundation Bottom Level)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.000	x	20	x	1.200	=	0.000 kN/m ²

at Shaft Bottom Level

F1	=	0.000	x	8.256	x	12.500	=	0.000 kN
M1	=	0.00	x	5.45	=	0.000 kN.m		

at Foundation Bottom Level

F3	=	0.000	x	9.456	x	12.500	=	0.000 kN
M3	=	0.00	x	6.24	=	0.000 kN.m		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.000	x	20	x	5.456	=	0.000 kN/m ²

(At Shaft bottom level) Below HFL	=	0.000	x	10	x	2.800	=	0.000 kN/m ²

(At Foundation bottom level) Below HFL	=	0.000	x	10	x	4.000	=	0.000 kN/m ²

F2	=	0.5	x	0.00	x	5.46	x	12.50
	=	0.000 kN						

F4	=	(	0.00 +	0.00	)	x	2.80	x	12.50
	=			2					
	=	0.000 kN							

F6	=	(	0.00 +	0.00	)	x	4.00	x	12.50
	=			2					
	=	0.000 kN							

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

M2	=	0.00	x	5.53	=	0.000 kN.m

M4	=	0.00	x	0.00	=	0.000 kN.m

Total Mome = 0.000 kN.m at Shaft Bottom

M2 = 0.00 x 6.73 = 0.000 kN.m

M6 = 0.00 x 0.00 = 0.000 kN.m

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	6914.666	9961.711	2243.504	2843.285
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	6914.666	9961.711	2243.504	2843.285
Due to Minimum Fluid Pressure	5627.416	8455.171	2044.846	2682.478
Governing of Two	6914.666	9961.711	2243.504	2843.285
Due to Live Load Surcharge(Static)	2856.483	3747.202	691.977	792.556
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

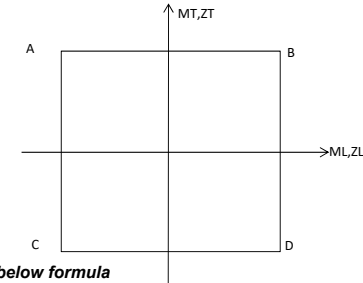
Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	932.33	kN	932.33	kN
Radius of Curvature	R	=	100.00	m	100.00	m
CENTRIFUGAL FORCE	C	=	117.46	kN	117.46	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1223.660 m

Properties of Footing Base:

A	=	115.000	m ²
ZL	=	176.333	m ³
ZT	=	239.583	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	1.160	1450.000	0.000	0.000
SIDL except Wearing Course	1			80.000	1.160	92.800	0.000	0.000
Wearing Course	1			137.500	1.160	159.500	0.000	0.000
				1467.500		1702.300		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.790	44.438	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.790	30.255	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.490	13.781	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.540	7.594	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	1.000	67.500	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	1.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.400	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.400	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.790	22.120	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.490	80.391	0.000	0.000
				396.297		266.078		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	44.455	1111.375	-2.100	-2333.887	0.000	0.000
Abutment Shaft	1	25	78.172	1954.310	1.046	2044.278	0.000	0.000
Back filling over heel slab	1	20	546.781	10935.625	-2.133	-23329.396	0.000	0.000
Front Filling over toe slab	1	20	80.625	1612.500	3.019	4867.500	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	53.125	1328.125	-1.757	-2333.333	0.000	0.000
Toe slab	1	25	31.875	796.875	2.894	2306.250	0.000	0.000
portion between heel & toe	1	25	18.000	450.000	1.000	450.000	0.000	0.000
Vertical Components of active earth pressure	1			1136.558	-4.600	-5228.169	0.000	0.000
				19870.805		-23272.836		0.000
Total				21734.602		-21304.459		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-3.440	-4085.000
0.950	76.000	-3.440	-261.440
1.000	137.500	-3.440	-473.000
	1401.000		-4819.440
0.950	53.438	-3.810	-203.597
0.950	36.382	-3.810	-138.616
0.950	26.719	-4.110	-109.814
0.950	13.359	-4.060	-54.239
0.950	64.125	-3.600	-230.850
0.950	0.000	-3.600	0.000
0.950	0.000	-4.200	0.000
0.950	0.000	-4.200	0.000
0.950	26.600	-3.810	-101.346
0.950	155.859	-4.110	-640.582
	376.482		-1479.044
0.950	1055.806	-6.700	-7073.902
0.950	1856.594	-3.554	-6598.269
0.950	10388.844	-6.733	-69951.607
0.950	1531.875	-1.581	-2422.500
0.950	0.000	0.000	0.000
0.950	1261.719	-6.357	-8020.573
0.950	757.031	-1.706	-1291.406
0.950	427.500	-3.600	-1539.000
0.950	1079.731	-9.200	-9933.521
	18877.265		-108914.896
	20654.747		-115213.379

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	3122.669		12401.741

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
3122.67	12401.74	0.00	0.00
3856.419	18705.387	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4684.003		18602.612
		5475.066		25398.630

Summary of Forces For SBC

P	21734.602	kN
ML	-2599.071	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Lloads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		21734.602		-21304.459		0.000
CWLL-Max. Reaction case	1	932.327	1.160	1081.499	2.411	2248.220
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		22955.395		-21549.906		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	3122.669		12401.741
due to Live load surcharge	1	792.556		3747.202

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4684.003		18602.612
due to Live load surcharge	1.2	951.067		4496.643
		6426.132		29895.273

Summary of Forces For SBC

P	22955.395	kN
ML	902.684	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Lloads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		21734.602		-21304.459		0.000
CWLL-Max. Reaction case	1	2561.336	1.160	2971.150	0.300	768.401
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		24584.405		-19660.255		768.401

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4684.00	18602.61	0.00	0.00
5475.066	25398.630	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	20654.747		-115213.38
0.000		-3.440	0.00
0.950		-9.200	-2521.20
	20654.747		-117734.58

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
3122.67	12401.74	0.00	0.00
792.556	3747.202	0.000	0.000
4648.97	22452.59	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4684.00	18602.61	0.00	0.00
951.07	4496.64	0.00	0.00
6426.132	29895.273	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	20654.74689		-115213.379
0.000		-3.440	0.00
0.950		-9.200	-2521.20
	20654.747		-117734.58

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	3122.669		12401.741
due to Live load surcharge	1	792.556		3747.202

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4684.003		18602.612
due to Live load surcharge	1.2	951.067		4496.643
		6426.132		29895.273

Summary of Forces For SBC		
P	24584.405	kN
ML	2792.334	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		1702.300		0.000
Substructure & Foundation -Portion 1				396.297		266.078		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	44.455	1111.375	-2.100	-2333.887	0.000	0.000
Shaft above HFL	1	25	46.397	1159.934	1.163	1349.384	0.000	0.000
Shaft below HFL	1	15	31.775	476.626	1.046	498.567	0.000	0.000
Back filling above HFL over heel slab	1	20	341.000	6820.000	-2.100	-14322.000	0.000	0.000
Back filling below HFL over heel slab	1	10	196.875	1968.750	-2.193	-4316.667	0.000	0.000
Front Filling over toe slab	1	10	80.625	806.250	3.019	2433.750	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	53.125	796.875	-1.757	-1400.000	0.000	0.000
Toe slab	1	15	31.875	478.125	2.894	1383.750	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	1.000	270.000	0.000	0.000
Vertical Components of active earth pressure	1			1034.871	-4.600	-4760.407	0.000	0.000
				15393.602		-20934.003		0.000
Total				17257.399		-18965.625		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-4819.440
	376.482		-1479.044
0.950	1055.806	-6.700	-7073.902
0.950	1101.937	-3.437	-3786.996
0.950	452.794	-3.554	-1609.214
0.950	6479.000	-6.700	-43409.300
0.950	1870.313	-6.793	-12704.271
0.950	765.938	-1.581	-1211.250
0.950	0.000	0.000	0.000
0.950	757.031	-6.357	-4812.344
0.950	454.219	-1.706	-774.844
0.950	256.500	-3.600	-923.400
0.950	983.128	-9.200	-9044.774
	14623.922		-87157.344
	16401.404		-93455.828

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	2843.285		9961.711

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4264.928		14942.567
		5055.990		21738.585

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
3122.67	12401.74	0.00	0.00
792.556	3747.202	0.000	0.000
4648.97	22452.59	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4684.00	18602.61	0.00	0.00
951.07	4496.64	0.00	0.00
6426.132	29895.273	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
2843.29	9961.71	0.00	0.00
3577.04	16265.36	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4264.93	14942.57	0.00	0.00
5055.99	21738.58	0.00	0.00

Summary of Forces For SBC		
P	17257.399	kN
ML	-2700.268	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		17257.399		-18965.625		0.000
CWLL-Min. Reaction case	1	466.273	1.160	540.877	3.109	1449.594
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		18012.139		-19751.695		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	2843.285		9961.711
due to Live load surcharge	1	792.556		3747.202

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4264.928		14942.567
due to live load surcharge	1.2	951.067		4496.643
		6007.057		26235.227

Summary of Forces For SBC		
P	18012.139	kN
ML	260.865	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		17257.399		-18965.625		0.000
CWLL-Min. Reaction case	1	858.664	1.160	996.050	0.300	257.599
Vertical Components of LL Surcharge	1	288.467	-4.600	-1326.946	0.000	0.000
Total		18404.529		-19296.522		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1232.251	6303.646
due to Earth pressure	1	2843.285		9961.711
due to Live load surcharge	1	792.556		3747.202

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16401.404		-93455.828
0.000	0.000	-3.440	0.00
0.950	274.043	-9.200	-2521.198
	16675.447		-95977.026

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
2843.29	9961.71	0.00	0.00
792.556	3747.202	0.000	0.000
4369.59	20012.56	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4264.93	14942.57	0.00	0.00
951.067	4496.643	0.000	0.000
6007.06	26235.23	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16401.404		-93455.828
0.000	0.000	-3.440	0.00
0.950	274.043	-9.200	-2521.198
	16675.447		-95977.026

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	6303.65	0.00	0.00
2843.29	9961.71	0.00	0.00
792.556	3747.202	0.000	0.000
4369.59	20012.56	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Earth pressure	1.5	4264.928		14942.567
due to live load surcharge	1.2	951.067		4496.643
		6007.057		26235.227

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
4264.93	14942.57	0.00	0.00
951.067	4496.643	0.000	0.000
6007.06	26235.23	0.00	0.00

Summary of Forces For SBC

P	18404.529	kN
ML	716.038	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.802 KN
		ah=	0.000	In Transverse direction	Weight of back fill below Ground level	=	2250.000 KN
		av=	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	1.160	1450.000	0.000	1232.784		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	1.160	92.800	0.000	1233.565		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	1.160	159.500	0.000	1233.116		0.000	0.000	0.000
				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.790	44.438	0.000	1232.816	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	1.532	38.297	0.000	0.000	0.000	0.790	30.255	0.000	1232.312	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.490	13.781						
Bracket - Tapered portion	1	25	0.563	14.063				0.540	7.594						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	1.000	67.500	0.000	1232.100	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1231.950	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1233.401	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1233.401	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.790	22.120				0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063				0.490	80.391				0.000	0.000	0.000
				396.297	0.000	0.000	0.000		266.078	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	44.455	1111.375	0.000	0.000	0.000	-2.100	-2333.887	0.000	1228.742	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	78.172	1954.310	0.000	0.000	0.000	1.046	2044.278	0.000	1229.305	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	546.781	10935.625	0.000	0.000	0.000	-2.133	-23329.396	0.000	1228.742	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	80.625	1612.500				3.019	4867.500				0.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	0.000
Heel slab	1	25	53.125	1328.125				-1.757	-2333.333				0.000	0.000	0.000
Toe slab	1	25	31.875	796.875				2.894	2306.250				0.000	0.000	0.000
portion between heel & toe	1	25	18.000	450.000				1.000	450.000				0.000	0.000	0.000
Vertical component of active earth pressure	1			1136.558				-4.600	-5228.169				0.000	0.000	0.000
Vertical component of dynamic increment of earth pressure	1			0.000				-4.600	0.000				0.000	0.000	0.000
				19870.805	0.000	0.000	0.000		-23272.836	0.000		0.000		0.000	0.000
Total =				21734.602	0.000	0.000	0.000		-21304.459	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-3.440	-4085.000	0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL

Design Calculation

RODIC

Stability of Foundation

SIDL except Wearing Course	0.95			76.000	0.000	-3.440	-261.440	0.000
Wearing Course	1.00			137.500	0.000	-3.440	-473.000	0.000
				1401.000	0.000		-4819.440	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-3.810	-203.597	0.000
Dirt Wall-Tapered portion	0.95	25	1.532	36.382	0.000	-3.810	-138.616	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-3.600	-230.850	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-3.600	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-4.200	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-4.200	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-3.810	-101.346	
Approach Slab	0.95	25	6.563	155.859		-4.110	-640.582	
				376.482	0.000		-1314.990	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	78.172	1856.594	0.000	-3.554	-6598.269	0.000
Solid Return wall	0.95	25	44.455	1055.806	0.000	-6.700	-7073.902	0.000
Back filling over heel slab	0.95	20	546.781	10388.844	0.000	-6.733	-69951.607	0.000
Front Filling over Pile Cap	0.95	20	80.625	1531.875		-1.581	-2422.500	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	53.125	1261.719		-6.357	-8020.573	
Toe slab	0.95	25	31.875	757.031		-1.706	-1291.406	
portion between heel & toe	0.95	25	18.000	427.500		-3.600	-1539.000	
Vertical component of active earth pressure	0.95			1079.731		-9.200	-9933.521	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-9.200	0.000	
				18877.265	0.000		-108914.90	0.000
Total =				20654.747	0.000		-115049.33	0.000

0.000

0.000

1.0	0.000	1232.816	0.000
1.0	0.000	1232.312	0.000
1.0	0.000	1232.100	0.000
1.0	0.000	1231.950	0.000
1.0	0.000	1233.401	0.000
1.0	0.000	1233.401	0.000
	0.000		0.000
1.0	0.000	1229.305	0.000
1.0	0.000	1228.742	0.000
1.0	0.000	1228.742	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.02
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	4684.003		18602.61
due to dynamic Earth pressure	1.5	0.000		0.00
		5475.066		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21734.602	21734.602	kN
ML	-2599.071	-2599.071	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
3856.42	18705.39	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612	0.000	0.000
0.000	0.000	0.000	0.000
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Forces from Substructure				20267.102	0.000	0.000	0.000		-23006.759	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	1.160	216.300	0.000	1234.316		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			57.69				-4.600	-265.389				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.600	0.000				0.000	0.000	
Total =				21978.761	0.000	0.000	0.000		-21353.548	0.000		0.000		449.644	0.000
0.000															

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-4819.44	0.000
Forces from Substructure				19253.747	0.000	0.000	-110229.89	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.440	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-9.200	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.200	0.00	
Total =				20654.747	0.000		-115049.33	0.000
0.000								

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	
due to Live load surcharge	0.20	158.511			749.440	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	4684.003		18602.612
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		5475.066		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21978.761	21978.761	KN
ML	-1898.720	-1898.720	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
158.51	749.44						
4014.93	19454.83	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

MT	449.644	449.644	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = 0.3 x $\alpha h \times P$ (kN)	Fv = 0.3 x $\alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		266.078	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		44.45	1111.37	0.000	0.000	0.000	-2.10	-2333.887	0.000	1228.74	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	46.397	1159.934	0.000	0.000	0.000	1.163	1349.384	0.000	1229.805	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	31.775	476.626	0.000	0.000	0.000	1.046	498.567	0.000	1227.160	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	341.000	6820.000	0.000	0.000	0.000	-2.100	-14322.000	0.000	1230.388	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	196.875	1968.750	0.000	0.000	0.000	-2.193	-4316.667	0.000	1225.960	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	80.625	806.250				3.019	2433.750				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	53.125	796.875				-1.757	-1400.000				0.000	0.000	
Toe slab	1	15	31.875	478.125				2.894	1383.750				0.000	0.000	
portion between heel & toe	1	15	18.000	270.000				1.000	270.000				0.000	0.000	
Vertical component of active earth pressure	1			1034.871				-4.600	-4760.407				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.600	0.000				0.000	0.000	
				15393.602	0.000	0.000	0.000		-21197.510	0.000		0.000		0.000	0.000
Total =				17257.399	0.000	0.000	0.000		-19229.132	0.000		0.000		0.000	0.000
					0.000					0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-4819.440	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1314.990	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	44.455	1055.806	0.000	-6.70	-7073.902	0.000
Shaft above HFL	0.95	25	46.397	1101.937	0.000	-3.437	-3786.996	0.000
Shaft below HFL	0.95	15	31.775	452.794	0.000	-3.554	-1609.214	0.000
Back filling above HFL over heel slab	0.95	20	341.000	6479.000	0.000	-6.700	-43409.300	0.000
Back filling below HFL over heel slab	0.95	10	196.875	1870.313	0.000	-6.793	-12704.271	0.000
Front Filling over Pile Cap	0.95	10	80.625	765.938		-1.581	-1211.250	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	53.125	757.031		-6.357	-4812.344	
Toe slab	0.95	15	31.875	454.219		-1.706	-774.844	
portion between heel & toe	0.95	15	18.000	256.500		-3.600	-923.400	
Vertical component of active earth pressure	0.95			983.128		-9.200	-9044.774	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-9.200	0.000	
				14623.922	0.000		-87157.344	0.000
Total =				16401.404	0.000		-93291.77	0.000
					0.000	0.000		

For Overturning or Sliding Effect

Load Factor	FL = $\alpha h \times P$ (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1228.742	0.000
1.0	0.000	1229.805	0.000
1.0	0.000	1227.160	0.000
1.0	0.000	1230.388	0.000
1.0	0.000	1225.960	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2843.285			9961.711	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	4264.928		14942.567
due to dynamic Earth pressure	1.5	0.000		0.000
		5055.990		21738.585

Summary of Forces For SBC

	Downward	Upward	
P	17257.399	17257.399	kN
ML	-2963.775	-2963.775	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
3577.04	16265.36	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93291.774	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Forces from Substructure				15789.899	0.000	0.000	0.000		-20931.432	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	1.160	108.175	0.000	1234.316		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			57.69				-4.600	-265.389				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.600	0.000				0.000	0.000	
Total =				17408.347	0.000	0.000	0.000		-19386.346	0.000		0.000		289.919	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-4819.440	0.000
Forces from Substructure				15000.404	0.000		-88472.334	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.44	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.440	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.200	0.000	0.000
Total =				16401.404	0.000		-93295.21	0.000
					0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ

Design Calculation

RODIC

Stability of Foundation

due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2843.285			9961.711	
due to Live load surcharge	0.20	158.511			749.440	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	4264.928		14942.567
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		5055.990		21738.585

Summary of Forces For SBC

	Downward	Upward	
P	17408.347	17408.347	kN
ML	-2371.548	-2371.548	kNm
MT	289.919	289.919	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x α_h x P (kN)	FT = α_h x P (kN)	Fv = 0.3 x α_{av} x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1702.300	0.000				0.000	0.000
Substructure & Foundation -Portion 1				396.297	0.000	0.000	0.000		266.078	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				19870.805	0.000	0.000	0.000		-23272.836	0.000		0.000		0.000	0.000
Total =				21734.602	0.000	0.000	0.000		-21304.459	0.000		0.000		0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x α_{av} x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-4819.44	0.000
Substructure & Foundation -Portion 1				376.482	0.000		-1314.99	0.000
Substructure & Foundation -Portion 2				18877.265	0.000		-108914.90	0.000
Total =				20654.747	0.000		-115049.33	0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x α_h x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	

733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
158.51	749.44						
3735.55	17014.80	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93295.214	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
3856.42	18705.39	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.018
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	4684.003		18602.6117
due to dynamic Earth pressure	1.5	0.000		0
		5475.066		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21734.602	21734.602	kN
ML	-2599.071	-2599.071	kNm
MT	0.000	0.000	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	21978.761	0.000	-21353.55	0.000	449.644
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1232.251	6303.646	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	3122.669			12401.741	
due to Live load surcharge	0.2	158.511			749.440	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1232.251	6796.018
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	4684.00		18602.612
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		5475.07		25398.630

Summary of Forces For SBC

	Downward	Upward	
P	21978.761	21978.761	kN
ML	-1898.720	-1898.720	kNm
MT	449.644	449.644	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612		
0.000	0.000		
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	20654.747	0.000	-115049.33	0.000
		0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3122.67	12401.74						
158.51	749.44						
4014.93	19454.83	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4684.003	18602.612		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5475.07	25398.63	0.00	0.00

Summary of Restoring Forces

Vertical Load	20654.747	kN
Moment	-115049.326	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure		1467.500	0.000	1702.300	0.000	0.000
Substructure & Foundation -Portion 1		396.297	0.000	266.078	0.000	0.000
Substructure & Foundation -Portion 2		15393.602	0.000	-21197.510	0.000	0.000
Total =		17257.399	0.000	-19229.132	0.000	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1232.25	6303.65	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	2843.29			9961.71	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1232.251	6796.02
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	4264.928		14942.57
due to dynamic Earth pressure	1.5	0.000		0.00
		5055.990		21738.58

Summary of Forces For SBC

	Downward	Upward	
P	17257.399	17257.399	kN
ML	-2963.775	-2963.775	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	17408.347	0.000	-19386.35	0.000	289.919

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1232.251	6303.646	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	2843.285			9961.711	
due to Live load surcharge	0.2	158.511			749.440	

Vertical Forces For Restoring or Resisting Effect

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure		1401.000	0.000		-4819.440	0.000
Substructure & Foundation		376.482	0.000		-1314.990	0.000
Substructure & Foundation		14623.922	0.000		-87157.344	0.000
Total =		16401.404	0.000		-93291.774	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
3577.04	16265.36	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93291.774	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Total =	16401.404	0.000		-93295.21	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	6303.65	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2843.29	9961.71						
158.51	749.44						
3735.55	17014.80	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1232.251	6796.02
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	4264.93		14942.57
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		5055.99		21738.58

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6796.02	0.00	0.00
0.00	0.00	0.00	0.00
4264.928	14942.567		
0.000	0.000		
0.000	0.000		
0.000	0.000		
5055.99	21738.58	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17408.347	17408.347	KN
ML	-2371.548	-2371.548	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	16401.404	kN
Moment	-93295.214	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	117.46	=	117.458 KN	Normal
Transverse Moment due to C.F.	=	117.458	x (	1234.601 -	1223.660)	=	1285.113 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
117.46	1285.11	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	117.46	=	23.492 KN	Seismic
Transverse Moment due to C.F.	=	23.492	x (	1234.601 -	1223.660)	=	257.023 kNm

23.49	257.02	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ _A	σ _B	σ _C	σ _D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= μP + c.A + F _p	FOS	Overturning moment	Restoring Moment = ΣP.eToe+M _p	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	21734.602	-2599.071	0.000	203.736	174.257	203.736	174.257	203.736	174.257	5475.066	14458.323	2.64	25398.630	115213.38	4.54
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	22955.395	2187.797	2248.220	196.589	221.403	177.821	202.635	221.403	177.821	6426.132	14458.323	2.25	29895.273	117734.58	3.94
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case- SV Load Case	24584.405	2792.334	768.401	201.149	232.820	194.735	226.406	232.820	194.735	6426.132	14458.323	2.25	29895.273	117734.58	3.94
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	17257.399	-2700.268	0.000	165.378	134.751	165.378	134.751	165.378	134.751	5055.990	11480.983	2.27	21738.585	93455.83	4.30
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	18012.139	1545.978	1449.594	153.910	171.445	141.809	159.344	171.445	141.809	6007.057	11672.813	1.94	26235.227	95977.03	3.66
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case- SV Load Case	18404.529	716.038	257.599	157.054	165.175	154.903	163.025	165.175	154.903	6007.057	11672.813	1.94	26235.227	95977.03	3.66
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	21734.602	-2599.071	0.000	203.736	174.257	203.736	174.257	203.736	174.257	5475.066	14458.323	2.64	25398.630	115049.33	4.53
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	21978.761	-1641.698	449.644	202.307	183.686	198.553	179.933	202.307	179.933	5475.066	14458.323	2.64	25398.630	115049.33	4.53
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	17257.399	-2963.775	0.000	166.872	133.257	166.872	133.257	166.872	133.257	5055.990	11480.983	2.27	21738.585	93291.77	4.29
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	17408.347	-2114.526	289.919	164.579	140.595	162.158	138.175	164.579	138.175	5055.990	11480.983	2.27	21738.585	93295.21	4.29
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	21734.602	-2599.071	0.000	203.736	174.257	203.736	174.257	203.736	174.257	5475.066	14458.323	2.64	25398.630	115049.33	4.53

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	21978.761	-1898.720	706.667	204.837	183.301	198.938	177.402	204.837	177.402	5475.066	14458.323	2.64	25398.630	115049.33	4.53
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	17257.399	-2963.775	0.000	166.872	133.257	166.872	133.257	166.872	133.257	5055.990	11480.983	2.27	21738.585	93291.77	4.29
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	17408.347	-2371.548	546.942	167.109	140.211	162.543	135.645	167.109	135.645	5055.990	11480.983	2.27	21738.585	93295.21	4.29
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A1 for Minor Bridge at Ch. 91+860**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians
 COS θ = 1.000
 SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
 Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
 Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
 SBC of soil-Normal Case = 380 kN/m²
 SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
 = 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
 = 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.123m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Design Calculation

RODIC

INPUT

Abutment Cap

Width of Abutment cap of Uniform portion	=	0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	=	0.720m	0.720m
Projection of Abutment Cap (Span Side)	=	0.000m	0.000m
Projection of Abutment Cap Back Side	=	0.000m	0.000m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.000m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.981m	0.981m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	4.250m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

FoundationAlong Traffic Direction:

Total Width of Footing	=	8.200m	
abutment pedestal width	=	1.200m	
abutment pedestal Height	=	1.200m	
Width of Toe Slab	=	2.750m	
Width of Heel Slab	=	4.250m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.200m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.200m	
Width of backfill on heel slab	=	4.250m	
Thickness of heel slab at back fill edge	=	1.200m	
Height of back fill at bottom edge of heel slab	=	7.853m	
Height of back fill at back fill edge of heel slab	=	7.153m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m	(skew dimension)
Width of foundation -Tapering portion	=	12.500m	(skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
1	Minor Bridge	91+860	1225.399	1219.903	1216.903	8.496

Levels

Deck Level at Median Edge=	1225.399m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1225.114m	Height of Superstructure	=	0.800m
Deck level at center line =	1225.399m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1224.534m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1224.533m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lv (uniform portion ends)	1224.233m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lv (corbel portion ends)	1224.233m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1224.233m	Height (Avg.) of Dirt Wall	=	0.723m
Ground level/LBL =	1219.903m	Abutment shaft Above G.L	=	4.330m
Abutment shaft bottom level =	1218.103m	Abutment Shaft below G.L	=	1.800m
Foundation level =	1216.903m	Height of abutment shaft	=	6.130m
HFL	1220.903m	MSL	=	1219.903m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D (HYSD Steel)	
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa (1/1.15 * fy)	
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8 N/mm ²	
Maximum tensile stress in steel under rare combination	=	300 N/mm ²	
Creep Coefficient			
For Abutment Shaft	=	1.2 for 365 days	
For Footing	=	1.2 for 365 days	

Clear Cover to Reinforcement

Earth Face	=	75 mm
Non-Earth Face	=	50 mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft = 0.160m in longitudinal direction
 Dist between c.g of superstructure and c.g. of abutment shaft = 0.000m in Transverse direction
 C.G. of crash barrier above deck level = 0.449m

From Superstructure analysis

Dead Load

Self weight of Slab = 0.80 x 10.00 x 12.50 x 25.00
 = 2500.00 KN
 Reaction at one end = 1250.00 KN
 Transverse Eccentricity = 0.000 m

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier = 2 x 8.00 x 10.00
 = 160.00 KN
 Reaction at one end = 80.00 KN
 Transverse Eccentricity = 0.00 m

Reaction Due to Wearing Course only

Weight due to Wearing Coat = 2.2 x 10 x 12.5
 = 275 KN
 Reaction at one end = 137.5 KN
 Transverse Eccentricity = 0.00 m

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transvers e ecc
2561.34	0.30

Min CWLL

Vertical	Transvers e ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

VOLUME CALCULATION

C.G. Of Footing = 4.100 m
 C.G. Of shaft from toe tip = 3.350 m
 Distance between c.g. of shaft and footing = 0.750 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.540	-3.560	0.000
-Trapering portion	1	12.50	0.300	0.123	0.463	-0.210	0.540	-3.560	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.240	-3.860	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-0.460	0.290	-3.810	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.750	-3.350	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.750	-3.350	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.850	3.330	35.397	0.171	0.921	-3.179	0.000
Shaft below HFL	1	12.50	1.090	2.300	31.348	0.053	0.803	-3.297	0.000
Solid Return Wall	2	4.25	0.500	7.646	32.495	-2.725	-1.975	-6.075	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.150	-3.950	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.150	-3.950	0.000
Footing									
Heel Slab	1	12.50	4.250	0.850	45.156		-1.683	-5.783	0.000
Toe Slab	1	12.50	2.750	0.850	29.219		2.536	-1.564	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		0.750	-3.350	0.000
Back filling above HFL over Heel Slab	1	12.50	4.250	4.496	238.850		-1.975	-6.075	0.000
Back filling below HFL over Heel Slab	1	12.50	4.250	3.150	167.344		-2.054	-6.154	0.000
Backfill above Heel slab	1	12.50	4.250	7.503	398.623		-2.008	-6.108	0.000
Front Filling over Toe Slab	1	12.50	2.750	2.150	73.906		2.650	-1.450	0.000
Side filling between heel and toe	1	0.00	1.200	2.150	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.240	-3.860	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.261	4.496	14.654		0.333	-3.767	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.219	3.150	8.633		0.223	-3.877	0.000

		L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN		-0.210	0.540	-3.560

SECTIONAL PROPERTIES

Width of Footing (B) = 8.2 m

Length of Footing (L) = 12.500 m

$$A = 8.200 \times 12.500 = 102.500 \text{ m}^2$$

$$ZL = 12.500 \times 11.207 = 140.083 \text{ m}^3$$

$$ZT = IT1 + IT2$$

distance of extreme point from centre

$$IT1 = 8.200 \times 162.760 = 1334.64 \text{ m}^4$$

$$IT2 \text{ (moment of inertia of triangle)} = 8.200 \times 0.000 + 0.500 \times 8.200 \times 0.000 \times 39.063$$

from centre of footing $= 0.000 \text{ m}^4$

Moment of inertia of two triangle = 0.000 m⁴

Total moment of inertia = 1334.64 m⁴

$$\text{Distance of extreme point from centre of footing} = 6.250 + 0.000 = 6.250 \text{ m}$$

Total Section modulus (ZT) = 213.542 m³

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviciilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case
	Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
	Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case
	Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
	Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case
	Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case
	Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case
	Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case
	Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone	5.0

Feq	=	Seismic forces to be resisted
Feq	=	Ah x (Dead load + Appropriate Live load)
Ah	=	horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \quad \frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 7.630 m

C.g. of Horizontal Force acting at a height from Foundation Level in Transverse direction
= 8.207 m

Abutment Cap Top Level - Foundation Level
= 7.630 m

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.96	m
Moment of Inertia , $I_{\text{longitudinal}}$	=	0.922	m^4
Moment of Inertia , $I_{\text{transverse}}$	=	156.250	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction

Force	=	100.548	KN
D	=	1467.50	KN
T	=	0.2416	sec

Transverse Direction

Force	=	15309.505	KN
D	=	1747.220	KN
T	=	0.0214	sec

Hard or Rocky Strata

$$S_a/g = 2.5$$

$$S_a/g = 2.5$$

$$\text{Seismic Coeff. In Longitudinal Direction} = 0$$

$$\text{Seismic Coeff. In Transverse Direction} = 0$$

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

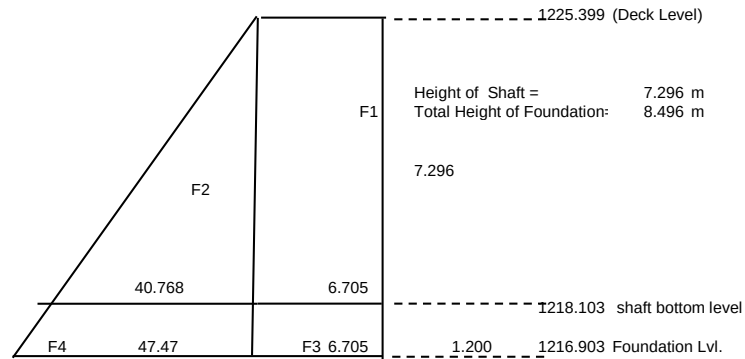
(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279	active component
	Kph	=	3.766	Passive component
	γ	=	20	kN/m ³

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL				1218.103 m (at Shaft Base)			
@ RL				1216.903 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.279	x	20	x	1.2	= 6.705 kN/m²
F1	=	6.705	x	7.296	x	12.500	= 611.515 kN
M1	=	611.51	x	3.65	=	2230.806 kN.m	at Shaft Bottom
F3	=	6.705	x	8.496	x	12.500	= 712.093 kN
M3	=	712.093	x	4.248	=	3024.971 kN.m	at Foundation
<u>Due to Active Earth Pressure</u>							
Intensity for triangular portion (At Shaft bottom level)	=	0.279	x	20	x	7.296	= 40.768 kN/m²
F2	=	0.5	x	40.77	x	7.296	x 12.50
	=	1859.005 kN					
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)							
M2	=	1859.01	x	3.06	=	5696.587 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)	=	0.279	x	20	x	8.496	= 47.473 kN/m²
F4	=	0.5	x	47.47	x	8.496	x 12.50
	=	2520.809 kN					
M4	=	2520.81	x	3.57	=	8995.054 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)

$$= 4.800 \times 7.296 = 35.021 \text{ kN/m}^2$$

$$F = 0.5 \times 35.021 \times 7.296 \times 12.500 = 1596.948 \text{ kN}$$

$$M = 1596.95 \times 2.432 = 3883.779 \text{ kN.m at Shaft Bottom}$$

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 8.496 = 40.78 \text{ kN/m}^2$$

$$F = 0.5 \times 40.781 \times 8.50 \times 12.500 = 2165.460 \text{ kN}$$

$$M = 2165.46 \times 2.832 = 6132.584 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

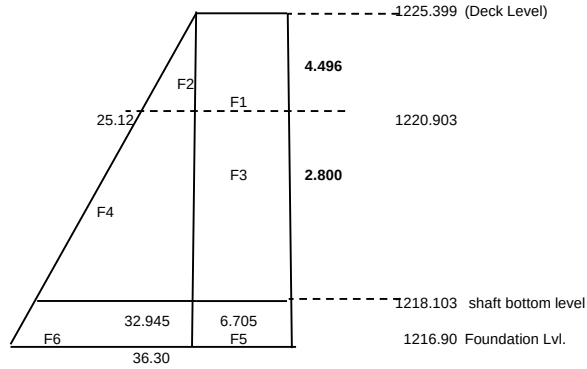
$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	5696.587	8995.054	1859.005	2520.809
Due to Minimum Fluid Pressure	3883.779	6132.584	1596.948	2165.460
Governing of Two	5696.587	8995.054	1859.005	2520.809
Due to Live Load Surcharge	2230.806	3024.971	611.515	712.093
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279	active component
	Kph	=	3.766	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL 1218.1 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	7.296	x	12.500	=	611.515 kN
M1	=	611.51	x	3.65	=	2230.806 kN.m		at Shaft Bottom
F3	=	6.705	x	8.496	x	12.500	=	712.093 kN
M3	=	712.09	x	4.25	=	3024.971 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	4.496	=	25.122 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	2.800	=	7.823 kN/m ²
F2	=	0.5	x	25.12	x	4.496	x	12.50
	=	705.933 kN						
F4	=	(25.12 + 32.94)	x	2.80	x	12.50		
	=	1016.174 kN						
Total Force	=	1722.107 kN						
M2	=	705.93	x	4.69	=	3309.641 kN.m		
M4	=	1016.17	x	1.34	=	1358.758 kN.m		
Total Mome	=	4668.40 kN.m						at Shaft Bottom

Intensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 4.496 = 25.122 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F_2 = 0.5 \times 25.12 \times 4.496 \times 12.50 = 705.933 \text{ kN}$$

$$F_6 = \left(\frac{25.12 + 36.30}{2} \right) \times 4.00 \times 12.50 = 1535.492 \text{ kN}$$

$$\text{Total Force} = 2241.426 \text{ kN}$$

$$M_2 = 705.93 \times 5.89 = 4156.760 \text{ kN.m}$$

$$M_6 = 1535.49 \times 1.88 = 2884.729 \text{ kN.m}$$

$$\text{Total Mome} = 7041.49 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

$$\text{Force due to passive @ Foundation, F} = 0.5 \times 0.000 \times 0.00 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	4668.399	7041.490	1722.107	2241.426
Due to Minimum Fluid Pressure	3883.779	6132.584	1596.948	2165.460
Governing of Two	4668.399	7041.490	1722.107	2241.426
Due to Live Load Surcharge	2230.806	3024.971	611.515	712.093
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000
αv	=	0.000
ϕ	=	30.00
δ	=	20.00
α	=	0.00
β	=	0.00

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
β	=	SLOPE OF EARTH FILL

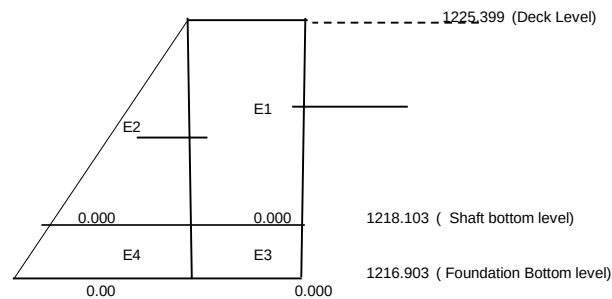
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \frac{0.000}{0.000}$$

$$C_a = \frac{1}{0.279} \frac{2}{0.279}$$

Ca	=	0.279
Ka	=	0.279
Dynamic Increment	=	0.279

3 Earth Pressure : DRY CASE (Seismic case)

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

**Earth Pressure Diagram for Dynamic Increment****Horizontal Forces and Moments @ RL**1218.1 m (at Shaft Base)
1216.9 m (at Foundation Bottom Level)**Due to Dynamic Live Load Surcharge**

at Shaft Bottom Level	=	0.000	x	20	x	1.2	=	0.000 kN/m ²
E1	=	0.000	x	7.296	x	12.500	=	0.000 kN
M1	=	0.000	x	4.888			=	0.000 kN.m
at Foundation Bottom Level	=	0.000	x	8.496	x	12.500	=	0.000 kN
E3	=	0.000	x	5.692			=	0.000 kN.m
M3	=	0.000	x				=	0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 7.296 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 8.496 = 0.000 \text{ kN/m}^2$$

$$\begin{aligned} E2 &= 0.50 \times 0.00 \times 7.30 \times 12.500 \\ &= 0.000 \text{ kN} \end{aligned}$$

$$\begin{aligned} E4 &= 0.50 \times 0.00 \times 8.50 \times 12.500 \\ &= 0.000 \text{ kN} \end{aligned}$$

$$M2 = 0.00 \times 3.65 = 0.000 \text{ kN.m (Shaft bottom level)}$$

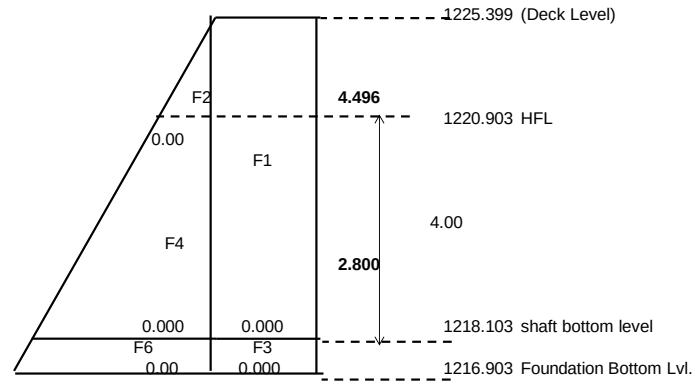
$$M4 = 0.00 \times 4.25 = 0.000 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	5696.587	8995.054	1859.005	2520.809
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	5696.587	8995.054	1859.005	2520.809
Due to Minimum Fluid Pressure	3883.779	6132.584	1596.948	2165.460
Governing of Two	5696.587	8995.054	1859.005	2520.809
Due to Live Load Surcharge (Static)	2230.806	3024.971	611.515	712.093
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					
1218.103 m (at Shaft Base)					
1216.903 m (at Foundation Bottom Level)					
<u>Due to Live Load Surcharge</u>					
Intensity for rectangular portion	=	0.000	x	20	x 1.200 = 0.000 kN/m ²
at Shaft Bottom Level					
F1	=	0.000	x	7.296	x 12.500 = 0.000 kN
M1	=	0.00	x	4.82	= 0.000 kN.m
at Foundation Bottom Level					
F3	=	0.000	x	8.496	x 12.500 = 0.000 kN
M3	=	0.00	x	5.61	= 0.000 kN.m

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

$$\text{Upto HFL} = 0.000 \times 20 \times 4.496 = 0.000 \text{ kN/m}^2$$

$$\text{(At Shaft bottom level) Below HFL} = 0.000 \times 10 \times 2.800 = 0.000 \text{ kN/m}^2$$

$$\text{(At Foundati bottom level) Below HFL} = 0.000 \times 10 \times 4.000 = 0.000 \text{ kN/m}^2$$

$$F2 = 0.5 \times 0.00 \times 4.50 = 0.000 \text{ kN}$$

$$F4 = \frac{(0.00 + 0.00)}{2} \times 2.80 = 0.000 \text{ kN}$$

$$F6 = \frac{(0.00 + 0.00)}{2} \times 4.00 = 0.000 \text{ kN}$$

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

$$M2 = 0.00 \times 5.05 = 0.000 \text{ kN.m}$$

$$M4 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Shaft Bottom

$$M2 = 0.00 \times 6.25 = 0.000 \text{ kN.m}$$

$$M6 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	4668.399	7041.490	1722.107	2241.426
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	4668.399	7041.490	1722.107	2241.426
Due to Minimum Fluid Pressure	3883.779	6132.584	1596.948	2165.460
Governing of Two	4668.399	7041.490	1722.107	2241.426
Due to Live Load Surcharge(Static)	2230.806	3024.971	611.515	712.093
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A Dry Case
	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A HFL Case
	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	SV Loading

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A Dry Case
	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A HFL Case
	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	SV Loading

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	HFL Case

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	HFL Case

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case

Design Speed	V	=	40.00	kmph
Live Load	W	=	932.33	kN
Radius of Curvature	R	=	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN

Seismic Case

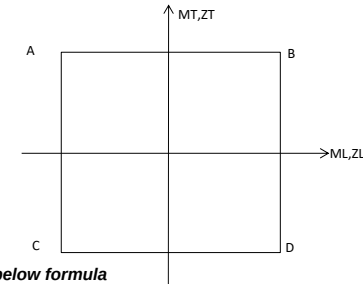
40.00	kmph
932.33	kN
0.00	m
0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1216.903 m

Properties of Footing Base:

A	=	102.500	m ²
ZL	=	140.083	m ³
ZT	=	213.542	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	0.910	1137.500	0.000	0.000
SIDL except Wearing Course	1			80.000	0.910	72.800	0.000	0.000
Wearing Course	1			137.500	0.910	125.125	0.000	0.000
				1467.500		1335.425		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.540	30.375	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.540	6.252	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.240	6.750	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.290	4.078	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.750	50.625	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.750	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.150	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1	25	0.000	0.000	0.150	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.540	15.120	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.240	39.375	0.000	0.000
				369.578		152.575		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	32.495	812.387	-1.975	-1604.465	0.000	0.000
Abutment Shaft	1	25	66.745	1668.629	0.803	1339.868	0.000	0.000
Back filling over heel slab	1	20	398.623	7972.469	-2.008	-16009.037	0.000	0.000
Front Filling over toe slab	1	20	73.906	1478.125	2.650	3917.604	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	45.156	1128.906	-1.683	-1900.326	0.000	0.000
Toe slab	1	25	29.219	730.469	2.536	1852.669	0.000	0.000
portion between heel & toe	1	25	18.000	450.000	0.750	337.500	0.000	0.000
Vertical Components of active earth pressure	1			917.500	-4.100	-3761.748	0.000	0.000
				15624.227		-15698.459		0.000
Total				17461.305		-14210.458		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-3.190	-3788.125
0.950	76.000	-3.190	-242.440
1.000	137.500	-3.190	-438.625
	1401.000		-4469.190
0.950	53.438	-3.560	-190.238
0.950	10.999	-3.560	-39.157
0.950	26.719	-3.860	-103.134
0.950	13.359	-3.810	-50.899
0.950	64.125	-3.350	-214.819
0.950	0.000	-3.350	0.000
0.950	0.000	-3.950	0.000
0.950	0.000	-3.950	0.000
0.950	26.600	-3.560	-94.696
0.950	155.859	-3.860	-601.617
	351.099		-1294.560
0.950	771.768	-6.075	-4688.491
0.950	1585.197	-3.297	-5226.435
0.950	7573.845	-6.108	-46261.351
0.950	1404.219	-1.450	-2035.573
0.950	0.000	0.000	0.000
0.950	1072.461	-5.783	-6202.399
0.950	693.945	-1.564	-1085.140
0.950	427.500	-3.350	-1432.125
0.950	871.625	-8.200	-7147.321
	14843.016		-75745.603
	16595.115		-81509.353

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.534	5599.246
due to Earth pressure	1	2520.809		8995.054

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5599.25	0.00	0.00
2520.81	8995.05	0.00	0.00
3254.559	14594.300	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Earth pressure	1.5	3781.214		13492.581
		4572.276		19529.179

Summary of Forces For SBC

P	17461.305	kN
ML	383.842	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		17461.305		-14210.458		0.000
CWLL-Max. Reaction case	1	932.327	0.910	848.417	2.411	2248.220
Vertical Components of LL Surcharge	1	259.181	-4.100	-1062.641	0.000	0.000
Total		18652.813		-14424.682		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.534	5599.246
due to Earth pressure	1	2520.809		8995.054
due to Live load surcharge	1	712.093		3024.971

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Earth pressure	1.5	3781.214		13492.581
due to Live load surcharge	1.2	854.512		3629.965
		5426.788		23159.145

Summary of Forces For SBC

P	18652.813	kN
ML	3194.590	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		17461.305		-14210.458		0.000
CWLL-Max. Reaction case	1	2561.336	0.910	2330.816	0.300	768.401
Vertical Components of LL Surcharge	1	259.181	-4.100	-1062.641	0.000	0.000
Total		20281.822		-12942.283		768.401

Horizontal Forces For SBC Calculation

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
3781.21	13492.58	0.00	0.00
4572.276	19529.179	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16595.115		-81509.35
0.000		-3.190	0.00
0.950		-8.200	-2019.02
	16595.115		-83528.37

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5599.25	0.00	0.00
2520.81	8995.05	0.00	0.00
712.093	3024.971	0.000	0.000
3966.65	17619.27	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
3781.21	13492.58	0.00	0.00
854.51	3629.97	0.00	0.00
5426.788	23159.145	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16595.11504		-81509.3529
0.000		-3.190	0.00
0.950		-8.200	-2019.02
	16595.115		-83528.37

Forces along Long. Axis		Forces along Trans. Axis	

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.534	5599.246
due to Earth pressure	1	2520.809		8995.054
due to Live load surcharge	1	712.093		3024.971

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Earth pressure	1.5	3781.214		13492.581
due to Live load surcharge	1.2	854.512		3629.965
		5426.788		23159.145

Summary of Forces For SBC		
P	20281.822	kN
ML	4676.988	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		1335.425		0.000
Substructure & Foundation -Portion 1				369.578		152.575		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	32.495	812.387	-1.975	-1604.465	0.000	0.000
Shaft above HFL	1	25	35.397	884.922	0.921	815.439	0.000	0.000
Shaft below HFL	1	15	31.348	470.224	0.803	377.579	0.000	0.000
Back filling above HFL over heel slab	1	20	238.850	4777.000	-1.975	-9434.575	0.000	0.000
Back filling below HFL over heel slab	1	10	167.344	1673.438	-2.054	-3436.745	0.000	0.000
Front Filling over toe slab	1	10	73.906	739.063	2.650	1958.802	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	45.156	677.344	-1.683	-1140.195	0.000	0.000
Toe slab	1	15	29.219	438.281	2.536	1111.602	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	0.750	202.500	0.000	0.000
Vertical Components of active earth pressure	1			815.812	-4.100	-3344.830	0.000	0.000
				11937.884		-14378.059		0.000
Total				13774.962		-12890.059		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.534	5599.246
due to Earth pressure	1	2241.426		7041.490

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Earth pressure	1.5	3362.138		10562.234
		4153.201		16598.832

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5599.25	0.00	0.00
2520.81	8995.05	0.00	0.00
712.093	3024.971	0.000	0.000
3966.65	17619.27	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
3781.21	13492.58	0.00	0.00
854.51	3629.97	0.00	0.00
5426.788	23159.145	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-4469.190
	351.099		-1294.560
0.950	771.768	-6.075	-4688.491
0.950	840.676	-3.179	-2672.103
0.950	446.713	-3.297	-1472.824
0.950	4538.150	-6.075	-27569.261
0.950	1589.766	-6.154	-9782.947
0.950	702.109	-1.450	-1017.786
0.950	0.000	0.000	0.000
0.950	643.477	-5.783	-3721.439
0.950	416.367	-1.564	-651.084
0.950	256.500	-3.350	-859.275
0.950	775.022	-8.200	-6355.177
	11340.990		-60157.213
	13093.089		-65920.963

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5599.25	0.00	0.00
2241.43	7041.49	0.00	0.00
2975.18	12640.74	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
3362.14	10562.23	0.00	0.00
4153.20	16598.83	0.00	0.00

Summary of Forces For SBC		
P	13774.962	kN
ML	-249.323	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		13774.962		-12890.059		0.000
CWLL-Min. Reaction case	1	466.273	0.910	424.309	3.109	1449.594
Vertical Components of LL Surcharge	1	259.181	-4.100	-1062.641	0.000	0.000
Total		14500.416		-13528.391		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.534	5599.246
due to Earth pressure	1	2241.426		7041.490
due to Live load surcharge	1	712.093		3024.971

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Earth pressure	1.5	3362.138		10562.234
due to live load surcharge	1.2	854.512		3629.965
		5007.713		20228.798

Summary of Forces For SBC		
P	14500.416	kN
ML	2137.316	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		13774.962		-12890.059		0.000
CWLL-Min. Reaction case	1	858.664	0.910	781.384	0.300	257.599
Vertical Components of LL Surcharge	1	259.181	-4.100	-1062.641	0.000	0.000
Total		14892.806		-13171.315		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.534	5599.246
due to Earth pressure	1	2241.426		7041.490
due to Live load surcharge	1	712.093		3024.971

Horizontal Forces For Overturning or Sliding Effect**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	13093.089		-65920.963
0.000	0.000	-3.190	0
0.950	246.222	-8.200	-2019.017
	13339.310		-67939.981

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5599.25	0.00	0.00
2241.43	7041.49	0.00	0.00
712.093	3024.971	0.000	0.000
3687.27	15665.71	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
3362.14	10562.23	0.00	0.00
854.512	3629.965	0.000	0.000
5007.71	20228.80	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	13093.089		-65920.963
0.000	0.000	-3.190	0.00
0.950	246.222	-8.200	-2019.017
	13339.310		-67939.981

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5599.25	0.00	0.00
2241.43	7041.49	0.00	0.00
712.093	3024.971	0.000	0.000
3687.27	15665.71	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Earth pressure	1.5	3362.138		10562.234
due to live load surcharge	1.2	854.512		3629.965
		5007.713		20228.798

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
3362.14	10562.23	0.00	0.00
854.512	3629.965	0.000	0.000
5007.71	20228.80	0.00	0.00

Summary of Forces For SBC		
P	14892.806	kN
ML	2494.392	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	α _h =	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	533.487 KN
		α _h =	0.000	In Transverse direction	Weight of back fill below Ground level	=	1912.500 KN
		α _v =	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = α _h x P (kN)	FT = 0.3 x α _h x P (kN)	Fv = 0.3 x α _v x P (kN)	Long. Ecc. (eL1) (m)	ML = Px _e L1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px _e T	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	0.910	1137.500	0.000	1225.067		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	0.910	72.800	0.000	1225.848		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	0.910	125.125	0.000	1225.399		0.000	0.000	0.000
				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.540	30.375	0.000	1225.099	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.000	0.000	0.000	0.540	6.252	0.000	1224.737	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.240	6.750						
Bracket - Tapered portion	1	25	0.563	14.063				0.290	4.078						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.750	50.625	0.000	1224.383	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.750	0.000	0.000	1224.233	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000	1225.399	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000	1225.399	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.540	15.120				0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063				0.240	39.375				0.000	0.000	0.000
				369.578	0.000	0.000	0.000		152.575	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	32.495	812.387	0.000	0.000	0.000	-1.975	-1604.465	0.000	1221.647	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	66.745	1668.629	0.000	0.000	0.000	0.803	1339.868	0.000	1222.068	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	398.623	7972.469	0.000	0.000	0.000	-2.008	-16009.037	0.000	1221.647	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	73.906	1478.125				2.650	3917.604				0.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	0.000
Heel slab	1	25	45.156	1128.906				-1.683	-1900.326				0.000	0.000	0.000
Toe slab	1	25	29.219	730.469				2.536	1852.669				0.000	0.000	0.000
portion between heel & toe	1	25	18.000	450.000				0.750	337.500				0.000	0.000	0.000
Vertical component of active earth pressure	1			917.500				-4.100	-3761.748				0.000	0.000	0.000
Vertical component of dynamic increment of earth pressure	1			0.000				-4.100	0.000				0.000	0.000	0.000
				15624.227	0.000	0.000	0.000		-15698.459	0.000		0.000		0.000	0.000
Total =				17461.305	0.000	0.000	0.000		-14210.458	0.000		0.000		0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x α _v x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px _e L2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-3.190	-3788.125	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-3.190	-242.440	0.000

For Overturning or Sliding Effect

Load Factor	FL = α _h x P (kN)	C.g. of Force (m)	MLs due to FL

Design Calculation

RODIC

Stability of Foundation

Wearing Course	1.00			137.500	0.000	-3.190	-438.625	0.000
				1401.000	0.000		-4469.190	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-3.560	-190.238	0.000
Dirt Wall-Tapered portion	0.95	25	0.463	10.999	0.000	-3.560	-39.157	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-3.350	-214.819	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-3.350	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-3.950	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-3.950	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-3.560	-94.696	
Approach Slab	0.95	25	6.563	155.859		-3.860	-601.617	
				351.099	0.000		-1140.527	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	66.745	1585.197	0.000	-3.297	-5226.435	0.000
Solid Return wall	0.95	25	32.495	771.768	0.000	-6.075	-4688.491	0.000
Back filling over heel slab	0.95	20	398.623	7573.845	0.000	-6.108	-46261.351	0.000
Front Filling over Pile Cap	0.95	20	73.906	1404.219		-1.450	-2035.573	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	45.156	1072.461		-5.783	-6202.399	
Toe slab	0.95	25	29.219	693.945		-1.564	-1085.140	
portion between heel & toe	0.95	25	18.000	427.500		-3.350	-1432.125	
Vertical component of active earth pressure	0.95			871.625		-8.200	-7147.321	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.200	0.000	
				14843.016	0.000		-75745.60	0.000
Total =				16595.115	0.000		-81355.32	0.000

0.000

0.000

1.0	0.000	1225.099	0.000					
1.0	0.000	1224.737	0.000					
1.0	0.000	1224.383	0.000					
1.0	0.000	1224.233	0.000					
1.0	0.000	1225.399	0.000					
1.0	0.000	1225.399	0.000					
	0.000		0.000					
1.0	0.000	1222.068	0.000					
1.0	0.000	1221.647	0.000					
1.0	0.000	1221.647	0.000					
	0.000		0.000					
	0.000		0.000					

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.534	5599.246	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2520.809			8995.054	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.60
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3781.214		13492.58
due to dynamic Earth pressure	1.5	0.000		0.00
		4572.276		19529.179

Summary of Forces For SBC

	Downward	Upward	
P	17461.305	17461.305	kN
ML	383.842	383.842	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2520.81	8995.05						
3254.56	14594.30	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3781.214	13492.581	0.000	0.000
0.000	0.000	0.000	0.000
4572.28	19529.18	0.00	0.00

Summary of Restoring Forces

Vertical Load	16595.115	kN
Moment	-81355.319	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Forces from Substructure				15993.805	0.000	0.000	0.000		-15545.883	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	0.910	169.683	0.000	1226.599		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			51.84				-4.100	-212.528				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.100	0.000				0.000	0.000	
Total =				17699.607	0.000	0.000	0.000		-14253.303	0.000		0.000		449.644	0.000
					0.000		0.000				0.000				

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-4469.19	0.000
Forces from Substructure				15194.115	0.000	0.000	-76886.13	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.190	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-8.200	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.200	0.00	
Total =				16595.115	0.000		-81355.32	0.000
					0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.534	5599.246	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2520.809			8995.054	
due to Live load surcharge	0.20	142.419			604.994	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2520.81	8995.05						
142.42	604.99						
3396.98	15199.29	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3781.214		13492.581
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		4572.276	19529.179	

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3781.214	13492.581		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4572.28	19529.18	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17699.607	17699.607	kN
ML	945.992	945.992	kNm
MT	449.644	449.644	kNm

Summary of Restoring Forces

Vertical Load	16595.115	kN
Moment	-81355.319	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLS due to Fv	C.g. of Force (m)	MLS due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		152.575	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		32.50	812.39	0.000	0.000	0.000	-1.98	-1604.465	0.000	1221.65	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	35.397	884.922	0.000	0.000	0.000	0.921	815.439	0.000	1222.568	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	31.348	470.224	0.000	0.000	0.000	0.803	377.579	0.000	1220.403	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	238.850	4777.000	0.000	0.000	0.000	-1.975	-9434.575	0.000	1223.151	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	167.344	1673.438	0.000	0.000	0.000	-2.054	-3436.745	0.000	1219.203	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	73.906	739.063				2.650	1958.802				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	45.156	677.344				-1.683	-1140.195				0.000	0.000	
Toe slab	1	15	29.219	438.281				2.536	1111.602				0.000	0.000	
portion between heel & toe	1	15	18.000	270.000				0.750	202.500				0.000	0.000	
Vertical component of active earth pressure	1			815.812				-4.100	-3344.830				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.100	0.000				0.000	0.000	
				11937.884	0.000	0.000	0.000		-14494.890	0.000		0.000		0.000	0.000
Total =				13774.962	0.000	0.000	0.000		-13006.889	0.000		0.000		0.000	0.000

0.000

For Overturning or Sliding Effect

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLS due to Fv
Superstructure				1401.000	0.000		-4469.190	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-1140.527	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	32.4955	771.768	0.000	-6.08	-4688.491	0.000
Shaft above HFL	0.95	25	35.397	840.676	0.000	-3.179	-2672.103	0.000
Shaft below HFL	0.95	15	31.348	446.713	0.000	-3.297	-1472.824	0.000
Back filling above HFL over heel slab	0.95	20	238.850	4538.150	0.000	-6.075	-27569.261	0.000
Back filling below HFL over heel slab	0.95	10	167.344	1589.766	0.000	-6.154	-9782.947	0.000
Front Filling over Pile Cap	0.95	10	73.906	702.109		-1.450	-1017.786	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	45.156	643.477		-5.783	-3721.439	
Toe slab	0.95	15	29.219	416.367		-1.564	-651.084	
portion between heel & toe	0.95	15	18.000	256.500		-3.350	-859.275	
Vertical component of active earth pressure	0.95			775.022		-8.200	-6355.177	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.200	0.000	
				11340.990	0.000		-60157.213	0.000
Total =				13093.089	0.000		-65766.93	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ

Design Calculation

RODIC

Stability of Foundation

due to Superstructure	1	733.750	0.000	1224.534	5599.246	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2241.426			7041.490	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3362.138		10562.234
due to dynamic Earth pressure	1.5	0.000		0.000
		4153.201		16598.832

Summary of Forces For SBC

	Downward	Upward	
P	13774.962	13774.962	kN
ML	-366.154	-366.154	kNm
MT	0.000	0.000	kNm

733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2241.43	7041.49						
2975.18	12640.74	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3362.138	10562.234		
0.000	0.000		
4153.20	16598.83	0.00	0.00

Summary of Restoring Forces

Vertical Load	13093.089	kN
Moment	-65766.930	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Forces from Substructure				12307.462	0.000	0.000	0.000		-14342.314	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	0.910	84.862	0.000	1226.599		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			51.84				-4.100	-212.528				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.100	0.000				0.000	0.000	
Total =				13920.053	0.000	0.000	0.000		-13134.556	0.000		0.000		289.919	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-4469.190	0.000
Forces from Substructure				11692.089	0.000		-61297.740	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.19	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.190	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.200	0.000	0.000
Total =				13093.089	0.000		-65770.12	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.534	5599.246	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2241.426			7041.490	
due to Live load surcharge	0.20	142.419			604.994	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2241.43	7041.49						
142.42	604.99						

3117.59 13245.73 0.00 0.00 0.00 0.00 0.00 0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	3362.138		10562.234
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		4153.201		16598.832

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3362.138	10562.234		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4153.20	16598.83	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	13920.053	13920.053	kN
ML	111.174	111.174	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	13093.089	kN
Moment	-65770.120	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		152.575	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				15624.227	0.000	0.000	0.000		-15698.459	0.000		0.000		0.000	0.000
Total =				17461.305	0.000	0.000	0.000		-14210.458	0.000		0.000		0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-4469.19	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-1140.53	0.000
Substructure & Foundation -Portion 2				14843.016	0.000		-75745.60	0.000
Total =				16595.115	0.000		-81355.32	0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.534	5599.246	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2520.809			8995.054	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2520.81	8995.05						
3254.56	14594.30	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.598
due to Substructure	1.5	0.000		0

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00

due to Active Earth pressure	1.5	3781.214	13492.5812
due to dynamic Earth pressure	1.5	0.000	0
		4572.276	19529.179

3781.214	13492.581		
0.000	0.000		
4572.28	19529.18	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17461.305	17461.305	kN
ML	383.842	383.842	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	16595.115	kN
Moment	-81355.319	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	17699.607	0.000	-14253.30	0.000	449.644
		0.000		0.000	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	16595.115	0.000	-81355.32	0.000
		0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.534	5599.246	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2520.809			8995.054	
due to Live load surcharge	0.2	142.419			604.994	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2520.81	8995.05						
142.42	604.99						
3396.98	15199.29	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1224.534	6036.598
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	3781.21		13492.581
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		4572.28		19529.179

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3781.214	13492.581		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4572.28	19529.18	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17699.607	17699.607	kN
ML	945.992	945.992	kNm
MT	449.644	449.644	kNm

Summary of Restoring Forces

Vertical Load	16595.115	kN
Moment	-81355.319	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure	1467.500	0.000	1335.425	0.000	0.000
Substructure & Foundation -Portion 1	369.578	0.000	152.575	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure	1401.000	0.000		-4469.190	0.000
Substructure & Foundation	351.099	0.000		-1140.527	0.000

Design Calculation

Substructure & Foundation -Portion 2	11937.884	0.000	-14494.890	0.000	0.000
Total =	13774.962	0.000	-13006.889	0.000	0.000
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1224.53	5599.25	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	2241.43			7041.49	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.534	6036.60
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3362.138		10562.23
due to dynamic Earth pressure	1.5	0.000		0.00
		4153.201		16598.83

Summary of Forces For SBC

	Downward	Upward	
P	13774.962	13774.962	kN
ML	-366.154	-366.154	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxL1	MLs due to Fv	MT = PxLT
Total =	13920.053	0.000	-13134.56	0.000	289.919
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1224.534	5599.246	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	2241.426			7041.490	
due to Live load surcharge	0.2	142.419			604.994	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1224.534	6036.60
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	3362.14		10562.23
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00

RODIC

Substructure & Foundation	11340.990	0.000		-60157.213	0.000
Total =	13093.089	0.000		-65766.930	0.000
		0.000			0.000

Stability of Foundation

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2241.43	7041.49						
2975.18	12640.74	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3362.138	10562.234		
0.000	0.000		
4153.20	16598.83	0.00	0.00

Summary of Restoring Forces

Vertical Load	13093.089	kN
Moment	-65766.930	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxL2	MLs due to Fv
Total =	13093.089	0.000		-65770.12	0.000
		0.000			0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5599.25	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2241.43	7041.49						
142.42	604.99						
3117.59	13245.73	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	6036.60	0.00	0.00
0.00	0.00	0.00	0.00
3362.138	10562.234		
0.000	0.000		
0.000	0.000		
0.000	0.000		

4153.20

16598.83

4153.20

16598.83

0.00

0.00

Summary of Forces For SBC			
	Downward	Upward	
P	13920.053	13920.053	kN
ML	111.174	111.174	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	13093.089	kN
Moment	-65770.120	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000	kN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1226.599 -	1216.903)	=	0.000	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000	kN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1226.599 -	1216.903)	=	0.000	kNm

0.00	0.00	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe+M_p}$	FOS
	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	17461.305	383.842	0.000	167.614	173.094	167.614	173.094	173.094	167.614	4572.276	11616.581	2.54	19529.179	81509.35	4.17
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	18652.813	3194.590	2248.220	169.702	215.312	148.645	194.255	215.312	148.645	5426.788	11616.581	2.14	23159.145	83528.37	3.61
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	20281.822	4676.988	768.401	168.083	234.857	160.886	227.660	234.857	160.886	5426.788	11616.581	2.14	23159.145	83528.37	3.61
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	13774.962	-249.323	0.000	136.170	132.610	136.170	132.610	136.170	132.610	4153.201	9165.162	2.21	16598.832	65920.96	3.97
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	14500.416	2137.316	1449.594	132.998	163.513	119.422	149.937	163.513	119.422	5007.713	9337.517	1.86	20228.798	67939.98	3.36
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	14892.806	2494.392	257.599	128.696	164.308	126.283	161.896	164.308	126.283	5007.713	9337.517	1.86	20228.798	67939.98	3.36
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															

Case 5 : DL+SIDL-Long. Seismic Dry Case	17461.305	383.842	0.000	167.614	173.094	167.614	173.094	173.094	167.614	4572.276	11616.581	2.54	19529.179	81355.32	4.17
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	17699.607	945.992	449.644	168.032	181.538	163.820	177.327	181.538	163.820	4572.276	11616.581	2.54	19529.179	81355.32	4.17
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	13774.962	-366.154	0.000	137.004	131.776	137.004	131.776	137.004	131.776	4153.201	9165.162	2.21	16598.832	65766.93	3.96
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	13920.053	111.174	289.919	136.369	137.957	133.654	135.241	137.957	133.654	4153.201	9165.162	2.21	16598.832	65770.12	3.96
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	17461.305	383.842	0.000	167.614	173.094	167.614	173.094	173.094	167.614	4572.276	11616.581	2.54	19529.179	81355.32	4.17
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	17699.607	945.992	449.644	168.032	181.538	163.820	177.327	181.538	163.820	4572.276	11616.581	2.54	19529.179	81355.32	4.17
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	13774.962	-366.154	0.000	137.004	131.776	137.004	131.776	137.004	131.776	4153.201	9165.162	2.21	16598.832	65766.93	3.96
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	13920.053	111.174	289.919	136.369	137.957	133.654	135.241	137.957	133.654	4153.201	9165.162	2.21	16598.832	65770.12	3.96
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION
Abutment A2 for Minor Bridge at Ch.
91+860**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.123m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	= 0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	= 0.720m	0.720m
Projection of Abutment Cap (Span Side)	= 0.000m	0.000m
Projection of Abutment Cap Back Side	= 0.000m	0.000m
Abutmentcap thickness (Uniform portion)	= 0.300m	
Abutmentcap thickness (Tapering Portion)	= 0.000m	
Length of Abutment Cap at top (Uniform portion)	= 12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.972m	0.972m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	4.250m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.000m
Thickness of Return wall at Bottom	=	0.000m

Foundation**Along Traffic Direction:**

Total Width of Footing	=	8.200m
abutment pedestal width	=	1.200m
abutment pedestal Height	=	1.200m
Width of Toe Slab	=	2.750m
Width of Heel Slab	=	4.250m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.200m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.200m
Width of backfill on heel slab	=	4.250m
Thickness of heel slab at back fill edge	=	1.200m
Height of back fill at bottom edge of heel slab	=	7.627m
Height of back fill at back fill edge of heel slab	=	6.927m

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)
Width of foundation -Tapering portion	=	12.500m (skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
	1 Minor Bridge	91+860	1225.172	1219.903	1216.903	8.269

Levels

Deck Level at Median Edge=	1225.172m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1224.887m	Height of Superstructure	=	0.800m
Deck level at center line =	1225.172m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1224.307m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1224.306m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lvl (uniform portion ends)	1224.006m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1224.006m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1224.006m	Height (Avg.) of Dirt Wall	=	0.723m
Ground level/LBL =	1219.903m	Abutment shaft Above G.L	=	4.103m
Abutment shaft bottom level =	1218.103m	Abutment Shaft below G.L	=	1.800m
Foundation level =	1216.903m	Height of abutment shaft	=	5.903m
HFL	1220.903m	MSL	=	1219.903m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, f_{ck}	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, f_{cd}	=	15.63 Mpa at 28 d (0.67/1.5 * f_{ck})	
Tensile strength of concrete , f_{ctm}	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
E_{cm}	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, f_y or f_{yk}	=	500 Mpa	
Design Yield Strength of Reinforcement, f_{yd}	=	434.78 Mpa	(1/1.15 * f_y)
Modulus of Elasticity of Steel (E_s)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 f_{ck}	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²
<u>Creep Coefficient</u>			
For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days
<u>Clear Cover to Reinforcement</u>			
Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.160m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.80	x	10.00	x	12.50	x	25.00
	=	2500.00	KN					
Reaction at one end	=	1250.00	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	10.00
	=	160.00	KN			
Reaction at one end	=	80.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	10	x	12.5
	=	275	KN			
Reaction at one end	=	137.5	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transverse ecc
2561.34	0.30

Min CWLL

Vertical	Transverse ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

VOLUME CALCULATION

C.G. Of Footing	=	4.100 m
C.G. Of shaft from toe tip	=	3.350 m
Distance between c.g. of shaft and footing	=	0.750 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.540	-3.560	0.000
-Trapering portion	1	12.50	0.300	0.123	0.463	-0.210	0.540	-3.560	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	0.240	-3.860	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-0.460	0.290	-3.810	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.750	-3.350	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.750	-3.350	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.846	3.103	32.820	0.174	0.924	-3.176	0.000
Shaft below HFL	1	12.50	1.086	2.300	31.227	0.055	0.805	-3.295	0.000
Solid Return Wall	2	4.25	0.500	7.419	31.531	-2.725	-1.975	-6.075	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.150	-3.950	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.600	0.150	-3.950	0.000
Footing									
Heel Slab	1	12.50	4.250	0.850	45.156		-1.683	-5.783	0.000
Toe Slab	1	12.50	2.750	0.850	29.219		2.536	-1.564	0.000
Portion between Heel and Toe	1	12.50	1.200	1.200	18.000		0.750	-3.350	0.000
Back filling above HFL over Heel Slab	1	12.50	4.250	4.269	226.791		-1.975	-6.075	0.000
Back filling below HFL over Heel Slab	1	12.50	4.250	3.150	167.344		-2.054	-6.154	0.000
Backfill above Heel slab	1	12.50	4.250	7.277	386.564		-2.009	-6.109	0.000
Front Filling over Toe Slab	1	12.50	2.750	2.150	73.906		2.650	-1.450	0.000
Side filling between heel and toe	1	0.00	1.200	2.150	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	0.240	-3.860	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.252	4.269	13.464		0.334	-3.766	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.228	3.150	8.965		0.226	-3.874	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN		-0.210	0.540	-3.560

SECTIONAL PROPERTIES

Width of Footing (B)	=	8.2 m
Length of Footing (L)	=	12.500 m

A	=	8.200	x	12.500	=	102.500 m ²
ZL	=	12.500	x	11.207	=	140.083 m ³
ZT	=	IT1	+	IT2		

distance of extreme point from centre

IT1	=	8.200	x	162.760	=	1334.64 m ⁴
IT2 (moment of inertia of triangle)	=	8.200	x	0.000	+	0.500 x 8.200 x 0.000 x 39.063
from centre of footing	=	0.000	m ⁴			

Moment of inertia of two triangle	=	0.000 m ⁴

Total moment of inertia	=	1334.64 m ⁴

Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250 m

Total Section modulus (ZT)	=	213.542 m ³

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviceability Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation**(As Per IRC:6-2014 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 7.403 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 7.980 m

Abutment Cap Top Level - Foundation Level
= 7.403 m

Dimensions of Abutment Shaft

Length = 12.50 m
 Width = 0.96 m

Moment of Inertia , $I_{longitudinal}$ = 0.922 m^4
 Moment of Inertia , $I_{transverse}$ = 156.250 m^4

Ecm = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 110.084 KN
 D = 1467.50 KN
 T = 0.2309 sec

Transverse Direction

Force = 16709.222 KN
 D = 1747.220 KN
 T = 0.0205 sec

Hard or Rocky Strata

Sa/g = 2.5 Sa/g = 2.5

Seismic Coeff. In Longitudinal Direction = 0

Seismic Coeff. In Transverse Direction = 0

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

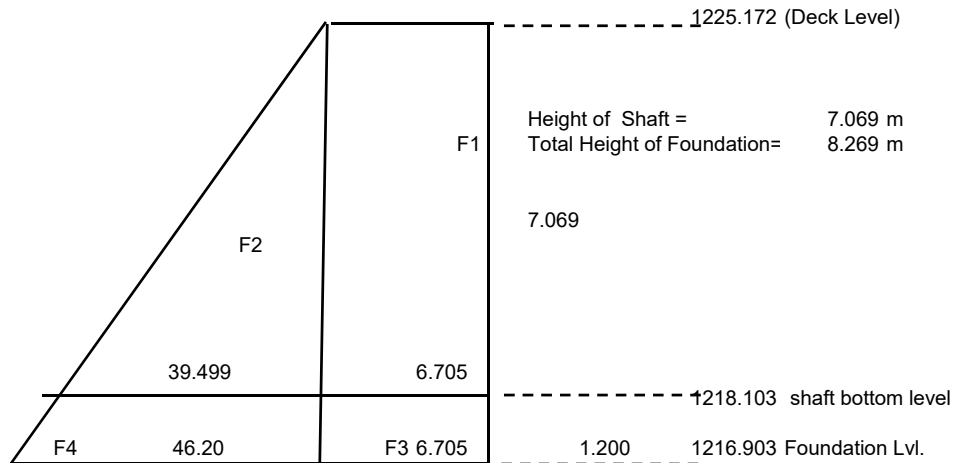
(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m
Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1218.103 m (at Shaft Base)			
@ RL					1216.903 m (at Foundation Level)			
<u>Due to Live Load Surcharge</u>								
Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m^2
F1	=	6.705	x	7.069	x	12.500	=	592.489 kN
M1	=	592.49	x	3.53	=	2094.152 kN.m	at Shaft Bottom	
F3	=	6.705	x	8.269	x	12.500	=	693.067 kN
M3	=	693.067	x	4.135	=	2865.485 kN.m	at Foundation	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)							
	=	0.279	x	20	x	7.069	= 39.499 kN/m^2
F2	=	0.5	x	39.50	x	7.069	x 12.50
	=	1745.127 kN					
(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)							
M2	=	1745.13	x	2.97	=	5181.246 kN.m	at Shaft Bottom
Intensity for triangular portion (At Foundation level)							
	=	0.279	x	20	x	8.269	= 46.204 kN/m^2
F4	=	0.5	x	46.20	x	8.269	x 12.50
	=	2387.905 kN					
M4	=	2387.90	x	3.47	=	8293.145 kN.m	at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014		γ fluid	=	4.8 kN/m ³		
Intensity for triangular portion (At Shaft bottom level)						
=	4.800	x	7.069	=	33.931 kN/m^2	
F	=	0.5	x	33.931	x	7.069 x 12.500
	=	1499.123 kN				

Design Calculation

RODIC

Earth_Normal Dry

$$M = 1499.12 \times 2.356 = 3532.433 \text{ kN.m at Shaft Bottom}$$

Intensity for triangular portion (At Foundation level)

$$= 4.800 \times 8.269 = 39.69 \text{ kN/m}^2$$

$$F = 0.5 \times 39.691 \times 8.27 \times 12.500 = 2051.291 \text{ kN}$$

$$M = 2051.29 \times 2.756 = 5654.041 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

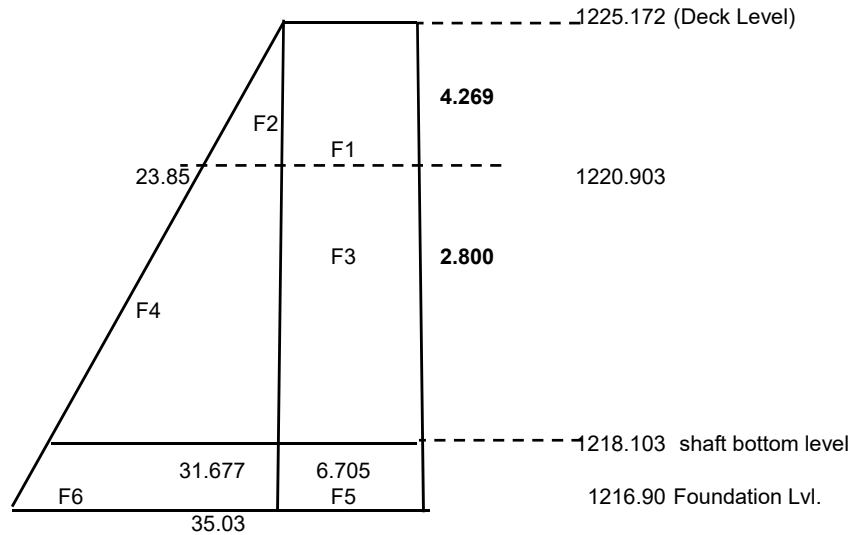
$$= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	5181.246	8293.145	1745.127	2387.905
Due to Minimum Fluid Pressure	3532.433	5654.041	1499.123	2051.291
Governing of Two	5181.246	8293.145	1745.127	2387.905
Due to Live Load Surcharge	2094.152	2865.485	592.489	693.067
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Horizontal Forces and Moments @ RL****1218.1 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	7.069	x	12.500	=	592.489 kN
M1	=	592.49	x	3.53	=	2094.152 kN.m		at Shaft Bottom
F3	=	6.705	x	8.269	x	12.500	=	693.067 kN
M3	=	693.07	x	4.13	=	2865.485 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	4.269	=	23.854 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	2.800	=	7.823 kN/m ²
F2	=	0.5	x	23.85	x	4.269	x	12.50
	=	636.449 kN						
F4	=	$\left(\frac{23.85 + 31.68}{2} \right) \times$			2.80	x	12.50	
	=	971.780 kN						
Total Force =		1608.229 kN						
M2	=	636.45	x	4.59	=	2923.195 kN.m		
M4	=	971.78	x	1.33	=	1296.606 kN.m		
Total Mome =		4219.80 kN.m		at Shaft Bottom				

Intensity for

triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 4.269 = 23.854 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 23.85 \times 4.269 = 636.449 \text{ kN}$$

$$F6 = \left(\frac{23.85 + 35.03}{2} \right) \times 4.00 \times 12.50$$

$$= 1472.072 \text{ kN}$$

$$\text{Total Force} = 2108.521 \text{ kN}$$

$$M2 = 636.45 \times 5.79 = 3686.934 \text{ kN.m}$$

$$M6 = 1472.07 \times 1.87 = 2757.889 \text{ kN.m}$$

$$\text{Total Mome} = 6444.82 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	4219.802	6444.823	1608.229	2108.521
Due to Minimum Fluid Pressure	3532.433	5654.041	1499.123	2051.291
Governing of Two	4219.802	6444.823	1608.229	2108.521
Due to Live Load Surcharge	2094.152	2865.485	592.489	693.067
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry CaseAs per Clause 219.5.4 , IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

$$\begin{aligned} \alpha h &= 0.000 \\ \alpha v &= 0.000 \\ \phi &= 30.00 & 0.524 \\ \delta &= 20.00 & 0.349 \\ \alpha &= 0.00 & 0.000 \\ \beta &= 0.00 & 0.000 \end{aligned}$$

$$\begin{aligned} \alpha h &= \text{HORIZONTAL SEISMIC COEFFICIENT} \\ \alpha v &= \text{VERTICAL SEISMIC COEFFICIENT} \\ \phi &= \text{ANGLE OF INTERNAL FRICTION OF SOIL} \\ \delta &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL} \\ \alpha &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,} \\ \beta &= \text{SLOPE OF EARTH FILL} \end{aligned}$$

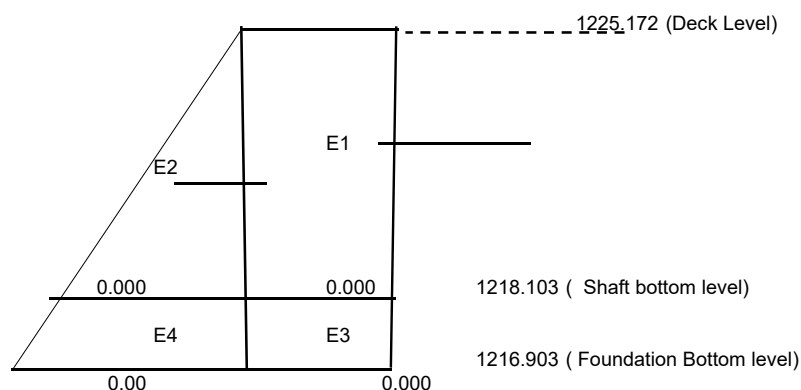
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.000 \\ 0.000 \end{matrix}$$

$$C_a = \begin{matrix} 1 & 2 \\ 0.279 & 0.279 \end{matrix}$$

$$\begin{aligned} C_a &= 0.279 \\ K_a &= 0.279 \\ \text{Dynamic Increment} &= 0.279 \quad -0.279 \quad 0.000 \end{aligned}$$

3 Earth Pressure :**DRY CASE (Seismic case)**

$$\begin{aligned} \text{Equivalent Live Load Surcharge height} &= 1.2 \text{ m} \\ \text{Assuming } \gamma_{\text{dry}} &= 20 \text{ kN/m}^3 \\ \gamma_{\text{water}} &= 10.00 \text{ kN/m}^3 \end{aligned}$$

**Earth Pressure Diagram for Dynamic Increment****Horizontal Forces and Moments @ RL****1218.1 m (at Shaft Base)****1216.9 m (at Foundation Bottom Level)**Due to Dynamic Live Load Surcharge

$$\begin{aligned} &= 0.000 \quad x \quad 20 \quad x \quad 1.2 \quad = \quad 0.000 \text{ kN/m}^2 \\ \text{at Shaft Bottom Level} & \\ E1 &= 0.000 \quad x \quad 7.069 \quad x \quad 12.500 \quad = \quad 0.000 \text{ kN} \\ M1 &= 0.000 \quad x \quad 4.736 \quad = \quad 0.000 \text{ kN.m} \\ \text{at Foundation Bottom Level} & \\ E3 &= 0.000 \quad x \quad 8.269 \quad x \quad 12.500 \quad = \quad 0.000 \text{ kN} \\ M3 &= 0.000 \quad x \quad 5.540 \quad = \quad 0.000 \text{ kN.m} \end{aligned}$$

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 7.069 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 8.269 = 0.000 \text{ kN/m}^2$$

$$E2 = 0.50 \times 0.00 \times 7.07 \times 12.500$$

$$= 0.000 \text{ kN}$$

$$E4 = 0.50 \times 0.00 \times 8.27 \times 12.500$$

$$= 0.000 \text{ kN}$$

$$M2 = 0.00 \times 3.53 = 0.000 \text{ kN.m (Shaft bottom level)}$$

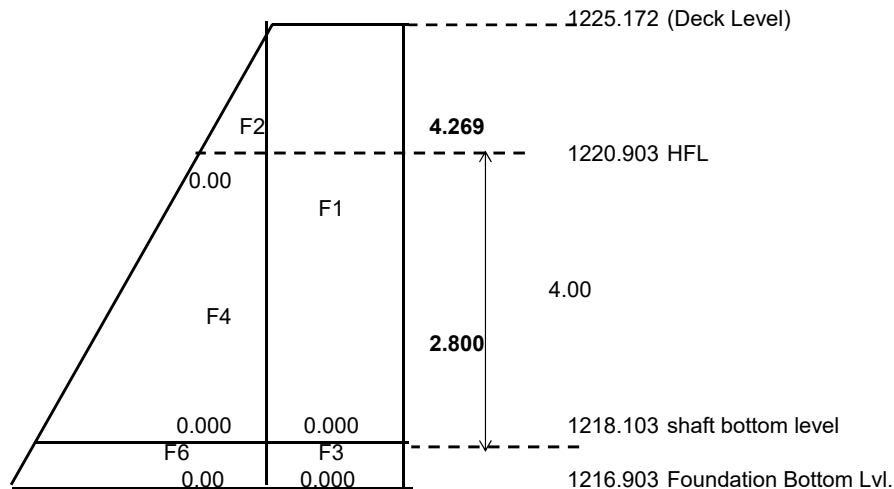
$$M4 = 0.00 \times 4.13 = 0.000 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	5181.246	8293.145	1745.127	2387.905
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	5181.246	8293.145	1745.127	2387.905
Due to Minimum Fluid Pressure	3532.433	5654.041	1499.123	2051.291
Governing of Two	5181.246	8293.145	1745.127	2387.905
Due to Live Load Surcharge (Static)	2094.152	2865.485	592.489	693.067
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1218.103 m (at Shaft Base)****1216.903 m (at Foundation Bottom Level)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.000	x	20	x	1.200	=	0.000 kN/m ²

at Shaft Bottom Level

F1	=	0.000	x	7.069	x	12.500	=	0.000 kN
M1	=	0.00	x	4.67	=	0.000 kN.m		

at Foundation Bottom Level

F3	=	0.000	x	8.269	x	12.500	=	0.000 kN
M3	=	0.00	x	5.46	=	0.000 kN.m		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.000	x	20	x	4.269	=	0.000 kN/m ²

(At Shaft bottom level) Below HFL	=	0.000	x	10	x	2.800	=	0.000 kN/m ²

(At Foundation bottom level) Below HFL	=	0.000	x	10	x	4.000	=	0.000 kN/m ²

F2	=	0.5	x	0.00	x	4.27	x	12.50
	=	0.000 kN						

F4	=	(0.00 + 0.00)	x	2.80	x	12.50		
	=	0.000 kN						

F6	=	(0.00 + 0.00)	x	4.00	x	12.50		
	=	0.000 kN						

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

M2	=	0.00	x	4.93	=	0.000 kN.m

M4	=	0.00	x	0.00	=	0.000 kN.m

Total Mome = 0.000 kN.m at Shaft Bottom

M2 = 0.00 x 6.13 = 0.000 kN.m

M6 = 0.00 x 0.00 = 0.000 kN.m

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	4219.802	6444.823	1608.229	2108.521
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	4219.802	6444.823	1608.229	2108.521
Due to Minimum Fluid Pressure	3532.433	5654.041	1499.123	2051.291
Governing of Two	4219.802	6444.823	1608.229	2108.521
Due to Live Load Surcharge(Static)	2094.152	2865.485	592.489	693.067
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

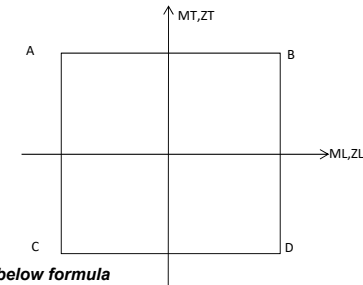
Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	932.33	kN	932.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1216.903 m

Properties of Footing Base:

A	=	102.500	m ²
ZL	=	140.083	m ³
ZT	=	213.542	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	0.910	1137.500	0.000	0.000
SIDL except Wearing Course	1			80.000	0.910	72.800	0.000	0.000
Wearing Course	1			137.500	0.910	125.125	0.000	0.000
				1467.500		1335.425		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.540	30.375	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.540	6.252	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	0.240	6.750	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	0.290	4.078	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.750	50.625	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.750	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.150	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.150	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.540	15.120	0.000	0.000
Approach Slab	1	25	6.563	164.063	0.240	39.375	0.000	0.000
				369.578		152.575		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	31.531	788.269	-1.975	-1556.831	0.000	0.000
Abutment Shaft	1	25	64.048	1601.188	0.805	1288.846	0.000	0.000
Back filling over heel slab	1	20	386.564	7731.281	-2.009	-15532.692	0.000	0.000
Front Filling over toe slab	1	20	73.906	1478.125	2.650	3917.604	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	45.156	1128.906	-1.683	-1900.326	0.000	0.000
Toe slab	1	25	29.219	730.469	2.536	1852.669	0.000	0.000
portion between heel & toe	1	25	18.000	450.000	0.750	337.500	0.000	0.000
Vertical Components of active earth pressure	1			869.126	-4.100	-3563.417	0.000	0.000
				15225.950		-15030.972		0.000
Total				17063.028		-13542.971		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.307	5432.685
due to Earth pressure	1	2387.905		8293.145

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-3.190	-3788.125
0.950	76.000	-3.190	-242.440
1.000	137.500	-3.190	-438.625
	1401.000		-4469.190
0.950	53.438	-3.560	-190.238
0.950	10.999	-3.560	-39.157
0.950	26.719	-3.860	-103.134
0.950	13.359	-3.810	-50.899
0.950	64.125	-3.350	-214.819
0.950	0.000	-3.350	0.000
0.950	0.000	-3.950	0.000
0.950	0.000	-3.950	0.000
0.950	26.600	-3.560	-94.696
0.950	155.859	-3.860	-601.617
	351.099		-1294.560
0.950	748.855	-6.075	-4549.296
0.950	1521.128	-3.295	-5012.221
0.950	7344.717	-6.109	-44869.398
0.950	1404.219	-1.450	-2035.573
0.950	0.000	0.000	0.000
0.950	1072.461	-5.783	-6202.399
0.950	693.945	-1.564	-1085.140
0.950	427.500	-3.350	-1432.125
0.950	825.670	-8.200	-6770.493
	14464.653		-73561.375
	16216.752		-79325.125

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5432.69	0.00	0.00
2387.90	8293.14	0.00	0.00
3121.655	13725.830	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Earth pressure	1.5	3581.857		12439.717
		4372.919		18296.744

Summary of Forces For SBC

P	17063.028	kN
ML	182.858	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		17063.028		-13542.971		0.000
CWLL-Max. Reaction case	1	932.327	0.910	848.417	2.411	2248.220
Vertical Components of LL Surcharge	1	252.256	-4.100	-1034.249	0.000	0.000
Total		18247.611		-13728.803		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.307	5432.685
due to Earth pressure	1	2387.905		8293.145
due to Live load surcharge	1	693.067		2865.485

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Earth pressure	1.5	3581.857		12439.717
due to Live load surcharge	1.2	831.680		3438.583
		5204.600		21735.326

Summary of Forces For SBC

P	18247.611	kN
ML	2862.512	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		17063.028		-13542.971		0.000
CWLL-Max. Reaction case	1	2561.336	0.910	2330.816	0.300	768.401
Vertical Components of LL Surcharge	1	252.256	-4.100	-1034.249	0.000	0.000
Total		19876.620		-12246.404		768.401

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
3581.86	12439.72	0.00	0.00
4372.919	18296.744	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16216.752		-79325.12
0.000		-3.190	0.00
0.950		-8.200	-1965.07
	16216.752		-81290.20

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5432.69	0.00	0.00
2387.90	8293.14	0.00	0.00
693.067	2865.485	0.000	0.000
3814.72	16591.32	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
3581.86	12439.72	0.00	0.00
831.68	3438.58	0.00	0.00
5204.600	21735.326	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	16216.75175		-79325.1248
0.000		-3.190	0.00
0.950		-8.200	-1965.07
	16216.752		-81290.20

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.307	5432.685
due to Earth pressure	1	2387.905		8293.145
due to Live load surcharge	1	693.067		2865.485

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Earth pressure	1.5	3581.857		12439.717
due to Live load surcharge	1.2	831.680		3438.583
		5204.600		21735.326

Summary of Forces For SBC		
P	19876.620	kN
ML	4344.911	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		1335.425		0.000
Substructure & Foundation -Portion 1				369.578		152.575		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	31.531	788.269	-1.975	-1556.831	0.000	0.000
Shaft above HFL	1	25	32.820	820.510	0.924	757.975	0.000	0.000
Shaft below HFL	1	15	31.227	468.406	0.805	377.035	0.000	0.000
Back filling above HFL over heel slab	1	20	226.791	4535.813	-1.975	-8958.230	0.000	0.000
Back filling below HFL over heel slab	1	10	167.344	1673.438	-2.054	-3436.745	0.000	0.000
Front Filling over toe slab	1	10	73.906	739.063	2.650	1958.802	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	45.156	677.344	-1.683	-1140.195	0.000	0.000
Toe slab	1	15	29.219	438.281	2.536	1111.602	0.000	0.000
Portion between Heel & Toe	1	15	18.000	270.000	0.750	202.500	0.000	0.000
Vertical Components of active earth pressure	1			767.439	-4.100	-3146.499	0.000	0.000
				11537.499		-13720.280		0.000
Total				13374.577		-12232.280		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-4469.190
	351.099		-1294.560
0.950	748.855	-6.075	-4549.296
0.950	779.485	-3.176	-2475.811
0.950	444.986	-3.295	-1466.259
0.950	4309.022	-6.075	-26177.308
0.950	1589.766	-6.154	-9782.947
0.950	702.109	-1.450	-1017.786
0.950	0.000	0.000	0.000
0.950	643.477	-5.783	-3721.439
0.950	416.367	-1.564	-651.084
0.950	256.500	-3.350	-859.275
0.950	729.067	-8.200	-5978.349
	10960.624		-57972.824
	12712.723		-63736.574

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.307	5432.685
due to Earth pressure	1	2108.521		6444.823

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Earth pressure	1.5	3162.781		9667.234
		3953.844		15524.261

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5432.69	0.00	0.00
2387.90	8293.14	0.00	0.00
693.067	2865.485	0.000	0.000
3814.72	16591.32	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
3581.86	12439.72	0.00	0.00
831.68	3438.58	0.00	0.00
5204.600	21735.326	0.000	0.000

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5432.69	0.00	0.00
2108.52	6444.82	0.00	0.00
2842.27	11877.51	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
3162.78	9667.23	0.00	0.00
3953.84	15524.26	0.00	0.00

Summary of Forces For SBC		
P	13374.577	kN
ML	-354.772	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		13374.577		-12232.280		0.000
CWLL-Min. Reaction case	1	466.273	0.910	424.309	3.109	1449.594
Vertical Components of LL Surcharge	1	252.256	-4.100	-1034.249	0.000	0.000
Total		14093.106		-12842.220		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.307	5432.685
due to Earth pressure	1	2108.521		6444.823
due to Live load surcharge	1	693.067		2865.485

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Earth pressure	1.5	3162.781		9667.234
due to live load surcharge	1.2	831.680		3438.583
		4785.524		18962.843

Summary of Forces For SBC		
P	14093.106	kN
ML	1900.773	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		13374.577		-12232.280		0.000
CWLL-Min. Reaction case	1	858.664	0.910	781.384	0.300	257.599
Vertical Components of LL Surcharge	1	252.256	-4.100	-1034.249	0.000	0.000
Total		14485.497		-12485.144		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1224.307	5432.685
due to Earth pressure	1	2108.521		6444.823
due to Live load surcharge	1	693.067		2865.485

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	12712.723		-63736.574
0.000	0.000	-3.190	0.00
0.950	239.643	-8.200	-1965.072
	12952.366		-65701.646

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5432.69	0.00	0.00
2108.52	6444.82	0.00	0.00
693.067	2865.485	0.000	0.000
3535.34	14742.99	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
3162.78	9667.23	0.00	0.00
831.680	3438.583	0.000	0.000
4785.52	18962.84	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	12712.723		-63736.574
0.000	0.000	-3.190	0.00
0.950	239.643	-8.200	-1965.072
	12952.366		-65701.646

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	5432.69	0.00	0.00
2108.52	6444.82	0.00	0.00
693.067	2865.485	0.000	0.000
3535.34	14742.99	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Earth pressure	1.5	3162.781		9667.234
due to live load surcharge	1.2	831.680		3438.583
		4785.524		18962.843

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
3162.78	9667.23	0.00	0.00
831.680	3438.583	0.000	0.000
4785.52	18962.84	0.00	0.00

Summary of Forces For SBC

P	14485.497	kN
ML	2257.849	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

ah= 0.000 In Longitudinal direction

ah= 0.000 In Transverse direction

av= 0.000 In Vertical direction

Weight of shaft below Ground level

= 533.433 kN

Weight of back fill below Ground level

= 1912.500 kN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	0.910	1137.500	0.000	1224.840		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	0.910	72.800	0.000	1225.621		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	0.910	125.125	0.000	1225.172		0.000	0.000	0.000
				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.540	30.375	0.000	1224.872	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.000	0.000	0.000	0.540	6.252	0.000	1224.510	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				0.240	6.750						
Bracket - Tapered portion	1	25	0.563	14.063				0.290	4.078						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.750	50.625	0.000	1224.156	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.750	0.000	0.000	1224.006	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000	1225.172	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000	1225.172	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.540	15.120				0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063				0.240	39.375				0.000	0.000	0.000
				369.578	0.000	0.000	0.000		152.575	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	31.531	788.269	0.000	0.000	0.000	-1.975	-1556.831	0.000	1221.534	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	64.048	1601.188	0.000	0.000	0.000	0.805	1288.846	0.000	1221.955	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	386.564	7731.281	0.000	0.000	0.000	-2.009	-15532.692	0.000	1221.534	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	73.906	1478.125				2.650	3917.604				0.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	0.000
Heel slab	1	25	45.156	1128.906				-1.683	-1900.326				0.000	0.000	0.000
Toe slab	1	25	29.219	730.469				2.536	1852.669				0.000	0.000	0.000
portion between heel & toe	1	25	18.000	450.000				0.750	337.500				0.000	0.000	0.000
Vertical component of active earth pressure	1			869.126				-4.100	-3563.417				0.000	0.000	0.000
Vertical component of dynamic increment of earth pressure	1			0.000				-4.100	0.000				0.000	0.000	0.000
				15225.950	0.000	0.000	0.000		-15030.972	0.000		0.000		0.000	0.000
Total =				17063.028	0.000	0.000	0.000		-13542.971	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-3.190	-3788.125	0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL

Design Calculation

RODIC

Stability of Foundation

SIDL except Wearing Course	0.95			76.000	0.000	-3.190	-242.440	0.000
Wearing Course	1.00			137.500	0.000	-3.190	-438.625	0.000
Substructure & Foundation -Portion 1				1401.000	0.000		-4469.190	0.000
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-3.560	-190.238	0.000
Dirt Wall-Tapered portion	0.95	25	0.463	10.999	0.000	-3.560	-39.157	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-3.350	-214.819	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-3.350	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-3.950	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-3.950	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-3.560	-94.696	
Approach Slab	0.95	25	6.563	155.859		-3.860	-601.617	
Substructure & Foundation -Portion 2				351.099	0.000		-1140.527	0.000
Abutment Shaft	0.95	25	64.048	1521.128	0.000	-3.295	-5012.221	0.000
Solid Return wall	0.95	25	31.531	748.855	0.000	-6.075	-4549.296	0.000
Back filling over heel slab	0.95	20	386.564	7344.717	0.000	-6.109	-44869.398	0.000
Front Filling over Pile Cap	0.95	20	73.906	1404.219		-1.450	-2035.573	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	45.156	1072.461		-5.783	-6202.399	
Toe slab	0.95	25	29.219	693.945		-1.564	-1085.140	
portion between heel & toe	0.95	25	18.000	427.500		-3.350	-1432.125	
Vertical component of active earth pressure	0.95			825.670		-8.200	-6770.493	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.200	0.000	
				14464.653	0.000		-73561.37	0.000
Total =				16216.752	0.000		-79171.09	0.000

0.000

0.000

1.0	0.000	1224.872	0.000
1.0	0.000	1224.510	0.000
1.0	0.000	1224.156	0.000
1.0	0.000	1224.006	0.000
1.0	0.000	1225.172	0.000
1.0	0.000	1225.172	0.000
	0.000		0.000
1.0	0.000	1221.955	0.000
1.0	0.000	1221.534	0.000
1.0	0.000	1221.534	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.307	5432.685	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2387.905			8293.145	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.03
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3581.857		12439.72
due to dynamic Earth pressure	1.5	0.000		0.00
		4372.919		18296.744

Summary of Forces For SBC

	Downward	Upward	
P	17063.028	17063.028	kN
ML	182.858	182.858	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2387.90	8293.14						
3121.65	13725.83	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3581.857	12439.717	0.000	0.000
0.000	0.000	0.000	0.000
4372.92	18296.74	0.00	0.00

Summary of Restoring Forces

Vertical Load	16216.752	kN
Moment	-79171.091	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Forces from Substructure				15595.528	0.000	0.000	0.000		-14878.396	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	0.910	169.683	0.000	1226.372		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			50.45				-4.100	-206.850				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.100	0.000				0.000	0.000	
Total =				17299.945	0.000	0.000	0.000		-13580.138	0.000		0.000		449.644	0.000
0.000															

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-4469.19	0.000
Forces from Substructure				14815.752	0.000	0.000	-74701.90	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.190	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-8.200	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.200	0.00	
Total =				16216.752	0.000		-79171.09	0.000
0.000								

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.307	5432.685	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2387.905			8293.145	
due to Live load surcharge	0.20	138.613			573.097	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2387.90	8293.14						
138.61	573.10						
3260.27	14298.93	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3581.857		12439.717
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		4372.919		18296.744

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3581.857	12439.717		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4372.92	18296.74	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	17299.945	17299.945	KN
ML	718.789	718.789	kNm

Summary of Restoring Forces

Vertical Load	16216.752	kN
Moment	-79171.091	kNm

MT	449.644	449.644	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = 0.3 x $\alpha_h \times P$ (kN)	Fv = 0.3 x $\alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		152.575	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		31.53	788.27	0.000	0.000	0.000	-1.98	-1556.831	0.000	1221.53	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	32.820	820.510	0.000	0.000	0.000	0.924	757.975	0.000	1222.455	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	31.227	468.406	0.000	0.000	0.000	0.805	377.035	0.000	1220.403	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	226.791	4535.813	0.000	0.000	0.000	-1.975	-8958.230	0.000	1223.038	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	167.344	1673.438	0.000	0.000	0.000	-2.054	-3436.745	0.000	1219.203	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	73.906	739.063				2.650	1958.802				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	45.156	677.344				-1.683	-1140.195				0.000	0.000	
Toe slab	1	15	29.219	438.281				2.536	1111.602				0.000	0.000	
portion between heel & toe	1	15	18.000	270.000				0.750	202.500				0.000	0.000	
Vertical component of active earth pressure	1			767.439				-4.100	-3146.499				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-4.100	0.000				0.000	0.000	
				11537.499	0.000	0.000	0.000		-13830.586	0.000		0.000		0.000	0.000
Total =				13374.577	0.000	0.000	0.000		-12342.586	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x $\alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-4469.190	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-1140.527	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	31.53075	748.855	0.000	-6.08	-4549.296	0.000
Shaft above HFL	0.95	25	32.820	779.485	0.000	-3.176	-2475.811	0.000
Shaft below HFL	0.95	15	31.227	444.986	0.000	-3.295	-1466.259	0.000
Back filling above HFL over heel slab	0.95	20	226.791	4309.022	0.000	-6.075	-26177.308	0.000
Back filling below HFL over heel slab	0.95	10	167.344	1589.766	0.000	-6.154	-9782.947	0.000
Front Filling over Pile Cap	0.95	10	73.906	702.109		-1.450	-1017.786	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	45.156	643.477		-5.783	-3721.439	
Toe slab	0.95	15	29.219	416.367		-1.564	-651.084	
portion between heel & toe	0.95	15	18.000	256.500		-3.350	-859.275	
Vertical component of active earth pressure	0.95			729.067		-8.200	-5978.349	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-8.200	0.000	
				10960.624	0.000		-57972.824	0.000
Total =				12712.723	0.000		-63582.54	0.000

0.000

0.000

For Overturning or Sliding Effect

Load Factor	FL = $\alpha_h \times P$ (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1221.534	0.000
1.0	0.000	1222.455	0.000
1.0	0.000	1220.403	0.000
1.0	0.000	1223.038	0.000
1.0	0.000	1219.203	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.307	5432.685	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2108.521			6444.823	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	3162.781		9667.234
due to dynamic Earth pressure	1.5	0.000		0.000
		3953.844		15524.261

Summary of Forces For SBC

	Downward	Upward	
P	13374.577	13374.577	kN
ML	-465.078	-465.078	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2108.52	6444.82						
2842.27	11877.51	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3162.781	9667.234		
0.000	0.000		
3953.84	15524.26	0.00	0.00

Summary of Restoring Forces

Vertical Load	12712.723	kN
Moment	-63582.540	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Lloads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Forces from Substructure				11907.077	0.000	0.000	0.000		-13678.011	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	0.910	84.862	0.000	1226.372		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			50.45				-4.100	-206.850				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-4.100	0.000				0.000	0.000	
Total =				13518.283	0.000	0.000	0.000		-12464.573	0.000		0.000		289.919	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Lloads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-4469.190	0.000
Forces from Substructure				11311.723	0.000		-59113.350	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.19	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.190	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.200	0.000	0.000
Total =				12712.723	0.000		-63585.73	0.000
					0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ

Design Calculation

RODIC

Stability of Foundation

due to Superstructure	1	733.750	0.000	1224.307	5432.685	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2108.521			6444.823	
due to Live load surcharge	0.20	138.613			573.097	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	3162.781		9667.234
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		3953.844		15524.261

Summary of Forces For SBC

	Downward	Upward	
P	13518.283	13518.283	kN
ML	-13.969	-13.969	kNm
MT	289.919	289.919	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x α_h x P (kN)	FT = α_h x P (kN)	Fv = 0.3 x α_{av} x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		1335.425	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		152.575	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				15225.950	0.000	0.000	0.000		-15030.972	0.000		0.000		0.000	0.000
Total =				17063.028	0.000	0.000	0.000		-13542.971	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x α_{av} x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-4469.19	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-1140.53	0.000
Substructure & Foundation -Portion 2				14464.653	0.000		-73561.37	0.000
Total =				16216.752	0.000		-79171.09	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x α_h x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.307	5432.685	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2387.905			8293.145	

733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2108.52	6444.82						
138.61	573.10						
2980.88	12450.60	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3162.781	9667.234		
0.000	0.000		
0.000	0.000		
0.000	0.000		
3953.84	15524.26	0.00	0.00

Summary of Restoring Forces

Vertical Load	12712.723	kN
Moment	-63585.730	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2387.90	8293.14						
3121.65	13725.83	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.027
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	3581.857		12439.7172
due to dynamic Earth pressure	1.5	0.000		0
		4372.919		18296.744

Summary of Forces For SBC

	Downward	Upward	
P	17063.028	17063.028	KN
ML	182.858	182.858	kNm
MT	0.000	0.000	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	17299.945	0.000	-13580.14	0.000	449.644
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1224.307	5432.685	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	2387.905			8293.145	
due to Live load surcharge	0.2	138.613			573.097	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1224.307	5857.027
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	3581.86		12439.717
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		4372.92		18296.744

Summary of Forces For SBC

	Downward	Upward	
P	17299.945	17299.945	KN
ML	718.789	718.789	kNm
MT	449.644	449.644	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation****Summary of Restoring Forces**

Vertical Load	16216.752	kN
Moment	-79171.091	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3581.857	12439.717		
0.000	0.000		
4372.92	18296.74	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	16216.752	0.000	-79171.09	0.000
		0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2387.90	8293.14						
138.61	573.10						
3260.27	14298.93	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3581.857	12439.717		
0.000	0.000		
0.000	0.000		
0.000	0.000		
4372.92	18296.74	0.00	0.00

Summary of Restoring Forces

Vertical Load	16216.752	kN
Moment	-79171.091	kNm

Vertical Forces For Restoring or Resisting Effect

Lloads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Superstructure		1467.500	0.000	1335.425	0.000	0.000
Substructure & Foundation -Portion 1		369.578	0.000	152.575	0.000	0.000
Substructure & Foundation -Portion 2		11537.499	0.000	-13830.586	0.000	0.000
Total =		13374.577	0.000	-12342.586	0.000	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1224.31	5432.69	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	2108.52			6444.82	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1224.307	5857.03
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	3162.781		9667.23
due to dynamic Earth pressure	1.5	0.000		0.00
		3953.844		15524.26

Summary of Forces For SBC

	Downward	Upward	
P	13374.577	13374.577	kN
ML	-465.078	-465.078	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Lloads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times e_{L1}$	MLs due to F_v	$MT = P \times e_T$
Total =	13518.283	0.000	-12464.57	0.000	289.919

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1224.307	5432.685	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	2108.521			6444.823	
due to Live load surcharge	0.2	138.613			573.097	

Horizontal Forces For Overturning or Sliding Effect

Lloads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times e_{L2}$	MLs due to F_v
Superstructure		1401.000	0.000		-4469.190	0.000
Substructure & Foundation		351.099	0.000		-1140.527	0.000
Substructure & Foundation		10960.624	0.000		-57972.824	0.000
Total =		12712.723	0.000		-63582.540	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2108.52	6444.82						
2842.27	11877.51	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3162.781	9667.234		
0.000	0.000		
3953.84	15524.26	0.00	0.00

Summary of Restoring Forces

Vertical Load	12712.723	kN
Moment	-63582.540	kNm

Vertical Forces For Restoring or Resisting Effect

Lloads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times e_{L2}$	MLs due to F_v
Total =	12712.723	0.000		-63585.73	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	5432.69	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2108.52	6444.82						
138.61	573.10						
2980.88	12450.60	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1224.307	5857.03
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	3162.78		9667.23
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		3953.84		15524.26

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	5857.03	0.00	0.00
0.00	0.00	0.00	0.00
3162.781	9667.234		
0.000	0.000		
0.000	0.000		
0.000	0.000		
3953.84	15524.26	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	13518.283	13518.283	kN
ML	-13.969	-13.969	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	12712.723	kN
Moment	-63585.730	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000 kN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1226.372 -	1216.903)	=	0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000 kN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1226.372 -	1216.903)	=	0.000 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force = $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_p$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	17063.028	182.858	0.000	165.163	167.774	165.163	167.774	167.774	165.163	4372.919	11351.726	2.60	18296.744	79325.12	4.34
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	18247.611	2862.512	2248.220	168.119	208.988	147.063	187.932	208.988	147.063	5204.600	11351.726	2.18	21735.326	81290.20	3.74
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	19876.620	4344.911	768.401	166.500	228.533	159.303	221.336	228.533	159.303	5204.600	11351.726	2.18	21735.326	81290.20	3.74
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	13374.577	-354.772	0.000	133.016	127.951	133.016	127.951	133.016	127.951	3953.844	8898.906	2.25	15524.261	63736.57	4.11
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	14093.106	1900.773	1449.594	130.713	157.851	117.136	144.274	157.851	117.136	4785.524	9066.656	1.89	18962.843	65701.65	3.46
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	14485.497	2257.849	257.599	126.410	158.646	123.998	156.233	158.646	123.998	4785.524	9066.656	1.89	18962.843	65701.65	3.46
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	17063.028	182.858	0.000	165.163	167.774	165.163	167.774	167.774	165.163	4372.919	11351.726	2.60	18296.744	79171.09	4.33
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	17299.945	718.789	449.644	165.754	176.017	161.543	171.805	176.017	161.543	4372.919	11351.726	2.60	18296.744	79171.09	4.33
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	13374.577	-465.078	0.000	133.804	127.164	133.804	127.164	133.804	127.164	3953.844	8898.906	2.25	15524.261	63582.54	4.10
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	13518.283	-13.969	289.919	133.343	133.144	130.628	130.428	133.343	130.428	3953.844	8898.906	2.25	15524.261	63585.73	4.10
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	17063.028	182.858	0.000	165.163	167.774	165.163	167.774	167.774	165.163	4372.919	11351.726	2.60	18296.744	79171.09	4.33

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	17299.945	718.789	449.644	165.754	176.017	161.543	171.805	176.017	161.543	4372.919	11351.726	2.60	18296.744	79171.09	4.33
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	13374.577	-465.078	0.000	133.804	127.164	133.804	127.164	133.804	127.164	3953.844	8898.906	2.25	15524.261	63582.54	4.10
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	13518.283	-13.969	289.919	133.343	133.144	130.628	130.428	133.343	130.428	3953.844	8898.906	2.25	15524.261	63585.73	4.10
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A1 for Minor Bridge at Ch. 94+075**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.123m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Design Calculation

RODIC

INPUT

Abutment Cap

Width of Abutment cap of Uniform portion	=	0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	=	0.720m	0.720m
Projection of Abutment Cap (Span Side)	=	0.000m	0.000m
Projection of Abutment Cap Back Side	=	0.000m	0.000m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.000m	
Length of Abutment Cap at top (Uniform portion)	=	12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.779m	0.779m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	2.600m	
Thickness of Return wall at Top	=	0.500m	
Thickness of Return wall at Bottom	=	0.500m	

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m	
Height of wall at abutment	=	0.000m	
Length of Return wall	=	0.000m	
Thickness of Return wall at Top	=	0.000m	
Thickness of Return wall at Bottom	=	0.000m	

Foundation**Along Traffic Direction:**

Total Width of Footing	=	5.400m	
abutment pedestal width	=	1.000m	
abutment pedestal Height	=	1.000m	
Width of Toe Slab	=	1.800m	
Width of Heel Slab	=	2.600m	
Thickness of Toe slab at tip	=	0.500m	
Thickness of Toe slab near shaft	=	1.000m	
Thickness of heel slab at tip	=	0.500m	
Thickness of heel slab near shaft	=	1.000m	
Width of backfill on heel slab	=	2.600m	
Thickness of heel slab at back fill edge	=	1.000m	
Height of back fill at bottom edge of heel slab	=	5.327m	
Height of back fill at back fill edge of heel slab	=	4.827m	

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)	
Width of foundation -Tapering portion	=	12.500m (skew dimension)	

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
1	Minor Bridge	94+075	1163.889	1160.919	1157.919	5.97

Levels

Deck Level at Median Edge=	1163.889m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1163.604m	Height of Superstructure	=	0.800m
Deck level at center line =	1163.889m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1163.024m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1163.023m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lv (uniform portion ends)	1162.723m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lv (corbel portion ends)	1162.723m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1162.723m	Height (Avg.) of Dirt Wall	=	0.723m
Ground level/LBL =	1160.919m	Abutment shaft Above G.L	=	1.804m
Abutment shaft bottom level =	1158.919m	Abutment Shaft below G.L	=	2.000m
Foundation level =	1157.919m	Height of abutment shaft	=	3.804m
HFL	1161.919m	MSL	=	1160.919m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D (HYSD Steel)	
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa (1/1.15 * fy)	
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8 N/mm ²	
Maximum tensile stress in steel under rare combination	=	300 N/mm ²	
Creep Coefficient			
For Abutment Shaft	=	1.2 for 365 days	
For Footing	=	1.2 for 365 days	

Clear Cover to Reinforcement

Earth Face	=	75 mm
Non-Earth Face	=	50 mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft = 0.160m in longitudinal direction
 Dist between c.g of superstructure and c.g. of abutment shaft = 0.000m in Transverse direction
 C.G. of crash barrier above deck level = 0.449m

From Superstructure analysis

Dead Load

Self weight of Slab = 0.80 x 10.00 x 12.50 x 25.00
 = 2500.00 KN
 Reaction at one end = 1250.00 KN
 Transverse Eccentricity = 0.000 m

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier = 2 x 8.00 x 10.00
 = 160.00 KN
 Reaction at one end = 80.00 KN
 Transverse Eccentricity = 0.00 m

Reaction Due to Wearing Course only

Weight due to Wearing Coat = 2.2 x 10 x 12.5
 = 275 KN
 Reaction at one end = 137.5 KN
 Transverse Eccentricity = 0.00 m

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transverse ecc
2561.34	0.30

Min CWLL

Vertical	Transverse ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap = 1.144
 Impact Factor for Abut. Shaft Base = 1.000

VOLUME CALCULATION

C.G. Of Footing = 2.700 m
 C.G. Of shaft from toe tip = 2.300 m
 Distance between c.g. of shaft and footing = 0.400 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.190	-2.510	0.000
-Trapering portion	1	12.50	0.300	0.123	0.463	-0.210	0.190	-2.510	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	-0.110	-2.810	0.000
(Corbel) 0.5	1	12.50	0.300	0.300	0.563	-0.460	-0.060	-2.760	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.400	-2.300	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.400	-2.300	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.750	0.804	7.533	0.125	0.525	-2.175	0.000
Shaft below HFL	1	12.50	0.890	2.500	27.800	0.053	0.453	-2.247	0.000
Solid Return Wall	2	2.60	0.500	5.220	13.572	-1.800	-1.400	-4.100	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	-0.100	-2.800	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	-0.100	-2.800	0.000
Footing									
Heel Slab	1	12.50	2.600	0.750	24.375		-1.256	-3.956	0.000
Toe Slab	1	12.50	1.800	0.750	16.875		1.700	-1.000	0.000
Portion between Heel and Toe	1	12.50	1.000	1.000	12.500		0.400	-2.300	0.000
Back filling above HFL over Heel Slab	1	12.50	2.600	1.970	64.025		-1.400	-4.100	0.000
Back filling below HFL over Heel Slab	1	12.50	2.600	3.250	105.625		-1.433	-4.133	0.000
Backfill above Heel slab	1	12.50	2.600	5.077	165.019		-1.421	-4.121	0.000
Front Filling over Toe Slab	1	12.50	1.800	2.250	50.625		1.767	-0.933	0.000
Side filling between heel and toe	1	0.00	1.000	2.250	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	-0.110	-2.810	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.059	1.970	1.457		0.026	-2.674	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.221	3.250	8.971		-0.026	-2.726	0.000

		L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN		-0.210	0.190	-2.510

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviciilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case
	Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
	Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFL Case	Case 3 : DL+SIDL-Normal HFL Case
	Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case
	Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case
	Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case
	Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case
	Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case
	Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone 5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.)
or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

$$= 5.104 \text{ m}$$

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

$$= 5.681 \text{ m}$$

Abutment Cap Top Level - Foundation Level

$$= 5.104 \text{ m}$$

Dimensions of Abutment Shaft

Length	=	12.50	m
Width	=	0.86	m
Moment of Inertia , $I_{\text{longitudinal}}$	=	0.663	m^4
Moment of Inertia , $I_{\text{transverse}}$	=	139.974	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction

Force	=	241.489	KN
D	=	1467.50	KN
T	=	0.1559	sec

Transverse Direction

Force	=	43617.048	KN
D	=	1747.220	KN
T	=	0.0127	sec

Hard or Rocky Strata

$$S_a/g = 2.5$$

$$S_a/g = 2.5$$

Seismic Coeff. In Longitudinal Direction = 0

Seismic Coeff. In Transverse Direction = 0

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

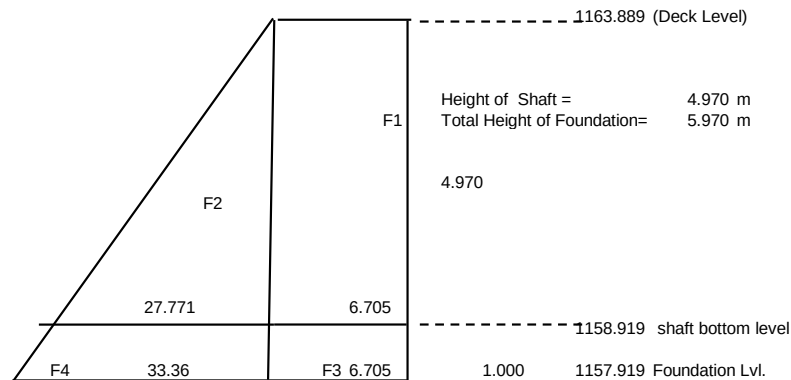
Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m

Assuming

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL					1158.919 m (at Shaft Base)			
@ RL					1157.919 m (at Foundation Level)			
Due to Live Load Surcharge								
Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m ²
F1	=	6.705	x	4.970	x	12.500	=	416.561 kN
M1	=	416.56	x	2.48	=	1035.154 kN.m	at Shaft Bottom	
F3	=	6.705	x	5.970	x	12.500	=	500.376 kN
M3	=	500.376	x	2.985	=	1493.623 kN.m	at Foundation	

Due to Active Earth Pressure

$$\begin{aligned} \text{Intensity for triangular portion (At Shaft bottom level)} &= 0.279 \times 20 \times 4.970 = 27.771 \text{ kN/m}^2 \\ F2 &= 0.5 \times 27.77 \times 4.970 \times 12.50 \\ &= \mathbf{862.628 \text{ kN}} \end{aligned}$$

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

$$M2 = 862.63 \times 2.09 = \mathbf{1800.651 \text{ kN.m}} \quad \text{at Shaft Bottom}$$

$$\begin{aligned} \text{Intensity for triangular portion (At Foundation level)} &= 0.279 \times 20 \times 5.970 = 33.358 \text{ kN/m}^2 \\ F4 &= 0.5 \times 33.36 \times 5.970 \times 12.50 \\ &= \mathbf{1244.686 \text{ kN}} \end{aligned}$$

$$M4 = 1244.69 \times 2.51 = \mathbf{3120.925 \text{ kN.m}} \quad \text{at Foundation}$$

Force Due To Fluid Pressure

$$\text{As per Cl. 214.1 of IRC :6 -2014} \quad \gamma_{\text{fluid}} = 4.8 \text{ kN/m}^3$$

$$\begin{aligned} \text{Intensity for triangular portion (At Shaft bottom level)} &= 4.800 \times 4.970 = 23.856 \text{ kN/m}^2 \\ F &= 0.5 \times 23.856 \times 4.970 \times 12.500 \\ &= \mathbf{741.027 \text{ kN}} \end{aligned}$$

$$M = 741.03 \times 1.657 = \mathbf{1227.635 \text{ kN.m}} \quad \text{at Shaft Bottom}$$

$$\begin{aligned} \text{Intensity for triangular portion (At Foundation level)} &= 4.800 \times 5.970 = 28.66 \text{ kN/m}^2 \\ F &= 0.5 \times 28.656 \times 5.97 \times 12.500 \\ &= \mathbf{1069.227 \text{ kN}} \end{aligned}$$

$$M = 1069.23 \times 1.990 = \mathbf{2127.762 \text{ kN.m}} \quad \text{at Foundation}$$

Intensity of Passive pressure

$$\begin{aligned} &= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2 \\ \text{Force due to passive @ Foundation, F} &= 0.5 \times 0.000 \times 12.50 \\ &= \mathbf{0.000 \text{ kN}} \end{aligned}$$

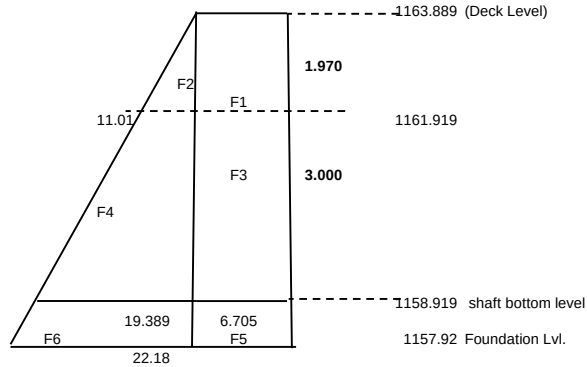
$$\begin{aligned} \text{Moment due to passive @ Foundation, M} &= 0.000 \times 0.000 = \mathbf{0.000 \text{ kN.m}} \quad \text{at Foundation} \end{aligned}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	1800.651	3120.925	862.628	1244.686
Due to Minimum Fluid Pressure	1227.635	2127.762	741.027	1069.227
Governing of Two	1800.651	3120.925	862.628	1244.686
Due to Live Load Surcharge	1035.154	1493.623	416.561	500.376
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279	active component
	Kph	=	3.766	passive component
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL 1158.9 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	4.970	x	12.500	=	416.561 kN
M1	=	416.56	x	2.48	=	1035.154 kN.m		at Shaft Bottom
F3	=	6.705	x	5.970	x	12.500	=	500.376 kN
M3	=	500.38	x	2.98	=	1493.623 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	1.970	=	11.008 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	3.000	=	8.382 kN/m ²
F2	=	0.5	x	11.01	x	1.970	x	12.50
	=	135.532 kN						
F4	=	(11.01 + 19.39)	x	3.00	x	12.50		
	=	569.943 kN						
Total Force	=	705.475 kN						
M2	=	135.53	x	3.83	=	518.737 kN.m		
M4	=	569.94	x	1.36	=	776.337 kN.m		
Total Mome	=	1295.07 kN.m						at Shaft Bottom

Design Calculation

RODIC

Earth_Normal HFL

Intensity for
triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 1.970 = 11.008 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 11.01 \times 1.970 \times 12.50 = 135.532 \text{ kN}$$

$$F6 = \left(\frac{11.01 + 22.18}{2} \right) \times 4.00 \times 12.50 = 829.769 \text{ kN}$$

$$\text{Total Force} = 965.302 \text{ kN}$$

$$M2 = 135.53 \times 4.83 = 654.270 \text{ kN.m}$$

$$M6 = 829.77 \times 1.78 = 1473.283 \text{ kN.m}$$

$$\text{Total Mome} = 2127.55 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

$$\text{Force due to passive @ Foundation, F} = 0.5 \times 0.000 \times 0.00 \times 12.50$$

$$= 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	1295.074	2127.553	705.475	965.302
Due to Minimum Fluid Pressure	1227.635	2127.762	741.027	1069.227
Governing of Two	1295.074	2127.762	741.027	1069.227
Due to Live Load Surcharge	1035.154	1493.623	416.561	500.376
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

$$\begin{aligned} \alpha h &= 0.000 \\ \alpha v &= 0.000 \\ \phi &= 30.00 & 0.524 \\ \delta &= 20.00 & 0.349 \\ \alpha &= 0.00 & 0.000 \\ \beta &= 0.00 & 0.000 \end{aligned}$$

$$\begin{aligned} \alpha h &= \text{HORIZONTAL SEISMIC COEFFICIENT} \\ \alpha v &= \text{VERTICAL SEISMIC COEFFICIENT} \\ \phi &= \text{ANGLE OF INTERNAL FRICTION OF SOIL} \\ \delta &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL} \\ \alpha &= \text{ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,} \\ \beta &= \text{SLOPE OF EARTH FILL} \end{aligned}$$

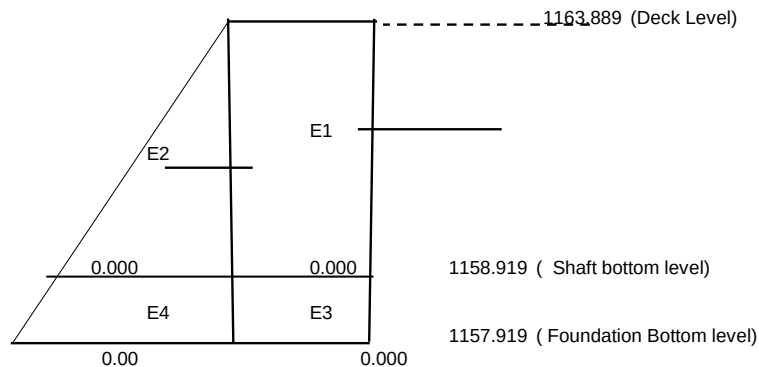
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \begin{matrix} 0.000 \\ 0.000 \end{matrix}$$

$$C_a = \begin{matrix} 1 & 2 \\ 0.279 & 0.279 \end{matrix}$$

$$\begin{aligned} C_a &= 0.279 \\ K_a &= 0.279 \\ \text{Dynamic Increment} &= 0.279 \quad -0.279 \quad 0.000 \end{aligned}$$

3 Earth Pressure : DRY CASE (Seismic case)

$$\begin{aligned} \text{Equivalent Live Load Surcharge height} &= 1.2 \text{ m} \\ \text{Assuming } \gamma_{\text{dry}} &= 20 \text{ kN/m}^3 \\ \gamma_{\text{water}} &= 10.00 \text{ kN/m}^3 \end{aligned}$$

**Earth Pressure Diagram for Dynamic Increment**

Horizontal Forces and Moments @ RL**1158.9 m (at Shaft Base)****1157.9 m (at Foundation Bottom Level)****Due to Dynamic Live Load Surcharge**

=	0.000	x	20	x	1.2	=	0.000 kN/m ²
<u>at Shaft Bottom Level</u>							
E1	=	0.000	x	4.970	x	12.500	= 0.000 kN
M1	=	0.000	x	3.330			= 0.000 kN.m
<u>at Foundation Bottom Level</u>							
E3	=	0.000	x	5.970	x	12.500	= 0.000 kN
M3	=	0.000	x	4.000			= 0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

=	0.000	x	20	x	4.970	=	0.000 kN/m ²

(at Foundation Bottom Level)

=	0.000	x	20	x	5.970	=	0.000 kN/m ²

E2	=	0.50	x	0.00	x	4.97	x	12.500
	=	0.000	kN					

E4	=	0.50	x	0.00	x	5.97	x	12.500
	=	0.000	kN					

M2	=	0.00	x	2.48	=	0.000	kN.m	(Shaft bottom level)

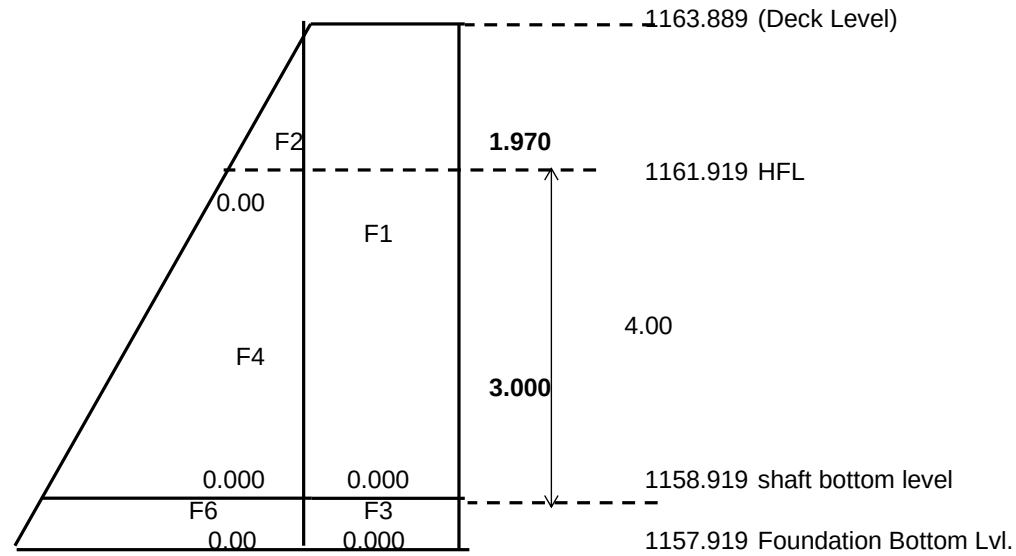
M4	=	0.00	x	2.98	=	0.000	kN.m	(Foundation Bottom level)

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	1800.651	3120.925	862.628	1244.686
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	1800.651	3120.925	862.628	1244.686
Due to Minimum Fluid Pressure	1227.635	2127.762	741.027	1069.227
Governing of Two	1800.651	3120.925	862.628	1244.686
Due to Live Load Surcharge (Static)	1035.154	1493.623	416.561	500.376
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram**

Horizontal Forces and Moments @ RL

1158.919 m (at Shaft Base)

1157.919 m (at Foundation Bottom Level)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.000	x	20	x	1.200	=	0.000 kN/m ²

at Shaft Bottom Level

F1	=	0.000	x	4.970	x	12.500	=	0.000 kN
M1	=	0.00	x	3.28	=	0.000 kN.m		

at Foundation Bottom Level

F3	=	0.000	x	5.970	x	12.500	=	0.000 kN
M3	=	0.00	x	3.94	=	0.000 kN.m		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

$$\text{Upto HFL} = 0.000 \times 20 \times 1.970 = 0.000 \text{ kN/m}^2$$

$$\text{(At Shaft bottom level) Below HFL} = 0.000 \times 10 \times 3.000 = 0.000 \text{ kN/m}^2$$

$$\text{(At Foundati bottom level) Below HFL} = 0.000 \times 10 \times 4.000 = 0.000 \text{ kN/m}^2$$

$$F2 = 0.5 \times 0.00 \times 1.97 = 12.50$$

$$= 0.000 \text{ kN}$$

$$F4 = \frac{(0.00 + 0.00)}{2} \times 3.00 = 12.50$$

$$= 0.000 \text{ kN}$$

$$F6 = \frac{(0.00 + 0.00)}{2} \times 4.00 = 12.50$$

$$= 0.000 \text{ kN}$$

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

$$M2 = 0.00 \times 3.98 = 0.000 \text{ kN.m}$$

$$M4 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

$$\text{Total Mome} = 0.000 \text{ kN.m} \quad \text{at Shaft Bottom}$$

$$M2 = 0.00 \times 4.98 = 0.000 \text{ kN.m}$$

$$M6 = 0.00 \times 0.00 = 0.000 \text{ kN.m}$$

$$\text{Total Mome} = 0.000 \text{ kN.m} \quad \text{at Foundation Bottom Level}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	1295.074	2127.553	705.475	965.302
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	1295.074	2127.553	705.475	965.302
Due to Minimum Fluid Pressure	1227.635	2127.762	741.027	1069.227
Governing of Two	1295.074	2127.762	741.027	1069.227
Due to Live Load Surcharge(Static)	1035.154	1493.623	416.561	500.376
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\text{Braking Force} = 0.2 \times 1000 + 0.05 \times 364 = 218.2 \text{ KN}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A Dry Case
	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A HFL Case
	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	SV Loading

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A Dry Case
	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A HFL Case
	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	SV Loading

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	HFL Case

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	HFL Case

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μ R)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case

Design Speed	V	=	40.00	kmph
Live Load	W	=	932.33	kN
Radius of Curvature	R	=	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN

Seismic Case

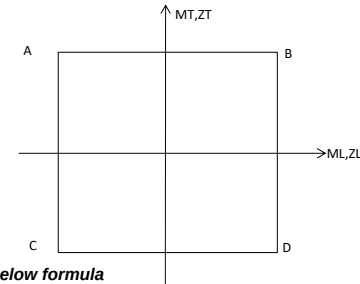
40.00	kmph
932.33	kN
0.00	m
0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1157.919 m

Properties of Footing Base:

A	=	67.500	m ²
ZL	=	60.750	m ³
ZT	=	140.625	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = Px eL1 (kNm)	Trans. Ecc (eT) (m)	MT = Px eT (kNm)
Superstructure								
Dead Load	1			1250.000	0.560	700.000	0.000	0.000
SIDL except Wearing Course	1			80.000	0.560	44.800	0.000	0.000
Wearing Course	1			137.500	0.560	77.000	0.000	0.000
				1467.500		821.800		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.190	10.688	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.190	2.200	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.110	-3.094	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	-0.060	-0.844	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.400	27.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.400	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	-0.100	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1	25	0.000	0.000	-0.100	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.190	5.320	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.110	-18.047	0.000	0.000
				369.578		23.223		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	13.572	339.300	-1.400	-475.020	0.000	0.000
Abutment Shaft	1	25	35.333	883.327	0.453	400.077	0.000	0.000
Back filling over heel slab	1	20	165.019	3300.375	-1.421	-4690.942	0.000	0.000
Front Filling over toe slab	1	20	50.625	1012.500	1.767	1788.750	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	24.375	609.375	-1.256	-765.104	0.000	0.000
Toe slab	1	25	16.875	421.875	1.700	717.188	0.000	0.000
portion between heel & toe	1	25	12.500	312.500	0.400	125.000	0.000	0.000
Vertical Components of active earth pressure	1			453.028	-2.700	-1223.177	0.000	0.000
				7540.843		-4123.291		0.000
Total				9377.921		-3278.268		0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = Px eL2 (kNm)
0.950	1187.500	-2.140	-2541.250
0.950	76.000	-2.140	-162.640
1.000	137.500	-2.140	-294.250
	1401.000		-2998.140
0.950	53.438	-2.510	-134.128
0.950	10.999	-2.510	-27.608
0.950	26.719	-2.810	-75.080
0.950	13.359	-2.760	-36.872
0.950	64.125	-2.300	-147.488
0.950	0.000	-2.300	0.000
0.950	0.000	-2.800	0.000
0.950	0.000	-2.800	0.000
0.950	26.600	-2.510	-66.766
0.950	155.859	-2.810	-437.965
	351.099		-925.906
0.950	322.335	-4.100	-1321.573
0.950	839.160	-2.247	-1885.659
0.950	3135.356	-4.121	-12921.856
0.950	961.875	-0.933	-897.750
0.950	0.000	0.000	0.000
0.950	578.906	-3.956	-2289.896
0.950	400.781	-1.000	-400.781
0.950	296.875	-2.300	-682.813
0.950	430.377	-5.400	-2324.036
	7163.800		-23254.218
	8915.900		-27178.264

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1163.024	3745.794
due to Earth pressure	1	1244.686		3120.925

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3745.79	0.00	0.00
1244.69	3120.92	0.00	0.00
1978.436	6866.718	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Earth pressure	1.5	1867.028		4681.387
		2658.091		8719.761

Summary of Forces For SBC

P	9377.921	kN
ML	3588.450	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		9377.921		-3278.268		0.000
CWLL-Max. Reaction case	1	932.327	0.560	522.103	2.411	2248.220
Vertical Components of LL Surcharge	1	182.122	-2.700	-491.729	0.000	0.000
Total		10492.369		-3247.895		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1163.024	3745.794
due to Earth pressure	1	1244.686		3120.925
due to Live load surcharge	1	500.376		1493.623

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Earth pressure	1.5	1867.028		4681.387
due to Live load surcharge	1.2	600.451		1792.347
		3258.542		10512.108

Summary of Forces For SBC

P	10492.369	kN
ML	5112.446	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		9377.921		-3278.268		0.000
CWLL-Max. Reaction case	1	2561.336	0.560	1434.348	0.300	768.401
Vertical Components of LL Surcharge	1	182.122	-2.700	-491.729	0.000	0.000
Total		12121.379		-2335.649		768.401

Horizontal Forces For SBC Calculation

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
1867.03	4681.39	0.00	0.00
2658.091	8719.761	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8915.900		-27178.26
0.000		-2.140	0.00
0.950		-5.400	-934.29
	8915.900		-28112.55

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3745.79	0.00	0.00
1244.69	3120.92	0.00	0.00
500.376	1493.623	0.000	0.000
2478.81	8360.34	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
1867.03	4681.39	0.00	0.00
600.45	1792.35	0.00	0.00
3258.542	10512.108	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8915.899617		-27178.2643
0.000		-2.140	0.00
0.950		-5.400	-934.29
	8915.900		-28112.55

Forces along Long. Axis		Forces along Trans. Axis	

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1163.024	3745.794
due to Earth pressure	1	1244.686		3120.925
due to Live load surcharge	1	500.376		1493.623

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Earth pressure	1.5	1867.028		4681.387
due to Live load surcharge	1.2	600.451		1792.347
		3258.542		10512.108

Summary of Forces For SBC

P	12121.379	kN
ML	6024.692	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		821.800		0.000
Substructure & Foundation -Portion 1				369.578		23.223		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	13.572	339.300	-1.400	-475.020	0.000	0.000
Shaft above HFL	1	25	7.533	188.334	0.525	98.878	0.000	0.000
Shaft below HFL	1	15	27.800	416.995	0.453	188.866	0.000	0.000
Back filling above HFL over heel slab	1	20	64.025	1280.500	-1.400	-1792.700	0.000	0.000
Back filling below HFL over heel slab	1	10	105.625	1056.250	-1.433	-1513.958	0.000	0.000
Front Filling over toe slab	1	10	50.625	506.250	1.767	894.375	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	24.375	365.625	-1.256	-459.063	0.000	0.000
Toe slab	1	15	16.875	253.125	1.700	430.313	0.000	0.000
Portion between Heel & Toe	1	15	12.500	187.500	0.400	75.000	0.000	0.000
Vertical Components of active earth pressure	1			389.167	-2.700	-1050.750	0.000	0.000
				5101.901		-3605.676		0.000
Total				6938.979		-2760.653		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1163.024	3745.794
due to Earth pressure	1	1069.227		2127.762

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Earth pressure	1.5	1603.840		3191.643
		2394.903		7230.017

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3745.79	0.00	0.00
1244.69	3120.92	0.00	0.00
500.376	1493.623	0.000	0.000
2478.81	8360.34	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
1867.03	4681.39	0.00	0.00
600.45	1792.35	0.00	0.00
3258.542	10512.108	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-2998.140
	351.099		-925.906
0.950	322.335	-4.100	-1321.573
0.950	178.918	-2.175	-389.144
0.950	396.146	-2.247	-890.170
0.950	1216.475	-4.100	-4987.547
0.950	1003.438	-4.133	-4147.542
0.950	480.938	-0.933	-448.875
0.950	0.000	0.000	0.000
0.950	347.344	-3.956	-1373.938
0.950	240.469	-1.000	-240.469
0.950	178.125	-2.300	-409.688
0.950	369.708	-5.400	-1996.426
	4846.806		-16511.768
	6598.905		-20435.814

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3745.79	0.00	0.00
1069.23	2127.76	0.00	0.00
1802.98	5873.56	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
1603.84	3191.64	0.00	0.00
2394.90	7230.02	0.00	0.00

Summary of Forces For SBC		
P	6938.979	kN
ML	3112.902	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		6938.979		-2760.653		0.000
CWLL-Min. Reaction case	1	466.273	0.560	261.113	3.109	1449.594
Vertical Components of LL Surcharge	1	182.122	-2.700	-491.729	0.000	0.000
Total		7587.374		-2991.270		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1163.024	3745.794
due to Earth pressure	1	1069.227		2127.762
due to Live load surcharge	1	500.376		1493.623

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Earth pressure	1.5	1603.840		3191.643
due to live load surcharge	1.2	600.451		1792.347
		2995.354		9022.364

Summary of Forces For SBC		
P	7587.374	kN
ML	4375.908	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		6938.979		-2760.653		0.000
CWLL-Min. Reaction case	1	858.664	0.560	480.852	0.300	257.599
Vertical Components of LL Surcharge	1	182.122	-2.700	-491.729	0.000	0.000
Total		7979.765		-2771.531		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1163.024	3745.794
due to Earth pressure	1	1069.227		2127.762
due to Live load surcharge	1	500.376		1493.623

Horizontal Forces For Overturning or Sliding Effect**Vertical Forces For Restoring or Resisting Effect**

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	6598.905		-20435.814
0.000	0.000	-2.140	0
0.950	173.016	-5.400	-934.286
	6771.921		-21370.100

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3745.79	0.00	0.00
1069.23	2127.76	0.00	0.00
500.376	1493.623	0.000	0.000
2303.35	7367.18	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
1603.84	3191.64	0.00	0.00
600.451	1792.347	0.000	0.000
2995.35	9022.36	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	6598.905		-20435.814
0.000	0.000	-2.140	0.00
0.950	173.016	-5.400	-934.286
	6771.921		-21370.100

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3745.79	0.00	0.00
1069.23	2127.76	0.00	0.00
500.376	1493.623	0.000	0.000
2303.35	7367.18	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Earth pressure	1.5	1603.840		3191.643
due to live load surcharge	1.2	600.451		1792.347
		2995.354		9022.364

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
1603.84	3191.64	0.00	0.00
600.451	1792.347	0.000	0.000
2995.35	9022.36	0.00	0.00

Summary of Forces For SBC		
P	7979.765	kN
ML	4595.647	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	α _h =	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	534.701 KN
		α _h =	0.000	In Transverse direction	Weight of back fill below Ground level	=	1300.000 KN
		α _v =	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = α _h x P (kN)	FT = 0.3 x α _h x P (kN)	Fv = 0.3 x α _v x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	0.560	700.000	0.000	1163.557		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	0.560	44.800	0.000	1164.338		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	0.560	77.000	0.000	1163.889		0.000	0.000	0.000
				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.190	10.688	0.000	1163.589	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.000	0.000	0.000	0.190	2.200	0.000	1163.227	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				-0.110	-3.094						
Bracket - Tapered portion	1	25	0.563	14.063				-0.060	-0.844						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.400	27.000	0.000	1162.873	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1162.723	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	-0.100	0.000	0.000	1163.889	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1	25	0.000	0.000	0.000	0.000	0.000	-0.100	0.000	0.000	1163.889	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.190	5.320				0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063				-0.110	-18.047				0.000	0.000	
				369.578	0.000	0.000	0.000		23.223	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	13.572	339.300	0.000	0.000	0.000	-1.400	-475.020	0.000	1161.350	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	35.333	883.327	0.000	0.000	0.000	0.453	400.077	0.000	1161.821	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	165.019	3300.375	0.000	0.000	0.000	-1.421	-4690.942	0.000	1161.350	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	50.625	1012.500				1.767	1788.750				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	24.375	609.375				-1.256	-765.104				0.000	0.000	
Toe slab	1	25	16.875	421.875				1.700	717.188				0.000	0.000	
portion between heel & toe	1	25	12.500	312.500				0.400	125.000				0.000	0.000	
Vertical component of active earth pressure	1			453.028				-2.700	-1223.177				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-2.700	0.000				0.000	0.000	
				7540.843	0.000	0.000	0.000		-4123.291	0.000		0.000		0.000	0.000
Total =				9377.921	0.000	0.000	0.000		-3278.268	0.000		0.000		0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x α _v x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-2.140	-2541.250	0.000
SIDL except Wearing Course	0.95			76.000	0.000	-2.140	-162.640	0.000

For Overturning or Sliding Effect

Load Factor	FL = α _h x P (kN)	C.g. of Force (m)	MLs due to FL

Design Calculation

RODIC

Stability of Foundation

Wearing Course	1.00			137.500	0.000	-2.140	-294.250	0.000
				1401.000	0.000		-2998.140	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-2.510	-134.128	0.000
Dirt Wall-Tapered portion	0.95	25	0.463	10.999	0.000	-2.510	-27.608	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-2.300	-147.488	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-2.300	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-2.800	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-2.800	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-2.510	-66.766	
Approach Slab	0.95	25	6.563	155.859		-2.810	-437.965	
				351.099	0.000		-813.955	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	35.333	839.160	0.000	-2.247	-1885.659	0.000
Solid Return wall	0.95	25	13.572	322.335	0.000	-4.100	-1321.573	0.000
Back filling over heel slab	0.95	20	165.019	3135.356	0.000	-4.121	-12921.856	0.000
Front Filling over Pile Cap	0.95	20	50.625	961.875		-0.933	-897.750	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	24.375	578.906		-3.956	-2289.896	
Toe slab	0.95	25	16.875	400.781		-1.000	-400.781	
portion between heel & toe	0.95	25	12.500	296.875		-2.300	-682.813	
Vertical component of active earth pressure	0.95			430.377		-5.400	-2324.036	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-5.400	0.000	
				7163.800	0.000		-23254.22	0.000
Total =				8915.900	0.000		-27066.31	0.000

0.000

0.000

1.0	0.000	1163.589	0.000					
1.0	0.000	1163.227	0.000					
1.0	0.000	1162.873	0.000					
1.0	0.000	1162.723	0.000					
1.0	0.000	1163.889	0.000					
1.0	0.000	1163.889	0.000					
	0.000		0.000					
1.0	0.000	1161.821	0.000					
1.0	0.000	1161.350	0.000					
1.0	0.000	1161.350	0.000					
	0.000		0.000					
	0.000		0.000					

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1163.024	3745.794	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1244.686			3120.925	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.37
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	1867.028		4681.39
due to dynamic Earth pressure	1.5	0.000		0.00
		2658.091		8719.761

Summary of Forces For SBC

	Downward	Upward	
P	9377.921	9377.921	kN
ML	3588.450	3588.450	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	8915.900	kN
Moment	-27066.313	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Vertical Forces For SBC Calculation

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1244.69	3120.92						
1978.44	6866.72	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00
1867.028	4681.387	0.000	0.000
0.000	0.000	0.000	0.000
2658.09	8719.76	0.00	0.00

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Forces from Substructure				7910.421	0.000	0.000	0.000		-4100.068	0.000				0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	0.560	104.421	0.000	1165.089		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			36.42				-2.700	-98.346				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-2.700	0.000				0.000	0.000	
Total =				9600.810	0.000	0.000	0.000		-3272.193	0.000		0.000		449.644	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-2998.14	0.000
Forces from Substructure				7514.900	0.000	0.000	-24068.17	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-2.140	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-5.400	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-5.400	0.00	
Total =				8915.900	0.000		-27066.31	0.000
					0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1163.024	3745.794	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1244.686			3120.925	
due to Live load surcharge	0.20	100.075			298.725	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1244.69	3120.92						
100.08	298.72						
2078.51	7165.44	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	1867.028		4681.387
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		2658.091		8719.761

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00
1867.028	4681.387		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2658.09	8719.76	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	9600.810	9600.810	kN
ML	3893.249	3893.249	kNm
MT	449.644	449.644	kNm

Summary of Restoring Forces

Vertical Load	8915.900	kN
Moment	-27066.313	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha h \times P$ (kN)	FT = $0.3 \times \alpha h \times P$ (kN)	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		23.223	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		13.57	339.30	0.000	0.000	0.000	-1.40	-475.020	0.000	1161.35	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	7.533	188.334	0.000	0.000	0.000	0.525	98.878	0.000	1162.321	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	27.800	416.995	0.000	0.000	0.000	0.453	188.866	0.000	1161.419	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	64.025	1280.500	0.000	0.000	0.000	-1.400	-1792.700	0.000	1162.904	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	105.625	1056.250	0.000	0.000	0.000	-1.433	-1513.958	0.000	1160.169	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	50.625	506.250				1.767	894.375				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	24.375	365.625				-1.256	-459.063				0.000	0.000	
Toe slab	1	15	16.875	253.125				1.700	430.313				0.000	0.000	
portion between heel & toe	1	15	12.500	187.500				0.400	75.000				0.000	0.000	
Vertical component of active earth pressure	1			351.341				-2.700	-948.621				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-2.700	0.000				0.000	0.000	
				5064.075	0.000	0.000	0.000		-3501.931	0.000		0.000		0.000	0.000
Total =				6901.153	0.000	0.000	0.000		-2656.908	0.000		0.000		0.000	0.000

0.000

For Overturning or Sliding Effect

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-2998.140	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-813.955	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	13.572	322.335	0.000	-4.10	-1321.573	0.000
Shaft above HFL	0.95	25	7.533	178.918	0.000	-2.175	-389.144	0.000
Shaft below HFL	0.95	15	27.800	396.146	0.000	-2.247	-890.170	0.000
Back filling above HFL over heel slab	0.95	20	64.025	1216.475	0.000	-4.100	-4987.547	0.000
Back filling below HFL over heel slab	0.95	10	105.625	1003.438	0.000	-4.133	-4147.542	0.000
Front Filling over Pile Cap	0.95	10	50.625	480.938		-0.933	-448.875	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	24.375	347.344		-3.956	-1373.938	
Toe slab	0.95	15	16.875	240.469		-1.000	-240.469	
portion between heel & toe	0.95	15	12.500	178.125		-2.300	-409.688	
Vertical component of active earth pressure	0.95			333.774		-5.400	-1802.380	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-5.400	0.000	
				4810.871	0.000		-16317.722	0.000
Total =				6562.971	0.000		-20129.82	0.000

0.000

0.000

Load Factor	FL = $\alpha h \times P$ (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1161.350	0.000
1.0	0.000	1162.321	0.000
1.0	0.000	1161.419	0.000
1.0	0.000	1162.904	0.000
1.0	0.000	1160.169	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)

Forces along Long. Axis

FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ

Design Calculation

RODIC

Stability of Foundation

due to Superstructure	1	733.750	0.000	1163.024	3745.794	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1069.227			2127.762	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	1447.953		3191.329
due to dynamic Earth pressure	1.5	0.000		0.000
		2239.015		7229.703

Summary of Forces For SBC

	Downward	Upward	
P	6901.153	6901.153	kN
ML	3216.648	3216.648	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	6562.971	kN
Moment	-20129.817	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Forces from Substructure				5433.653	0.000	0.000	0.000		-3478.708	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	0.560	52.223	0.000	1165.089		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			36.42				-2.700	-98.346				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-2.700	0.000				0.000	0.000	
Total =				7030.832	0.000	0.000	0.000		-2703.031	0.000		0.000		289.919	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-2998.140	0.000
Forces from Substructure				5161.971	0.000		-17131.677	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-2.14	0.00
Vertical component of LL Surcharge	0.00			0.00		-2.140	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-5.400	0.000	0.000
Total =				6562.971	0.000		-20131.96	0.000

0.000

0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1163.024	3745.794	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1069.227			2127.762	
due to Live load surcharge	0.20	100.075			298.725	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sinθ	FT Cosθ	MT Cosθ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1069.23	2127.76						
100.08	298.72						

1903.05 6172.28 0.00 0.00 0.00 0.00 0.00 0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	1447.953		3191.329
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		2239.015		7229.703

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00
1447.953	3191.329		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2239.02	7229.70	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	7030.832	7030.832	kN
ML	3469.249	3469.249	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	6562.971	kN
Moment	-20131.957	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		23.223	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				7540.843	0.000	0.000	0.000		-4123.291	0.000		0.000		0.000	0.000
Total =				9377.921	0.000	0.000	0.000		-3278.268	0.000		0.000		0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure				1401.000	0.000		-2998.14	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-813.95	0.000
Substructure & Foundation -Portion 2				7163.800	0.000		-23254.22	0.000
Total =				8915.900	0.000		-27066.31	0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1163.024	3745.794	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1244.686			3120.925	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1244.69	3120.92						
1978.44	6866.72	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.374
due to Substructure	1.5	0.000		0

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00

due to Active Earth pressure	1.5	1867.028	4681.38677
due to dynamic Earth pressure	1.5	0.000	0
		2658.091	8719.761

1867.028	4681.387		
0.000	0.000		
2658.09	8719.76	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	9377.921	9377.921	kN
ML	3588.450	3588.450	kNm
MT	0.000	0.000	kNm

Summary of Restoring Forces

Vertical Load	8915.900	kN
Moment	-27066.313	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	9600.810	0.000	-3272.19	0.000	449.644
		0.000		0.000	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL2$	MLs due to F_v
Total =	8915.900	0.000	-27066.31	0.000
		0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1163.024	3745.794	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1244.686			3120.925	
due to Live load surcharge	0.2	100.075			298.725	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1244.69	3120.92						
100.08	298.72						
2078.51	7165.44	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1163.024	4038.374
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	1867.03		4681.387
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		2658.09		8719.761

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00
1867.028	4681.387		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2658.09	8719.76	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	9600.810	9600.810	kN
ML	3893.249	3893.249	kNm
MT	449.644	449.644	kNm

Summary of Restoring Forces

Vertical Load	8915.900	kN
Moment	-27066.313	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure	1467.500	0.000	821.800	0.000	0.000
Substructure & Foundation -Portion 1	369.578	0.000	23.223	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure	1401.000	0.000		-2998.140	0.000
Substructure & Foundation	351.099	0.000		-813.955	0.000

Design Calculation

Substructure & Foundation -Portion 2	5064.075	0.000	-3501.931	0.000	0.000
Total =	6901.153	0.000	-2656.908	0.000	0.000
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1163.02	3745.79	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	1069.23			2127.76	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1163.024	4038.37
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	1447.953		3191.33
due to dynamic Earth pressure	1.5	0.000		0.00
		2239.015		7229.70

Summary of Forces For SBC

	Downward	Upward	
P	6901.153	6901.153	kN
ML	3216.648	3216.648	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	7030.832	0.000	-2703.03	0.000	289.919
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1163.024	3745.794	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	1069.227			2127.762	
due to Live load surcharge	0.2	100.075			298.725	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1163.024	4038.37
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	1447.95		3191.33
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00

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Substructure & Foundation	4810.871	0.000	-16317.722	0.000
Total =	6562.971	0.000	-20129.817	0.000
		0.000		0.000

Stability of Foundation

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1069.23	2127.76						
1802.98	5873.56	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00
1447.953	3191.329		
0.000	0.000		
2239.02	7229.70	0.00	0.00

Summary of Restoring Forces

Vertical Load	6562.971	kN
Moment	-20129.817	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	6562.971	0.000		-20131.96	0.000
		0.000			0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3745.79	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1069.23	2127.76						
100.08	298.72						
1903.05	6172.28	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	4038.37	0.00	0.00
0.00	0.00	0.00	0.00
1447.953	3191.329		
0.000	0.000		
0.000	0.000		
0.000	0.000		

2239.02

7229.70

2239.02

7229.70

0.00

0.00

Summary of Forces For SBC			
	Downward	Upward	
P	7030.832	7030.832	kN
ML	3469.249	3469.249	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	6562.971	kN
Moment	-20131.957	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000	kN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1165.089 -	1157.919)	=	0.000	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000	kN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1165.089 -	1157.919)	=	0.000	kNm

0.00	0.00	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe+M_p}$	FOS
	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Normal Dry Case	9377.921	3588.450	0.000	79.863	198.001	79.863	198.001	198.001	79.863	2658.091	6241.130	2.35	8719.761	27178.26	3.12
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	10492.369	5112.446	2248.220	87.274	255.585	55.300	223.611	255.585	55.300	3258.542	6241.130	1.92	10512.108	28112.55	2.67
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	12121.379	6024.692	768.401	85.868	284.212	74.940	273.284	284.212	74.940	3258.542	6241.130	1.92	10512.108	28112.55	2.67
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	6938.979	3112.902	0.000	51.558	154.041	51.558	154.041	154.041	51.558	2394.903	4619.233	1.93	7230.017	20435.81	2.83
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	7587.374	4375.908	1449.594	50.682	194.745	30.066	174.129	194.745	30.066	2995.354	4740.345	1.58	9022.364	21370.10	2.37
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	7979.765	4595.647	257.599	44.402	195.699	40.738	192.035	195.699	40.738	2995.354	4740.345	1.58	9022.364	21370.10	2.37
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															

Case 5 : DL+SIDL-Long. Seismic Dry Case	9377.921	3588.450	0.000	79.863	198.001	79.863	198.001	198.001	79.863	2658.091	6241.130	2.35	8719.761	27066.31	3.10
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	9600.810	3893.249	449.644	81.345	209.518	74.950	203.123	209.518	74.950	2658.091	6241.130	2.35	8719.761	27066.31	3.10
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	6901.153	3216.648	0.000	49.290	155.188	49.290	155.188	155.188	49.290	2239.015	4594.079	2.05	7229.703	20129.82	2.78
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	7030.832	3469.249	289.919	49.115	163.329	44.992	159.206	163.329	44.992	2239.015	4594.079	2.05	7229.703	20131.96	2.78
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	9377.921	3588.450	0.000	79.863	198.001	79.863	198.001	198.001	79.863	2658.091	6241.130	2.35	8719.761	27066.31	3.10
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	9600.810	3893.249	449.644	81.345	209.518	74.950	203.123	209.518	74.950	2658.091	6241.130	2.35	8719.761	27066.31	3.10
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	6901.153	3216.648	0.000	49.290	155.188	49.290	155.188	155.188	49.290	2239.015	4594.079	2.05	7229.703	20129.82	2.78
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	7030.832	3469.249	289.919	49.115	163.329	44.992	159.206	163.329	44.992	2239.015	4594.079	2.05	7229.703	20131.96	2.78
								SAFE	SAFE			SAFE			SAFE

**DESIGN OF WALL TYPE ABUTMENT
WITH OPEN FOUNDATION Abutment
A2 for Minor Bridge at Ch. 94+075**

Details of Superstructure:

Skew Angle of Bridge = 0 Degree = 0.000 Radians COS θ = 1.000
SIN θ = 0.000

Radius of Curvature of Superstructure = 0 m
Design speed of vehicle = 40 kmph

	Right Dimensions	Skew Dimensions
Span -c/c of Brg.	= 9.580m	9.580m
Thickness of Expansion Joint	= 0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side) =	0.200m	0.200m
Slab projection Beyond C/L of Bearing (Span Side) =	0.200m	0.200m
Span -c/c of E.J.	= 10.000m	10.00m
Type of Superstructure	= RCC SOLID SLAB	
Width of Crash barrier (Both Side)	= 0.500m	
Width of Carriageway	= 11.500m	
Projection beyond crash barrier	= 0.050m	
Thickness of Wearing coat	= 0.065m	
Length of Approach Slab (Right)	= 3.500m	3.500m
Width of Footpath on both side	= 0.000m	
Railing/kerb on footpath edge	= 0.000m	
Total Width of Superstructure	= 12.500m	
Median Width minus 20mm gap	= 0.000m	

Bearings

Type of Bearing = Tar Paper Bearing
Coeff. Of Friction for Paper Tar Bearing = 0.5

Type of Soil = 1 Hard or Rocky Strata

NBC of soil -Normal Case = 350 kN/m² (as per geotechnical report with ground improvement)
SBC of soil-Normal Case = 380 kN/m²
SBC of soil-Seismic Case = 475 kN/m²

Coeff. of friction between concrete and soil = 0.7 for weathered rock

Permissible FOS against Sliding = 1 Normal Case
= 1 Seismic Case

Permissible FOS against Overturning = 1 Normal Case
= 1 Seismic Case

Dirt Wall

	Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	= 0.300m	0.300m
Width of Dirt wall at Bottom	= 0.300m	0.300m
Height of Uniform portion	= 0.600m	
Height of Trapering portion	= 0.123m	
Length of Dirt Wall at top (Uniform portion)	= 12.500m	12.500m
Length of Dirt Wall at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment Cap

Width of Abutment cap of Uniform portion	= 0.720m	0.720m
Width of Abutmentcap at bottom of Tapering Portion	= 0.720m	0.720m
Projection of Abutment Cap (Span Side)	= 0.000m	0.000m
Projection of Abutment Cap Back Side	= 0.000m	0.000m
Abutmentcap thickness (Uniform portion)	= 0.300m	
Abutmentcap thickness (Tapering Portion)	= 0.000m	
Length of Abutment Cap at top (Uniform portion)	= 12.500m	12.500m
Length of Abutment Cap at bottom (Tapering Portion)	= 12.500m	12.500m

Abutment- Wall Type

Thickness of Abutment	=	0.720m	
Width of abutment shaft	=	12.500m	12.500m
Thickness of Abutment shaft at Top	=	0.720m	0.720m
Thickness of Abutment shaft at HFL	=	0.768m	0.768m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	2.600m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.000m
Thickness of Return wall at Bottom	=	0.000m

Foundation**Along Traffic Direction:**

Total Width of Footing	=	5.400m
abutment pedestal width	=	1.000m
abutment pedestal Height	=	1.000m
Width of Toe Slab	=	1.800m
Width of Heel Slab	=	2.600m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.000m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.000m
Width of backfill on heel slab	=	2.600m
Thickness of heel slab at back fill edge	=	1.000m
Height of back fill at bottom edge of heel slab	=	5.141m
Height of back fill at back fill edge of heel slab	=	4.641m

Across Traffic Direction:

Width of foundation -Uniform portion	=	12.500m (skew dimension)
Width of foundation -Tapering portion	=	12.500m (skew dimension)

Sr. No.	Structure	Chainage	FRL	GRL	FND. LVL	FRL-FND.LVL
	1 Minor Bridge	94+075	1163.703	1160.919	1157.919	5.784

Levels

Deck Level at Median Edge=	1163.703m	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	1163.418m	Height of Superstructure	=	0.800m
Deck level at center line =	1163.703m	Min. Height of Footpath Side Pedestal (1)	=	0.000m
Soffit Level at center of bridge =	1162.838m	Height of Pedestal (2)	=	0.000m
Abutment cap top level =	1162.837m	Height of Pedestal (3)	=	0.000m
Abutment cap bottom lvl (uniform portion ends)	1162.537m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1162.537m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1162.537m	Height (Avg.) of Dirt Wall	=	0.723m
Ground level/LBL =	1160.919m	Abutment shaft Above G.L	=	1.618m
Abutment shaft bottom level =	1158.919m	Abutment Shaft below G.L	=	2.000m
Foundation level =	1157.919m	Height of abutment shaft	=	3.618m
HFL	1161.919m	MSL	=	1160.919m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete, fck	=	35.00 Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63 Mpa at 28 d (0.67/1.5 * fck)	
Tensile strength of concrete , fctm	=	2.77 MPa	
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Ecm	=	32308.250 N/mm ²	
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	
Dry weight of Concrete	=	25 kN/m ³	
Dry unit weight of soil	=	20 kN/m ³	
Permissible Crack Width	=	0.3 mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²
<u>Creep Coefficient</u>			
For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days
<u>Clear Cover to Reinforcement</u>			
Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data:

NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone	=	5	
Z =Zone factor	=	0	
I =Importance factor	=	1.2	
R =Response Reduction factor	=	3	in Longitudinal direction
	=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.160m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.80	x	10.00	x	12.50	x	25.00
	=	2500.00	KN					
Reaction at one end	=	1250.00	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	10.00
	=	160.00	KN			
Reaction at one end	=	80.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	10	x	12.5
	=	275	KN			
Reaction at one end	=	137.5	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = 0.9 (for 3 Lane)
 Congestion factor = 1 (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

SV Loading**Max CWLL**

Vertical	Transverse ecc
2561.34	0.30

Min CWLL

Vertical	Transverse ecc
858.66	0.30

MAXIMUM TRASVERSE MOMENT CASE:**1- 70RW + 2-CLASS A****Max CWLL**

Vertical	Transverse ecc
932.33	2.41

Min CWLL

Vertical	Transverse ecc
466.27	3.11

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for CI A Wheeled loading

Impact Factor upto abut. cap	=	1.144
Impact Factor for Abut. Shaft Base	=	1.000

VOLUME CALCULATION

C.G. Of Footing	=	2.700 m
C.G. Of shaft from toe tip	=	2.300 m
Distance between c.g. of shaft and footing	=	0.400 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m ³	m	m	m	
Dirt Wall -Uniform portion	1	12.50	0.300	0.600	2.250	-0.210	0.190	-2.510	0.000
-Trapering portion	1	12.50	0.300	0.123	0.463	-0.210	0.190	-2.510	0.000
Bracket (Rectangle)	1	12.50	0.300	0.300	1.125	-0.510	-0.110	-2.810	0.000
(Corbel)	0.5	1	12.50	0.300	0.563	-0.460	-0.060	-2.760	0.000
Cap (uniform portion)	1	12.50	0.720	0.300	2.700	0.000	0.400	-2.300	0.000
Cap (Corbel Portion)	1	12.50	0.720	0.000	0.000	0.000	0.400	-2.300	0.000
		12.50	0.720						
Shaft above HFL	1	12.50	0.744	0.618	5.747	0.128	0.528	-2.172	0.000
Shaft below HFL	1	12.50	0.884	2.500	27.622	0.056	0.456	-2.244	0.000
Solid Return Wall	2	2.60	0.500	5.034	13.088	-1.800	-1.400	-4.100	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.000	0.000	0.000	-0.500	-0.100	-2.800	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.000	0.000	0.000	-0.500	-0.100	-2.800	0.000
Footing									
Heel Slab	1	12.50	2.600	0.750	24.375		-1.256	-3.956	0.000
Toe Slab	1	12.50	1.800	0.750	16.875		1.700	-1.000	0.000
Portion between Heel and Toe	1	12.50	1.000	1.000	12.500		0.400	-2.300	0.000
Back filling above HFL over Heel Slab	1	12.50	2.600	1.784	57.980		-1.400	-4.100	0.000
Back filling below HFL over Heel Slab	1	12.50	2.600	3.250	105.625		-1.433	-4.133	0.000
Backfill above Heel slab	1	12.50	2.600	4.891	158.974		-1.422	-4.122	0.000
Front Filling over Toe Slab	1	12.50	1.800	2.250	50.625		1.767	-0.933	0.000
Side filling between heel and toe	1	0.00	1.000	2.250	0.000		0.000	0.000	0.000
Approach Slab	1	12.500	1.750	0.300	6.563	-0.510	-0.110	-2.810	0.000
Back fill above HFL on flared portion of stem	1	12.50	0.048	1.784	1.067		0.028	-2.672	0.000
Back fill below HFL on flared portion of stem	1	12.50	0.232	3.250	9.432		-0.023	-2.723	0.000

			L		eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	8 kN/m	1.750	28.00kN	-0.210	0.190	-2.510

SECTIONAL PROPERTIES

Width of Footing (B)	=	5.4 m
Length of Footing (L)	=	12.500 m

A	=	5.400	x	12.500	=	67.500	m ²
ZL	=	12.500	x	4.860	=	60.750	m ³
ZT	=	IT1	+	IT2			

distance of extreme point from centre

IT1	=	5.400	x	162.760	=	878.91	m ⁴
IT2 (moment of inertia of triangle)	=	5.400	x	0.000	+	0.500 x 5.400 x 0.000 x	39.063
from centre of footing	=	0.000	m ⁴				

Moment of inertia of two triangle	=	0.000	m ⁴

Total moment of inertia	=	878.91	m ⁴

Distance of extreme point from centre of footing	=	6.250	+	0.000	=	6.250 m

Total Section modulus (ZT)	=	140.625	m ³

Load Factors (As per IRC:6-2014)**Table 3.1 Partial Safety Factor For Verification of Equilibrium**

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Load, SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Serviceability Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Load+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation**(As Per IRC:6-2014 , Clause 219)**

Horizontal Seismic Force For Zone

5.0

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \frac{S_a}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D^{1/2}}{1000F}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 4.918 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 5.495 m

Abutment Cap Top Level - Foundation Level
= 4.918 m

Dimensions of Abutment Shaft

Length = 12.50 m
Width = 0.86 m

Moment of Inertia , $I_{\text{longitudinal}}$ = 0.663 m^4
Moment of Inertia , $I_{\text{transverse}}$ = 139.974 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force = 269.938 KN
D = 1467.50 KN
T = 0.1475 sec

Transverse Direction

Force = 48489.377 KN
D = 1747.220 KN
T = 0.0120 sec

Hard or Rocky Strata

Sa/g = 2.5 Sa/g = 2.5

Seismic Coeff. In Longitudinal Direction = 0

Seismic Coeff. In Transverse Direction = 0

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

For Design of Foundation

(35% increment in Seismic Coeff for Foundation as per IRC:6-2014, Clause No. 219.8)

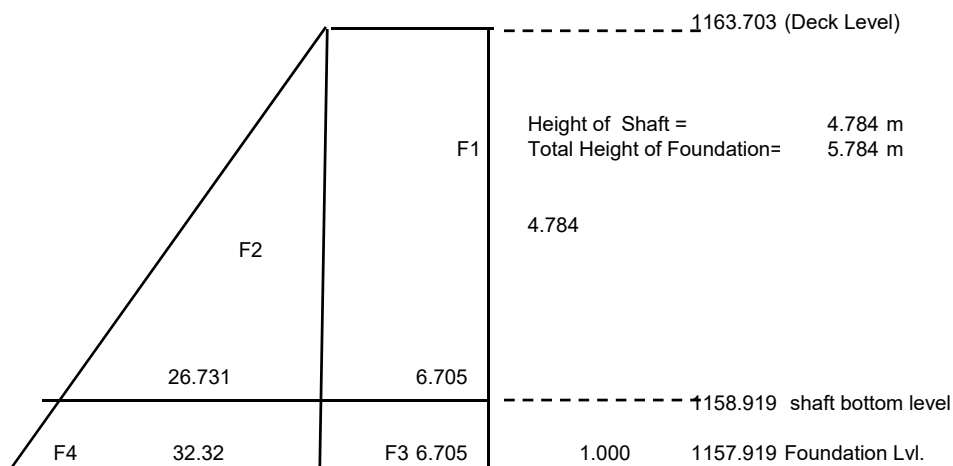
Ah	=	0.000	In Longitudinal direction
Ah	=	0.000	In Transverse direction
Av	=	0.000	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	θ_1	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m ³	

Equivalent Live Load Surcharge height = 1.2 m

Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL					1158.919 m (at Shaft Base)		
@ RL					1157.919 m (at Foundation Level)		
<u>Due to Live Load Surcharge</u>							
Intensity for rectangular portion	=	0.279	x	20	x	1.2	= 6.705 kN/m^2
F1	=	6.705	x	4.784	x	12.500	= 400.971 kN
M1	=	400.97	x	2.39	=	959.124 kN.m	at Shaft Bottom
F3	=	6.705	x	5.784	x	12.500	= 484.786 kN
M3	=	484.786	x	2.892	=	1402.003 kN.m	at Foundation

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)
 = 0.279 x 20 x 4.784 = 26.731 kN/m²

F2 = 0.5 x 26.73 x 4.784 x 12.50
 = 799.270 kN

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2 = 799.27 x 2.01 = 1605.957 kN.m at Shaft Bottom

Intensity for triangular portion (At Foundation level)
 = 0.279 x 20 x 5.784 = 32.319 kN/m²

F4 = 0.5 x 32.32 x 5.784 x 12.50
 = 1168.335 kN

M4 = 1168.34 x 2.43 = 2838.214 kN.m at Foundation

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
 = 4.800 x 4.784 = 22.963 kN/m²

F = 0.5 x 22.963 x 4.784 x 12.50
 = 686.600 kN

Design Calculation

RODIC

Earth_Normal Dry

$$M = 686.60 \times 1.595 = 1094.898 \text{ kN.m at Shaft Bottom}$$

$$\text{Intensity for triangular portion (At Foundation level)} = 4.800 \times 5.784 = 27.76 \text{ kN/m}^2$$

$$F = 0.5 \times 27.763 \times 5.78 \times 12.500 = 1003.640 \text{ kN}$$

$$M = 1003.64 \times 1.928 = 1935.017 \text{ kN.m at Foundation}$$

Intensity of Passive pressure

$$\begin{aligned} &= 3.766 \times 20 \times 0.000 = 0.000 \text{ kN/m}^2 \\ \text{Force due to passive @ Foundation, F} &= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN} \end{aligned}$$

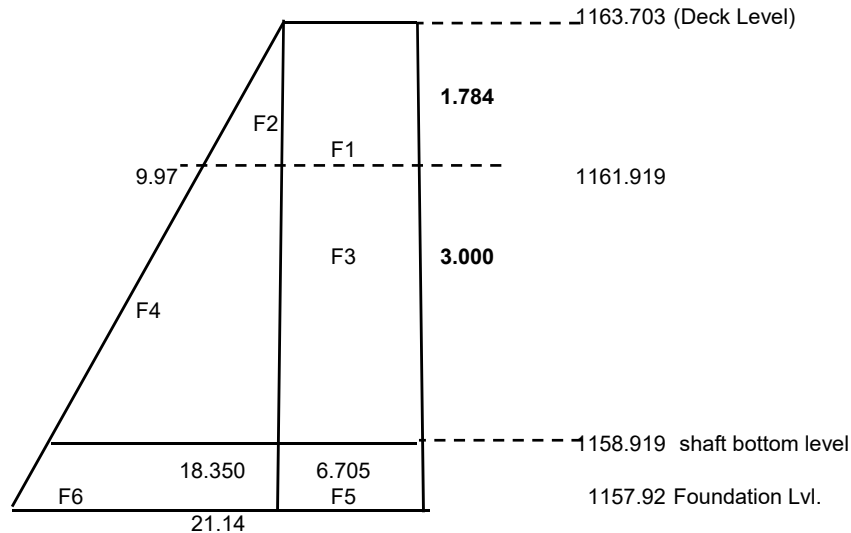
$$\begin{aligned} \text{Moment due to passive @ Foundation, M} &= 0.000 \times 0.000 = 0.000 \text{ kN.m at Foundation} \end{aligned}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom	At Foundation Lvl	At Shaft Bottom Lvl	At Foundation Lvl
	kN-m	kN-m	kN	kN
Due to active Earth Pressure	1605.957	2838.214	799.270	1168.335
Due to Minimum Fluid Pressure	1094.898	1935.017	686.600	1003.640
Governing of Two	1605.957	2838.214	799.270	1168.335
Due to Live Load Surcharge	959.124	1402.003	400.971	484.786
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 passive component	
	γ_d	=	20 kN/m ³	
	γ_{water}	=	10 kN/m ³	
Equivalent Live Load Surcharge height		=	1.2 m	
Assuming				

**Horizontal Forces and Moments @ RL****1158.9 m (at Shaft Base)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m ²
F1	=	6.705	x	4.784	x	12.500	=	400.971 kN
M1	=	400.97	x	2.39	=	959.124 kN.m		at Shaft Bottom
F3	=	6.705	x	5.784	x	12.500	=	484.786 kN
M3	=	484.79	x	2.89	=	1402.003 kN.m		at Foundation Level

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	1.784	=	9.968 kN/m ²
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	3.000	=	8.382 kN/m ²
F2	=	0.5	x	9.97	x	1.784	x	12.50
	=	111.148 kN						
F4	=	$\left(\frac{9.97 + 18.35}{2} \right) \times$			3.00	x	12.50	
	=	530.969 kN						
Total Force =		642.116 kN						
M2	=	111.15	x	3.75	=	416.724 kN.m		
M4	=	530.97	x	1.35	=	717.876 kN.m		
Total Mome =		1134.60 kN.m		at Shaft Bottom				

Intensity for

triangular portion

$$\text{Upto HFL} = 0.279 \times 20 \times 1.784 = 9.968 \text{ kN/m}^2$$

$$\text{at Foundation level} = 0.279 \times 10 \times 4.000 = 11.175 \text{ kN/m}^2$$

$$F2 = 0.5 \times 9.97 \times 1.784 \times 12.50 = 111.148 \text{ kN}$$

$$F6 = \left(\frac{9.97 + 21.14}{2} \right) \times 4.00 \times 12.50 = 777.804 \text{ kN}$$

$$\text{Total Force} = 888.952 \text{ kN}$$

$$M2 = 111.15 \times 4.75 = 527.872 \text{ kN.m}$$

$$M6 = 777.80 \times 1.76 = 1369.352 \text{ kN.m}$$

$$\text{Total Mome} = 1897.22 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Intensity of Passive pressure:

$$= 3.766 \times 10 \times 0.00 = 0.000 \text{ kN/m}^2$$

Force due to passive @ Foundation, F

$$= 0.5 \times 0.000 \times 12.50 = 0.000 \text{ kN}$$

Moment due to passive @ Foundation, M

$$= 0.000 \times 0.000 = 0.000 \text{ kN.m} \quad \text{Foundation Lvl.}$$

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	1134.600	1897.224	642.116	888.952
Due to Minimum Fluid Pressure	1094.898	1935.017	686.600	1003.640
Governing of Two	1134.600	1935.017	686.600	1003.640
Due to Live Load Surcharge	959.124	1402.003	400.971	484.786
Due to Passive pressure		0.000		0.000

Earth Pressure : Seismic Dry CaseAs per Clause 219.5.4 , IRC:6-2014

Seismic Zone = 5.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha) \cos \delta}{\cos^2 \alpha \cos(\alpha + \delta + \lambda) \cos \lambda [1 + \sqrt{\sin(\phi + \delta) \sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda) \cos(\alpha - \beta))}]^2} (1 \pm \alpha v)$$

αh	=	0.000
αv	=	0.000
ϕ	=	30.00
δ	=	20.00
α	=	0.00
β	=	0.00

αh	=	HORIZONTAL SEISMIC COEFFICIENT
αv	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

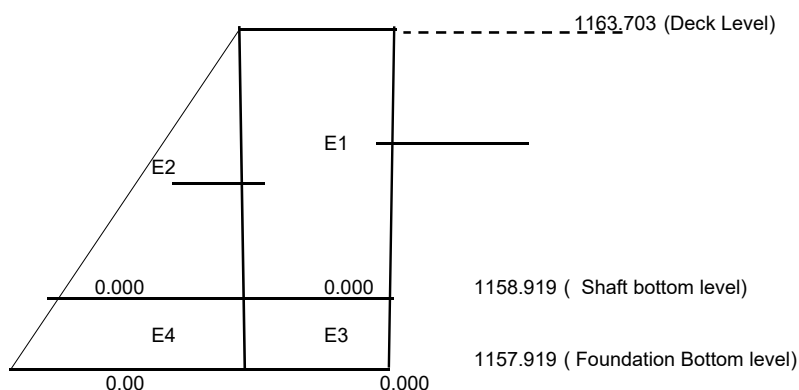
$$\lambda = \tan^{-1} \frac{\alpha h}{(1 \pm \alpha v)} = \frac{0.000}{0.000}$$

$$C_a = \frac{1}{0.279} \frac{2}{0.279}$$

Ca	=	0.279		
Ka	=	0.279		
Dynamic Increment	=	0.279	-0.279	0.000

3 Earth Pressure :**DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height	=	1.2 m
Assuming γ_{dry}	=	20 kN/m ³
γ_{water}	=	10.00 kN/m ³

**Earth Pressure Diagram for Dynamic Increment****Horizontal Forces and Moments @ RL**

1158.9 m (at Shaft Base)
1157.9 m (at Foundation Bottom Level)

Due to Dynamic Live Load Surcharge

	=	0.000	x	20	x	1.2	=	0.000 kN/m ²
at Shaft Bottom Level								
E1	=	0.000	x	4.784	x	12.500	=	0.000 kN
M1	=	0.000	x	3.205			=	0.000 kN.m
at Foundation Bottom Level								
E3	=	0.000	x	5.784	x	12.500	=	0.000 kN
M3	=	0.000	x	3.875			=	0.000 kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

$$= 0.000 \times 20 \times 4.784 = 0.000 \text{ kN/m}^2$$

(at Foundation Bottom Level)

$$= 0.000 \times 20 \times 5.784 = 0.000 \text{ kN/m}^2$$

$$E2 = 0.50 \times 0.00 \times 4.78 \times 12.500$$

$$= 0.000 \text{ kN}$$

$$E4 = 0.50 \times 0.00 \times 5.78 \times 12.500$$

$$= 0.000 \text{ kN}$$

$$M2 = 0.00 \times 2.39 = 0.000 \text{ kN.m (Shaft bottom level)}$$

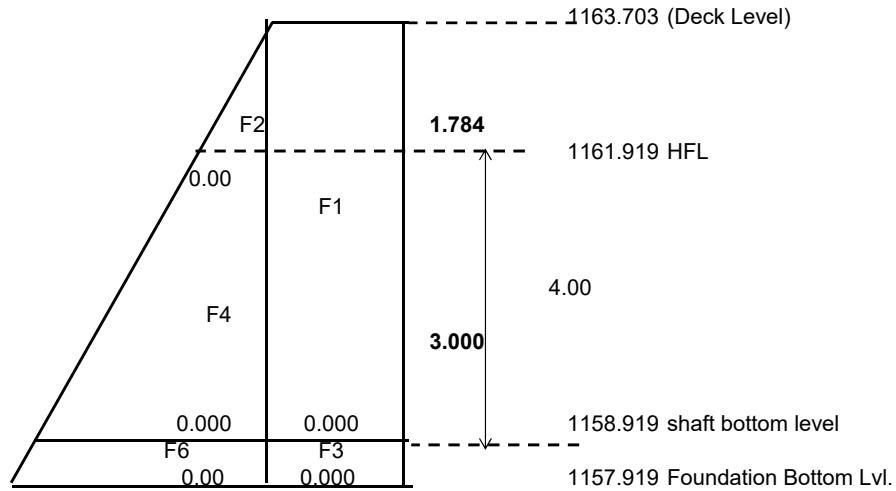
$$M4 = 0.00 \times 2.89 = 0.000 \text{ kN.m (Foundation Bottom level)}$$

Summary of Moment and Horizontal Force**Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	1605.957	2838.214	799.270	1168.335
Due to active Earth Pressure (dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	1605.957	2838.214	799.270	1168.335
Due to Minimum Fluid Pressure	1094.898	1935.017	686.600	1003.640
Governing of Two	1605.957	2838.214	799.270	1168.335
Due to Live Load Surcharge (Static)	959.124	1402.003	400.971	484.786
Due to Live Load Surcharge(Dynamic)	0.000	0.000	0.000	0.000
Due to Passive pressure		0.000		0.000

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.000
γ_d	=	20 kN/m ³
γ_{water}	=	10 kN/m ³
Equivalent Live Load Surcharge height	=	1.2 m
Assuming		

**Earth Pressure Diagram****Horizontal Forces and Moments @ RL****1158.919 m (at Shaft Base)****1157.919 m (at Foundation Bottom Level)****Due to Live Load Surcharge**

Intensity for rectangular portion	=	0.000	x	20	x	1.200	=	0.000 kN/m ²

at Shaft Bottom Level

F1	=	0.000	x	4.784	x	12.500	=	0.000 kN
M1	=	0.00	x	3.16	=	0.000 kN.m		

at Foundation Bottom Level

F3	=	0.000	x	5.784	x	12.500	=	0.000 kN
M3	=	0.00	x	3.82	=	0.000 kN.m		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.000	x	20	x	1.784	=	0.000 kN/m ²

(At Shaft bottom level) Below HFL	=	0.000	x	10	x	3.000	=	0.000 kN/m ²

(At Foundation bottom level) Below HFL	=	0.000	x	10	x	4.000	=	0.000 kN/m ²

F2	=	0.5	x	0.00	x	1.78	x	12.50
	=	0.000 kN						

F4	=	(	0.00 +	0.00	)	x	3.00	x	12.50
	=			2					
	=	0.000 kN							

F6	=	(	0.00 +	0.00	)	x	4.00	x	12.50
	=			2					
	=	0.000 kN							

Total Force (F2 + F4)	=	0.000 kN	at Shaft Bottom Level
Total Force (F2 + F6)	=	0.000 kN	at Foundation Bottom Level

M2	=	0.00	x	3.89	=	0.000 kN.m

M4	=	0.00	x	0.00	=	0.000 kN.m

Total Mome = 0.000 kN.m at Shaft Bottom

M2 = 0.00 x 4.89 = 0.000 kN.m

M6 = 0.00 x 0.00 = 0.000 kN.m

Total Mome = 0.000 kN.m at Foundation Bottom Level

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundatio n Bottom Lvl kN
Due to active Earth Pressure(Static)	1134.600	1897.224	642.116	888.952
Due to active Earth Pressure (Dynamic Increment)	0.000	0.000	0.000	0.000
Total Earth Pressure	1134.600	1897.224	642.116	888.952
Due to Minimum Fluid Pressure	1094.898	1935.017	686.600	1003.640
Governing of Two	1134.600	1935.017	686.600	1003.640
Due to Live Load Surcharge(Static)	959.124	1402.003	400.971	484.786
Due to Live Load Surcharge (Dynamic Increment)	0.000	0.000	0.000	0.000
Due to passive pressure		0.000		0.000

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1250.00	1.35	1.35	1687.50	1687.50	
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00	
WC	=	137.50	1.75	1.75	240.63	240.63	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax- Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax- Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

$$\begin{aligned} \text{Braking Force} &= 0.2 \times 1000 + 0.05 \times 364 \\ &= 218.2 \text{ KN} \end{aligned}$$

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.3	1018.063	1018.063	1- 70RW + 2-CLASS A
	2036.13	0	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.3	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.35	1.35	1687.50	1687.50
SIDL except wc	=	80.00	1.35	1.35	108.00	108.00
WC	=	137.50	1.75	1.75	240.63	240.63
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax- Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Min Reaction case	2036.13	327.300	1018.063	1018.063	1- 70RW + 2- CLASS A
	2036.13	0.000	1018.063	1018.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2036.13	327.300	1018.063	1018.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.00	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.64	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.64	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.64	1018.063	1018.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	2036.13	0.000	1018.063	1018.063	
DL+SIDL+LL-Max Reaction case		2036.13	43.640	1018.063	1018.063	Dry Case
DL+SIDL+LL-Min Reaction case		2036.13	43.640	1018.063	1018.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2036.13	43.640	1018.063	1018.063	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1	1.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1.00	80.00	80.00
WC	=	137.50	1	1.00	137.50	137.50
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Min Reaction case	1467.50	218.200	733.750	733.750	1- 70RW + 2- CLASS A
	1467.50	0.000	733.750	733.750	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1467.50	218.200	733.750	733.750	

Dry Case

HFL Case

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	0.000	733.750	733.750	
DL+SIDL+LL-Max Reaction case	1467.50	43.640	733.750	733.750	Dry Case
DL+SIDL+LL-Min Reaction case	1467.50	43.640	733.750	733.750	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1467.50	43.640	733.750	733.750	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1250.00	1.05	1.05	1312.50	1312.50
SIDL except wc	=	80.00	1.05	1.05	84.00	84.00
WC	=	137.50	1.35	1.35	185.63	185.63
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax- Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case:

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Min Reaction case	1582.13	327.300	791.063	791.063	1- 70RW + 2- CLASS A
	1582.13	0.000	791.063	791.063	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1582.13	327.300	791.063	791.063	

Dry Case

HFL Case

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.00	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.00	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.00	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.00	791.063	791.063	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1467.50	1582.13	0.000	791.063	791.063	
DL+SIDL+LL-Max Reaction case		1582.13	0.000	791.063	791.063	Dry Case
DL+SIDL+LL-Min Reaction case		1582.13	0.000	791.063	791.063	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1582.13	0.000	791.063	791.063	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1250.00	1	1	1	1250.00	1250.00	1250.00
SIDL except wc	=	80.00	1	1	1	80.00	80.00	80.00
WC	=	137.50	1.20	1.20	1.20	165.00	165.00	165.00
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 218.2 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A Dry Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Min Reaction case	1495.00	218.200	747.500	747.500	1- 70RW + 2- CLASS A HFL Case
	1495.00	0.000	747.500	747.500	SV Loading
DL+SIDL+LL-Max Transv. Moment case	1495.00	218.200	747.500	747.500	

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	163.650	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	163.650	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	163.650	747.500	747.500	

Normal Case: Quasi Permanent Combination

	Vertical Force (R)	Fh	μR	Max (Fh/2 or μR)	
DL+SIDL	1495.00	0.000	747.500	747.500	
DL+SIDL+LL-Max Reaction case	1495.00	0.000	747.500	747.500	Dry Case
DL+SIDL+LL-Min Reaction case	1495.00	0.000	747.500	747.500	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1495.00	0.000	747.500	747.500	

Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

$$\text{CENTRIFUGAL FORCE } C = \frac{W V^2}{127 R}$$

Normal Case**Seismic Case**

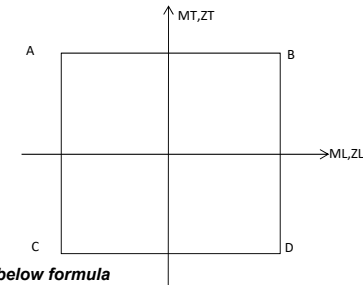
Design Speed	V	=	40.00	kmph	40.00	kmph
Live Load	W	=	932.33	kN	932.33	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1157.919 m

Properties of Footing Base:

A	=	67.500	m ²
ZL	=	60.750	m ³
ZT	=	140.625	m ³



For Skew bridges, Resolve the moment due to braking force, Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	$ML = ML \cos \theta + MT \sin \theta$
Moment along transverse axis	$MT = MT \cos \theta - ML \sin \theta$

Case 1 : DL+SIDL-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1250.000	0.560	700.000	0.000	0.000
SIDL except Wearing Course	1			80.000	0.560	44.800	0.000	0.000
Wearing Course	1			137.500	0.560	77.000	0.000	0.000
				1467.500		821.800		0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.190	10.688	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.190	2.200	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125	-0.110	-3.094	0.000	0.000
Bracket - Tapered portion	1	25	0.563	14.063	-0.060	-0.844	0.000	0.000
Cap - (uniform portion)	1	25	2.700	67.500	0.400	27.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.400	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	-0.100	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	-0.100	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	0.190	5.320	0.000	0.000
Approach Slab	1	25	6.563	164.063	-0.110	-18.047	0.000	0.000
				369.578		23.223		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	13.088	327.210	-1.400	-458.094	0.000	0.000
Abutment Shaft	1	25	33.369	834.226	0.456	379.992	0.000	0.000
Back filling over heel slab	1	20	158.974	3179.475	-1.422	-4521.682	0.000	0.000
Front Filling over toe slab	1	20	50.625	1012.500	1.767	1788.750	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	24.375	609.375	-1.256	-765.104	0.000	0.000
Toe slab	1	25	16.875	421.875	1.700	717.188	0.000	0.000
portion between heel & toe	1	25	12.500	312.500	0.400	125.000	0.000	0.000
Vertical Components of active earth pressure	1			425.239	-2.700	-1148.146	0.000	0.000
				7332.372		-3881.487		0.000
Total				9169.450		-3036.464		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1162.838	3609.316
due to Earth pressure	1	1168.335		2838.214

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
0.950	1187.500	-2.140	-2541.250
0.950	76.000	-2.140	-162.640
1.000	137.500	-2.140	-294.250
	1401.000		-2998.140
0.950	53.438	-2.510	-134.128
0.950	10.999	-2.510	-27.608
0.950	26.719	-2.810	-75.080
0.950	13.359	-2.760	-36.872
0.950	64.125	-2.300	-147.488
0.950	0.000	-2.300	0.000
0.950	0.000	-2.800	0.000
0.950	0.000	-2.800	0.000
0.950	26.600	-2.510	-66.766
0.950	155.859	-2.810	-437.965
	351.099		-925.906
0.950	310.849	-4.100	-1274.483
0.950	792.515	-2.244	-1778.797
0.950	3020.501	-4.122	-12450.951
0.950	961.875	-0.933	-897.750
0.950	0.000	0.000	0.000
0.950	578.906	-3.956	-2289.896
0.950	400.781	-1.000	-400.781
0.950	296.875	-2.300	-682.813
0.950	403.977	-5.400	-2181.478
	6965.753		-22489.857
	8717.852		-26413.903

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3609.32	0.00	0.00
1168.34	2838.21	0.00	0.00
1902.085	6447.530	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Earth pressure	1.5	1752.503		4257.321
		2543.566		8148.557

Summary of Forces For SBC

P	9169.450	kN
ML	3411.066	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		9169.450		-3036.464		0.000
CWLL-Max. Reaction case	1	932.327	0.560	522.103	2.411	2248.220
Vertical Components of LL Surcharge	1	176.448	-2.700	-476.409	0.000	0.000
Total		10278.224		-2990.770		2248.220

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1162.838	3609.316
due to Earth pressure	1	1168.335		2838.214
due to Live load surcharge	1	484.786		1402.003

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Earth pressure	1.5	1752.503		4257.321
due to Live load surcharge	1.2	581.744		1682.403
		3125.309		9830.960

Summary of Forces For SBC

P	10278.224	kN
ML	4858.762	kNm
MT	2248.220	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		9169.450		-3036.464		0.000
CWLL-Max. Reaction case	1	2561.336	0.560	1434.348	0.300	768.401
Vertical Components of LL Surcharge	1	176.448	-2.700	-476.409	0.000	0.000
Total		11907.234		-2078.525		768.401

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
1752.50	4257.32	0.00	0.00
2543.566	8148.557	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8717.852		-26413.90
0.000		-2.140	0.00
0.950		-5.400	-905.18
	8717.852		-27319.08

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3609.32	0.00	0.00
1168.34	2838.21	0.00	0.00
484.786	1402.003	0.000	0.000
2386.87	7849.53	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
1752.50	4257.32	0.00	0.00
581.74	1682.40	0.00	0.00
3125.309	9830.960	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	8717.852151		-26413.9029
0.000		-2.140	0.00
0.950		-5.400	-905.18
	8717.852		-27319.08

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1162.838	3609.316
due to Earth pressure	1	1168.335		2838.214
due to Live load surcharge	1	484.786		1402.003

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Earth pressure	1.5	1752.503		4257.321
due to Live load surcharge	1.2	581.744		1682.403
		3125.309		9830.960

Summary of Forces For SBC		
P	11907.234	kN
ML	5771.007	kNm
MT	768.401	kNm

Case 3 : DL+SIDL-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				1467.500		821.800		0.000
Substructure & Foundation -Portion 1				369.578		23.223		0.000
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	13.088	327.210	-1.400	-458.094	0.000	0.000
Shaft above HFL	1	25	5.747	143.668	0.528	75.845	0.000	0.000
Shaft below HFL	1	15	27.622	414.335	0.456	188.730	0.000	0.000
Back filling above HFL over heel slab	1	20	57.980	1159.600	-1.400	-1623.440	0.000	0.000
Back filling below HFL over heel slab	1	10	105.625	1056.250	-1.433	-1513.958	0.000	0.000
Front Filling over toe slab	1	10	50.625	506.250	1.767	894.375	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	24.375	365.625	-1.256	-459.063	0.000	0.000
Toe slab	1	15	16.875	253.125	1.700	430.313	0.000	0.000
Portion between Heel & Toe	1	15	12.500	187.500	0.400	75.000	0.000	0.000
Vertical Components of active earth pressure	1			365.295	-2.700	-986.296	0.000	0.000
				4894.509		-3378.115		0.000
Total				6731.587		-2533.092		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1162.838	3609.316
due to Earth pressure	1	1003.640		1935.017

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Earth pressure	1.5	1505.460		2902.526
		2296.522		6793.762

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3609.32	0.00	0.00
1168.34	2838.21	0.00	0.00
484.786	1402.003	0.000	0.000
2386.87	7849.53	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
1752.50	4257.32	0.00	0.00
581.74	1682.40	0.00	0.00
3125.309	9830.960	0.000	0.000

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	1401.000		-2998.140
	351.099		-925.906
0.950	310.849	-4.100	-1274.483
0.950	136.485	-2.172	-296.457
0.950	393.618	-2.244	-883.474
0.950	1101.620	-4.100	-4516.642
0.950	1003.438	-4.133	-4147.542
0.950	480.938	-0.933	-448.875
0.950	0.000	0.000	0.000
0.950	347.344	-3.956	-1373.938
0.950	240.469	-1.000	-240.469
0.950	178.125	-2.300	-409.688
0.950	347.030	-5.400	-1873.963
	4649.784		-15763.625
	6401.883		-19687.671

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3609.32	0.00	0.00
1003.64	1935.02	0.00	0.00
1737.39	5544.33	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
1505.46	2902.53	0.00	0.00
2296.52	6793.76	0.00	0.00

Summary of Forces For SBC		
P	6731.587	kN
ML	3011.241	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		6731.587		-2533.092		0.000
CWLL-Min. Reaction case	1	466.273	0.560	261.113	3.109	1449.594
Vertical Components of LL Surcharge	1	176.448	-2.700	-476.409	0.000	0.000
Total		7374.308		-2748.388		1449.594

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1162.838	3609.316
due to Earth pressure	1	1003.640		1935.017
due to Live load surcharge	1	484.786		1402.003

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Earth pressure	1.5	1505.460		2902.526
due to live load surcharge	1.2	581.744		1682.403
		2878.266		8476.165

Summary of Forces For SBC		
P	7374.308	kN
ML	4197.948	kNm
MT	1449.594	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		6731.587		-2533.092		0.000
CWLL-Min. Reaction case	1	858.664	0.560	480.852	0.300	257.599
Vertical Components of LL Surcharge	1	176.448	-2.700	-476.409	0.000	0.000
Total		7766.699		-2528.650		257.599

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	733.750	1162.838	3609.316
due to Earth pressure	1	1003.640		1935.017
due to Live load surcharge	1	484.786		1402.003

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	6401.883		-19687.671
0.000	0.000	-2.140	0.000
0.950	167.625	-5.400	-905.177
	6569.508		-20592.849

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3609.32	0.00	0.00
1003.64	1935.02	0.00	0.00
484.786	1402.003	0.000	0.000
2222.18	6946.34	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
1505.46	2902.53	0.00	0.00
581.744	1682.403	0.000	0.000
2878.27	8476.17	0.00	0.00

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	6401.883		-19687.671
0.000	0.000	-2.140	0.000
0.950	167.625	-5.400	-905.177
	6569.508		-20592.849

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
733.75	3609.32	0.00	0.00
1003.64	1935.02	0.00	0.00
484.786	1402.003	0.000	0.000
2222.18	6946.34	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Earth pressure	1.5	1505.460		2902.526
due to live load surcharge	1.2	581.744		1682.403
		2878.266		8476.165

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
1505.46	2902.53	0.00	0.00
581.744	1682.403	0.000	0.000
2878.27	8476.17	0.00	0.00

Summary of Forces For SBC

P	7766.699	kN
ML	4417.686	kNm
MT	257.599	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	ah=	0.000	In Longitudinal direction	Weight of shaft below Ground level	=	535.103 KN
		ah=	0.000	In Transverse direction	Weight of back fill below Ground level	=	1300.000 KN
		av=	0.000	In Vertical direction			

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = ah x P (kN)	FT = 0.3 x ah x P (kN)	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Superstructure															
Dead Load	1			1250.000		0.000	0.000	0.560	700.000	0.000	1163.371		0.000	0.000	0.000
SIDL except Wearing Course	1			80.000		0.000	0.000	0.560	44.800	0.000	1164.152		0.000	0.000	0.000
Wearing Course	1			137.500		0.000	0.000	0.560	77.000	0.000	1163.703		0.000	0.000	0.000
				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	2.250	56.250	0.000	0.000	0.000	0.190	10.688	0.000	1163.403	0.000	0.000	0.000	0.000
Dirt Wall-Tapered portion	1	25	0.463	11.578	0.000	0.000	0.000	0.190	2.200	0.000	1163.041	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1	25	1.125	28.125				-0.110	-3.094						
Bracket - Tapered portion	1	25	0.563	14.063				-0.060	-0.844						
Cap - (uniform portion)	1	25	2.700	67.500	0.000	0.000	0.000	0.400	27.000	0.000	1162.687	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000	1162.537	0.000	0.000	0.000	0.000
Cantilever Return Wall-Rectangle portion	1	25	0.000	0.000	0.000	0.000	0.000	-0.100	0.000	0.000	1163.703	0.000	0.000	0.000	0.000
Cantilever Return Wall-Triangle portion	1	25	0.000	0.000	0.000	0.000	0.000	-0.100	0.000	0.000	1163.703	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				0.190	5.320				0.000	0.000	0.000
Approach Slab	1	25	6.563	164.063				-0.110	-18.047				0.000	0.000	0.000
				369.578	0.000	0.000	0.000		23.223	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	13.088	327.210	0.000	0.000	0.000	-1.400	-458.094	0.000	1161.257	0.000	0.000	0.000	0.000
Abutment Shaft	1	25	33.369	834.226	0.000	0.000	0.000	0.456	379.992	0.000	1161.728	0.000	0.000	0.000	0.000
Back filling over heel slab	1	20	158.974	3179.475	0.000	0.000	0.000	-1.422	-4521.682	0.000	1161.257	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	50.625	1012.500				1.767	1788.750				0.000	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	0.000
Heel slab	1	25	24.375	609.375				-1.256	-765.104				0.000	0.000	0.000
Toe slab	1	25	16.875	421.875				1.700	717.188				0.000	0.000	0.000
portion between heel & toe	1	25	12.500	312.500				0.400	125.000				0.000	0.000	0.000
Vertical component of active earth pressure	1			425.239				-2.700	-1148.146				0.000	0.000	0.000
Vertical component of dynamic increment of earth pressure	1			0.000				-2.700	0.000				0.000	0.000	0.000
				7332.372	0.000	0.000	0.000		-3881.487	0.000		0.000		0.000	0.000
Total =				9169.450	0.000	0.000	0.000		-3036.464	0.000		0.000		0.000	0.000

0.000

0.000

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x av x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1187.500	0.000	-2.140	-2541.250	0.000

For Overturning or Sliding Effect

Load Factor	FL = ah x P (kN)	C.g. of Force (m)	MLs due to FL

Design Calculation

RODIC

Stability of Foundation

SIDL except Wearing Course	0.95			76.000	0.000	-2.140	-162.640	0.000
Wearing Course	1.00			137.500	0.000	-2.140	-294.250	0.000
				1401.000	0.000		-2998.140	0.000
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	0.95	25	2.250	53.438	0.000	-2.510	-134.128	0.000
Dirt Wall-Tapered portion	0.95	25	0.463	10.999	0.000	-2.510	-27.608	0.000
Bracket - Uniform portion	0.95	25	1.125	26.719				
Bracket - Tapered portion	0.95	25	0.563	13.359				
Cap - (uniform portion)	0.95	25	2.700	64.125	0.000	-2.300	-147.488	0.000
Cap - (corbel portion)	0.95	25	0.000	0.000	0.000	-2.300	0.000	0.000
Cantilever Return Wall-Rectangle portion	0.95	25	0.000	0.000	0.000	-2.800	0.000	0.000
Cantilever Return Wall-Triangle portion	0.95	25	0.000	0.000	0.000	-2.800	0.000	0.000
RCC Railing or Crash Barrier	0.95			26.600		-2.510	-66.766	
Approach Slab	0.95	25	6.563	155.859		-2.810	-437.965	
				351.099	0.000		-813.955	0.000
Substructure & Foundation -Portion 2								
Abutment Shaft	0.95	25	33.369	792.515	0.000	-2.244	-1778.797	0.000
Solid Return wall	0.95	25	13.088	310.849	0.000	-4.100	-1274.483	0.000
Back filling over heel slab	0.95	20	158.974	3020.501	0.000	-4.122	-12450.951	0.000
Front Filling over Pile Cap	0.95	20	50.625	961.875		-0.933	-897.750	
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000	
Heel slab	0.95	25	24.375	578.906		-3.956	-2289.896	
Toe slab	0.95	25	16.875	400.781		-1.000	-400.781	
portion between heel & toe	0.95	25	12.500	296.875		-2.300	-682.813	
Vertical component of active earth pressure	0.95			403.977		-5.400	-2181.478	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-5.400	0.000	
				6965.753	0.000		-22489.86	0.000
Total =				8717.852	0.000		-26301.95	0.000

0.000

0.000

1.0	0.000	1163.403	0.000
1.0	0.000	1163.041	0.000
1.0	0.000	1162.687	0.000
1.0	0.000	1162.537	0.000
1.0	0.000	1163.703	0.000
1.0	0.000	1163.703	0.000
	0.000		0.000
1.0	0.000	1161.728	0.000
1.0	0.000	1161.257	0.000
1.0	0.000	1161.257	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1162.838	3609.316	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1168.335			2838.214	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.24
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	1752.503		4257.32
due to dynamic Earth pressure	1.5	0.000		0.00
		2543.566		8148.557

Summary of Forces For SBC

	Downward	Upward	
P	9169.450	9169.450	KN
ML	3411.066	3411.066	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1168.34	2838.21						
1902.09	6447.53	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1752.503	4257.321	0.000	0.000
0.000	0.000	0.000	0.000
2543.57	8148.56	0.00	0.00

Summary of Restoring Forces

Vertical Load	8717.852	kN
Moment	-26301.951	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Forces from Substructure				7701.950	0.000	0.000	0.000		-3858.264	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			186.47		0.000	0.000	0.560	104.421	0.000	1164.903		2.411	449.644	0.000
Vertical component of LL Surcharge	0.20			35.29				-2.700	-95.282				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-2.700	0.000				0.000	0.000	
Total =				9391.205	0.000	0.000	0.000		-3027.326	0.000		0.000		449.644	0.000
0.000															

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = $0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000	0.000	-2998.14	0.000
Forces from Substructure				7316.852	0.000	0.000	-23303.81	0.000
CWLL-Max. Reaction case	0.00			0.00	0.000	-2.140	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-5.400	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-5.400	0.00	
Total =				8717.852	0.000		-26301.95	0.000
0.000								

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1162.838	3609.316	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1168.335			2838.214	
due to Live load surcharge	0.20	96.957			280.401	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	1752.503		4257.321
due to dynamic Earth pressure	1.5	0.000		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		2543.566		8148.557

Summary of Forces For SBC

	Downward	Upward	
P	9391.205	9391.205	KN
ML	3700.605	3700.605	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cos θ	ML Cos θ	FT Sin θ	MT Sin θ	FL Sin θ	ML Sin θ	FT Cos θ	MT Cos θ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1168.34	2838.21						
96.96	280.40						
1999.04	6727.93	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cos θ	ML Cos θ	FL Sin θ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1752.503	4257.321		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2543.57	8148.56	0.00	0.00

Summary of Restoring Forces

Vertical Load	8717.852	kN
Moment	-26301.951	kNm

MT	449.644	449.644	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = 0.3 x $\alpha_h \times P$ (kN)	Fv = 0.3 x $\alpha_v \times P$ (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		23.223	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2															
Solid Return wall	1		13.09	327.21	0.000	0.000	0.000	-1.40	-458.094	0.000	1161.26	0.000	0.00	0.000	0.000
Shaft above HFL	1	25	5.747	143.668	0.000	0.000	0.000	0.528	75.845	0.000	1162.228	0.000	0.000	0.000	0.000
Shaft below HFL	1	15	27.622	414.335	0.000	0.000	0.000	0.456	188.730	0.000	1161.419	0.000	0.000	0.000	0.000
Back filling above HFL over heel slab	1	20	57.980	1159.600	0.000	0.000	0.000	-1.400	-1623.440	0.000	1162.811	0.00	0.000	0.000	0.00
Back filling below HFL over heel slab	1	10	105.625	1056.250	0.000	0.000	0.000	-1.433	-1513.958	0.000	1160.169	0.00	0.000	0.000	0.00
Front Filling over Pile Cap	1	10	50.625	506.250				1.767	894.375				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	24.375	365.625				-1.256	-459.063				0.000	0.000	
Toe slab	1	15	16.875	253.125				1.700	430.313				0.000	0.000	
portion between heel & toe	1	15	12.500	187.500				0.400	75.000				0.000	0.000	
Vertical component of active earth pressure	1			323.552				-2.700	-873.590				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			0.000				-2.700	0.000				0.000	0.000	
				4852.766	0.000	0.000	0.000		-3263.883	0.000		0.000		0.000	0.000
Total =				6689.844	0.000	0.000	0.000		-2418.860	0.000		0.000		0.000	0.000
					0.000					0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				1401.000	0.000		-2998.140	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-813.955	0.000
Substructure & Foundation -Portion 2								
Solid Return wall	0.95	25	13.0884	310.849	0.000	-4.10	-1274.483	0.000
Shaft above HFL	0.95	25	5.747	136.485	0.000	-2.172	-296.457	0.000
Shaft below HFL	0.95	15	27.622	393.618	0.000	-2.244	-883.474	0.000
Back filling above HFL over heel slab	0.95	20	57.980	1101.620	0.000	-4.100	-4516.642	0.000
Back filling below HFL over heel slab	0.95	10	105.625	1003.438	0.000	-4.133	-4147.542	0.000
Front Filling over Pile Cap	0.95	10	50.625	480.938		-0.933	-448.875	
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000	
Heel slab	0.95	15	24.375	347.344		-3.956	-1373.938	
Toe slab	0.95	15	16.875	240.469		-1.000	-240.469	
portion between heel & toe	0.95	15	12.500	178.125		-2.300	-409.688	
Vertical component of active earth pressure	0.95			307.374		-5.400	-1659.822	
Vertical component of dynamic increment of earth pressure	0.95			0.000		-5.400	0.000	
				4610.128	0.000		-15549.484	0.000
Total =				6362.227	0.000		-19361.58	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = $\alpha_h \times P$ (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
1.0	0.000	1161.257	0.000
1.0	0.000	1162.228	0.000
1.0	0.000	1161.419	0.000
1.0	0.000	1162.811	0.000
1.0	0.000	1160.169	0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1162.838	3609.316	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1003.640			1935.017	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Substructure	1.5	0.000		0.000
due to Active Earth pressure	1.5	1333.428		2845.836
due to dynamic Earth pressure	1.5	0.000		0.000
		2124.490		6737.073

Summary of Forces For SBC

	Downward	Upward	
P	6689.844	6689.844	kN
ML	3125.474	3125.474	kNm
MT	0.000	0.000	kNm

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1003.64	1935.02						
1737.39	5544.33	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1333.428	2845.836		
0.000	0.000		
2124.49	6737.07	0.00	0.00

Summary of Restoring Forces

Vertical Load	6362.227	kN
Moment	-19361.578	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = Px eL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = Px eT	MTs due to FT
Forces from Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Forces from Substructure				5222.344	0.000	0.000	0.000		-3240.660	0.000		0.000		0.000	0.000
CWLL-Max. Reaction case	0.20			93.25		0.000	0.000	0.560	52.223	0.000	1164.903		3.109	289.919	0.000
Vertical component of LL Surcharge	0.20			35.29				-2.700	-95.282				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			0.00				-2.700	0.000				0.000	0.000	
Total =				6818.388	0.000	0.000	0.000		-2461.919	0.000		0.000		289.919	0.000
								0.000		0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = Px eL2	MLs due to Fv
Forces from Superstructure				1401.000	0.000		-2998.140	0.000
Forces from Substructure				4961.227	0.000		-16363.438	0.000
CWLL-Max. Reaction case	0.00			0.00	0.00		-2.14	0.00
Vertical component of LL Surcharge	0.00			0.00		-2.140	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-5.400	0.000	0.000
Total =				6362.227	0.000		-19363.72	0.000
					0.000			0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ

Design Calculation

RODIC

Stability of Foundation

due to Superstructure	1	733.750	0.000	1162.838	3609.316	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1003.640			1935.017	
due to Live load surcharge	0.20	96.957			280.401	

733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1003.64	1935.02						
96.96	280.40						
1834.35	5824.73	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	1333.428		2845.836
due to dynamic Earth pressure	1.5	0		0
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		2124.490		6737.073

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1333.428	2845.836		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2124.49	6737.07	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	6818.388	6818.388	kN
ML	3362.815	3362.815	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	6362.227	kN
Moment	-19363.718	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x α _h x P (kN)	FT = α _h x P (kN)	F _v = 0.3 x α _{av} x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to F _v	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				1467.500		0.000	0.000		821.800	0.000				0.000	0.000
Substructure & Foundation -Portion 1				369.578	0.000	0.000	0.000		23.223	0.000		0.000		0.000	0.000
Substructure & Foundation -Portion 2				7332.372	0.000	0.000	0.000		-3881.487	0.000		0.000		0.000	0.000
Total =				9169.450	0.000	0.000	0.000		-3036.464	0.000		0.000		0.000	0.000
							0.000			0.000					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	F _v = 0.3 x α _{av} x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to F _v
Superstructure				1401.000	0.000		-2998.14	0.000
Substructure & Foundation -Portion 1				351.099	0.000		-813.95	0.000
Substructure & Foundation -Portion 2				6965.753	0.000		-22489.86	0.000
Total =				8717.852	0.000		-26301.95	0.000
					0.000			0.000

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x α _h x P (kN)	C.g. of Force (m)	MLs due to FL
	0.000		0.000
	0.000		0.000
	0.000		0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1162.838	3609.316	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1168.335			2838.214	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1168.34	2838.21						
1902.09	6447.53	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.236
due to Substructure	1.5	0.000		0
due to Active Earth pressure	1.5	1752.503		4257.32086
due to dynamic Earth pressure	1.5	0.000		0
		2543.566		8148.557

Summary of Forces For SBC

	Downward	Upward	
P	9169.450	9169.450	kN
ML	3411.066	3411.066	kNm
MT	0.000	0.000	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case**Vertical Forces For SBC Calculation**

Lloads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	ML = $P \times eL1$	MLs due to F_v	MT = $P \times eT$
Total =	9391.205	0.000	-3027.33	0.000	449.644
		0.000		0.000	

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0.000	1162.838	3609.316	0.000
due to Substructure	1	0.000	0.000		0.000	0.000
due to Earth pressure	1	1168.335			2838.214	
due to Live load surcharge	0.2	96.957			280.401	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1162.838	3891.236
due to Substructure	1.5	0.00		0.000
due to Active Earth pressure	1.5	1752.50		4257.321
due to dynamic Earth pressure	1.5	0.00		0.000
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		2543.57		8148.557

Summary of Forces For SBC

	Downward	Upward	
P	9391.205	9391.205	kN
ML	3700.605	3700.605	kNm
MT	449.644	449.644	kNm

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1752.503	4257.321		
0.000	0.000		
2543.57	8148.56	0.00	0.00

Summary of Restoring Forces

Vertical Load	8717.852	kN
Moment	-26301.951	kNm

Vertical Forces For Restoring or Resisting Effect

Lloads	Vertical Load(P) kN.	$F_v = 0.3 \times \text{av} \times P$ (kN)	ML = $P \times eL2$	MLs due to F_v
Total =	8717.852	0.000	-26301.95	0.000
		0.000		0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1168.34	2838.21						
96.96	280.40						
1999.04	6727.93	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1752.503	4257.321		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2543.57	8148.56	0.00	0.00

Summary of Restoring Forces

Vertical Load	8717.852	kN
Moment	-26301.951	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Superstructure		1467.500	0.000	821.800	0.000	0.000
Substructure & Foundation -Portion 1		369.578	0.000	23.223	0.000	0.000
Substructure & Foundation -Portion 2		4852.766	0.000	-3263.883	0.000	0.000
Total =		6689.844	0.000	-2418.860	0.000	0.000

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.75	0.00	1162.84	3609.32	0.00
due to Substructure	1	0.00	0.00		0.00	0.00
due to Earth pressure	1	1003.64			1935.02	

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (kN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.063	1162.838	3891.24
due to Substructure	1.5	0.000		0.00
due to Active Earth pressure	1.5	1333.428		2845.84
due to dynamic Earth pressure	1.5	0.000		0.00
		2124.490		6737.07

Summary of Forces For SBC

	Downward	Upward	
P	6689.844	6689.844	kN
ML	3125.474	3125.474	kNm
MT	0.000	0.000	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case**Vertical Forces For SBC Calculation**

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	$ML = P \times eL1$	MLs due to F_v	$MT = P \times eT$
Total =	6818.388	0.000	-2461.92	0.000	289.919

Horizontal Forces For SBC Calculation

	load factor	FL (kN)	FT (kN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	733.750	0	1162.838	3609.316	0
due to Substructure	1	0.000	0		0.000	0
due to Earth pressure	1	1003.640			1935.017	
due to Live load surcharge	0.2	96.957			280.401	

Vertical Forces For Restoring or Resisting Effect

Loads		Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Superstructure		1401.000	0.000		-2998.140	0.000
Substructure & Foundation		351.099	0.000		-813.955	0.000
Substructure & Foundation		4610.128	0.000		-15549.484	0.000
Total =		6362.227	0.000		-19361.578	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1003.64	1935.02						
1737.39	5544.33	0.00	0.00	0.00	0.00	0.00	0.00

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1333.428	2845.836		
0.000	0.000		
2124.49	6737.07	0.00	0.00

Summary of Restoring Forces

Vertical Load	6362.227	kN
Moment	-19361.578	kNm

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	$F_v = 0.3 \times \alpha_v \times P$ (kN)	Long. Ecc. (eL2) @ Toe (m)	$ML = P \times eL2$	MLs due to F_v
Total =	6362.227	0.000		-19363.72	0.000

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
733.75	3609.32	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1003.64	1935.02						
96.96	280.40						
1834.35	5824.73	0.00	0.00	0.00	0.00	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		791.06	1162.838	3891.24
due to Substructure	1.5	0.00		0.00
due to Active Earth pressure	1.5	1333.43		2845.84
due to dynamic Earth pressure	1.5	0.00		0.00
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		2124.49		6737.07

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
791.06	3891.24	0.00	0.00
0.00	0.00	0.00	0.00
1333.428	2845.836		
0.000	0.000		
0.000	0.000		
0.000	0.000		
2124.49	6737.07	0.00	0.00

Summary of Forces For SBC

	Downward	Upward	
P	6818.388	6818.388	KN
ML	3362.815	3362.815	kNm
MT	289.919	289.919	kNm

Summary of Restoring Forces

Vertical Load	6362.227	kN
Moment	-19363.718	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000 KN	Normal
Transverse Moment due to C.F.	=	0.000	x (	1164.903 -	1157.919)	=	0.000 kNm

Forces along Long. Axis		Forces along Trans. Axis	
FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
0.00	0.00	0.00	0.00

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.)	=	0.20	x	0.00	=	0.000 KN	Seismic
Transverse Moment due to C.F.	=	0.000	x (	1164.903 -	1157.919)	=	0.000 kNm

0.00	0.00	0.00	0.00

Base pressure on corner A	=	σ_A	=	$P/A - ML/ZL + MT/ZT$
Base pressure on corner B	=	σ_B	=	$P/A + ML/ZL + MT/ZT$
Base pressure on corner C	=	σ_C	=	$P/A - ML/ZL - MT/ZT$
Base pressure on corner D	=	σ_D	=	$P/A + ML/ZL - MT/ZT$

LOAD CASES	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= $\mu P + c.A + F_p$	FOS	Overturning moment	Restoring Moment = $\Sigma P.e_{Toe} + M_p$	FOS
Normal Dry Case	kN	kNm	kNm	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN/m ²	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	9169.450	3411.066	0.000	79.694	191.993	79.694	191.993	191.993	79.694	2543.566	6102.497	2.40	8148.557	26413.90	3.24
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	10278.224	4858.762	2248.220	88.278	248.237	56.303	216.262	248.237	56.303	3125.309	6102.497	1.95	9830.960	27319.08	2.78
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	11907.234	5771.007	768.401	86.872	276.864	75.943	265.935	276.864	75.943	3125.309	6102.497	1.95	9830.960	27319.08	2.78
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	6731.587	3011.241	0.000	50.159	149.295	50.159	149.295	149.295	50.159	2296.522	4481.318	1.95	6793.762	19687.67	2.90
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	7374.308	4197.948	1449.594	50.455	188.659	29.839	168.043	188.659	29.839	2878.266	4598.656	1.60	8476.165	20592.85	2.43
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	7766.699	4417.686	257.599	44.175	189.613	40.511	185.950	189.613	40.511	2878.266	4598.656	1.60	8476.165	20592.85	2.43
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	9169.450	3411.066	0.000	79.694	191.993	79.694	191.993	191.993	79.694	2543.566	6102.497	2.40	8148.557	26301.95	3.23
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	9391.205	3700.605	449.644	81.411	203.242	75.016	196.847	203.242	75.016	2543.566	6102.497	2.40	8148.557	26301.95	3.23
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															
Case 7 : DL+SIDL-Long. Seismic HFL Case	6689.844	3125.474	0.000	47.661	150.557	47.661	150.557	150.557	47.661	2124.490	4453.559	2.10	6737.073	19361.58	2.87
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	6818.388	3362.815	289.919	47.720	158.430	43.597	154.306	158.430	43.597	2124.490	4453.559	2.10	6737.073	19363.72	2.87
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	9169.450	3411.066	0.000	79.694	191.993	79.694	191.993	191.993	79.694	2543.566	6102.497	2.40	8148.557	26301.95	3.23

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	9391.205	3700.605	449.644	81.411	203.242	75.016	196.847	203.242	75.016	2543.566	6102.497	2.40	8148.557	26301.95	3.23
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	6689.844	3125.474	0.000	47.661	150.557	47.661	150.557	150.557	47.661	2124.490	4453.559	2.10	6737.073	19361.58	2.87
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	6818.388	3362.815	289.919	47.720	158.430	43.597	154.306	158.430	43.597	2124.490	4453.559	2.10	6737.073	19363.72	2.87
								SAFE	SAFE			SAFE			SAFE

DESIGN OF 250M OPEN
SPANDREL STEEL ARCH BRIDGE

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1.0 Design Report

This design note represent design of bow string steel girder of 240m span.

1.1 Introduction:-

The Ultimate limit state method has been followed for designing the components of bridge

1.1.1 Unit System:-

Length	m
Force	kN
Stress	N/mm ²
Moment	kNm
Hog Mom/Com Str	-ve
Sag Mom/Ten Str	+ve

1.2 Reference documents :-

- 1 IRC codes /guidelines/special publications
- 2 MORTH specification
- 3 Specialised literature as relevant

1.3 Design Loading

The load which may arise during construction and service life is listed as following

1.3.1 Dead Loads

Dead load of the structure is calculated based on unit weights of materials given below

Structural Steel	78.50 kN/m ³
Reinforced concrete	25.00 kN/m ³
Green Weight of Concrete	26.00 kN/m ³
Temporary weight Due to Erection	150.00 kg/m ³

1.3.2 Superimposed Dead Load

The thickness of wearing coat has been adopted as 65mm and density is considered as 22.00 kN/m³

Load Intensity due to wearing course+overburden 2.0 kN/m²

Weight of Crash Barrier 8 kN/m along the traffic on each side of carriageway.

Weight of Railing 3 kN/m along the traffic on each side of carriageway.

1.3.3 Live Load

Dynamic Impact Factor

Impact Factor for class A loading

$$\frac{9}{13.5 + L} = 1.234$$

Impact Factor for 70R loading = 1.234

1.3.4 Braking Force

considered in the design of superstructure

1.3.5 Live load combinations

Live load combinations has been taken as per the provisions of IRC 6 -2017

1.3.6 Wind Load

Wind load has been considered as per clause 209.3 of IRC 6 2017

1.4 Assumptions:-

The following assumptions have been taken while designing.

- 1 Structure is designed for Plastic-Compact section-Semicompact section.

- 2 On top slab 65mm thick cc wearing coat is assumed for SIDL
- 4 Girders are assumed laterally unsupported for self wt. stage.
- 5 Bracings are designed for 50% of wind load. Remaining is shared by deck slab.
- 6 Modular ration of 15 for permanent loading and 7.5% for transient load is considered.
- 7 Stud connectors are designed for full shear interaction.
- 8 Load cycle of 2×10^6 of critical loading is consider in fatigue check

1.4 Loads:-

The different types of loads used as per IRC 6 : 2017 are.

- 1 Dead load.
- 2 In SIDL , crash barrier, Railing and wearing coat load is considered.
- 3 1 Lane of Class 70 R + 1 Lane of class A
- 4 3 Lane of class A Loading
- 5 SV Load

1.5 Material properties

- 1 Grade of Concrete M40
- 2 Grade of Reinforcement Steel Fe500D.
- 3 Grade of structural steel (Main Girders) E350 (As per table no. 2 of IS 2062:2011)

DESIGN INPUT:

Span of Arch	=	240 m
Length of Arch	=	260 m
Length of superstructure support	=	250 m
eff. Span of superstructure	=	25 m
Width of truss	=	13.5 m
Formation width	=	12.5 m
Carriageway Width	=	11.5 m
Footpath width	=	1.5 m
Spacing of truss arch	=	7.5 m
Depth of truss arch	=	4 m
Cross slope of deck slab	=	2.5 %
c/c distance of cross beam int.1	=	3.125 m
c/c distance of cross beam int.2	=	3.125 m
centre of outer cross beam from	=	1 m
Nos. Of cross beam intermediate	=	8 Nos
Nos. of cross beam end	=	2 Nos

Grade of Material:

Grade of Concrete	=	M40		
Grade of Structural Steel	=	E 450 for arch	and	E350 for other members
Characteristic strength of concr.	=	40 N/mm ²		
Yield stress in steel	=	450 N/mm ²		
Es	=	200000 N/mm ²		
Ec	=	33345.76 N/mm ²		

Ultimate strength of shear connector		146	kN	for	25	mm stud dia
Fatigue strength of shear connector		27	kN	for 2 x 10 ⁶ Life Cycle		
The permissible stress in the fillet w	=	108	Mpa			

Material Weight

Concrete Weight	=	25 kN/m ³
Steel Weight	=	78.5 kN/m ³

Material Safety Factor

γ_m	=	1.10	For Structural Steel Against Yield Stress
γ_m	=	1.25	For Shear Connector
γ_m	=	1.25	for Fillet weld/bolt

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{450}{1.10} = 409.091 \text{ N/mm}^2$$

$$\varepsilon = \sqrt{\frac{250}{f_y}} = 0.745$$

$$\text{Average Shear Stress} = \frac{f_y}{450} \div \gamma_m = \frac{450}{1.10} = 409.091 \text{ MPa}$$

Type of member	Nos.	Length (m)	Width	Front depth (m)	Front area of single truss
Top Chord of arch	2	260.00	0.7	1.00	260.00
Bottom Chord of arch	2	260.00	0.7	1.00	260.00
Diagonals of arch	120	6.60	0.5	0.50	198.00
Vertical Members	106	4.00	0.5	0.50	106.00
Spandrel column	26	18.50	1.00	0.70	168.35
					824.00

Deck Slab : 220 mm Thk.

Load intensity	=	0.22	x	25.00	=	5.5 kN/m ²
load carried by end stringers	=	5.5	x	2.5625	=	14.094 kN/m
load carried by Middle stringers1	=	5.5	x	3.125	=	17.188 kN/m
load carried by Middle stringers2	=	5.5	x	3.125	=	17.188 kN/m

Green weight of deck slab = 26 kN/m³ as per IRC:87-2011 , Clause 6.3.2.1.3

Temporary Construction Load	=	1.5 kN/m ²		
load carried by end stringers	=	1.5 x	2.5625 =	3.844 kN/m
load carried by Middle stringers1	=	1.5 x	3.125 =	4.688 kN/m
load carried by Middle stringers2	=	1.5 x	3.125 =	4.688 kN/m

2) SIDL - without surfacing :

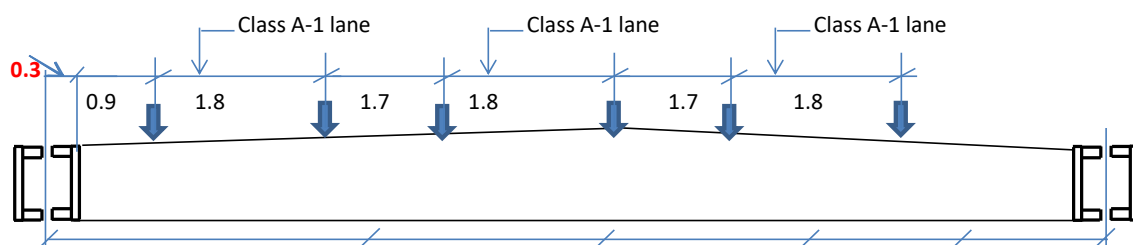
Crash Barrier Weight	=	8.00 kN/m
Rcc Railing	=	3.00 kN/m

3) Surfacing (Wearing Coat)	=	2.00 kN/m ²			
load carried by end stringers	=	2.00 x	2.5625	=	5.125 kN/m
load carried by Middle stringers	=	2.00 x	3.125	=	6.250 kN/m

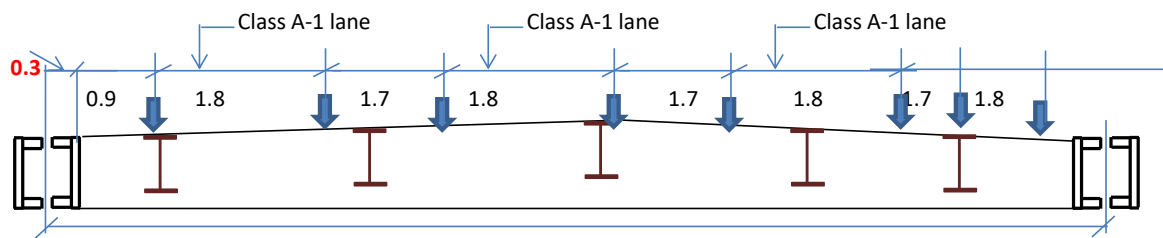
4) Footpath Load	=	0.00 kN/m ²			
load intensity on end stringers	=	1.5	x	0.00	= 0 kN/m

5) CWLL As per Table 2 of IRC:6-2017

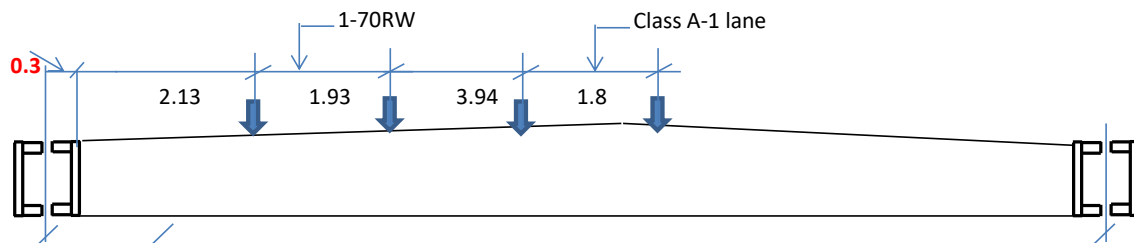
Position of 3 Lane Class A IRC Vehicle over Deck slab



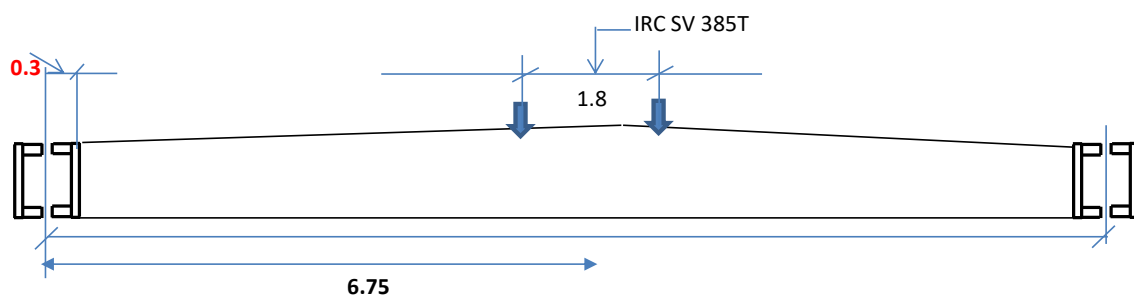
			increment by 0.5 m	
Position of 1st wheel of Class A from centre line of truss	=	1.2	1.7	m
Position of 2nd wheel of Class A from centre line of truss	=	3	3.5	m
Position of 3rd wheel of Class A from centre line of truss	=	4.7	5.2	m
Position of 4th wheel of Class A from centre line of truss	=	6.5	7	m
Position of 5th wheel of Class A from centre line of truss	=	8.2	8.7	m
Position of 6th wheel of Class A from centre line of truss	=	10	10.5	m

Position of 4 Lane Class A IRC Vehicle over Deck slab**NOT IN USE**

		increment by 0.5 m	
Position of 1st wheel of Class A from centre line of truss	=	1.2	1.7 m
Position of 2nd wheel of Class A from centre line of truss	=	3	3.5 m
Position of 3rd wheel of Class A from centre line of truss	=	4.7	5.2 m
Position of 4th wheel of Class A from centre line of truss	=	6.5	7 m
Position of 5th wheel of Class A from centre line of truss	=	8.2	8.7 m
Position of 6th wheel of Class A from centre line of truss	=	10	10.5 m
Position of 7th wheel of Class A from centre line of truss	=	11.7	12.2 m
Position of 8th wheel of Class A from centre line of truss	=	13.5	14 m

Position of 1-70R wheel + Class A-1Lane over Deck slab

		increment by 0.5 m	
Position of 1st wheel of 70R from centre line of truss	=	2.43	2.93 m
Position of 2nd wheel of 70R from centre line of truss	=	4.36	4.86 m
Position of 3rd wheel of Class A from centre line of truss	=	8.3	8.8 m
Position of 4th wheel of Class A from centre line of truss	=	10.1	10.6 m

Position of SV Laod over Deck slab

		at centre	0.3m eccentric
Position of 1st wheel from centre line of truss	=	5.85	6.15 m
Position of 2nd wheel from centre line of truss	=	7.65	7.95 m

LIVE LOAD IMPACT FACTOR

$$\text{Class A} = \frac{9}{13.5 + 25} = 1.234$$

$$70\text{RW} = 1.234 \quad \text{from Fig 5 of IRC:6-2014}$$

BRAKING LOAD

Numbers of vehicles on superstructure - 70R

$$= 5.760 \quad \text{say} \quad 6 \text{ Nos}$$

1-70R on 1st 2 lane =
 1-class A on remaining lane =
 1-70R+1-class A =

1st train	succeeding train				
200	100	100	100	100	100
27.7	27.7	27.7	27.7	27.7	27.7
227.7	127.7	127.7	127.7	127.7	127.7

6) WIND LOAD CASE As per Clause 209 of IRC:6-2017**CASE 1) : WHEN BASIC WIND SPEED AT BRIDGE LOCATION EXCEED THE BASIC WIND SPEED OF 36 m/ses**

$$\text{wind speed} = 39 \text{ m/s}$$

$$\text{Average height of exposed surface above Ground Surface/} = 100 \text{ m}$$

As per Table 12 of IRC 6:2017

$$\text{Basic wind speed} = 33.000 \text{ m/s}$$

$$V_z = 35.3 \text{ m/s}$$

$$P_z = 747 \text{ N/m}^2$$

For Hilly road : IF the bridge is situated in hill, wind pressure shall be increased by 20%

modified value of Hourly mean wind speed and wind pressure for this bridge are as per below

$$V_{z,\text{design}} = V_z \times 1.182 \times 1.2 = 50.06 \text{ m/s}$$

$$P_{z,\text{design}} = P_z \times 1.397 \times 1.2 = 1252.00 \text{ N/m}^2$$

Design Transverse Wind Force

$$F_T = P_z \times A_1 \times G \times C_d \quad \text{as per IRC 6:2014, Clause 209.3.3}$$

$$\text{Where, } P_z = 1252.00 \text{ N/m}^2$$

$$\text{Span Length} = 260.000 \text{ m}$$

$$\text{Average depth of superstructure} = 4.000 \text{ m}$$

$$\text{Area } A_1 \text{ in elevation} = 1040.000 \text{ m}^2$$

$$\text{Gust factor, } G = 2.5 \quad \text{ASSUMED}$$

Solidity ratio (ϕ) of truss is the ratio of the net area to overall area of the truss

$$\text{Net area of truss} = 824 \text{ m}^2$$

$$\text{overall area of truss} = 1040.00 \text{ m}^2$$

$$\phi = 0.792$$

For Windward truss

$$\text{Drag Coefficient } C_D = 1.600 \quad \text{Refer Table C-1 OF Annexure C of IRC 6:2017}$$

For Leeward truss

$$\text{Truss spacing ratio} = 1.875$$

$$\eta = 0.494 \quad \text{Refer Table C-2 OF Annexure C of IRC 6:2017}$$

$$C_D = 0.790$$

$$F_T = 4126.58 \text{ KN} \quad 5.008 \text{ kN/m}^2 \quad \text{For Windward truss}$$

$$F_T = 2037.50 \text{ KN} \quad 2.473 \text{ kN/m}^2 \quad \text{For Leeward truss}$$

Longitudinal Wind Force

as per clause 209.3.4

FL	=	50%	FT	=	2063.29 KN	2.504 kN/m ²	For Windward truss
FL	=	50%	FT	=	1018.75 KN	1.236 kN/m ²	For Leeward truss

Upward / Downward Wind Vertical Force (Fv)

Fv = Pz x A3 x G x CL as per IRC 6:2010, Caluse 209.3.5

Where ,

A3	=	Area in Plan (m2)	=	12.5	x	260	=	3250	m ²
				CL	=	0.75			
				G	=	2.5			
				Pz	=	1.252 kN/m ²			
			Fv	=	7629.35 KN	2.347 kN/m ²		Downward	
			Fv	=	-7629.4 KN	-2.347 kN/m ²		Upward	

CASE 2) : FOR THE WIND SPEED OF 36 m/ses

wind speed = 36 m/s

Average Height of Bridge from Ground Surface = 100 m

As per Table 5 of IRC 6:2014

Basic wind speed	=	33 m/s
Vz	=	35.3 m/s
Pz	=	747 N/m ²

For Hilly road : IF the bridge is situated in hill, wind pressure shall be increased by 20%

modified value of Hourly mean wind speed and wind pressure for this bridge are as per below

Vz,design	=	Vz	x	1.091	x	1.2	=	46.21 m/s
Pz,design	=	Pz	x	1.190	x	1.2	=	1066.79 N/m ²

Design Transverse Wind ForceF_T = Pz x A1 x G x Cd as per IRC 6:2014, Caluse 209.3.3Where , Pz = 1066.79 N/m²

Span Length	=	260.000 m
Depth of superstructure	=	4.000 m
Area A1 in elevation	=	1040.000 m ²

Gust factor , G assumed = 2.5 as per Clause 209.3.3

Solidity ratio (ϕ) of truss is the ratio of the net area to overall area of the truss

Net area of truss	=	824 m ²
overall area of truss	=	1040.00 m ²
ϕ	=	0.792
For Windward truss		
Drag Coefficient	CD	= 1.600 Refer Table C-1 OF Annexure C of IRC 6:2014
For Leeward truss		
Truss spacing ratio		= 1.875
	η	= 0.494 Refer Table C-2 OF Annexure C of IRC 6:2014
	CD	= 0.790

FT	=	3516.14 KN	4.267 kN/m ²	For Windward truss
FT	=	1736.09 KN	2.107 kN/m ²	For Leeward truss

Longitudinal Wind Force

as per clause 209.3.4

FL	=	50%	FT	=	1758.07 KN	2.134	For Windward truss
FL	=	50%	FT	=	868.05 KN	1.053	For Leeward truss

Upward / Downward Wind Vertical Force (Fv)

Fv = Pz x A3 x G x CL as per IRC 6:2010, Caluse 209.3.5

Where ,

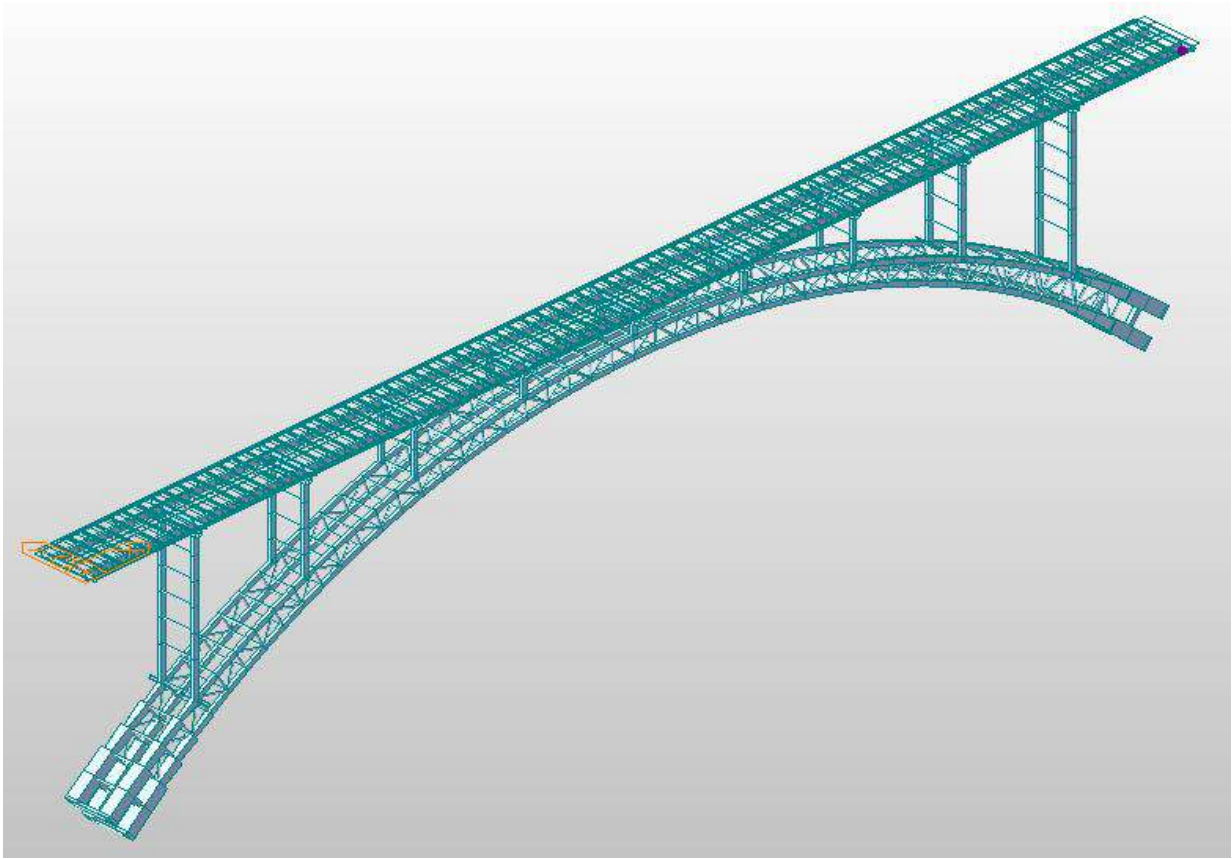
A3	=	Area in Plan (m2)	=	12.5	x	260	=	3250 m ²
		CL	=	0.75				
		G	=	2.5				
		Fv	=	6500.75 KN		2.000		Downward
		Fv	=	-6500.75 KN		-2.000		Upward

Wind Load on Live LoadF_T = Pz x A1 x G x Cd As per IRC 6:2014, Caluse 209.3.3

Height of vehicle above road way	=	3.00 m
Length of bridge	=	250.00 m
CD	=	1.20
G	=	2.50
Pz	=	1066.79 N/m ²
F _T	=	9.60 KN/m
corresponidng moment	=	14.40 kNm/m

Effective Bridge Temperature

Maximum Air Shade temperature	=	36.3	°C (as per Fig 15 of IRC:6-2017)
Minimum Air Shade temperature	=	-13.6	°C (as per Fig 16 of IRC:6-2017)
Mean of max and min temperature	=	24.95	°C (as per clause 215.2 of IRC:6-201)
Bridge temperature to be assumed	=	34.95	
Temperature Rise	=	34.95	
Temperature Fall	=	14.95	

MIDAS MODEL OF 250M OPEN SPANDREL STEEL ARCH

DESIGN OF CAPING BEAM **UNDER BEARING**

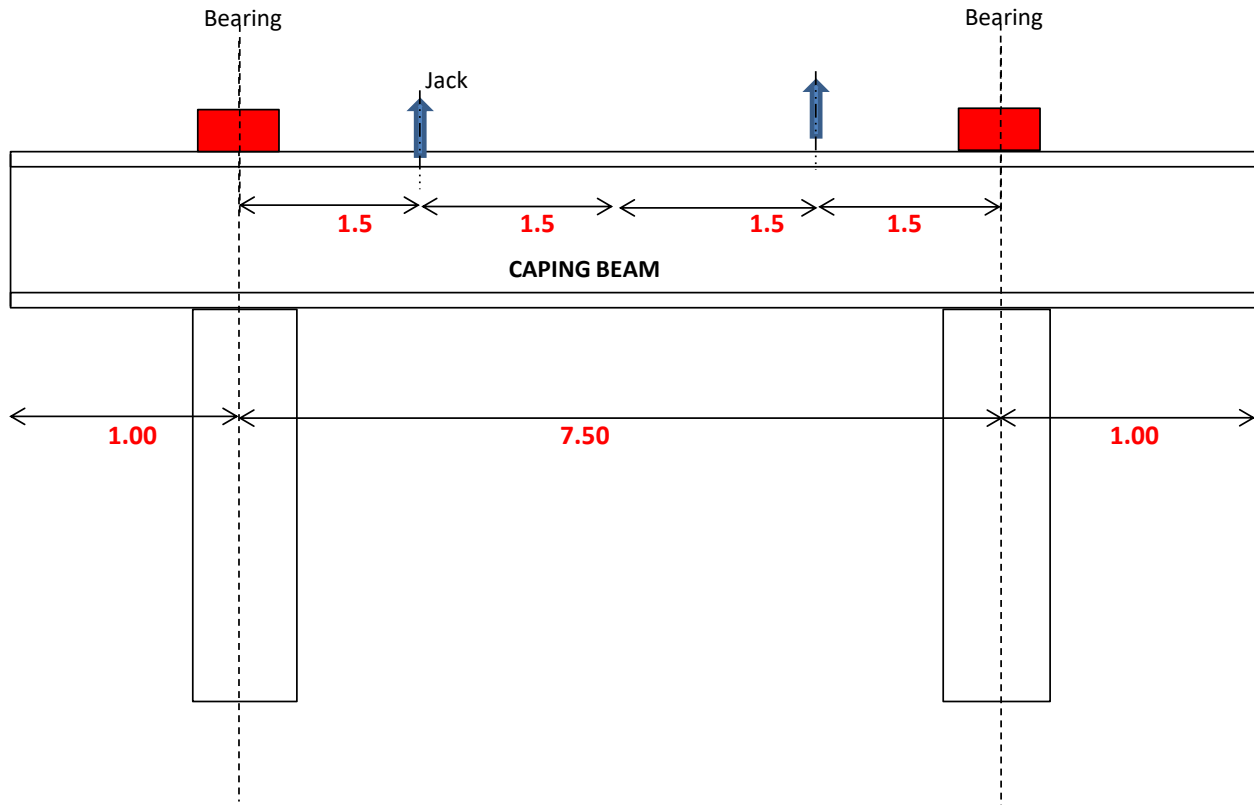
Design Data:

Fig. Typ. arrangement for Cap Beam for supporting Superstructure

Material Specification:

Grade of structural steel	=	E350	(As per table no. 2 of IS 2062:2006)
Yield strength of structural steel	=	330	Mpa for plate thickness between 20-40mm
Partial Safety Factor γ_m	=	1.10	

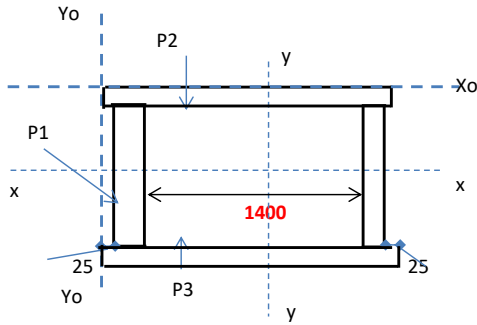
Max permissible bending stress in tension or compression.

$$s_{bct} = \frac{f_y}{\gamma_m} = \frac{330}{1.1} = 300.00 \text{ Mpa}$$

$$\epsilon = \sqrt{\frac{250}{f_y}} = 0.870$$

$$\begin{aligned} \text{Average Shear Stress} &= \frac{f_y}{\gamma_m} \\ &= \frac{330}{1.1} \\ &= 300.000 \text{ MPa} \end{aligned}$$

$$\text{The permissible stress in the fillet weld} = 108.000 \text{ Mpa}$$

SECTION PROPERTIES OF CAPING BEAM

Size of Plate P1	Length =	750 mm	Thick =	25 mm
Size of Plate P2	Length =	1500 mm	Thick =	25 mm
Size of Plate P3	Length =	1500 mm	Thick =	25 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1500 mm		
Width of Member at Bottom , B	=	1500 mm		
Depth of Member , D	=	800 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	18750	37.5	400	7.03E+05	7.50E+06	2.64E+07	3.00E+09	8.79E+08	9.77E+05	3.88E+09	2.73E+07
Plate 2 Left	37500	750	12.5	2.81E+07	4.69E+05	2.11E+10	5.86E+06	1.95E+06	7.03E+09	7.81E+06	2.81E+10
Plate 3 Left	37500	750	787.5	2.81E+07	2.95E+07	2.11E+10	2.33E+10	1.95E+06	7.03E+09	2.33E+10	2.81E+10
Plate 1 Right	18750	1462.5	400	2.74E+07	7.50E+06	4.01E+10	3.00E+09	8.79E+08	9.77E+05	3.88E+09	4.01E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	112500			8.44E+07	4.50E+07	8.23E+10	2.93E+10			3.10E+10	9.64E+10

Therefore distance of N.A. , X	=	750.00 mm									
Therefore distance of N.A. , Y	=	400.00 mm	Yb	=	400.000 mm						
Ixx	=	3.10E+10	-	112500 x	160000	=	1.30E+10 mm ⁴				
Iyy	=	9.64E+10	-	112500 x	562500	=	3.31E+10 mm ⁴				
rxx	=	340.24 mm			ryy	=	542.44 mm				

PRIS	AX	0.1125	IY	0.0331	IZ	0.0130	YD	0.80	ZD	1.50	

Zxxb = Ixx / Yb	=	3.26E+07 mm ³	Zxxt = Ixx / Yt	=	3.26E+07 mm ³
Elastic section modulus (Ze)	=	3.26E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **400.00** mm

Area above neutral axis (A1) = 56250 mm² Area below neutral axis (A2) = 56250 mm²

Moment balance about neutral axis
A2 - A1 = **0**

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	37500	388	1.45E+07
web	18750	187.50	3.52E+06
	56250		1.80E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Fl	37500	388	1.45E+07
web	18750	188	3.52E+06
	56250		1.80E+07

Y1	=	$\frac{\sum A_i Y_i}{\sum A_i}$	Y2	=	$\frac{\sum A_i Y_i}{\sum A_i}$
	=	320.83 mm		=	320.83 mm

Plastic section modulus (Zp) = A1*Y1 + A2*Y2 = **3.61E+07** mm³

Ze / Zp = 9.02E-01

DESIGN OF CAPING BEAM

Unsupported length of member $L_o = 7.50$ m
 Live load impact factor = 1

Sectional Properties:

$A = 1.13E-01 \text{ m}^2$ $r_{xx} = 0.340$ m
 $I_{xx} = 1.30E-02 \text{ m}^4$ $r_{yy} = 0.542$ m
 $I_{yy} = 3.31E-02 \text{ m}^4$

Results from Staad Analysis

Sr. No.	Loads	Load factors	Bending Moment , kNm	Shear Force , kN	Axial Force , kN
1	DL	1.35	1159	1495	0
3	SIDL1-Crash+Railing	1.35	275	367	0
4	SIDL2-Wearing Coat	1.75	193	258	0

Staad Results

	Member	Load Case	node	fx	fy	fz	mx	my	mz
Max Moment	2055	113	555	-126.176	2351.426	195.112	541.792	716.005	-4464.574
Max Shear Force	2030	107	319	-43.758	1368.031	1369.934	2325.631	-1837.182	1614.156
Max Torsion	2060	107	550	-4.996	1436.945	1358.424	2342.254	1804.291	-1729.048

ULS LOAD COMBINATION	Bending Moment , kNm	Shear Force , kN	Axial Force , kN
Normal Case - 1.35DL+1.35SIDL1+1.75SIDL2	5006.4	2359.0	344.00

Check for Section Class :

Welded section

Web Class

$d = 750$
 $t_w = 25$
 $d/t_w = 30$ Plastic

$\beta_b = 1.00$
 $Z_p = 3.61E+07 \text{ mm}^3$

DESIGN OF WEB FOR SHEAR :

Max Shear force = 2359.00 KN

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3} d t_w} \quad (\text{For Welded Section}) = 37500$$

$$V_n = 7144.71 \text{ KN} > 2359.00 \text{ KN} \quad \text{Safe in Shear} \quad 4286.825749$$

As the Shear force $V < 0.6 V_d$

Design bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 10828.13 \text{ KNm} > 5006.37 \text{ KNm}$$

Hence OK

&

<

where

$$\frac{1.2 Z_{ex} f_y}{\gamma_{m0}} = 11721.09 \text{ KNm}$$

(Note: Section is assumed as laterally unsupported beams)

Design bending strength of beam (M_d):

$$M_d = \beta_b Z_p f_{bd}$$

Elastic critical moment (M_{cr}):

$$M_{cr} = \beta_b Z_p f_{cr,b}$$

$$\beta_b = 9.02E-01 \quad (1 \text{ For Plastic/Compact section, } Z_e/Z_p \text{ for semicompact})$$

$$\text{Effective length for lateral torsional buckling}(L_{LT}) = 1 * L = 7.50 \text{ m}$$

$$\text{Radius of gyration of longitudinal girder} = 0.340 \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL}{r} = 22.04$$

$$h_f = 775.000 \quad t_f = 25.000 \quad h_f/t_f = 31.00$$

$$f_{cr,b} = 4524.7 \text{ Mpa}$$

$$\text{Plastic sectional modulus, } Z_p = 3.61E+07 \text{ mm}^3$$

$$M_{cr} = \beta_b Z_p f_{cr,b} = 1.47E+05 \text{ KNm}$$

$$\lambda_{LT} = 0.270$$

$$\phi_{LT} = 0.5(1 + \alpha_{LT}(\lambda_{LT} - 0.2) + \lambda_{LT}^2)$$

$$\alpha_{LT} = 0.49 \quad \text{For welded section}$$

$$\phi_{LT} = 0.554$$

$$\chi_{LT} = \frac{1}{\{\phi_{LT} + [\phi_{LT}^2 - \lambda_{LT}^2]^{0.5}\}} = 0.964$$

$$f_{bd} = \chi_{LT}(f_y/\gamma_{m0}) = 289.32 \text{ Mpa}$$

$$M_d = 9419.7 \text{ KNm} > 5006.37 \text{ KNm}$$

Hence OK

DESIGN OF JOINT BETWEEN FLANGE PLATE & WEB :-

$$\text{Assuming size of the fillet weld} = 12 \text{ mm}$$

$$\text{The permissible stress in the fillet weld} = 108 \text{ Mpa}$$

The shear strength of the fillet weld

$$\begin{aligned} P &= Pq \cdot L \cdot t \\ &= Pq \cdot t \quad \text{N/mm} \quad (t = \text{Throat Thickness}) \\ &= 86.4 \times 0.707 \times 12 \\ &= 733.02 \text{ N/mm.} \end{aligned}$$

First moment of area of Flange plate @ C.G. is

top plate

$$\begin{aligned} Q &= 1500 \times 25 \times (400.0 - 12.5) \\ &= 1.5E+07 \text{ mm}^3 \end{aligned}$$

The shear flow is ,

$$\begin{aligned} q &= \frac{VQ}{I} \\ &= \frac{2359.0 \times 1000 \times 1.5E+07}{1.3E+10} \\ &= 2632.12 \text{ N/mm} \end{aligned}$$

$$\text{the shear flow on each web side} = 2632.12 / 4 = 658.03 \text{ N/mm.}$$

$$\text{Providing } 12 \text{ mm fillet weld whose strength is } 733.02 \text{ N/mm.}$$

be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\text{weld length} = \frac{2632.12 \times 1000}{4 \times 733.02}$$

However Provide 12.00 mm fillet weld continuous throughout the length. $\frac{897.7}{1000}$ mm/1000 mm Length **safe**

First moment of area of Flange plate @ C.G. is bottom plate

$$Q = 1500 \times 25 \times (400.0 - 12.5) = 1.5E+07 \text{ mm}^3$$

The shear flow is ,

$$q = \frac{VQ}{I} = \frac{2359.0 \times 1000 \times 1.5E+07}{1.3E+10} = 2632.12 \text{ N/mm}$$

the shear flow on each web side = $\frac{2632.12}{4} = 658.03 \text{ N/mm}$.

Providing 12 mm fillet weld whose strength is 733.02 N/mm. be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\text{weld length} = \frac{2632.12 \times 1000}{4 \times 733.02} = 897.7 \text{ mm/1000 mm Length}$$

However Provide 12 mm fillet weld continuous throughout the length. **safe**

Fatigue check for Flange to web fillet weld

Partial Safety Factor = 1
 Shear flow at weld location = 658.03 N/mm (Max. of top and bottom)
 Assume Life cycle of bridge $N_{sc} = 2 \times 10^6$

Uncorrected Fatigue stress range :

a.) Normal Stress Range
 $f_f = \sqrt[3]{5 \times 10^6 / N_{sc}}$
 $f_{fn} = 103 \text{ Mpa}$ Load carrying weld
 $f_f = 139.79 \text{ Mpa}$

Design Fatigue strength :

Normal Stress
 $f \leq f_{fd} = \frac{\mu_r f_f}{\gamma_{mft}}$
 $\gamma_{mft} = 1.35$
 $\mu_r = \frac{(25/t_p)^{0.25}}{1.000} \leq 1.0$
 $f_{fd} = 103.6 \text{ Mpa}$

Allowable Shear flow = $\frac{1 \times 0.707 \times 12 \times 103.6}{878.52 \text{ N/mm}} > 658.03 \text{ N/mm}$
Safe

DESIGN OF SPANDREL **COLUMN**

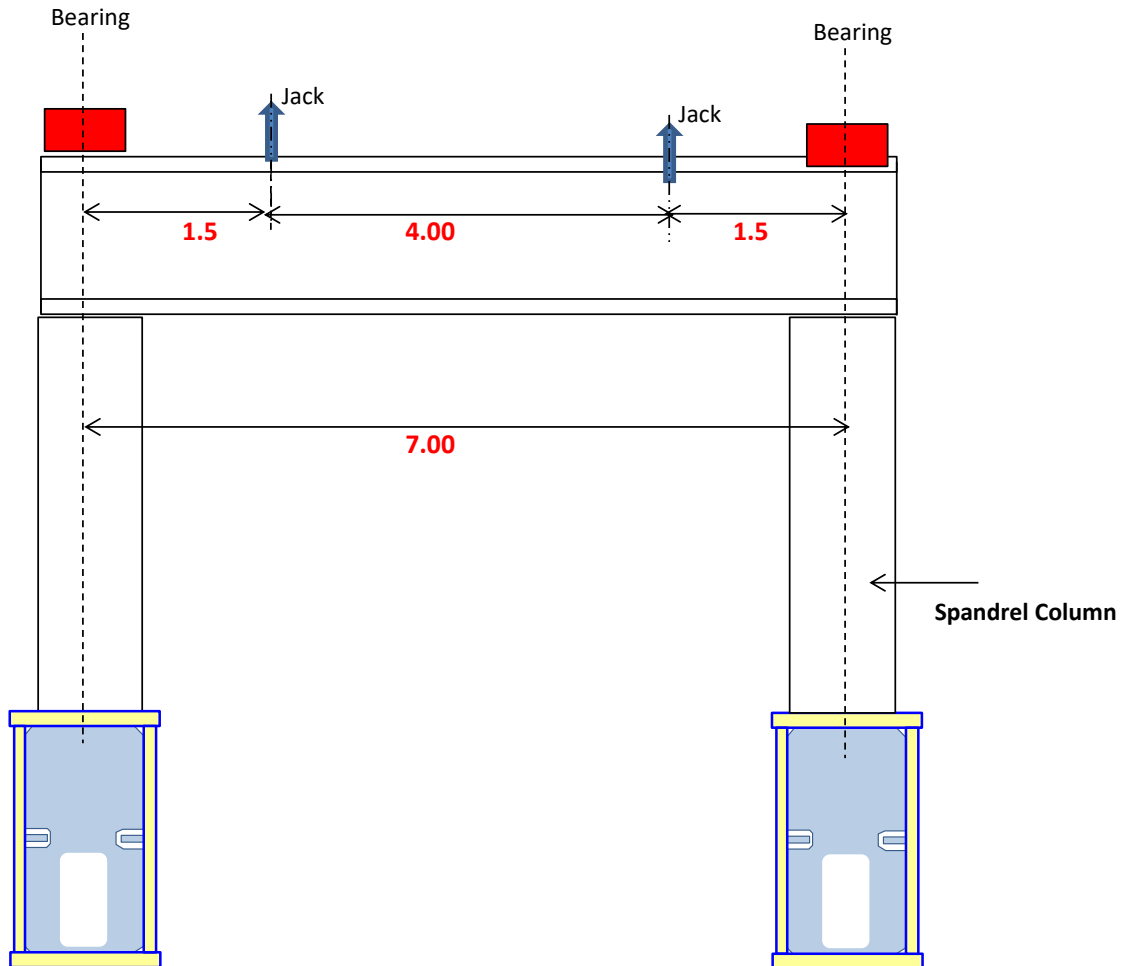
Design Data:

Fig. Typ. arrangement for Cap Beam for supporting Superstructure

Material Specification:

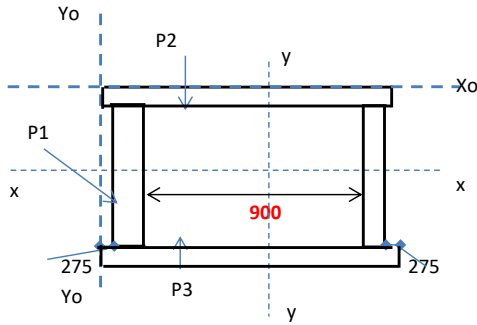
Grade of structural steel	=	E450	(As per table no. 2 of IS 2062:2006)
Yield strength of structural steel	=	430	Mpa for plate thickness between 20-40mm
Partial Safety Factor γ_m	=	1.10	

Max permissible bending stress in tension or compression.

$$s_{bct} = \frac{f_y}{\gamma_m} = \frac{430}{1.1} = 390.91 \text{ Mpa}$$

$$\epsilon = \sqrt{\frac{250}{f_y}} = 0.762$$

Average Shear Stress	=	$\frac{f_y}{\gamma_m}$	=	$\frac{430}{1.1}$	=	390.909 MPa

SECTION PROPERTIES OF SPANDREL COLUMN-END COLUMN OF HEIGHT 32M (TYPE -1)

Size of Plate P1	Length =	650 mm	Thick =	25 mm
Size of Plate P2	Length =	1500 mm	Thick =	25 mm
Size of Plate P3	Length =	1500 mm	Thick =	25 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1500 mm		
Width of Member at Bottom , B	=	1500 mm		
Depth of Member , D	=	700 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	16250	287.5	350	4.67E+06	5.69E+06	1.34E+09	1.99E+09	5.72E+08	8.46E+05	2.56E+09	1.34E+09
Plate 2 Left	37500	750	12.5	2.81E+07	4.69E+05	2.11E+10	5.86E+06	1.95E+06	7.03E+09	7.81E+06	2.81E+10
Plate 3 Left	37500	750	687.5	2.81E+07	2.58E+07	2.11E+10	1.77E+10	1.95E+06	7.03E+09	1.77E+10	2.81E+10
Plate 1 Right	16250	1212.5	350	1.97E+07	5.69E+06	2.39E+10	1.99E+09	5.72E+08	8.46E+05	2.56E+09	2.39E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	107500			8.06E+07	3.76E+07	6.74E+10	2.17E+10			2.29E+10	8.15E+10

Therefore distance of N.A. , X	=	750.00 mm									
Therefore distance of N.A. , Y	=	350.00 mm	Yb	=	350.000 mm						
Ixx	=	2.29E+10	-	107500 x		122500	=	9.69E+09 mm ⁴			
Iyy	=	8.15E+10	-	107500 x		562500	=	2.10E+10 mm ⁴			
rxx	=	300.25 mm				ryy	=	442.15 mm			

PRIS	AX	0.1075	IY	0.0210	IZ	0.0097	YD	0.70	ZD	1.50	

Zxxb = Ixx / Yb	=	2.77E+07 mm ³	Zxxt = Ixx / Yt	=	2.77E+07 mm ³
Elastic section modulus (Ze)	=	2.77E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **350.00** mm

Area above neutral axis (A1) = 53750 mm² Area below neutral axis (A2) = 53750 mm²

Moment balance about neutral axis

$$A2 - A1 = 0$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	37500	338	1.27E+07
web	16250	162.50	2.64E+06
	53750		1.53E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flng	37500	338	1.27E+07
web	16250	163	2.64E+06
	53750		1.53E+07

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1.53E+07}{53750} = 284.59 \text{ mm}$$

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1.53E+07}{53750} = 284.59 \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = 3.06E+07 \text{ mm}^3$$

$$Ze / Zp = 9.05E-01$$

DESIGN OF END VERTICAL MEMBER

Unsupported length of member	Lx	=	32.00 m
	LY	=	5.00 m
Live load impact factor		=	1

Sectional Properties:

A	=	1.08E-01 m ²	rxx	=	0.300 m
Ixx	=	9.69E-03 m ⁴	ryy	=	0.442 m
Iyy	=	2.10E-02 m ⁴			

	fx	fy	fz	mx	my	mz
Max Axial	-5517.13	347.44	-28.58	-143.68	592.44	-4168.14
Max MZ	-4531.33	272.98	56.61	212.59	632.42	5767.21
Max MY	-4844.75	354.68	-154.84	-143.62	2405.64	-4170.84
	-4531.33	369.05	56.61	212.59	632.42	5767.21
Max	5517.1	369.1	154.8	212.6	2405.6	5767.2

Check for Section Class :

Web Class

d	=	650
tw	=	25
d/tw	=	26.00 Plastic

β_b	=	1.00E+00
Zp	=	3.06E+07 mm ³

DESIGN OF WEB FOR SHEAR :

Max Shear force = 369.05 KN

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3} d^* t_w} \quad (\text{For Welded Section}) = 32500$$

$$V_n = 8068.47 \text{ KN} > 369.05 \text{ KN}$$

Safe in Shear

As the Shear force $V < 0.6 * V_d$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = \frac{11959.38}{1} \text{ KNm} > 5767.21 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_{ex} \cdot f_y}{\gamma_{m0}} = \frac{12988.65}{1} \text{ KNm} > \frac{1.2 \cdot Z_e \cdot f_y}{\gamma_{m0}}$$

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = \frac{11959.38}{1} \text{ KNm} > 2405.64 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_e \cdot f_y}{\gamma_{m0}} = \frac{12988.65}{1} \text{ KNm}$$

Axial Force Capacity of Section along X-X axis

Design Axial Force = 5517.1 KN Compressive Force

Effective length $1 \cdot L_x = 32.00 \text{ m}$ Minimum Radius of gyration, $r_{xx} = 0.300 \text{ m}$ Slenderness ratio = $\frac{kL_{xx}}{r_{xx}} = 106.58 < 180$
SAFE $E = 2.0 \times 10^5 \text{ MPa}$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_x)^2} = 173.8$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 1.573$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.317$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 1.971$$

$$b/t_f = 60 \quad h/t_w = 26$$

$$\alpha = 0.34 \quad \text{Maximum of buckling class 'b' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 123.8 \text{ MPa}$$

Design Strength of member, p_{dx}

$$P_{dx} = A_e \cdot f_{cdx} = 13308.42 \text{ KN} > 5517.13 \text{ KN}$$

OK

Axial Force Capacity of Section along Y-Y axis

Design Axial Force = 5517.13 KN Compressive Force

Effective length $1 \cdot L_y = 5.00 \text{ m}$

$$\text{Minimum Radius of gyration, } r_{yy} = 0.442 \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{yy}}{r_{yy}} = 11.31 < 180 \quad \boxed{\text{SAFE}}$$

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 15436.0$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.167$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.000$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.508$$

$$\alpha = 0.34 \quad \text{Maximum of buckling class 'b along z-z \& b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 390.9 \text{ MPa}$$

Design Strength of member, P_{dy}

$$P_{dy} = A_e * f_{cdy} = 42022.73 \text{ KN} > 5517.13 \text{ KN}$$

OK

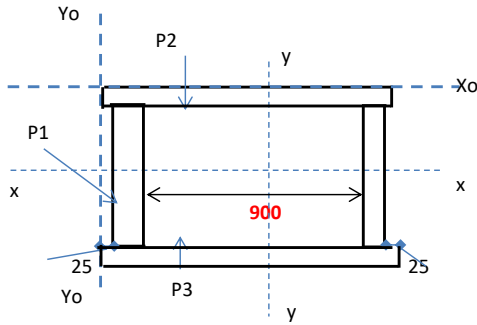
Check for Section Strength

as per clause 510.3.1.1 of IRC:24-2010

$$\frac{N}{N_d} + \frac{M_y}{M_{yd}} + \frac{M_z}{M_{zd}} \leq 1.0$$

$$\text{where, } M_z = M_x \quad \& \quad M_{zd} = M_{zd}$$

	N	My	Mz	Nd	Myd	Mzd	Ratio	Check
Max Axial	5517.13	592.44	4168.14	13308.42	11959.38	11959.38	0.813	SAFE
Max MZ	4531.33	632.42	5767.21				0.876	SAFE
Max MY	4844.75	2405.64	4170.84				0.914	SAFE

SECTION PROPERTIES OF SPANDREL COLUMN-END COLUMN OF HEIGHT 19M TO 5.0M (TYPE -2)

Size of Plate P1	Length =	650 mm	Thick =	25 mm
Size of Plate P2	Length =	1000 mm	Thick =	25 mm
Size of Plate P3	Length =	1000 mm	Thick =	25 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1000 mm		
Width of Member at Bottom , B	=	1000 mm		
Depth of Member , D	=	700 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	16250	37.5	350	6.09E+05	5.69E+06	2.29E+07	1.99E+09	5.72E+08	8.46E+05	2.56E+09	2.37E+07
Plate 2 Left	25000	500	12.5	1.25E+07	3.13E+05	6.25E+09	3.91E+06	1.30E+06	2.08E+09	5.21E+06	8.33E+09
Plate 3 Left	25000	500	687.5	1.25E+07	1.72E+07	6.25E+09	1.18E+10	1.30E+06	2.08E+09	1.18E+10	8.33E+09
Plate 1 Right	16250	962.5	350	1.56E+07	5.69E+06	1.51E+10	1.99E+09	5.72E+08	8.46E+05	2.56E+09	1.51E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	82500			4.13E+07	2.89E+07	2.76E+10	1.58E+10			1.69E+10	3.17E+10

Therefore distance of N.A. , X	=	500.00 mm									
Therefore distance of N.A. , Y	=	350.00 mm	Yb	=	350.000 mm						
Ixx	=	1.69E+10	-	82500 x	122500	=	6.84E+09 mm ⁴				
Iyy	=	3.17E+10	-	82500 x	250000	=	1.11E+10 mm ⁴				
rxx	=	287.99 mm			ryy	=	367.14 mm				

PRIS	AX	0.0825	IY	0.0111	IZ	0.0068	YD	0.70	ZD	1.00	

Zxxb = Ixx / Yb	=	1.95E+07 mm ³	Zxxt = Ixx / Yt	=	1.95E+07 mm ³
Elastic section modulus (Ze)	=	1.95E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **350.00** mm

Area above neutral axis (A1)	=	41250 mm ²	Area below neutral axis (A2)	=	41250 mm ²

Moment balance about neutral axis		
A2 - A1	=	0

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	25000	338	8.44E+06
web	16250	162.50	2.64E+06
	41250		1.11E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flng	25000	338	8.44E+06
web	16250	163	2.64E+06
	41250		1.11E+07

Y1	=	$\frac{\sum A_i Y_i}{\sum A_i}$	Y2	=	$\frac{\sum A_i Y_i}{\sum A_i}$
	=	268.56 mm		=	268.56 mm

Plastic section modulus (Zp)	=	A1*Y1 + A2*Y2	=	2.22E+07 mm ³

Ze / Zp	=	8.82E-01

DESIGN OF END VERTICAL MEMBER

Unsupported length of member	Lx	=	19.00 m
	LY	=	5.00 m
Live load impact factor		=	1

Sectional Properties:

A	=	8.25E-02 m ²	rxx	=	0.288 m
Ixx	=	6.84E-03 m ⁴	ryy	=	0.367 m
Iyy	=	1.11E-02 m ⁴			

	fx	fy	fz	mx	my	mz
Max Axial	-4642.98	280.72	-243.69	2582.08	3554.38	308.04
Max MZ	-4215.7	235.91	139.75	-2578.02	-989.72	4760.18
Max MY	-4642.98	280.72	-243.69	2582.08	3554.38	308.04
	-4215.7	288.32	139.75	-2578.02	-989.72	4760.18
Max	4643.0	288.3	243.7	2582.1	3554.4	4760.2

Check for Section Class :

Web Class

d	=	650
tw	=	25
d/tw	=	26.00 Plastic

β_b	=	1.00E+00
Z_p	=	2.22E+07 mm ³

DESIGN OF WEB FOR SHEAR :

Max Shear force = 288.32 KN

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3} d^* t_w} \quad (\text{For Welded Section}) = 32500$$

$$V_n = 8068.47 \text{ KN} > 288.32 \text{ KN}$$

Safe in Shear

As the Shear force $V < 0.6 * V_d$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 8661.08 \text{ KNm}$$

$$8661.08 > 4760.18 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_{ex} \cdot f_y}{\gamma_{m0}} = 9170.31 \text{ KNm}$$

$$8661.08 < 9170.31 \text{ KNm}$$

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = \frac{8661.08}{1} \text{ KNm} > 3554.38 \text{ KNm}$$

Hence OK

where

$$\frac{1.2 \cdot Z_{ey} \cdot f_y}{\gamma_{m0}} = 9170.31 \text{ KNm}$$

Axial Force Capacity of Section along X-X axis

Design Axial Force = 4643.0 KN Compressive Force

Effective length $1 \cdot L_x = 19.00 \text{ m}$

Minimum Radius of gyration, $r_{xx} = 0.288 \text{ m}$

Slenderness ratio = $\frac{k L_{xx}}{r_{xx}} = 65.98 < 180$

SAFE

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_x)^2} = 453.5$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.974$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.614$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 1.106$$

$$b/t_f = 40 \quad h/t_w = 26$$

$$\alpha = 0.34 \quad \text{Maximum of buckling class 'b along z-z & b along y-y' as per Table 4}$$

$$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 239.9 \text{ MPa}$$

Design Strength of member, P_{dx}

$$P_{dx} = A_e \cdot f_{cdx} = 19793.49 \text{ KN} > 4642.98 \text{ KN}$$

OK

Axial Force Capacity of Section along Y-Y axis

Design Axial Force = 4642.98 KN Compressive Force

Effective length $1 \cdot L_y = 5.00 \text{ m}$

$$\text{Minimum Radius of gyration, } r_{yy} = 0.367 \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{yy}}{r_{yy}} = 13.62 < 180 \quad \boxed{\text{SAFE}}$$

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 10642.7$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.201$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.000$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.520$$

$$\alpha = 0.34 \quad \text{Maximum of buckling class 'b along z-z \& b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 390.8 \text{ MPa}$$

Design Strength of member, P_{dy}

$$P_{dy} = A_e * f_{cd,y} = 32238.52 \text{ KN} > 4642.98 \text{ KN}$$

OK

Check for Section Strength

as per clause 510.3.1.1 of IRC:24-2010

$$\frac{N}{N_d} + \frac{M_y}{M_{yd}} + \frac{M_z}{M_{zd}} \leq 1.0$$

$$\text{where, } M_z = M_x \quad \& \quad M_{zd} = M_{zd}$$

	N	My	Mz	Nd	Myd	Mzd	Ratio	Check
Max Axial	4642.98	3554.38	308.04	19793.49	8661.08	8661.08	0.681	SAFE
Max MZ	4215.7	989.72	4760.18				0.877	SAFE
Max MY	4642.98	3554.38	308.04				0.681	SAFE

DESIGN OF ARCH RIBS
BOTH TOP AND BOTTOM

Material Specification:

Grade of structural steel	=	E450	(As per table no. 2 of IS 2062:2006)
Yield strength of structural steel	=	430	Mpa for plate thickness between 20-40mm
Partial Safety Factor γ_m	=	1.10	

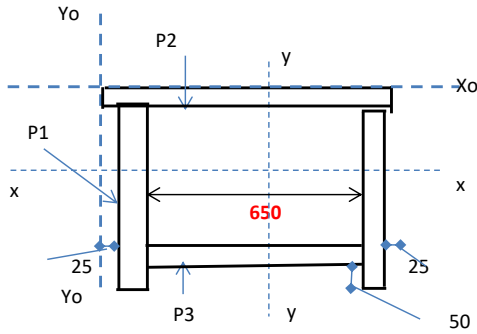
Max permissible bending stress in tension or compression.

$$s_{bct} = \frac{f_y}{\gamma_m} = \frac{430}{1.1} = 390.91 \text{ Mpa}$$

$$\varepsilon = \sqrt{\frac{250}{f_y}} = 0.762$$

$$\begin{aligned} \text{Average Shear Stress} &= \frac{f_y}{\gamma_m} \\ &= \frac{430}{1.1} \\ &= 390.909 \text{ MPa} \end{aligned}$$

$$\text{The permissible stress in the fillet weld} = 108.000 \text{ Mpa}$$

SECTION PROPERTIES OF TOP ARCH RIBS UPTO DISTANCE OF 20m FROM CROWN POINT

Size of Plate P1	Length =	1050 mm	Thick =	25 mm
Size of Plate P2	Length =	750 mm	Thick =	50 mm
Size of Plate P3	Length =	650 mm	Thick =	50 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	750 mm		
Width of Member at Bottom , B	=	700 mm		
Depth of Member , D	=	1100 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	26250	37.5	575	9.84E+05	1.51E+07	3.69E+07	8.68E+09	2.41E+09	1.37E+06	1.11E+10	3.83E+07
Plate 2 Left	37500	375	25	1.41E+07	9.38E+05	5.27E+09	2.34E+07	7.81E+06	1.76E+09	3.13E+07	7.03E+09
Plate 3 Left	32500	375	1025	1.22E+07	3.33E+07	4.57E+09	3.41E+10	6.77E+06	1.14E+09	3.42E+10	5.71E+09
Plate 1 Right	26250	712.5	575	1.87E+07	1.51E+07	1.33E+10	8.68E+09	2.41E+09	1.37E+06	1.11E+10	1.33E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	122500			4.59E+07	6.44E+07	2.32E+10	5.15E+10			5.64E+10	2.61E+10

Therefore distance of N.A. , X	=	375.00 mm									
Therefore distance of N.A. , Y	=	526.02 mm	Yb	=	573.980 mm						
Ixx	=	5.64E+10	-	122500 x	276697.5	=	2.25E+10 mm ⁴				
Iyy	=	2.61E+10	-	122500 x	140625	=	8.88E+09 mm ⁴				
rx	=	428.28 mm			ryy	=	269.31 mm				

PRIS	AX	0.1225	IY	0.0089	IZ	0.0225	YD	1.10	ZD	0.75	

Zxxb = Ixx / Yb	=	3.91E+07 mm ³	Zxxt = Ixx / Yt	=	4.27E+07 mm ³
Elastic section modulus (Ze)	=	3.91E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **487.50** mm

Area above neutral axis (A1)	=	59375 mm ²	Area below neutral axis (A2)	=	63125 mm ²

Moment balance about neutral axis		
A2 - A1	=	3750

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	37500	463	1.73E+07
web	21875	218.75	4.79E+06
	59375		2.21E+07

Y1	=	$\frac{\sum A_i Y_i}{\sum A_i}$
	=	372.70 mm

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flng	32500	538	1.75E+07
web	30625	306	9.38E+06
	63125		2.68E+07

Y2	=	$\frac{\sum A_i Y_i}{\sum A_i}$
	=	425.31 mm

Plastic section modulus (Zp)	=	A1*Y1 + A2*Y2	=	4.90E+07 mm ³

Ze / Zp	=	7.99E-01

DESIGN OF TOP ARCH RIBS UPTO DISTANCE OF 20m FROM CROWN POINT

Unsupported length of member	Lx	=	5.56 m
	LY	=	5.56 m
Live load impact factor		=	1

Sectional Properties:

A	=	1.23E-01 m ²	rxx	=	0.428 m
Ixx	=	2.25E-02 m ⁴	ryy	=	0.269 m
Iyy	=	8.88E-03 m ⁴			

Staad Pro Analysis Results

1740.7

	Member	Load Case	node	fx	fy	fz	mx	my	mz
Max Axial	25	113	49	-21030.1	1783.39	28.17	-312.47	-1111	-1337.4
Max MZ	25	106	49	-21013.5	1740.74	65.74	-312.47	-1130	7692.88
Max FY	85	107	173	-21030.1	3404.57	65.74	-312.47	-1130	7692.88
Max				21030.1	3404.6	65.7	312.5	1130.0	7692.9

Check for Section Class :

Web Class

d	=	1050
tw	=	25
d/tw	=	42 Plastic

Flange Class

b	=	750 mm
tf	=	50 mm
b/tf	=	15.000 Plastic

$$\beta_b = 1.00E+00$$

$$Z_p = 4.90E+07 \text{ mm}^3$$

0

DESIGN OF WEB FOR SHEAR :

Max Shear force

$$= 3404.57 \text{ KN}$$

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = \frac{V_n}{f_{yw}} \quad (\text{For Welded Section}) = 52500$$

$$V_n = 13033.68 \text{ KN} > 3404.57 \text{ KN}$$

Safe in Shear

$$\text{As the Shear force } V < 0.6 V_d$$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 19145.38 \text{ KNm}$$

$$> 7849.12 \text{ KNm}$$

Hence OK

$$> \frac{1.2 Z_e f_y}{\gamma_{m0}}$$

where

$$\frac{1.2 Z_e f_y}{\gamma_{m0}} = 18363.15 \text{ KNm}$$

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 19145.38 \text{ KNm}$$

$$> 1286.23 \text{ KNm}$$

Hence OK

$$> \frac{1.2 Z_e f_y}{\gamma_{m0}}$$

where

 γ_{m0}

$$\frac{1.2 \cdot Z_{ey} \cdot f_y}{\gamma_{m0}} = \boxed{18363.15} \text{ KNm}$$

Axial Force Capacity of Section along X-X axis

$$\text{Design Axial Force} = 21030.090 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length} = \boxed{5.56} \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{xx} = \boxed{0.428} \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{xx}}{r_{xx}} = 12.98 < 250 \quad \boxed{\text{SAFE}}$$

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_x)^2} = 11712.0$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.192$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.004$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.516$$

$$b/t_f = 15 \quad h/t_w = 42$$

$$\alpha = \boxed{0.49} \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 392.6 \text{ MPa}$$

Design Strength of member, p_{dx}

$$P_{dx} = A_e \cdot f_{cdx} = \boxed{48091.63} \text{ KN} > \boxed{21030.09} \text{ KN}$$

OK

Axial Force Capacity of Section along Y-Y axis

$$\text{Design Axial Force} = 21030.09 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length} = \boxed{5.56} \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{yy} = \boxed{0.269} \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{yy}}{r_{yy}} = 20.65 < 250 \quad \boxed{\text{SAFE}}$$

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 4631.2$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.305$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.947$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.572$$

$$\alpha = 0.49 \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 370.1 \text{ MPa}$$

Design Strength of member, p_{dy}

$$P_{dy} = A_e \cdot f_{cdy} = 45336.10 \text{ KN} > 21030.09 \text{ KN} \quad \text{OK}$$

Check for Overall stability of member for combined axial Compression and bending moment

As per Clause 510.3.2.2 of IRC:24-2010 -

$$P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$$

$$P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$$

Case 1 : Max compression with corresponding moment

$$\begin{aligned} P &= 21030.09 \text{ KN} \\ p_{dy} &= 45336.10 \text{ KN} \\ p_{dx} = p_{dz} &= 48091.63 \text{ KN} \\ M_z = M_x &= 7849.12 \text{ kNm} & M_y &= 1286.23 \text{ kNm} \\ M_{dz} = M_{dx} &= 19145.38 \text{ kNm} & M_{dy} &= 19145.38 \text{ kNm} \end{aligned}$$

$$K_z = 1 + (\lambda_z - 0.2) \cdot P / P_{dz} \leq (1 + 0.8 P / P_{dz})$$

$$\begin{aligned} \lambda_z &= 0.19 \\ K_z &= 0.996 \leq 1.350 \quad \text{OK} \end{aligned}$$

$$\Psi_z = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \quad \text{from staad}$$

$$C_{mz} = 0.6 + 0.4 \Psi_z = 0.800 \geq 0.4 \quad \text{SAFE}$$

$$K_y = 1 + (\lambda_y - 0.2) \cdot P / P_{dy} \leq (1 + 0.8 P / P_{dy})$$

$$\begin{aligned} \lambda_y &= 0.30 \\ K_y &= 1.049 \end{aligned}$$

$$\Psi_y = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \quad \text{from staad}$$

$$C_{my} = 0.6 + 0.4 \Psi_y = 0.80 \geq 0.4 \quad \text{SAFE}$$

$$\text{Generally } C_{MLT} = C_{mz} = 0.80$$

$$K_{LT} = 1 - (0.1 \lambda_{LT} \cdot n_y) / (C_{mLT} - 0.25) \geq 1 - (0.1 n_y) / (C_{mLT} - 0.25)$$

$$n_y = P / P_y = 0.464$$

$$\lambda_{LT} = 0.192$$

$$K_{LT} = 0.984 \geq 0.916 \quad \text{OK}$$

Check: $P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$

= $\frac{21030.09}{45336.10} + \frac{1.049 \times 0.800 \times 1286.23}{19145.38} + \frac{0.984 \times 7849.12}{19145.38}$

= 0.464 + 0.056 + 0.403

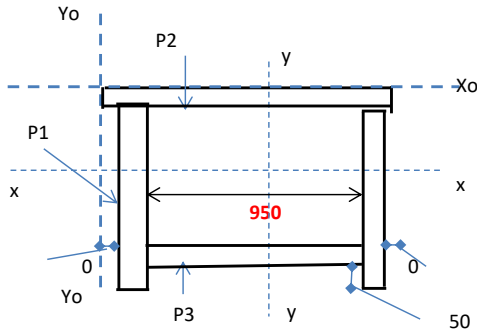
= 0.924 ≤ 1 OK

Check: $P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$

= $\frac{21030.09}{48091.63} + \frac{0.629 \times 0.800 \times 1286.23}{19145.38} + \frac{0.797 \times 7849.12}{19145.38}$

= 0.437 + 0.034 + 0.327

= 0.798 ≤ 1 OK

SECTION PROPERTIES OF TOP ARCH RIBS BETWEEN DISTANCE OF 60m -80M FROM CROWN POINT

Size of Plate P1	Length =	1250 mm	Thick =	25 mm
Size of Plate P2	Length =	1000 mm	Thick =	50 mm
Size of Plate P3	Length =	950 mm	Thick =	50 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1000 mm		
Width of Member at Bottom , B	=	1000 mm		
Depth of Member , D	=	1300 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	31250	12.5	675	3.91E+05	2.11E+07	4.88E+06	1.42E+10	4.07E+09	1.63E+06	1.83E+10	6.51E+06
Plate 2 Left	50000	500	25	2.50E+07	1.25E+06	1.25E+10	3.13E+07	1.04E+07	4.17E+09	4.17E+07	1.67E+10
Plate 3 Left	47500	500	1225	2.38E+07	5.82E+07	1.19E+10	7.13E+10	9.90E+06	3.57E+09	7.13E+10	1.54E+10
Plate 1 Right	31250	987.5	675	3.09E+07	2.11E+07	3.05E+10	1.42E+10	4.07E+09	1.63E+06	1.83E+10	3.05E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	160000			8.00E+07	1.02E+08	5.49E+10	9.98E+10			1.08E+11	6.26E+10

Therefore distance of N.A. , X	=	500.00 mm									
Therefore distance of N.A. , Y	=	635.16 mm	Yb	=	664.844 mm						
Ixx	=	1.08E+11	-	160000 x	403423.5	=	4.34E+10 mm ⁴				
Iyy	=	6.26E+10	-	160000 x	250000	=	2.26E+10 mm ⁴				
rxx	=	520.81 mm			ryy	=	375.80 mm				

PRIS	AX	0.1600	IY	0.0226	IZ	0.0434	YD	1.30	ZD	1.00	

Zxxb = Ixx / Yb	=	6.53E+07 mm ³	Zxxt = Ixx / Yt	=	6.83E+07 mm ³
Elastic section modulus (Ze)	=	6.53E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **650.00** mm

Area above neutral axis (A1)	=	80000 mm ²	Area below neutral axis (A2)	=	80000 mm ²

Moment balance about neutral axis

$$A2 - A1 = 0$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	50000	625	3.13E+07
web	30000	300.00	9.00E+06
	80000		4.03E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flng	47500	575	2.73E+07
web	32500	325	1.06E+07
	80000		3.79E+07

Y1	=	$\frac{\sum A_i Y_i}{\sum A_i}$	Y2	=	$\frac{\sum A_i Y_i}{\sum A_i}$
	=	503.13 mm		=	473.44 mm

Plastic section modulus (Zp)	=	A1*Y1 + A2*Y2	=	7.81E+07 mm ³

Ze / Zp	=	8.36E-01

DESIGN OF TOP ARCH RIBS BETWEEN DISTANCE OF 60m -80M FROM CROWN POINT

Unsupported length of member	Lx	=	5.56 m
	LY	=	5.56 m
Live load impact factor		=	1

Sectional Properties:

A	=	1.60E-01 m ²	rxx	=	0.521 m
Ixx	=	4.34E-02 m ⁴	ryy	=	0.376 m
Iyy	=	2.26E-02 m ⁴			

Staad Pro Analysis Results

	Member	Load Case	node	fx	fy	fz	mx	my	mz
Max Axial	16	390	33	-21293.3	-359.5	-751.87	-132.34	5516.01	633.84
Max MZ	97	106	195	-13773.2	1848.37	-667.98	186.08	-2797.7	5424.27
Max Fy	15	113	31	-13773.2	1870.2	-667.98	186.08	-2797.7	5424.27
Max My				-21004.5	-258.41	-909.38	184.45	12071.3	1428.02
Max				21293.3	1870.2	909.4	186.1	12071.3	5424.3

Check for Section Class :

Web Class

d	=	1250
tw	=	25
d/tw	=	50 Plastic

Flange Class

b	=	1000 mm
tf	=	50 mm
b/tf	=	20.000 Plastic

β_b	=	1.00E+00
Z_p	=	7.81E+07 mm ³

DESIGN OF WEB FOR SHEAR :

Max Shear force = 1870.20 KN

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = \frac{V_n \sqrt{3}}{f_{yw}} \quad (\text{For Welded Section}) = 62500$$

$$V_n = 15516.29 \text{ KN} > 1870.20 \text{ KN}$$

Safe in Shear

As the Shear force $V < 0.6 \cdot V_d$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 30539.77 \text{ KNm}$$

$$30539.77 > 5517.31 \text{ KNm}$$

Hence OK

&

$$M_{dy} = \frac{1.2 \cdot Z_e \cdot f_y}{\gamma_{m0}} = 30620.19 \text{ KNm}$$

where

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 30539.77 \text{ KNm}$$

$$30539.77 > 12164.37 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_{ey} \cdot f_y}{\gamma_{m0}} = \boxed{30620.19} \text{ KNm} \quad \& \quad < \frac{1.2 \cdot Z_{ey} \cdot f_y}{\gamma_{m0}}$$

Axial Force Capacity of Section along X-X axis

$$\text{Design Axial Force} = 21293.330 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length} = \boxed{5.56} \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{xx} = \boxed{0.521} \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{xx}}{r_{xx}} = 10.68 < 250 \quad \boxed{\text{SAFE}}$$

$$E = 2.0E+05 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_x)^2} = 17319.3$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.158$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.022$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.502$$

$$b/t_f = 20 \quad h/t_w = 50$$

$$\alpha = \boxed{0.49} \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 399.4 \text{ MPa}$$

Design Strength of member, p_{dx}

$$P_{dx} = A_e \cdot f_{cdx} = \boxed{63908.80} \text{ KN} > \boxed{21293.33} \text{ KN}$$

OK

Axial Force Capacity of Section along Y-Y axis

$$\text{Design Axial Force} = 21293.33 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length} = \boxed{5.56} \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{yy} = \boxed{0.376} \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{yy}}{r_{yy}} = 14.80 < 250 \quad \boxed{\text{SAFE}}$$

$$E = 2.0E+05 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 9017.5$$

$$\lambda = \sqrt{\frac{(KL/ry)^2}{f_y}} = 0.218$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.991$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.528$$

$$\alpha = 0.49 \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 387.3 \text{ MPa}$$

Design Strength of member, p_{dy}

$$P_{dy} = A_e \cdot f_{cd,y} = 61960.13 \text{ KN} > 21293.33 \text{ KN} \quad \text{OK}$$

Check for Overall stability of member for combined axial Compression and bending moment

As per Clause 510.3.2.2 of IRC:24-2010 -

$$P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$$

$$P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$$

Case 1 : Max compression with corresponding moment

$$\begin{aligned} P &= 21293.33 \text{ KN} \\ p_{dy} &= 61960.13 \text{ KN} \\ p_{dx} = p_{dz} &= 63908.80 \text{ KN} \\ M_z = M_x &= 5517.31 \text{ kNm} & M_y &= 12164.37 \text{ kNm} \\ M_{dz} = M_{dx} &= 30539.77 \text{ kNm} & M_{dy} &= 30539.77 \text{ kNm} \end{aligned}$$

$$K_z = 1 + (\lambda_z - 0.2) \cdot P / P_{dz} \leq (1 + 0.8 P / P_{dz})$$

$$\begin{aligned} \lambda_z &= 0.16 \\ K_z &= 0.986 \leq 1.267 \quad \text{OK} \end{aligned}$$

$$\Psi_z = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \quad \text{from staad}$$

$$C_{mz} = 0.6 + 0.4 \Psi_z = 0.800 \geq 0.4 \quad \text{SAFE}$$

$$K_y = 1 + (\lambda_y - 0.2) \cdot P / P_{dy} \leq (1 + 0.8 P / P_{dy})$$

$$\begin{aligned} \lambda_y &= 0.22 \\ K_y &= 1.006 \end{aligned}$$

$$\Psi_y = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \quad \text{from staad}$$

$$C_{my} = 0.6 + 0.4 \Psi_y = 0.80 \geq 0.4 \quad \text{SAFE}$$

$$\text{Generally } C_{MLT} = C_{mz} = 0.80$$

$$K_{LT} = 1 - (0.1 \lambda_{LT} \cdot n_y) / (C_{mLT} - 0.25) \geq 1 - (0.1 n_y) / (C_{mLT} - 0.25)$$

$$n_y = P / P_y = 0.344$$

$$\lambda_{LT} = 0.158$$

$K_{LT} = 0.990 \geq 0.938$ OK

Check: $P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$

$= \frac{21293.33}{61960.13} + \frac{1.006 \times 0.800 \times 12164.37}{30539.77} + \frac{0.990 \times 5517.31}{30539.77}$

$= 0.344 + 0.321 + 0.179$

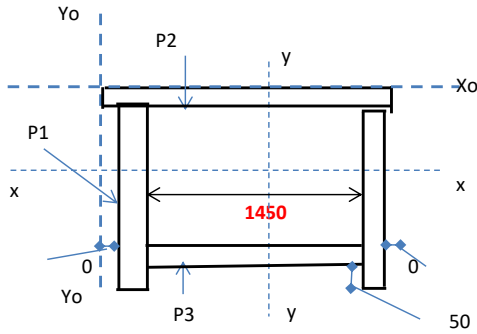
$= 0.843 \leq 1$ OK

Check: $P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$

$= \frac{21293.33}{63908.80} + \frac{0.604 \times 0.800 \times 12164.37}{30539.77} + \frac{0.789 \times 5517.31}{30539.77}$

$= 0.333 + 0.192 + 0.142$

$= 0.668 \leq 1$ OK

SECTION PROPERTIES OF TOP ARCH RIBS BETWEEN DISTANCE OF 80m -100M FROM CROWN POINT

Size of Plate P1	Length =	1450 mm	Thick =	25 mm
Size of Plate P2	Length =	1500 mm	Thick =	50 mm
Size of Plate P3	Length =	1450 mm	Thick =	50 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1500 mm		
Width of Member at Bottom , B	=	1500 mm		
Depth of Member , D	=	1500 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo2	Ayo2	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo2 , mm ⁴	Iyy + Axo2 , mm ⁴
Plate 1 Left	36250	12.5	775	4.53E+05	2.81E+07	5.66E+06	2.18E+10	6.35E+09	1.89E+06	2.81E+10	7.55E+06
Plate 2 Left	75000	750	25	5.63E+07	1.88E+06	4.22E+10	4.69E+07	1.56E+07	1.41E+10	6.25E+07	5.63E+10
Plate 3 Left	72500	750	1425	5.44E+07	1.03E+08	4.08E+10	1.47E+11	1.51E+07	1.27E+10	1.47E+11	5.35E+10
Plate 1 Right	36250	1487.5	775	5.39E+07	2.81E+07	8.02E+10	2.18E+10	6.35E+09	1.89E+06	2.81E+10	8.02E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	220000			1.65E+08	1.61E+08	1.63E+11	1.91E+11			2.04E+11	1.90E+11

Therefore distance of N.A. , X	=	750.00 mm									
Therefore distance of N.A. , Y	=	733.52 mm	Yb	=	766.477 mm						
Ixx	=	2.04E+11	-	220000 x	538055.6	=	8.52E+10 mm ⁴				
Iyy	=	1.90E+11	-	220000 x	562500	=	6.62E+10 mm ⁴				
rxx	=	622.22 mm			ryy	=	548.56 mm				

PRIS	AX	0.2200	IY	0.0662	IZ	0.0852	YD	1.50	ZD	1.50	

Zxxb = Ixx / Yb	=	1.11E+08 mm ³	Zxxt = Ixx / Yt	=	1.16E+08 mm ³
Elastic section modulus (Ze)	=	1.11E+08 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **750.00** mm

Area above neutral axis (A1)	=	110000 mm ²	Area below neutral axis (A2)	=	110000 mm ²

Moment balance about neutral axis

$$A2 - A1 = 0$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	75000	725	5.44E+07
web	35000	350.00	1.23E+07
	110000		6.66E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flng	72500	675	4.89E+07
web	37500	375	1.41E+07
	110000		6.30E+07

Y1	=	$\frac{\sum A_i Y_i}{\sum A_i}$	Y2	=	$\frac{\sum A_i Y_i}{\sum A_i}$
	=	605.68 mm		=	572.73 mm

Plastic section modulus (Zp)	=	A1*Y1 + A2*Y2	=	1.30E+08 mm ³

Ze / Zp	=	8.57E-01

DESIGN OF TOP ARCH RIBS BETWEEN DISTANCE OF 80m -100M FROM CROWN POINT

Unsupported length of member	Lx	=	5.56 m
	LY	=	5.56 m
Live load impact factor		=	1

Sectional Properties:

A	=	2.20E-01 m ²	rxx	=	0.622 m
Ixx	=	8.52E-02 m ⁴	ryy	=	0.549 m
Iyy	=	6.62E-02 m ⁴			

Staad Pro Analysis Results

	Member	Load Case	node	fx	fy	fz	mx	my	mz
Max Axial	104	112	211	-28654.6	569.9	1018.7	725.06	21036	-5119.1
Max MZ	68	346	139	-22753.5	-735.74	-1010.2	-610.34	21128	6490.33
Max MY	11	112	21	-22753.5	1037.65	-1010.2	-610.34	21128	6490.33
Max FY	101	113	205	-26682	-833.57	-1038.6	1844.52	22536.8	3487.19
Max				28654.6	1037.7	1038.6	1844.5	22536.8	6490.3

Check for Section Class :

Web Class

d	=	1450
tw	=	25
d/tw	=	58 Plastic

Flange Class

b	=	1500	mm
tf	=	50	mm
b/tf	=	30.000	Semicompact

$$\beta_b = 1.00E+00$$

$$Z_p = 1.30E+08 \text{ mm}^3$$

DESIGN OF WEB FOR SHEAR :**Max Shear force**

$$= 1037.65 \text{ KN}$$

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}} = \frac{A_v}{d * t_w} \quad (\text{For Welded Section}) = 72500$$

$$V_n = 17998.89 \text{ KN} > 1037.65 \text{ KN}$$

Safe in Shear

$$\text{As the Shear force } V < 0.6 * V_d$$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 50671.59 \text{ KNm}$$

$$> 7412.59 \text{ KNm}$$

Hence OK

&

$$< \frac{1.2 * Z_e * f_y}{\gamma_{m0}} \quad \text{SAFE}$$

where

$$\frac{1.2 * Z_e * f_y}{\gamma_{m0}} = 52127.00 \text{ KNm}$$

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 50671.59 \text{ KNm}$$

$$> 23459.05 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_e \cdot f_y}{\gamma_{m0}} = \frac{52127.00}{\text{KNm}} \quad \& \quad < \frac{1.2 \cdot Z_e \cdot f_y}{\gamma_{m0}}$$

Axial Force Capacity of Section along X-X axis

$$\text{Design Axial Force} = 28654.580 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length} = 5.56 \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{xx} = 0.622 \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{xx}}{r_{xx}} = 8.94 < 250 \quad \boxed{\text{SAFE}}$$

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_x)^2} = 24720.8$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.132$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.035$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.492$$

$$b/t_f = 30 \quad h/t_w = 58$$

$$\alpha = 0.49 \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 404.7 \text{ MPa}$$

Design Strength of member, p_{dx}

$$P_{dx} = A_e \cdot f_{cdx} = 89025.74 \text{ KN} > 28654.58 \text{ KN}$$

OK

Axial Force Capacity of Section along Y-Y axis

$$\text{Design Axial Force} = 28654.58 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length} = 5.56 \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{yy} = 0.549 \text{ m}$$

$$\text{Slenderness ratio} = \frac{kL_{yy}}{r_{yy}} = 10.14 < 250 \quad \boxed{\text{SAFE}}$$

$$E = 2.0 \times 10^5 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 19214.5$$

$$\lambda = \sqrt{\frac{(KL/ry)^2}{\frac{f_y}{f_{cc}}}} = 0.150$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.000$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.499$$

$$\alpha = \boxed{0.49} \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 390.9 \text{ MPa}$$

Design Strength of member, p_{dy}

$$P_{dy} = A_e \cdot f_{cdy} = \boxed{86000.00} \text{ KN} > \boxed{28654.58} \text{ KN} \quad \text{OK}$$

Check for Overall stability of member for combined axial Compression and bending moment

As per Clause 510.3.2.2 of IRC:24-2010 -

$$P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$$

$$P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$$

Case 1 : Max compression with corresponding moment

P	=	28654.58 KN			
p_{dy}	=	86000.00 KN			
$p_{dx} = p_{dy}$	=	89025.74 KN			
$M_z = M_x$	=	7412.59 kNm	M_y	=	23459.05 kNm
$M_{dz} = M_{dx}$	=	50671.59 kNm	M_{dy}	=	50671.59 kNm

$$K_z = 1 + (\lambda_z - 0.2) \cdot P / P_{dz} \leq (1 + 0.8 P / P_{dz})$$

λ_z	=	0.13		
K_z	=	0.978	$\leq$	1.257 OK

$$\Psi_z = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \quad \text{from staad}$$

$$C_{mz} = 0.6 + 0.4 \Psi_z = 0.800 \geq 0.4 \quad \text{SAFE}$$

$$K_y = 1 + (\lambda_y - 0.2) \cdot P / P_{dy} \leq (1 + 0.8 P / P_{dy})$$

λ_y	=	0.15
K_y	=	0.983

$$\Psi_y = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \quad \text{from staad}$$

$$C_{my} = 0.6 + 0.4 \Psi_y = 0.80 \geq 0.4 \quad \text{SAFE}$$

$$\text{Generally } C_{MLT} = C_{mz} = 0.80$$

$$K_{LT} = 1 - (0.1 \lambda_{LT} \cdot n_y) / (C_{MLT} - 0.25) \geq 1 - (0.1 n_y) / (C_{MLT} - 0.25)$$

$$n_y = P / P_y = 0.333$$

$$\lambda_{LT} = 0.132$$

$K_{LT} = 0.992 \geq 0.939$ OK

Check: $P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$

$= \frac{28654.58}{86000.00} + \frac{0.983 \times 0.800 \times 23459.05}{50671.59} + \frac{0.992 \times 7412.59}{50671.59}$

$= 0.333 + 0.364 + 0.145$

$= 0.842 \leq 1$ OK

Check: $P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$

$= \frac{28654.58}{89025.74} + \frac{0.590 \times 0.800 \times 23459.05}{50671.59} + \frac{0.782 \times 7412.59}{50671.59}$

$= 0.322 + 0.218 + 0.114$

$= 0.655 \leq 1$ OK

CALCULATION OF ANCHORAGE BOLT

Design bending moment along z-z axis	=	7412.6 kNm	
Lever arm	=	1.5 m	
Force carried by each flange	=	4941.73 KN	
Minimum Tension in Bolt	=	490 KN	Class 8.8 - M36
Total Bolts required	=	10.085	
	say	20 bolts on each long flange side	
Design bending moment along y-y axis	=	23459.1 kNm	
Lever arm	=	1.50 m	
Force carried by each flange	=	15639.37 KN	
Minimum Tension in Bolt	=	490 KN	Class 8.8 - M36
Total Bolts required	=	31.917	
	say	40 bolts on each short flange side	
Length of Each Bolt :			
fbd	=	3 N/mm ²	
F	=	490 KN	
Anchorage Length of bolt	=	1444.184 say	1500 mm

DESIGN OF ARCH **VERTICAL MEMBERS**

DESIGN OF ARCH VERTICAL MEMBERS

Staad-Pro results:

Axial Force, Pu	=	1979.00 KN
Long. Moment, ML	=	275.00 kNm
Shear Force	=	90.00 KN

Sectional Properties:

outer diameter of pipe, D	=	450 mm
thickness of pipe, t	=	10 mm
inner diameter of pipe, d	=	430 mm

Cross section area , A	=	1.382E+04 mm ²
Moment of Inertia, Ix=Iy	=	3.347E+08 mm ⁴
Moment of Inertia, Ixy	=	6.694E+08 mm ⁴

Radius of giration , rxx=ryy	=	155.604 mm
Elastic Sectional Modulus, Zxx=Zyy	=	1487509 mm ³

Plastic section modulus, Zp	=	1.936E+06 mm ³

Material Stress:

fy	=	350 N/mm ²
γmo	=	1.10

Check for Section

D/t _f	=	45.000 Compact

Design Section capacity in Axial Compression

Unsupported length of column	=	5.60 m

Effective length (1.0*L)	=	5.60 m

Minimum Radius of gyration	=	155.604 mm

$\frac{KL}{r}$	=	35.99	<	180	OK

E	=	2.0E+05 MPa

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 1524.0$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.479$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.931$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.64$$

$$\alpha = 0.21 \text{ for buckling class 'a' as per Table 4}$$

$$f_{cd} = \frac{\chi f_y}{\gamma_{m0}} = 296.1 \text{ MPa}$$

Design Strength of member in axial compression:

$$P_d = A_e \cdot f_{cd} = 4092.996 \text{ KN}$$

Design Strength of member in axial tension:

Strength on the basis of gross section yielding

$$\begin{aligned} T_{dg} &= A_g \cdot f_y / \gamma_{m0} \\ &= 1.38 \times 10^4 \times \frac{350.000}{1.10} = 4398.23 \text{ KN} \end{aligned}$$

Design bending strength of section : clause 509.2 of IRC:24-2010**Shear Capacity**

$$\begin{aligned} V_n &= V_p = \frac{A_v f_{yw}}{\sqrt{3}} \\ A_v &= 2A/p \quad (\text{For circular hollow tube}) = 8.800 \times 10^3 \end{aligned}$$

$$V_n = 1778.24 \text{ KN} > 90.00 \text{ KN}$$

Safe in Shear

$$\begin{aligned} \text{Design shear force} &= 90.0 \text{ KN} < 0.6 \times V_n \\ 0.6 \times V_n &= 1066.94 \text{ KN} \end{aligned}$$

Design bending strength of beam (M_d) for design shear force is less than 0.6 times shear capacity :

$$M_d = \beta_b Z_p f_y / \gamma_{m0}$$

$$\beta_b = 1 \quad (1 \text{ For Plastic/Compact, } Z_e/Z_p \text{ for semicompact})$$

$$Z_p = 1.94 \times 10^6 \text{ mm}^3$$

$$M_d = 616.1 \text{ KNm}$$

Combined Axial Compression and Bending:

Section strength

$$\frac{N}{N_d} + \frac{M}{M_d} \leq 1 \quad \text{Clause 510.3.1.1 of IRC:24-2010}$$

Case 1:

$$N = 1979.000$$

$$N_d = 4092.996$$

$$M = 275$$

$$M_d = 616.1$$

$$\frac{1979.000}{4092.996} + \frac{275}{616.1} = 0.484 + 0.446 = 0.930$$

SAFE

DESIGN OF ARCH **DIAGONAL MEMBERS**

DESIGN OF ARCH BRACING

Staad-Pro results:

Axial Force, Pu	=	4012.00 KN
Long. Moment, ML	=	260.00 kNm
Shear Force	=	50.00 KN

Sectional Properties:

outer diameter of pipe, D	=	550 mm
thickness of pipe, t	=	12 mm
inner diameter of pipe, d	=	526 mm

Cross section area , A	=	2.028E+04 mm ²
Moment of Inertia, Ix=Iy	=	7.342E+08 mm ⁴
Moment of Inertia, Ixy	=	1.468E+09 mm ⁴

Radius of giration , rxx=ryy	=	190.259 mm
Elastic Sectional Modulus, Zxx=Zyy	=	2669754 mm ³

Plastic section modulus, Zp	=	3.474E+06 mm ³

Material Stress:

fy	=	350 N/mm ²
γmo	=	1.10

Check for Section

D/t _f	=	45.833 Compact

Design Section capacity in Axial Compression

Unsupported length of column	=	7.00 m

Effective length (1.0*L)	=	7.00 m

Minimum Radius of gyration	=	190.259 mm

$\frac{kL}{r}$	=	36.79	<	180	OK

E	=	2.0E+05 MPa

f_{cc}	=	$\frac{\pi^2 E}{(KL/r_y)^2}$	=	1458.2

λ	=	$\sqrt{\frac{f_y}{f_{cc}}}$	=	0.490

χ	=	$\frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})}$	=	0.927

Φ	=	$0.5(1 + \alpha(\lambda - 0.2) + \lambda^2)$	=	0.65

α	=	0.21	for buckling class 'a' as per Table 4

$$f_{cd} = \frac{\chi f_y}{\gamma_{m0}} = 295.1 \text{ MPa}$$

Design Strength of member in axial compression:

$$P_d = A_e \cdot f_{cd} = 5984.715 \text{ KN}$$

Design Strength of member in axial tension:

Strength on the basis of gross section yielding

$$\begin{aligned} T_{dg} &= A_g \cdot f_y / \gamma_{m0} \\ &= 2.03 \times 10^4 \times \frac{350.000}{1.10} = 6453.40 \text{ KN} \end{aligned}$$

Design bending strength of section : clause 509.2 of IRC:24-2010**Shear Capacity**

$$\begin{aligned} V_n &= V_p = \frac{A_v f_{yw}}{\sqrt{3}} \\ A_v &= 2A/p \quad (\text{For circular hollow tube}) = 1.291 \times 10^4 \end{aligned}$$

$$V_n = 2609.16 \text{ KN} > 50.00 \text{ KN}$$

Safe in Shear

$$\begin{aligned} \text{Design shear force} &= 50.0 \text{ KN} < 0.6 \times V_n \\ 0.6 \times V_n &= 1565.50 \text{ KN} \end{aligned}$$

Design bending strength of beam (M_d) for design shear force is less than 0.6 times shear capacity :

$$M_d = \beta_b Z_p f_y / \gamma_{m0}$$

$$\beta_b = 1 \quad (1 \text{ For Plastic/Compact, } Z_e/Z_p \text{ for semicompact})$$

$$Z_p = 3.47 \times 10^6 \text{ mm}^3$$

$$M_d = 1105.3 \text{ KNm}$$

Combined Axial Compression and Bending:

Section strength

$$\frac{N}{N_d} + \frac{M}{M_d} \leq 1 \quad \text{Clause 510.3.1.1 of IRC:24-2010}$$

Case 1:

$$N = 4012.000$$

$$N_d = 5984.715$$

$$M = 260$$

$$M_d = 1105.3$$

$$\frac{4012.000}{5984.715} + \frac{260}{1105.3} = 0.670 + 0.235 = 0.906$$

SAFE

DESIGN OF ARCH **BRACING MEMBERS**

DESIGN OF ARCH BRACING MEMBERS

Staad-Pro results:

Axial Force, Pu	=	560.00 KN
Long. Moment, ML	=	1700.00 kNm
Shear Force	=	460.00 KN

Sectional Properties:

outer diameter of pipe, D	=	650 mm
thickness of pipe, t	=	16 mm
inner diameter of pipe, d	=	618 mm

Cross section area , A	=	3.187E+04 mm ²
Moment of Inertia, Ix=Iy	=	1.602E+09 mm ⁴
Moment of Inertia, Ixy	=	3.204E+09 mm ⁴

Radius of giration , rxx=ryy	=	224.224 mm
Elastic Sectional Modulus, Zxx=Zyy	=	4929930 mm ³

Plastic section modulus, Zp	=	6.433E+06 mm ³

Material Stress:

fy	=	350 N/mm ²
γmo	=	1.10

Check for Section

D/t _f	=	40.625 Plastic

Design Section capacity in Axial Compression

Unsupported length of column	=	7.50 m

Effective length (1.0*L)	=	7.50 m

Minimum Radius of gyration	=	224.224 mm

$\frac{kL}{r}$	=	33.45	<	180	OK

E	=	2.0E+05 MPa

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 1764.3$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.445$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.940$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.62$$

$$\alpha = 0.21 \text{ for buckling class 'a' as per Table 4}$$

$$f_{cd} = \frac{\chi f_y}{\gamma_{m0}} = 299.2 \text{ MPa}$$

Design Strength of member in axial compression:

$$P_d = A_e \cdot f_{cd} = 9535.801 \text{ KN}$$

Design Strength of member in axial tension:

Strength on the basis of gross section yielding

$$\begin{aligned} T_{dg} &= A_g \cdot f_y / \gamma_{m0} \\ &= 3.19E+04 \times \frac{350.000}{1.10} = 10139.92 \text{ KN} \end{aligned}$$

Design bending strength of section : clause 509.2 of IRC:24-2010**Shear Capacity**

$$\begin{aligned} V_n &= V_p = \frac{A_v f_{yw}}{\sqrt{3}} \\ A_v &= 2A/p \quad (\text{For circular hollow tube}) = 2.029E+04 \end{aligned}$$

$$V_n = 4099.65 \text{ KN} > 460.00 \text{ KN}$$

Safe in Shear

$$\begin{aligned} \text{Design shear force} &= 460.0 \text{ KN} < 0.6 \times V_n \\ 0.6 \times V_n &= 2459.79 \text{ KN} \end{aligned}$$

Design bending strength of beam (M_d) for design shear force is less than 0.6 times shear capacity :

$$M_d = \beta_b Z_p f_y / \gamma_{m0}$$

$$\beta_b = 1 \quad (1 \text{ For Plastic/Compact, } Z_e/Z_p \text{ for semicompact})$$

$$Z_p = 6.43E+06 \text{ mm}^3$$

$$M_d = 2046.8 \text{ KNm}$$

Combined Axial Compression and Bending:

Section strength

$$\frac{N}{N_d} + \frac{M}{M_d} \leq 1 \quad \text{Clause 510.3.1.1 of IRC:24-2010}$$

Case 1:

$$\begin{aligned} N &= 560.000 \\ N_d &= 9535.801 \\ M &= 1700 \\ M_d &= 2046.8 \end{aligned}$$

$$\frac{560.000}{9535.801} + \frac{1700}{2046.8} = 0.059 + 0.831 = 0.889$$

SAFE

QUANTITY OF STEEL FROM MIDAS MODEL

Superstructure	334.3085	
Arch	886.1327	
Arch Verticals	45.46516	
Arch Diagonals	98.5989	
Arch Bracing	202.3912	
Spandrel column	301.5205	
spandrel ties	9.07254	
cap	72.39969	
	1949.889 T	2437.36
additional	2339.867 T	
 PLAN ARE	3125	
Steelk	748.76 KG/SQM	

DESIGN OF 180M OPEN
SPANDREL STEEL ARCH BRIDGE

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1.0 Design Report

This design note represent design of bow string steel girder of 170m span.

1.1 Introduction:-

The Ultimate limit state method has been followed for designing the components of bridge

1.1.1 Unit System:-

Length	m
Force	kN
Stress	N/mm ²
Moment	kNm
Hog Mom/Com Str	-ve
Sag Mom/Ten Str	+ve

1.2 Reference documents :-

- 1 IRC codes /guidelines/special publications
- 2 MORTH specification
- 3 Specialised literature as relevant

1.3 Design Loading

The load which may arise during construction and service life is listed as following

1.3.1 Dead Loads

Dead load of the structure is calculated based on unit weights of materials given below

Structural Steel	78.50 kN/m ³
Reinforced concrete	25.00 kN/m ³
Green Weight of Concrete	26.00 kN/m ³
Temporary weight Due to Erection	150.00 kg/m ³

1.3.2 Superimposed Dead Load

The thickness of wearing coat has been adopted as 65mm and density is considered as 22.00 kN/m³

Load Intensity due to wearing course+overburden 2.0 kN/m²

Weight of Crash Barrier 8 kN/m along the traffic on each side of carriageway.

Weight of Railing 3 kN/m along the traffic on each side of carriageway.

1.3.3 Live Load

Dynamic Impact Factor

Impact Factor for class A loading

$$\frac{9}{13.5 + L} = 1.250$$

Impact Factor for 70R loading = 1.250

1.3.4 Braking Force

considered in the design of superstructure

1.3.5 Live load combinations

Live load combinations has been taken as per the provisions of IRC 6 -2017

1.3.6 Wind Load

Wind load has been considered as per clause 209.3 of IRC 6 2017

1.4 Assumptions:-

The following assumptions have been taken while designing.

- 1 Structure is designed for Plastic-Compact section-Semicompact section.

- 2 On top slab 65mm thick cc wearing coat is assumed for SIDL
- 4 Girders are assumed laterally unsupported for self wt. stage.
- 5 Bracings are designed for 50% of wind load. Remaining is shared by deck slab.
- 6 Modular ration of 15 for permanent loading and 7.5% for transient load is considered.
- 7 Stud connectors are designed for full shear interaction.
- 8 Load cycle of 2×10^6 of critical loading is consider in fatigue check

1.4 Loads:-

The different types of loads used as per IRC 6 : 2017 are.

- 1 Dead load.
- 2 In SIDL , crash barrier, Railing and wearing coat load is considered.
- 3 1 Lane of Class 70 R + 1 Lane of class A
- 4 3 Lane of class A Loading
- 5 SV Load

1.5 Material properties

- 1 Grade of Concrete M40
- 2 Grade of Reinforcement Steel Fe500D.
- 3 Grade of structural steel (Main Girders) E450 and E350

DESIGN INPUT:

Span of Arch	=	170 m
Length of Arch	=	191 m
Length of superstructure support	=	180 m
eff. Span of superstructure	=	22.5 m
Width of truss	=	12.5 m
Formation width	=	12.5 m
Carriageway Width	=	11.5 m
Footpath width	=	1.5 m
Spacing of truss arch	=	7.5 m
Depth of truss arch	=	2.3 m
Cross slope of deck slab	=	2.5 %
c/c distance of cross beam int.1	=	3 m
c/c distance of cross beam int.2	=	3 m
centre of outer cross beam from	=	1 m
Nos. Of cross beam intermediate	=	7 Nos
Nos. of cross beam end	=	2 Nos

Grade of Material:

Grade of Concrete	=	M40		
Grade of Structural Steel	=	E 450 for arch	and	E350 for other members
Characteristic strength of concr.	=	40 N/mm ²		
Yield stress in steel	=	450 N/mm ²		
Es	=	200000 N/mm ²		
Ec	=	33345.76 N/mm ²		

Ultimate strength of shear connector		146	kN	for	25	mm stud dia
Fatigue strength of shear connector		27	kN	for 2 x 10 ⁶ Life Cycle		
The permissible stress in the fillet w	=	108	Mpa			

Material Weight

Concrete Weight	=	25 kN/m ³
Steel Weight	=	78.5 kN/m ³

Material Safety Factor

γ_m	=	1.10	For Structural Steel Against Yield Stress
γ_m	=	1.25	For Shear Connector
γ_m	=	1.25	for Fillet weld/bolt

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{450}{1.10} = 409.091 \text{ N/mm}^2$$

$$\varepsilon = \sqrt{\frac{250}{f_y}} = 0.745$$

$$\text{Average Shear Stress} = \frac{f_y}{450} \div \gamma_m = \frac{450}{1.10} = 409.091 \text{ MPa}$$

Type of member	Nos.	Length (m)	Width	Front depth (m)	Front area of single truss
Chord of arch	1	191.00	1	2.30	219.65
Bottom Chord of arch	0	191.00	0	1.00	0.00
Diagonals of arch	0	6.60	0.5	0.50	0.00
Vertical Members	0	4.00	0.5	0.50	0.00
Spandrel column	8	33.00	1.00	0.70	92.40
					219.65

Deck Slab : 220 mm Thk.

Load intensity	=	0.22	x	25.00	=	5.5 kN/m ²
load carried by end stringers	=	5.5	x	2.5	=	13.750 kN/m
load carried by Middle stringers1	=	5.5	x	3	=	16.500 kN/m
load carried by Middle stringers2	=	5.5	x	3	=	16.500 kN/m

Green weight of deck slab = 26 kN/m³ as per IRC:87-2011 , Clause 6.3.2.1.3

Temporary Construction Load	=	1.5 kN/m ²		
load carried by end stringers	=	1.5 x	2.5 =	3.750 kN/m
load carried by Middle stringers1	=	1.5 x	3 =	4.500 kN/m
load carried by Middle stringers2	=	1.5 x	3 =	4.500 kN/m

2) SIDL - without surfacing :

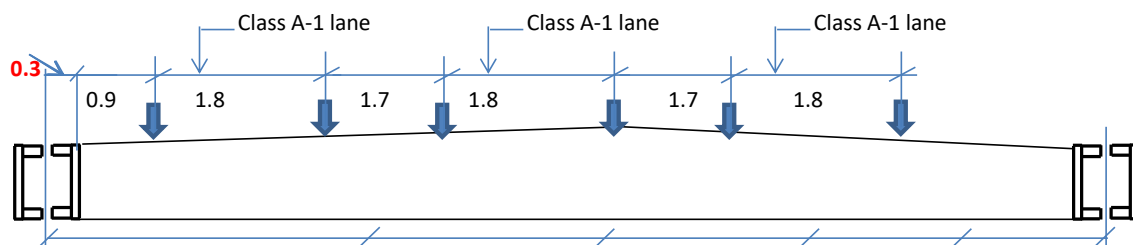
Crash Barrier Weight	=	8.00 kN/m
Rcc Railing	=	3.00 kN/m

3) Surfacing (Wearing Coat)	=	2.00 kN/m ²			
load carried by end stringers	=	2.00 x	2.5	=	5.000 kN/m
load carried by Middle stringers	=	2.00 x	3	=	6.000 kN/m

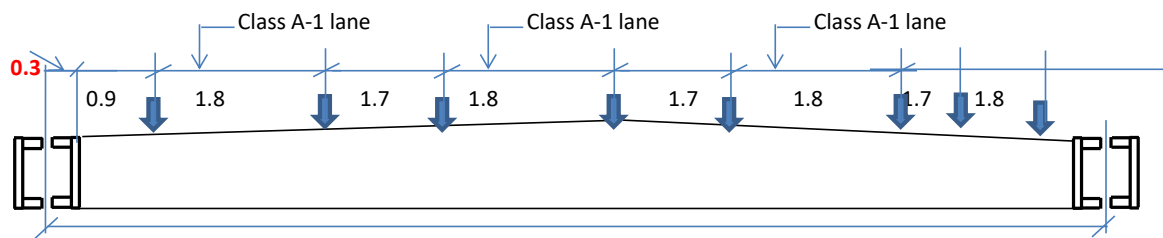
4) Footpath Load	=	0.00 kN/m ²			
load intensity on end stringers	=	1.5	x	0.00	= 0 kN/m

5) CWLL As per Table 2 of IRC:6-2017

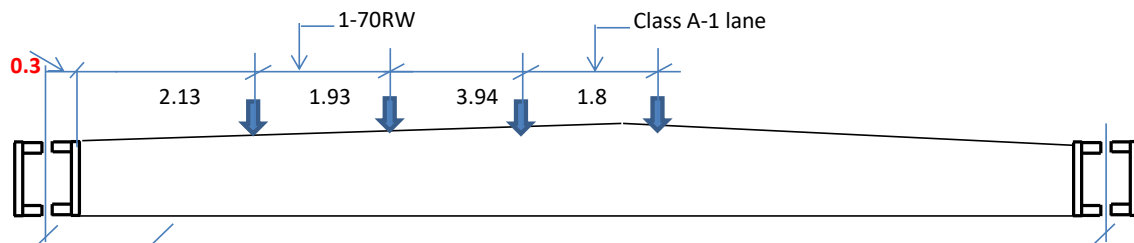
Position of 3 Lane Class A IRC Vehicle over Deck slab



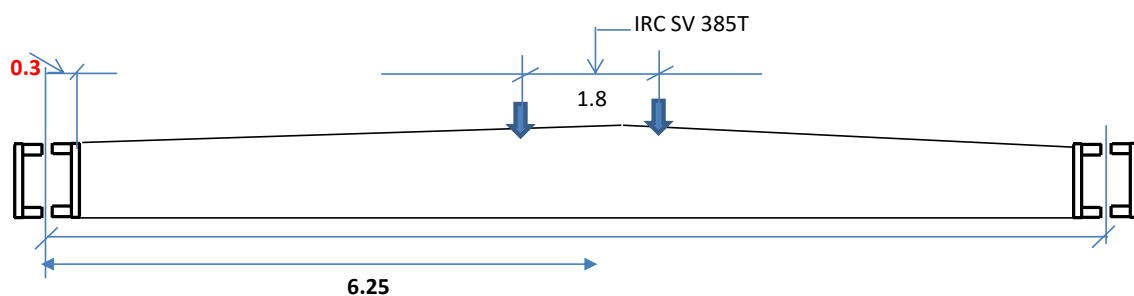
			increment by 0.5 m	
Position of 1st wheel of Class A from centre line of truss	=	1.2	1.7	m
Position of 2nd wheel of Class A from centre line of truss	=	3	3.5	m
Position of 3rd wheel of Class A from centre line of truss	=	4.7	5.2	m
Position of 4th wheel of Class A from centre line of truss	=	6.5	7	m
Position of 5th wheel of Class A from centre line of truss	=	8.2	8.7	m
Position of 6th wheel of Class A from centre line of truss	=	10	10.5	m

Position of 4 Lane Class A IRC Vehicle over Deck slab**NOT IN USE**

		increment by 0.5 m	
Position of 1st wheel of Class A from centre line of truss	=	1.2	1.7 m
Position of 2nd wheel of Class A from centre line of truss	=	3	3.5 m
Position of 3rd wheel of Class A from centre line of truss	=	4.7	5.2 m
Position of 4th wheel of Class A from centre line of truss	=	6.5	7 m
Position of 5th wheel of Class A from centre line of truss	=	8.2	8.7 m
Position of 6th wheel of Class A from centre line of truss	=	10	10.5 m
Position of 7th wheel of Class A from centre line of truss	=	11.7	12.2 m
Position of 8th wheel of Class A from centre line of truss	=	13.5	14 m

Position of 1-70R wheel + Class A-1Lane over Deck slab

		increment by 0.5 m	
Position of 1st wheel of 70R from centre line of truss	=	2.43	2.93 m
Position of 2nd wheel of 70R from centre line of truss	=	4.36	4.86 m
Position of 3rd wheel of Class A from centre line of truss	=	8.3	8.8 m
Position of 4th wheel of Class A from centre line of truss	=	10.1	10.6 m

Position of SV Laod over Deck slab

		at centre	0.3m eccentric
Position of 1st wheel from centre line of truss	=	5.35	5.65 m
Position of 2nd wheel from centre line of truss	=	7.15	7.45 m

LIVE LOAD IMPACT FACTOR

$$\text{Class A} = \frac{9}{13.5 + 22.5} = 1.250$$

$$70\text{RW} = 1.250 \quad \text{from Fig 5 of IRC:6-2014}$$

BRAKING LOAD

Numbers of vehicles on superstructure - 70R

$$= 4.147 \quad \text{say} \quad 6 \text{ Nos}$$

1-70R on 1st 2 lane =
 1-class A on remaining lane =
 1-70R+1-class A =

1st train	succeeding train				
200	100	100	100	100	100
27.7	27.7	27.7	27.7	27.7	27.7
227.7	127.7	127.7	127.7	127.7	127.7

6) WIND LOAD CASE As per Clause 209 of IRC:6-2017**CASE 1) : WHEN BASIC WIND SPEED AT BRIDGE LOCATION EXCEED THE BASIC WIND SPEED OF 36 m/ses**

$$\text{wind speed} = 39 \text{ m/s}$$

$$\text{Average height of exposed surface above Ground Surface/} = 100 \text{ m}$$

As per Table 12 of IRC 6:2017

$$\text{Basic wind speed} = 33.000 \text{ m/s}$$

$$V_z = 35.3 \text{ m/s}$$

$$P_z = 747 \text{ N/m}^2$$

For Hilly road : IF the bridge is situated in hill, wind pressure shall be increased by 20%

modified value of Hourly mean wind speed and wind pressure for this bridge are as per below

$$V_{z,\text{design}} = V_z \times 1.182 \times 1.2 = 50.06 \text{ m/s}$$

$$P_{z,\text{design}} = P_z \times 1.397 \times 1.2 = 1252.00 \text{ N/m}^2$$

Design Transverse Wind Force

$$F_T = P_z \times A_1 \times G \times C_d \quad \text{as per IRC 6:2014, Clause 209.3.3}$$

$$\text{Where, } P_z = 1252.00 \text{ N/m}^2$$

$$\text{Span Length} = 191.000 \text{ m}$$

$$\text{Average depth of superstructure} = 4.000 \text{ m}$$

$$\text{Area } A_1 \text{ in elevation} = 764.000 \text{ m}^2$$

$$\text{Gust factor, } G = 2.5 \quad \text{ASSUMED}$$

Solidity ratio (ϕ) of truss is the ratio of the net area to overall area of the truss

$$\text{Net area of truss} = 220 \text{ m}^2$$

$$\text{overall area of truss} = 764.00 \text{ m}^2$$

$$\phi = 0.288$$

For Windward truss

$$\text{Drag Coefficient } C_D = 1.750 \quad \text{Refer Table C-1 OF Annexure C of IRC 6:2017}$$

For Leeward truss

$$\text{Truss spacing ratio} = 3.261$$

$$\eta = 0.882 \quad \text{Refer Table C-2 OF Annexure C of IRC 6:2017}$$

$$C_D = 1.543$$

$$F_T = 1203.13 \text{ KN} \quad 5.477 \text{ kN/m}^2 \quad \text{For Windward truss}$$

$$F_T = 1060.91 \text{ KN} \quad 4.830 \text{ kN/m}^2 \quad \text{For Leeward truss}$$

Longitudinal Wind Force

as per clause 209.3.4

FL	=	50%	FT	=	601.56 KN	2.739 kN/m ²	For Windward truss
FL	=	50%	FT	=	530.46 KN	2.415 kN/m ²	For Leeward truss

Upward / Downward Wind Vertical Force (Fv)

Fv = Pz x A3 x G x CL as per IRC 6:2010, Caluse 209.3.5

Where ,

A3	=	Area in Plan (m2)	=	12.5	x	191	=	2387.5 m ²
				CL	=	0.75		
				G	=	2.5		
				Pz	=	1.252 kN/m ²		
			Fv	=	5604.64 KN	2.347 kN/m ²	Downward	
			Fv	=	-5604.6 KN	-2.347 kN/m ²	Upward	

CASE 2) : FOR THE WIND SPEED OF 36 m/ses

wind speed = 36 m/s

Average Height of Bridge from Ground Surface = 100 m

As per Table 5 of IRC 6:2014

Basic wind speed	=	33 m/s
Vz	=	35.3 m/s
Pz	=	747 N/m ²

For Hilly road : IF the bridge is situated in hill, wind pressure shall be increased by 20%

modified value of Hourly mean wind speed and wind pressure for this bridge are as per below

Vz,design	=	Vz	x	1.091	x	1.2	=	46.21 m/s
Pz,design	=	Pz	x	1.190	x	1.2	=	1066.79 N/m ²

Design Transverse Wind ForceF_T = Pz x A1 x G x Cd as per IRC 6:2014, Caluse 209.3.3Where , Pz = 1066.79 N/m²

Span Length	=	191.000 m
Depth of superstructure	=	4.000 m
Area A1 in elevation	=	764.000 m ²

Gust factor , G assumed = 2.5 as per Clause 209.3.3

Solidity ratio (ϕ) of truss is the ratio of the net area to overall area of the truss

Net area of truss	=	220 m ²
overall area of truss	=	764.00 m ²
ϕ	=	0.288
For Windward truss		
Drag Coefficient	CD	= 1.600 Refer Table C-1 OF Annexure C of IRC 6:2014
For Leeward truss		
Truss spacing ratio		= 3.261
	η	= 0.882 Refer Table C-2 OF Annexure C of IRC 6:2014
	CD	= 1.411

FT	=	937.28 KN	4.267 kN/m ²	For Windward truss
FT	=	826.49 KN	3.763 kN/m ²	For Leeward truss

Longitudinal Wind Force

as per clause 209.3.4

FL	=	50%	FT	=	468.64 KN	2.134	For Windward truss
FL	=	50%	FT	=	413.24 KN	1.881	For Leeward truss

Upward / Downward Wind Vertical Force (Fv)

Fv = Pz x A3 x G x CL as per IRC 6:2010, Caluse 209.3.5

Where ,

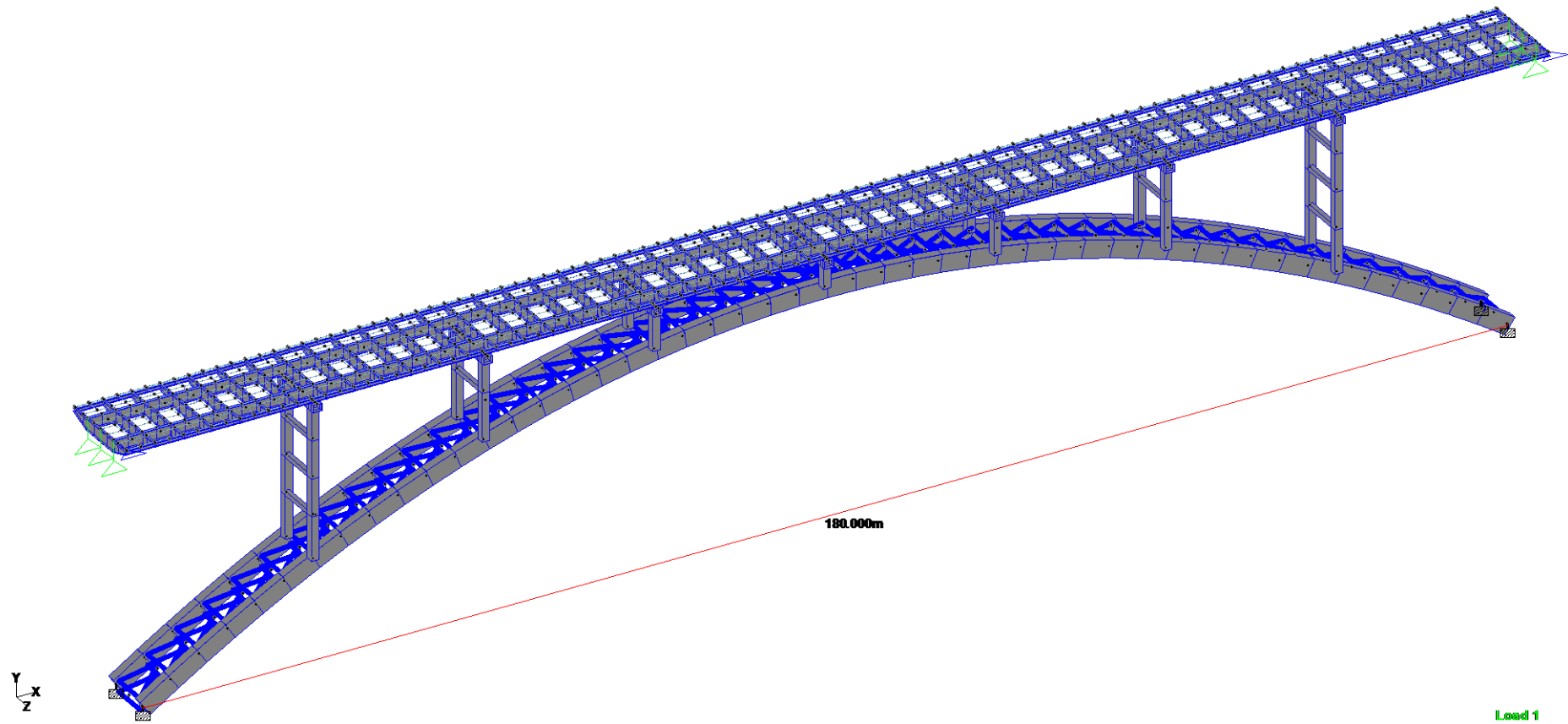
A3	=	Area in Plan (m2)	=	12.5	x	191	=	2387.5 m ²
		CL	=	0.75				
		G	=	2.5				
		Fv	=	4775.55 KN		2.000		Downward
		Fv	=	-4775.55 KN		-2.000		Upward

Wind Load on Live LoadF_T = Pz x A1 x G x Cd As per IRC 6:2014, Caluse 209.3.3

Height of vehicle above road way	=	3.00 m
Length of bridge	=	180.00 m
CD	=	1.20
G	=	2.50
Pz	=	1066.79 N/m ²
F _T	=	9.60 KN/m
corresponidng moment	=	14.40 kNm/m

Effective Bridge Temperature

Maximum Air Shade temperature	=	36.3	°C (as per Fig 15 of IRC:6-2017)
Minimum Air Shade temperature	=	-13.6	°C (as per Fig 16 of IRC:6-2017)
Mean of max and min temperature	=	24.95	°C (as per clause 215.2 of IRC:6-201)
Bridge temperature to be assumed	=	34.95	
Temperature Rise	=	34.95	
Temperature Fall	=	14.95	

STAAD MODEL OF 180M OPEN SPANDREL STEEL ARCH

DESIGN OF STEEL PLATE GIRDER BRIDGE

C/C of BEARINGS = 22.50m

FOR OPEN SPANDREL ARCH BRIDGE

Design Data

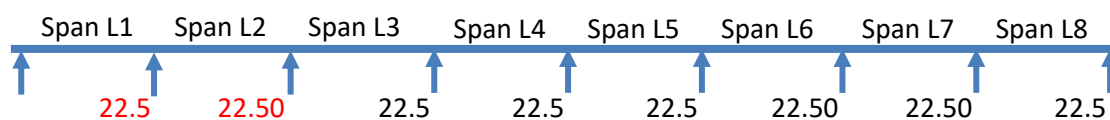


Fig. Showing Span arrangement

End Span L1	=	22.5 m
Intermediate Span L2 to L7	=	22.50 m
End Span L8	=	22.5 m

Calculation of Effective Span :

Effective span for outer spans L1 & L8	= L_o	=	$0.8 * L1$	=	18.00 m
Effective span for Inner spans L2 to L7	= L_o	=	$0.7 * L2$	=	15.75 m
Effective span for intermediate support	= L_o	=	$0.25 * (L1 + L2)$	=	11.25 m
			$0.25 * (L2 + L3)$		

Note: as per clause 603.3.3. of IRC:22-2015 , Reinforcements placed parallel to the span of the steel beam within the effective width of concrete slab at the continuous support will only be effective in analyzing the hogging moment capacity of the composite girder at continuous support

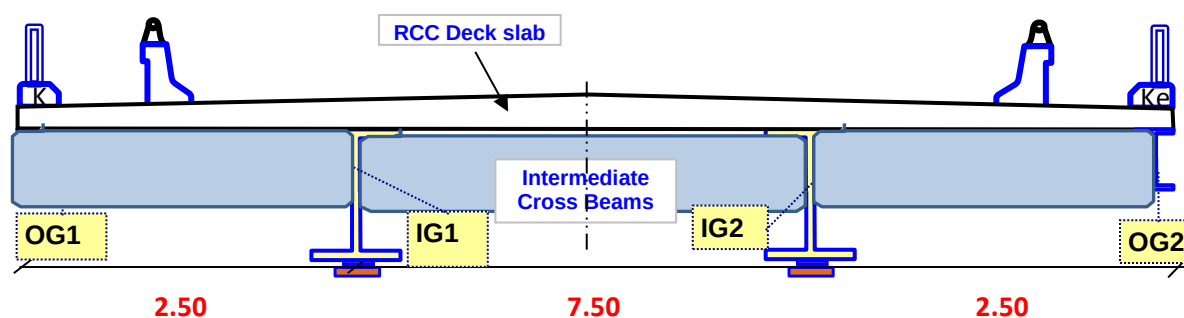
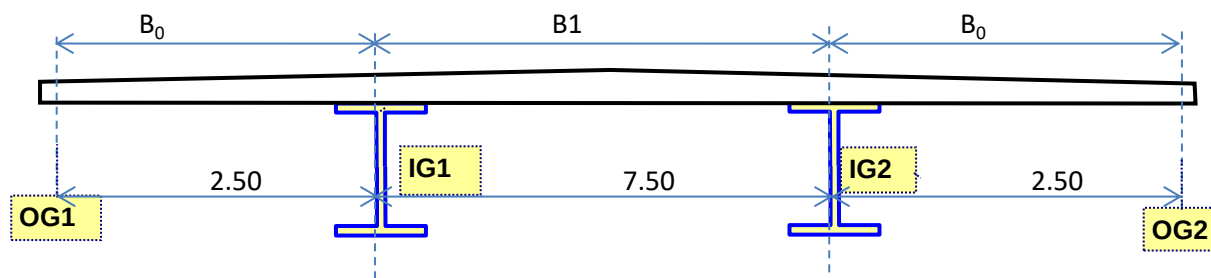


Fig. Showing Cross section of Superstructure

Cross slope of superstructure	=	2.5	%
Width of kerb & RCC Railing	=	0.3	each side
Carriageway width	=	7.50	m
Overall width of bridge	=	12.50	m
Spacing of main girder.	=	7.50	m
Deck slab thickness at centre	=	0.220	m
Deck slab thickness at edge	=	0.220	m
Thick. of Deck Slab at Main L-Gir. Location	=	0.220	m
Thick. of Deck Slab at Edge L-Gir. Location	=	0.220	m

Calculation of Effective width of flanges for Inner Girder IG1 & IG2 :



Effective width of flanges :

$$b_{\text{eff}} = \frac{L_0}{8} + X$$

where $\frac{L_0}{8} \leq \frac{B1}{2}$

and $X = \frac{B_0}{8} \leq \frac{L_0}{8}$

$$B1 = 7.50$$

$$B_0 = 2.50$$

Location	L_0	$L_0/8$	$B1/2$	$X = B_0$	b_{eff}
for outer span L1	18.00	2.25	3.75	2.25	4.50
for Intermediate span L2 to L7	15.75	1.969	3.75	1.97	3.94
for Intermediate Support betn span L1 & L2	11.25	1.406	3.75	1.41	2.81
for Intermediate Support betn span L2 & L3	11.25	1.406	3.75	1.41	2.81

units in meter

1.3.3 Live Load

Dynamic Impact Factor

Impact Factor for class A loading = $\frac{9}{13.5 + L}$

span (m)	Class A	Class 70R
22.5	1.25	1.22
22.50	1.25	1.25

Dimensions of Main Longitudinal Girder (IG1 & IG2) for Mid Span Location

Web plate size (without slab)	=	1440 X 20	mm
Top Flange thickness Plate-1	=	500 X 20	mm
Top Flange thickness Plate-2	=	0 X 0	mm
Bottom Flange thickness Plate-1	=	500 X 20	mm
Bottom Flange thickness Plate-2	=	450 X 20	mm

Dimensions of Main Longitudinal Girder (IG1 & IG2) for Intermediate and End Support

Web plate size (without slab)	=	1440	X 20	mm
Top Flange thickness Plate-1	=	500	X 20	mm
Top Flange thickness Plate-2	=	450	X 20	mm
Bottom Flange thickness Plate-1	=	500	X 20	mm
Bottom Flange thickness Plate-2	=	0	X 0	mm

Depth of cross girder = 0.500 m

PARTIAL SAFETY FACTOR

γ_m	=	1.10	For Structural Steel Against Yield Stress
γ_m	=	1.25	For Shear Connector
$\gamma_{m.st}$	=	1.15	For reinforcement

MATERIAL PROPERTIES

Grade of structural steel (Main Girders) Fe490	350	Mpa	plate thk <20
	330	Mpa	20-40
	320	Mpa	>40
Grade of Secondary Members (ie rolled section)	250	Mpa	
Grade of concrete	M 40		
Type of steel	HYSD Fe 500	D	
Ultimate strength of shear connector	149	kN	For 25 mm dia Stud
Fatigue strength of shear connector	39	kN	

MAXIMUM FLEXURAL MOMENTS

from Staad-Pro Elastic analysis

		End span of length 22.5m				Intermediate span of length 22.5m			
Sr. No.	Loads	At Mid-Span (kNm)	Member No.	At Support (kNm)	Member No.	At Mid-Span (kNm)	Member No.	At Support (kNm)	Member No.
1	Self-Weight of Girder	370	544	566	5215	308	4420	472	4415
2	Weight of Slab	1208		2108		1007		1757	
3	SIDL1-Crash+Railing	184		487		153		406	
4	SIDL2-Wearing Coat	142		379		118		316	
5	FPLL	125		331		104		276	
6	1-70RW	1039		1604		866	3340	1337	3336
7	2-CLASS	926		1508		772	3338	1257	
8	Seismic force	604		1090		503	3703	908	
9	Wind Force	138		308		115		257	

MAXIMUM SHEAR FORCE

from Staad-Pro Elastic analysis

		End span of length 22.5m				Intermediate span of length 22.5m			
Sr. No.	Loads	At Mid-Span (kN)	Member No.	At Support (kN)	Member No.	At Mid-Span (kN)	Member No.	At Support (kN)	Member No.
1	Self-Weight of Girder	106	5162	155	5215	69.4	2978	118	4415
2	Weight of Slab	395		583		229		418	
3	SIDL1-Crash+Railing	95		171		64.5		126	
4	SIDL2-Wearing Coat	74		135		50.4		96.6	
5	FPLL	64.8		116		44.3		84.9	
6	1-70RW	290		475		248	3703	433	3315
7	2-CLASS	253		414		217		366	
8	Seismic force	75		102		129		374	
9	Wind Force	183		70.6		58.1		96	

MAXIMUM FLEXURAL MOMENTS AT SPLICE LOCATION i.e L/4 FROM BEARING CENTRE

from Staad-Pro Elastic analysis

		End span of length 22.5m	
Sr. No.	Loads	At Mid-Span (kNm)	Member No.
1	Self-Weight of Girder	556	542
2	Weight of Slab	2134	
3	SIDL1-Crash+Railing	290	
4	SIDL2-Wearing Coat	224	
5	FPLL	198	
6	1-70RW	899	
7	2-CLASS	829	
8	Seismic force	195	
9	Wind Force	238	

MAXIMUM RELATIVE DISPLACEMENT

from Staad-Pro Elastic analysis

		End span of length 22.5m	
Sr. No.	Loads	At Mid-Span (kNm)	NODE NO.
1	Self-Weight of Girder	2.075	379
2	Weight of Slab	31.69	
3	SIDL1-Crash+Railing	3.758	
4	SIDL2-Wearing Coat	2.917	
5	FPLL	2.542	
6	1-70RW	9.272	
7	2-CLASS	2.696	

DESIGN OF MAIN LONGITUDINAL PLATE GIRDER
(IG1) FROM ULTIMATE LIMIT STATE METHOD
FOR POSITIVE (SAGGING) BENDING REGION
OF CRITICAL OUTER SPAN L1

Sectional Properties of Main Longitudinal Girder (IG1 & IG2) for Mid Span Location
{POSITIVE (SAGGING) BENDING REGION}

Critical Span = L1

Top Flange thickness Plate-1	=	20	mm
Top Flange thickness Plate-2	=	0	mm
Bottom Flange thickness Plate-1	=	20	mm
Bottom Flange thickness Plate-2	=	20	mm
Depth of the Web Plate	=	1440	mm
Thickness of the web	=	20	mm

web plate of size = **1440** x **20**

Top Flange Area -

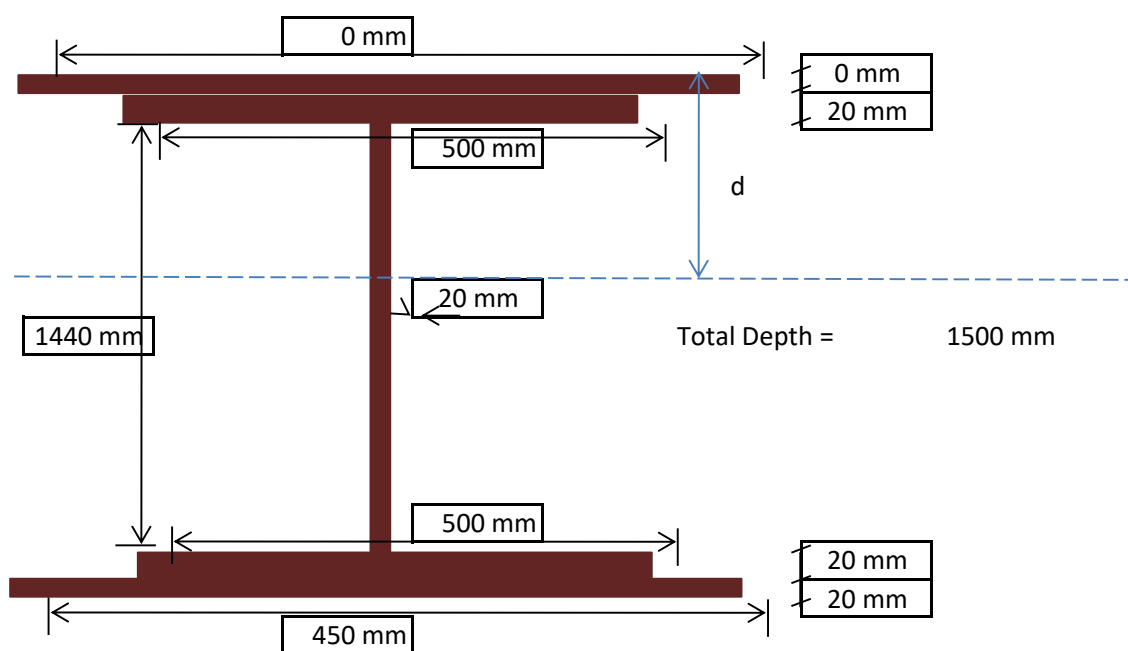
I) Top Plate-1	500	x	20	=	10000	mm ²
II) Top Plate-2	0	x	0	=	0	mm ²

A_f	=	10000	mm ²

Bottom Flange Area -

I) Bottom Plate-1	500	x	20	=	10000	mm ²
II) Bottom Plate-2	450	x	20	=	9000	mm ²

A_f	=	19000	mm ²



Check for Section Class :

Flange Class

b	=	240	mm
tf	=	20	mm
b/tf	=	12.00	Slender

Web Class

d	=	1440	
tw	=	20	
d/tw	=	72.00	Compact

Elastic Properties

SR.	ELEMENT		Ai(mm ²)	Ye (mm)	AYi	AY ² s	Ixx (self)	It =
NO.				(from top)				AY ² s + Ixx
1	Top Flange Plate-1		10000	10	100000	1.0E+06	3.3E+05	1.3E+06
2	Top Flange Plate-2		0	0	0	0.0E+00	0.0E+00	0.0E+00
3	Web		28800	740	21312000	1.6E+10	5.0E+09	2.1E+10
4	Bottom Flange Plate-1		10000	1470	14700000	2.2E+10	3.3E+05	2.2E+10
5	Bottom Flange Plate-2		9000	1490	13410000	2.0E+10	3.0E+05	2.0E+10
	Σ		57800.00		5.0E+07			6.2E+10

Therefore distance of N.A. from top fibre

$$= \frac{\sum Ay_c}{\sum A} = \frac{5.0E+07}{57800.00} = 856.78 \text{ mm}$$

$$\begin{aligned} \text{M.I. About N. A.} &= 6.2E+10 - 57800.00 \times (856.78)^2 \\ I_{xx} &= 1.99E+10 \text{ mm}^4 \\ y_b &= D - y_t \\ &= 1500 - 856.78 = 643.22 \text{ mm} \\ Z_b &= \frac{I_{xx}}{y_b} = \frac{2.0E+10}{643.22} = 3.1E+07 \text{ mm}^3 \\ Z_t &= \frac{I_{xx}}{y_t} = \frac{2.0E+10}{856.78} = 2.3E+07 \text{ mm}^3 \\ \text{Elastic section modulus (Ze)} &= 2.32E+07 \text{ mm}^3 \end{aligned}$$

Plastic Properties of Girder Considering Full Shear Area

Assume distance of neutral axis from Top of top flange is d.

$$d = 965.00 \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned} A1 &= (0 \times 0 + 500 \times 20 + 20 \times (d - 0 - 20)) \\ &= 28900 \text{ mm}^2 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned} A2 &= (450 \times 20 + 500 \times 20 + 20 \times (1500 - d - 20 - 20)) \\ &= 28900 \text{ mm}^2 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = 0$$

Calculation of Effective Cross section

$$\begin{aligned} t_w &= 20.00 \text{ mm} \\ f_y &= 330 \text{ Mpa} \\ \varepsilon &= 0.87 \\ 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the compression flange} \\ 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the plastic neutral axis} \\ \text{inactive portion} &= 0.00 \text{ mm} && \text{As the web is in Compact Class} \\ &&& \text{Refer class 603.1.3} \end{aligned}$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	10000	955	9550000
Top Flng 2	0	965	0
web	18900	472.50	8930250
	28900		1.85E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flr	10000	505	5050000
Bottom Flr	9000	525	4725000
web	9900	248	2450250
	28900		12225250

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \boxed{639.46} \text{ mm}$$

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \boxed{423.02} \text{ mm}$$

$$\begin{aligned} \text{Effective Cross sectional area} &= \boxed{5.8E+04} \text{ mm}^2 \\ \text{Plastic section modulus (Zp)} &= A1*Y1 + A2*Y2 = \boxed{3.1E+07} \text{ mm}^3 \end{aligned}$$

Plastic Properties of Girder Excluding Full Shear Area

Assume distance of neutral axis from bottom of top flange is d.

$$d = \boxed{945.00} \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned} A1 &= (0 \times 0 + 500 \times 20 + 20 \times d) \\ &= 28900 \text{ mm}^2 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned} A2 &= (450 \times 20 + 500 \times 20 + 20 \times (1440 - d)) \\ &= 28900 \text{ mm}^2 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = \boxed{0}$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	10000	955	9550000
Top Flng 2			
web			
	10000		9.55E+06

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flr	10000	505	5050000
Bottom Flng 2			
web			
	10000		5050000

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = 955.00 \text{ mm}$$

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = 505.00 \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = 1.46E+07 \text{ mm}^3$$

COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER FOR PERMENANT LOAD CASE

Critical Span	=	L1

Effective Width of Concrete Slab For Inner Girder

$$b_{\text{eff}} = 4.50 \text{ m}$$

Depth of Slab at Inner Girder location

$$= 0.220 \text{ m}$$

Modular Ratio

$$m = 15 \text{ For Permanent loading}$$

$$m = 7.5 \text{ For Transient Loading}$$

For the calculation of equivalent area of deck, divide the effective width of concrete slab by modular ratio

Effective Width of Concrete Slab for Inner Girder For Permanent Loading

$$\frac{4500.00}{15.00} = 300.00 \text{ mm}$$

Calculation of the Moment of Inertia for Composite Section for Girder

SR. NO.	ELEMENT	Ai(mm ²)	ye(mm)	Aye(mm ³)	Ay ² _e (mm ⁴)	Ixx (self) (mm ⁴)	I _t = Ixx (self)+Ay ² _e
1	Inner Girder	57800	1076.78	6.2E+07	6.7E+10	2.0E+10	8.69E+10
2	Deck Slab	66000.0	110.00	7.3E+06	8.0E+08	2.7E+08	1.06E+09
Σ		123800.0		6.9E+07			8.80E+10

$$\text{Therefore of N.A. from Top Fibre of Deck Slab} = \frac{6.9E+07}{1.2E+05} = 561.37 \text{ mm}$$

Moment of Inertia about N.A. of the composite Section

$$= 8.8E+10 - 1.2E+05 \times (561.3732)^2$$

$$= 5E+10 \text{ mm}^4$$

$$I_{xx} = 4.90E+10 = 4.90E+10 \text{ mm}^4$$

$$y_t = 561 \text{ mm}, \quad y_b = 1159 \text{ mm}$$

$$Z_t = \frac{I_{xx}}{y_t} = \frac{5E+10}{561} = 8.72E+07 \text{ mm}^3$$

$$Z_b = \frac{I_{xx}}{y_b} = \frac{5E+10}{1159} = 4.23E+07 \text{ mm}^3$$

$$\text{Elastic section modulus (Ze)} = 4.23E+07 \text{ mm}^3$$

COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER FOR TRANSIENT LOAD CASE

Effective Width of Concrete Slab for Inner Girder For Transient Loading

$$\frac{4500.00}{7.50} = 600.00 \text{ mm}$$

Calculation of the Moment of Inertia for Composite Section for Girder

SR. NO.	ELEMENT	$A_i(\text{mm}^2)$	$y_e(\text{mm})$	$Ay_e(\text{mm}^3)$	$Ay_e^2(\text{mm}^4)$	$I_{xx}(\text{self})(\text{mm}^4)$	$I_t = I_{xx}(\text{self}) + Ay_e^2$
1	Inner Girder	57800	1076.78	6.2E+07	6.7E+10	2.0E+10	8.69E+10
2	Deck Slab	132000.0	110.00	1.5E+07	1.6E+09	5.3E+08	2.13E+09
Σ		189800		7.7E+07			8.91E+10

Therefore of N.A. from Top Fibre of Deck Slab $= \frac{7.7E+07}{1.9E+05} = 404.42 \text{ mm}$

Moment of Inertia about N.A. of the composite Section

$$= 8.9E+10 - 1.9E+05 \times (404.4152)^2$$

$$= 6E+10 \text{ mm}^4$$

$$I_{xx} = 6E+10 = 5.80E+10 \text{ mm}^4$$

$$y_t = 404 \text{ mm}, \quad y_b = 1316 \text{ mm}$$

$$Z_t = \frac{I_{xx}}{y_t} = \frac{6E+10}{404} = 1.43E+08 \text{ mm}^3$$

$$Z_b = \frac{I_{xx}}{y_b} = \frac{6E+10}{1316} = 4.41E+07 \text{ mm}^3$$

Elastic section modulus (Z_e) $= 4.41E+07 \text{ mm}^3$

BENDING MOMENT SUMMARY AT MID SPAN

Stage I

Self weight of Girder alone

Partial Safety Factor

COMBINATIONS			
ULS	SLS		
Basic	Rare		Quasi
1.35	1.00		1.00

Max Bending Moment (Inner Girder)

=

498.96	369.60			KN-m
143.10	106.00			KN

Max Shear Force (Inner Girder)

=

Stage II

Green concrete Stage

Partial Safety Factor

Basic	Rare		Quasi
1.35	1.00		1.00

Max Bending moment (Inner Girder)

=

1631.34	1208.40			KN-m
533.25	395.00			KN

Max Shear Force (Inner Girder)

=

Stage III

Composite action stage

SIDL -1

Crash barrier

Partial Safety Factor

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare		Quasi	
1.35	1.00		1.00	
247.86	183.60			KN-m
128.25	95.00			KN

SIDL -2

wearing coat

Partial Safety Factor

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare		Quasi	
1.75	1.20		1.20	
247.80	169.92		0.00	KN-m
129.50	88.80		0.00	KN

Live Load Results

Foothpath live load

Partial Safety Factor

Basic		Rare	
1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

187.20	143.52	124.80	93.60	KN-m
97.20	74.52	64.80	48.60	KN

1-Lane of 70 R Wheeled Load

Impact Factor

=

Partial Safety Factor

1.22			
1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

1906.41	1461.58	1270.94	953.21	KN-m
532.01	407.87	354.67	266.00	KN

2 lane of class A

Impact Factor

=	1.25			
Partial Safety Factor	1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

1737.00	1331.70	1158.00	868.50	KN-m
474.38	363.69	316.25	237.19	KN

Live Load Combinations**2 lane of Class A + FPLL**

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
1924.20	1475.22	1282.80	962.10	KN-m
571.58	438.21	381.05	285.79	KN

1 lane of 70R Wheeled + FPLL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
2093.61	1605.10	1395.74	1046.81	KN-m
629.21	482.39	419.47	314.60	KN

Seismic Forces

Partial Safety Factor

=

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

service	construction
1.50	0.75
905.40	452.70
112.50	56.25

Wind Forces

Partial Safety Factor

=

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare	
Leading	Accompanying	Leading	Accompanying
1.50	0.90	1.00	0.60
207.00	124.20	138.00	82.80
274.50	164.70	183.00	109.80

Summary of Total Forces**DL**

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare	
2130.30	1578.00	KN-m
676.35	501.00	KN

SIDL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare	
495.66	353.52	KN-m
257.75	183.80	KN

Governing Live loads

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
2093.61	1605.10	1395.74	1046.81	KN-m
629.21	482.39	419.47	314.60	KN

Total ULS Bending Moment For Construction and Service Stages

			Basic		Rare		
			CWLL Leading	CWLL Accompanying	CWLL Leading	CWLL Accompanying	
DL+SIDL	For Inner Girder		2625.96	2625.96	1931.52	1931.52	KN-m
DL+SIDL+EQ	For Inner Girder		3078.66	3078.66			KN-m
DL+SIDL+WL	For Inner Girder		2750.16	2832.96	2014.32	2069.52	KN-m
During Construction Stages			3078.66	3078.66	2014.32	2069.52	KN-m
DL+SIDL+LL	For Inner Girder	=	4719.57	4231.06	3327.26	2978.33	KN-m
DL+SIDL+LL+EQ	For Inner Girder		5624.97	5136.46			KN-m
DL+SIDL+LL+WL	For Inner Girder		4843.77	4438.06	3410.06	3116.33	KN-m
During Service Stages			5624.97	5136.46	3410.06	3116.33	KN-m

Total ULS Shear Force For Construction and Service Stages

			Basic		Rare		
			CWLL Leading	CWLL Accompanying	CWLL Leading	CWLL Accompanying	
DL+SIDL	For Inner Girder	=	934.10	934.10	684.80	684.80	KN
DL+SIDL+EQ	For Inner Girder	=	990.35	990.35			KN
DL+SIDL+WL	For Inner Girder	=	1098.80	1208.60	794.60	867.80	KN
During Construction Stages			1098.80	1208.60	794.60	867.80	KN
DL+SIDL+LL	For Inner Girder	=	1563.31	1416.49	1104.27	999.40	KN
DL+SIDL+LL+EQ	For Inner Girder	=	1675.81	1528.99			KN
DL+SIDL+LL+WL	For Inner Girder	=	1728.01	1690.99	1214.07	1182.40	KN
During Service Stages			1728.01	1690.99	1214.07	1182.40	KN

Ultimate Design of Sagging (Mid-Span) Region- For Shear

Max Shear force for composite section = 1728.01 KN

Material Properties

Partial Safety Factor γ_m = $\frac{f_y}{f_{yk}}$ = $\frac{350}{318.1818}$ = 1.10

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{350}{1.1} = 318.1818 \text{ Mpa}$$

$$\epsilon = \sqrt{\frac{250}{f_y}} = 0.845$$

$$\text{Average Shear Stress} = \frac{f_y}{\gamma_m} = \frac{350}{1.1} = 318.1818 \text{ MPa}$$

Min. Dimension Requirement

$$\text{Min overall depth} = \frac{L}{25} = \frac{22500}{25} = 900 \text{ mm}$$

$$\text{Overall depth Provide} = 1480 \text{ mm} \quad \text{Hence OK}$$

$$\text{Min Spacing} = \frac{L}{20} = \frac{22500}{20} = 1125 \text{ mm}$$

$$\text{Maximum Spacing of Girder provided} = 7500 \text{ mm} \quad \text{Hence OK}$$

Dimension Check

Minimum Web Thickness

a.) For vertical Stiffener

Serviceability Requirement

$$\frac{d}{t_w} \leq 200\epsilon$$

$$\frac{d}{t_w} = 6.09 < 20.00$$

Vertical Stiffener not required

b.) For horizontal Stiffener

$$\frac{d}{t_w} \leq 200\epsilon \quad 3d \geq c \geq d$$

$$\frac{c}{t_w} \leq 200\epsilon \quad 0.74d \leq c < d$$

$$\frac{d}{t_w} \leq 270\epsilon \quad c < d$$

$$t_w = \boxed{8.52} < \boxed{20.00}$$

Horizontal Stiffener not required

To avoid Flange Buckling

$$\frac{d}{t_w} \leq 345\epsilon_f^2 \quad \text{Stiffener not provided}$$

$$\frac{d}{t_w} \leq 345\epsilon_f^2 \quad c \geq 1.5 d$$

$$\frac{d}{t_w} \leq 345\epsilon_f \quad c < 1.5 d$$

$$t_w = \boxed{4.94} < \boxed{20.00}$$

Hence OK

DESIGN OF WEB FOR SHEAR :

$$\text{Max Shear force at support of composite section} = \boxed{1728.01} \text{ KN}$$

a.) Plastic Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = d * t_w \quad (\text{For Welded Section})$$

$$V_n = \boxed{5819.69} \text{ KN} > \boxed{1728.01} \text{ KN}$$

Safe in Shear

b.) Shear Buckling Design

$$\frac{d}{t_w} > 67\epsilon \quad \text{Without Stiffener}$$

$$> 67\epsilon * \sqrt{K_v/5.35} \quad \text{With Stiffener}$$

$$\frac{1440}{20} = 72.00 > 56.63$$

Hence OK

Simple Post - Critical Method

$$\begin{aligned}
 K_v &= 5.35 && \text{When stiffeners are provided only at support} \\
 &= 4.0 + 5.35/(c/d)^2 &= & \boxed{7.16} && \text{For } c/d < 1.0 \\
 &= 5.35 + 4.0/(c/d)^2 &= & \boxed{7.16} && \text{For } c/d \geq 1.0 \\
 c/d &= \boxed{1.30} \\
 K_v &= \boxed{7.16} \\
 \tau_{cr,e} &= \frac{K_v \pi^2 E}{12(1-\mu^2)(d/t_w)^2} &= & \boxed{249.51} \text{ Mpa} \\
 \lambda_w &= \sqrt{\frac{f_{yw}}{\sqrt{3} \tau_{cr,e}}} &= & \boxed{0.90} \\
 \text{i.) } \lambda_w &\leq 0.8 \\
 \tau_b &= \frac{f_{yw}}{\sqrt{3}} &= & \boxed{202.07} \text{ Mpa} \\
 \text{ii.) } 0.8 &\leq \lambda_w \leq 1.2 \\
 \tau_b &= [1 - 0.8(\lambda_w - 0.8)] \times \frac{f_{yw}}{\sqrt{3}} &= & \boxed{185.92} \text{ Mpa} \\
 \text{iii.) } \lambda_w &\geq 1.2 \\
 \tau_b &= \frac{f_{yw}}{\sqrt{3} \lambda_w^2} &= & \boxed{249.51} \text{ Mpa}
 \end{aligned}$$

Therefore, $\tau_b = \boxed{185.92} \text{ Mpa}$

Shear force for web buckling

$$V_n = V_{cr} = A_v \tau_b = \boxed{4867.66} \text{ KN} > \boxed{1728.01} \text{ KN}$$

Safe in Buckling

ULTIMATE DESIGN OF INNER GIRDER SUBJECTED TO SAGGING MOMENT

As the Inner girder is subjected to maximum bending moment and shear force hence critical for design

Critical Span	=	L1

DESIGN STAGE I : DEAD LOAD (SELF WEIGHT, GREEN WEIGHT OF SLAB AND TEMPORARY LOAD)

Assuming the girder is laterally supported throughout the span

Max Bending Moment -DL including self weight , green weight & temporary load = 2130.30 kNm

Elastic section modulus (Ze)	=	2.32E+07 mm ³
Plastic section modulus (Zp)	=	3.07E+07 mm ³
β_b	=	1 Plastic/Compact section

If Shear force (V) is less than 0.6 times shear capacity Vd, there is no reduction in plastic bending resistance of the section. Therefore plastic bending capacity of the section is given as

Design bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_m} = \frac{9769.93}{1} \text{ kNm}$$

If Shear force (V) is greater than 0.6 times shear capacity Vd, the bending resistance is reduced as the contribution of web to the bending gets diminished. Therefore reduced bending capacity is given as

(For Plastic and compact section)

$$M_{dv} = M_d - \beta(M_d - M_{fd}) \leq \frac{1.2 Z_e f_y}{\gamma_m}$$

$$\beta = 0.084 = (2 V/V_d - 1)^2$$

$$M_{fd} = \frac{Z_p f_y}{\gamma_m} = \frac{4645.45}{1} \text{ kNm}$$

$$M_{dv} = \frac{9338.95}{1} > \frac{8872.66}{1} \text{ kNm}$$

Max Shear force for composite section

$$V = 1728.01 \text{ KN}$$

Shear Capacity of the section

$$V_d = 4867.66 \text{ KN}$$

As the Shear force $V < 0.6 * V_d$

Design bending strength

$$M_d = \frac{9769.93}{1} \text{ kNm} > 2130.30 \text{ kNm}$$

Hence OK

DESIGN STAGE II : DL+SIDL- PERMENANT LOAD CASE

Max . Bending Moment due to DL+SIDL = **3078.66** kN.m

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{350}{1.1} = \boxed{318.182} \text{ Mpa}$$

Plastic moment of resistance

Position of plastic neutral axis

$$\begin{aligned} b_{eff}d_s &= 9.90E+05 \text{ mm}^2 \\ a &= \frac{(f_y/\gamma_m)}{0.36(f_{ck})} = 22.1 \\ A_s &= 57800 \text{ mm}^2 \\ A_f &= 10000 \text{ mm}^2 \\ a*A_s &= 1.28E+06 \text{ mm}^2 \\ a*A_f &= 2.21E+05 \text{ mm}^2 \\ b_{eff}d_s + 2aA_f &= 1.43E+06 \text{ mm}^2 \\ d_s &= 220 \text{ mm} \\ t_f &= 20 \text{ mm} \\ b_f &= 500 \text{ mm} \\ t_w &= 20 \text{ mm} \\ d_c &= \boxed{671.37} \text{ mm} \end{aligned}$$

$$b_{eff}d_s > a*A_s \quad \text{Neutral axis within slab}$$

$$b_{eff}d_s < a*A_s < b_{eff}d_s + 2aA_f \quad \text{Neutral axis within steel flange}$$

$$b_{eff}d_s + 2aA_f < a*A_s \quad \text{Neutral axis within web}$$

Neutral axis	Value of x_u (mm)	Moment Capacity (M_p) (Mpa)
within slab	283.810	1.22E+10
within steel flange	232.9954	1.21E+10
within web	64.886	1.19E+10

Neutral axis within Top flange of a composite section 233.00 mm depth from top of deck.

Moment of resistance $M_p = \boxed{12116.36} \text{ KNm}$
 $> \boxed{3078.66} \text{ KNm}$
Hence OK

DESIGN STAGE III : DL+SIDL+LL (TRANSIENT LOAD CASE)

Max . Bending Moment due to DL+SIDL+LL = **5624.97** kN.m

$$f_{ck} = 40 \text{ N/mm}^2, \quad f_{ct} = 0.7 \cdot \text{Sqrt}(f_{ck}) = 4.43 \text{ N/mm}^2$$

As per clause no. 603.1 of IRC:22-2015

$$\text{Increased bending moment} = M \times 40 \text{ fct/fck \%} = 0.00 \text{ kNm}$$

Note: As the concrete at support has considered cracked assuming the plastic hinges will develop and hence neglected concrete at hogging portion of span in the staad analysis . Hence there is no need to increased the sagging moment by amount 40.fct/fck as per clause no. 603.1. of IRC:22-2015

$$\text{Final bending moment} = 5624.97 \text{ kNm}$$

Plastic moment of resistance

Position of plastic neutral axis

$$\begin{aligned} b_{\text{eff}}d_s &= 9.90\text{E}+05 \text{ mm}^2 \\ a &= \frac{(f_y/\gamma_m)}{0.36(f_{ck})} = 22.1 \\ A_s &= 57800 \text{ mm}^2 \\ A_f &= 10000 \text{ mm}^2 \\ a*A_s &= 1277146 \text{ mm}^2 \\ a*A_f &= 220960 \text{ mm}^2 \\ b_{\text{eff}}d_s + 2aA_f &= 1431919 \text{ mm}^2 \\ d_s &= 220 \text{ mm} \\ t_f &= 20 \text{ mm} \\ b_f &= 500 \text{ mm} \\ t_w &= 20 \text{ mm} \\ d_c &= 966.78 \text{ mm} \end{aligned}$$

$$b_{\text{eff}}d_s > a*A_s \quad \text{Neutral axis within slab}$$

$$b_{\text{eff}}d_s < a*A_s < b_{\text{eff}}d_s + 2aA_f \quad \text{Neutral axis in steel flange}$$

$$b_{\text{eff}}d_s + 2aA_f < a*A_s \quad \text{Neutral axis within web}$$

Neutral axis	Value of x_u (mm)	Moment Capacity (M_p) (Mpa)
within slab	283.810	1.76E+10
within steel flange	232.9954	1.75E+10
within web	64.886	1.74E+10

Neutral axis within Top flange of a composite section 233.00 mm depth from top.

$$\text{Moment of resistance } M_p = 17549.20 \text{ KNm}$$

>

$$5624.97 \text{ KNm}$$

Hence OK

SUMMARY OF BENDING MOMENT CAPACITY

Load Cases	Inner Girder		
	Ultimate Bending Moment	Plastic Moment Capacity	STATUS
Stage I : DL	2130.30	9769.93	OK
Stage II : DL+SIDL	3078.66	12116.36	OK
Stage III: DL+SIDL+LL	5624.97	17549.20	OK

DESIGN OF PLATE GIRDER FROM ULTIMATE
LIMIT STATE METHOD
FOR NEGATIVE (HOGGING) BENDING REGION
OF CRITICAL OUTER SPAN L1

BENDING MOMENT SUMMARY AT SUPPORT

Stage I

Self weight of Girder alone

Partial Safety Factor

COMBINATIONS			
ULS	SLS		
Basic	Rare		Quasi
1.35	1.00		1.00

Max Bending Moment (Inner Girder)

=

764.64	566.40			KN-m
209.25	155.00			KN

Max Shear Force (Inner Girder)

=

Stage II

Green concrete Stage

Partial Safety Factor

Basic	Rare		Quasi
1.35	1.00		1.00

Max Bending moment (Inner Girder)

=

2846.34	2108.40			KN-m
787.05	583.00			KN

Max Shear Force (Inner Girder)

=

Stage III

Composite action stage

SIDL -1

Crash barrier

Partial Safety Factor

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare		Quasi	
1.35	1.00		1.00	
657.72	487.20			KN-m
230.85	171.00			KN

SIDL -2

wearing coat

Partial Safety Factor

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare		Quasi	
1.75	1.20		1.20	
663.60	455.04		0.00	KN-m
236.25	162.00		0.00	KN

Live Load Results

Foothpath live load

Partial Safety Factor

Basic		Rare	
1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

496.80	380.88	331.20	248.40	KN-m
174.00	133.40	116.00	87.00	KN

1-Lane of 70 R Wheeled Load

Impact Factor

=

Partial Safety Factor

1.22			
1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

2943.27	2256.51	1962.18	1471.64	KN-m
871.39	668.06	580.93	435.69	KN

2 lane of class A

Impact Factor

=	1.25			
Partial Safety Factor	1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

2828.25	2168.33	1885.50	1414.13	KN-m
776.25	595.13	517.50	388.13	KN

Live Load Combinations

Lane Reduction Factor= 1.00

2 lane of Class A + FPLL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
3325.05	2549.21	2216.70	1662.53	KN-m
950.25	728.53	633.50	475.13	KN

1 lane of 70R Wheeled + FPLL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
3440.07	2637.39	2293.38	1720.04	KN-m
1045.39	801.46	696.93	522.69	KN

Seismic Forces

Partial Safety Factor

=

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

service construction

1.50 0.75

1634.40	817.20
153.00	76.50

Wind Forces

Partial Safety Factor

=

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare	
Leading	Accompanying	Leading	Accompanying
1.50	0.90	1.00	0.60
462.60	277.56	308.40	185.04
105.90	63.54	70.60	42.36

Summary of Total Forces**DL**

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare	
3610.98	2674.80	KN-m
996.30	738.00	KN

SIDL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare	
1321.32	942.24	KN-m
467.10	333.00	KN

Governing Live loads

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
3440.07	2637.39	2293.38	1720.04	KN-m
1045.39	801.46	696.93	522.69	KN

Total ULS Bending Moment For Construction and Service Stages

			Basic		Rare		
			CWLL Leading	CWLL Accompanying	CWLL Leading	CWLL Accompanying	
DL+SIDL	For Inner Girder		4932.30	4932.30	3617.04	3617.04	KN-m
DL+SIDL+EQ	For Inner Girder		5749.50	5749.50			KN-m
DL+SIDL+WL	For Inner Girder		5209.86	5394.90	3802.08	3925.44	KN-m
During Construction Stages			5749.50	5749.50	3802.08	3925.44	KN-m
DL+SIDL+LL	For Inner Girder	=	8372.37	7569.69	5910.42	5337.08	KN-m
DL+SIDL+LL+EQ	For Inner Girder		10006.77	9204.09			KN-m
DL+SIDL+LL+WL	For Inner Girder		8649.93	8032.29	6095.46	5645.48	KN-m
During Service Stages			10006.77	9204.09	6095.46	5645.48	KN-m

Total ULS Shear Force For Construction and Service Stages

			Basic		Rare		
			CWLL Leading	CWLL Accompanying	CWLL Leading	CWLL Accompanying	
DL+SIDL	For Inner Girder	=	1463.40	1463.40	1071.00	1071.00	KN
DL+SIDL+EQ	For Inner Girder	=	1539.90	1539.90			KN
DL+SIDL+WL	For Inner Girder	=	1526.94	1569.30	1113.36	1141.60	KN
During Construction Stages			1539.90	1569.30	1113.36	1141.60	KN
DL+SIDL+LL	For Inner Girder	=	2508.79	2264.86	1767.93	1593.69	KN
DL+SIDL+LL+EQ	For Inner Girder	=	2661.79	2417.86			KN
DL+SIDL+LL+WL	For Inner Girder	=	2572.33	2370.76	1810.29	1664.29	KN
During Service Stages			2661.79	2417.86	1810.29	1664.29	KN

Sectional Properties of Main Longitudinal Girder (IG1 & IG2) for Support Location
{NEGATIVE (HOGGING) BENDING REGION}

Critical Span	=	L1

Top Flange thickness Plate-1	=	<table><tr><td>20</td></tr></table> mm	20
20			
Top Flange thickness Plate-2	=	<table><tr><td>20</td></tr></table> mm	20
20			
Bottom Flange thickness Plate-1	=	<table><tr><td>20</td></tr></table> mm	20
20			
Bottom Flange thickness Plate-2	=	<table><tr><td>0</td></tr></table> mm	0
0			
Depth of the Web Plate	=	<table><tr><td>1440</td></tr></table> mm	1440
1440			
Thickness of the web	=	<table><tr><td>20</td></tr></table> mm	20
20			

web plate of size	=	1440	x	20

Top Flange Area -

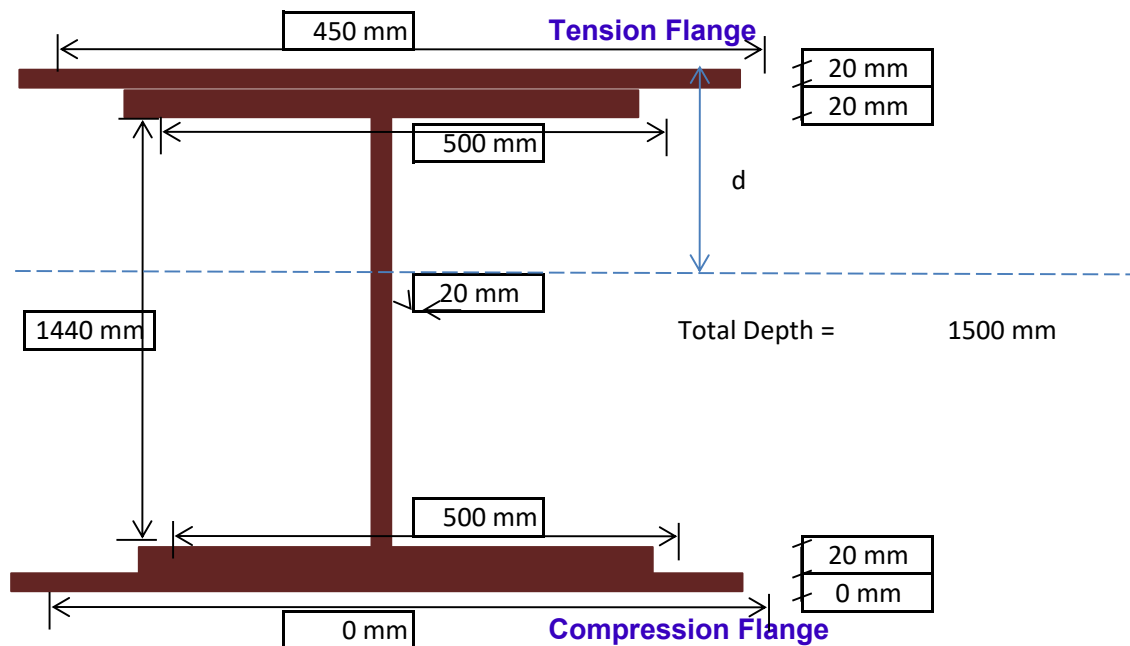
I)Top Plate-1	500	x	20	=	10000	mm ²
II) Top Plate-2	450	x	20	=	9000	mm2

A_f	=	19000	mm ²

Bottom Flange Area -

I) Bottom Plate-1	500	x	20	=	10000	mm ²
II) Bottom Plate-2	0	x	0	=	0	mm ²

A_f	=	10000	mm ²



Check for Section Class :

Flange Class

$$\begin{aligned}
 b &= 240 \text{ mm} \\
 t_f &= 20 \text{ mm} \\
 b/t_f &= 12.00 \text{ Slender}
 \end{aligned}$$

Web Class

$$\begin{aligned}
 d &= 1440 \\
 t_w &= 20 \\
 d/t_w &= 72.00 \text{ Compact}
 \end{aligned}$$

CALCULATION OF SECTIONAL PROPERTIES**Elastic Properties**

SR.	ELEMENT	$A_i(\text{mm}^2)$	$Y_e(\text{mm})$	AY_i	AY_i^2s	$I_{xx}(\text{self})$	$I_t =$
NO.			(from top)				$AY_i^2s + I_{xx}$
1	Top Flange Plate-1	10000	30	300000	9.0E+06	3.3E+05	9.3E+06
2	Top Flange Plate-2	9000	10	90000	9.0E+05	3.0E+05	1.2E+06
3	Web	28800	760	21888000	1.7E+10	5.0E+09	2.2E+10
4	Bottom Flange Plate-1	10000	1490	14900000	2.2E+10	3.3E+05	2.2E+10
5	Bottom Flange Plate-2	0	1500	0	0.0E+00	0.0E+00	0.0E+00
	Σ	57800.00		3.7E+07			4.4E+10

Therefore distance of N.A. from top fibre - Tension Fibre

$$= \frac{\Sigma AY_c}{\Sigma A} = \frac{3.7E+07}{57800.00} = 643.22 \text{ mm}$$

Therefore distance of N.A. from bottom fibre - Compression Fibre

$$\begin{aligned}
 Y_b &= D - Y_t \\
 &= 1500 - 643.22 = 856.78 \text{ mm}
 \end{aligned}$$

$$\text{M.I. About N. A.} = 4.4E+10 - 57800.00 \times (6.43E+02)^2$$

$$I_{xx} = 1.99E+10 \text{ mm}^4$$

$$Z_b = \frac{I_{xx}}{Y_b} = \frac{2.0E+10}{856.78} = 2.3E+07 \text{ mm}^3$$

$$Z_t = \frac{I_{xx}}{Y_t} = \frac{2.0E+10}{643.22} = 3.1E+07 \text{ mm}^3$$

$$\text{Elastic section modulus (Ze)} = 2.32E+07 \text{ mm}^3$$

Plastic Properties

Assume distance of neutral axis from Top of top flange is d.

$$d = 535.00 \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned}
 A1 &= (450 \times 20 + 500 \times 20 + 20 \times (d-20-20)) \\
 &= 28900 \text{ mm}^2
 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned}
 A2 &= (0 \times 0 + 500 \times 20 + 20 \times (1500 - d - 0 - 20)) \\
 &= 28900 \text{ mm}^2
 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = 0$$

Calculation of Effective Cross section

$$\begin{aligned}
 t_w &= 20.00 \text{ mm} \\
 f_y &= 330 \text{ Mpa} \\
 \varepsilon &= 0.87 \\
 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the compression flange} \\
 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the plastic neutral axis} \\
 \text{inactive portion} &= 0.00 \text{ mm} && \text{As the web is in Compact Class} \\
 &&& \text{Refer class 603.1.3}
 \end{aligned}$$

Area in Tension

S. No.	Area A_i (mm ²)	distance from N.A Y_i (mm)	$A_i \cdot Y_i$ (mm ³)
Top Flng 1	10000	505	5050000
Top Flng 2	9000	525	4725000
web	9900	247.50	2450250
	28900		1.22E+07

Area in Compression

S. No.	Area A_i (mm ²)	distance from N.A Y_i (mm)	$A_i \cdot Y_i$ (mm ³)
Bottom Flr	10000	955	9550000
Bottom Flr	0	965	0
web	18900	473	8930250
	28900		18480250

$$\begin{aligned}
 Y_1 &= \frac{\sum A_i Y_i}{\sum A_i} \\
 &= \boxed{423.02} \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 Y_2 &= \frac{\sum A_i Y_i}{\sum A_i} \\
 &= \boxed{639.46} \text{ mm}
 \end{aligned}$$

$$\text{Plastic section modulus (Zp)} = A_1 \cdot Y_1 + A_2 \cdot Y_2 = \boxed{3.1E+07} \text{ mm}^3$$

COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER FOR PERMENANT LOAD CASE

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{350}{1.1} = \boxed{318.182} \text{ Mpa}$$

$$\text{Critical Span} = L_1$$

Effective Width of Concrete Slab For Inner Girder

Depth of Slab at Inner Girder location

$$\begin{aligned}
 b_{eff} &= \boxed{2.81} \text{ m} \\
 &= 0.220 \text{ m}
 \end{aligned}$$

Modular Ratio

$$\begin{aligned}
 m &= 15 \text{ For Permanent loading} \\
 m &= 7.5 \text{ For Transient Loading}
 \end{aligned}$$

For the calculation of equivalent area of deck, divide the effective width of concrete slab by modular ratio

Effective Width of Concrete Slab for Inner Girder For Permanent Loading

$$\frac{2812.50}{15.00} = \boxed{187.50} \text{ mm}$$

Calculation of Moment of Inertia for Composite Section of Girder

SR. NO.	ELEMENT	A_i (mm ²)	y_e (mm)	$A_y e$ (mm ³)	$A y_e^2$ (mm ⁴)	I_{xx} (self) (mm ⁴)	$I_t =$ $I_{xx} \text{ (self)} + A y_e^2$
1	Inner Girder	57800	863.22	5.0E+07	4.3E+10	2.0E+10	6.30E+10

2	Deck Slab	41250.0	110.00	4.5E+06	5.0E+08	1.7E+08	6.66E+08
Σ		99050.0		5.4E+07			6.36E+10

$$\text{Therefore of N.A. from Top Fibre of Deck Slab} = \frac{5.4E+07}{9.9E+04} = 549.54 \text{ mm}$$

Moment of Inertia about N.A. of the composite Section

$$I_{xx} = 3.37E+10 \text{ mm}^4 = 6.4E+10 - 9.9E+04 \times (549.5356)^2$$

$$\begin{aligned} y_t &= 550 \text{ mm}, & y_b &= 1170 \text{ mm} \\ Z_t &= \frac{I_{xx}}{y_t} = \frac{3E+10}{550} = 6.14E+07 \text{ mm}^3 \\ Z_b &= \frac{I_{xx}}{y_b} = \frac{3E+10}{1170} = 2.88E+07 \text{ mm}^3 \end{aligned}$$

$$\text{Elastic section modulus (Ze)} = 2.88E+07 \text{ mm}^3$$

COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER FOR TRANSIENT LOAD CASE

Effective Width of Concrete Slab for Inner Girder For Transient Loading

$$\frac{2812.50}{7.50} = 375.00 \text{ mm}$$

Calculation of the Moment of Inertia for Composite Section for Girder

SR. NO.	ELEMENT	Ai(mm ²)	ye(mm)	Aye(mm ³)	Ay ² _e (mm ⁴)	Ixx (self) (mm ⁴)	I _t = Ixx (self)+Ay ² _e
1	Inner Girder	57800	863.22	5.0E+07	4.3E+10	2.0E+10	6.30E+10
2	Deck Slab	82500.0	110.00	9.1E+06	1.0E+09	3.3E+08	1.33E+09
Σ		140300		5.9E+07			6.43E+10

$$\text{Therefore of N.A. from Top Fibre of Deck Slab} = \frac{5.9E+07}{1.4E+05} = 420.31 \text{ mm}$$

Moment of Inertia about N.A. of the composite Section

$$= 6.4E+10 - 1.4E+05 \times (420.3065)^2$$

$$\begin{aligned} I_{xx} &= 3.95E+10 \text{ mm}^4 \\ y_t &= 420 \text{ mm}, & y_b &= 1300 \text{ mm} \\ Z_t &= \frac{I_{xx}}{y_t} = \frac{4E+10}{420} = 9.40E+07 \text{ mm}^3 \\ Z_b &= \frac{I_{xx}}{y_b} = \frac{4E+10}{1300} = 3.04E+07 \text{ mm}^3 \end{aligned}$$

$$\text{Elastic section modulus (Ze)} = 3.04E+07 \text{ mm}^3$$

Sectional Properties of Main Longitudinal Girder (IG1 & IG2) for Support Location
{NEGATIVE (HOGGING) BENDING REGION}

Critical Span	=	L1

Top Flange thickness Plate-1	=	<table><tr><td>20</td></tr></table> mm	20
20			
Top Flange thickness Plate-2	=	<table><tr><td>20</td></tr></table> mm	20
20			
Bottom Flange thickness Plate-1	=	<table><tr><td>20</td></tr></table> mm	20
20			
Bottom Flange thickness Plate-2	=	<table><tr><td>0</td></tr></table> mm	0
0			
Depth of the Web Plate	=	<table><tr><td>1440</td></tr></table> mm	1440
1440			
Thickness of the web	=	<table><tr><td>20</td></tr></table> mm	20
20			

web plate of size = 1440 x 20

Top Flange Area -

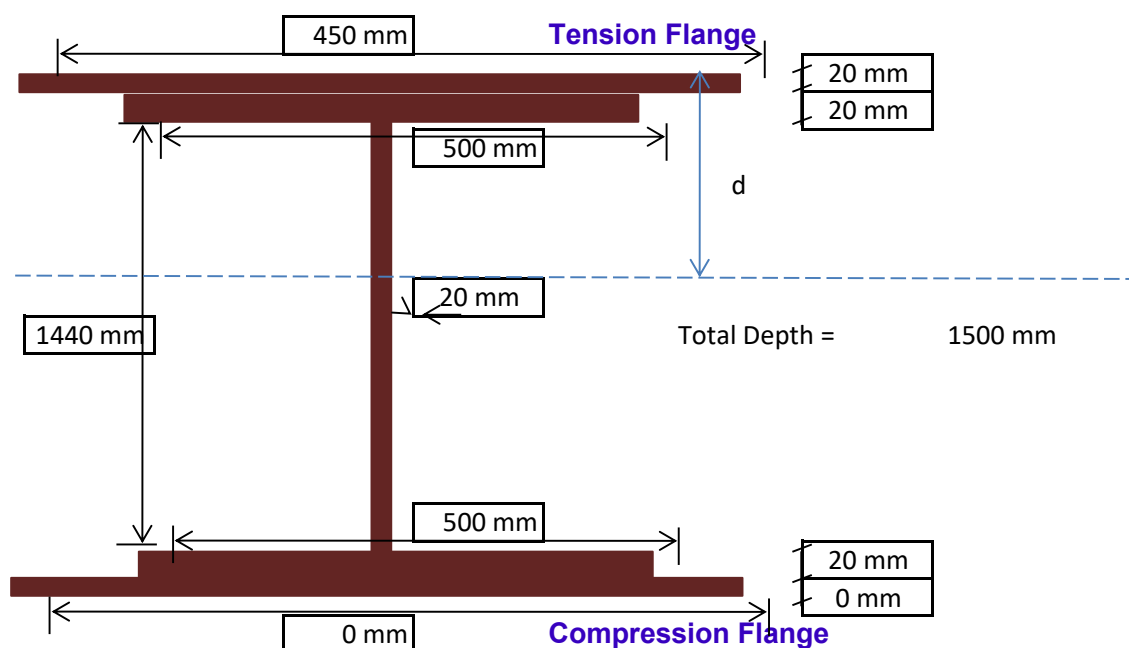
I)Top Plate-1	500	x	20	=	10000	mm ²
II) Top Plate-2	450	x	20	=	9000	mm2

A_f	=	19000	mm ²

Bottom Flange Area -

I) Bottom Plate-1	500	x	20	=	10000	mm ²
II) Bottom Plate-2	0	x	0	=	0	mm ²

A_f	=	10000	mm ²



Check for Section Class :

Flange Class

$$\begin{aligned}
 b &= 240 \text{ mm} \\
 t_f &= 20 \text{ mm} \\
 b/t_f &= 12.00 \text{ Slender}
 \end{aligned}$$

Web Class

$$\begin{aligned}
 d &= 1440 \\
 t_w &= 20 \\
 d/t_w &= 72.00 \text{ Compact}
 \end{aligned}$$

CALCULATION OF SECTIONAL PROPERTIES**Elastic Properties**

SR.	ELEMENT	Ai(mm ²)	Ye (mm)	AYi	AY ² s	Ixx (self)	It =
NO.			(from top)				AY ² s + Ixx
1	Top Flange Plate-1	10000	30	300000	9.0E+06	3.3E+05	9.3E+06
2	Top Flange Plate-2	9000	10	90000	9.0E+05	3.0E+05	1.2E+06
3	Web	28800	760	21888000	1.7E+10	5.0E+09	2.2E+10
4	Bottom Flange Plate-1	10000	1490	14900000	2.2E+10	3.3E+05	2.2E+10
5	Bottom Flange Plate-2	0	1500	0	0.0E+00	0.0E+00	0.0E+00
	Σ	57800.00		3.7E+07			4.4E+10

Therefore distance of N.A. from top fibre - Tension Fibre

$$= \frac{\Sigma A y_c}{\Sigma A} = \frac{3.7E+07}{57800.00} = 643.22 \text{ mm}$$

Therefore distance of N.A. from bottom fibre - Compression Fibre

$$\begin{aligned}
 y_b &= D - y_t \\
 &= 1500 - 643.22 = 856.78 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 \text{M.I. About N. A.} &= 4.4E+10 - 57800.00 \times (6.43E+02)^2 \\
 I_{xx} &= 1.99E+10 \text{ mm}^4
 \end{aligned}$$

$$\begin{aligned}
 Z_b &= \frac{I_{xx}}{y_b} = \frac{2.0E+10}{856.78} = 2.3E+07 \text{ mm}^3 \\
 Z_t &= \frac{I_{xx}}{y_t} = \frac{2.0E+10}{643.22} = 3.1E+07 \text{ mm}^3
 \end{aligned}$$

$$\text{Elastic section modulus (Ze)} = 2.32E+07 \text{ mm}^3$$

Plastic Properties of Girder Considering Full Shear Area

Assume distance of neutral axis from Top of top flange is d.

$$d = 535.00 \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned}
 A1 &= (450 \times 20 + 500 \times 20 + 20 \times (d-20-20)) \\
 &= 28900 \text{ mm}^2
 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned}
 A2 &= (0 \times 0 + 500 \times 20 + 20 \times (1500 - d - 0 - 20)) \\
 &= 28900 \text{ mm}^2
 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = 0$$

Calculation of Effective Cross section

$$\begin{aligned}
 t_w &= 20.00 \text{ mm} \\
 f_y &= 330 \text{ Mpa} \\
 \varepsilon &= 0.87 \\
 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the compression flange} \\
 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the plastic neutral axis} \\
 \text{inactive portion} &= 0.00 \text{ mm} && \text{As the web is in Compact Class} \\
 &&& \text{Refer class 603.1.3}
 \end{aligned}$$

Area in Tension

S. No.	Area A_i (mm ²)	distance from N.A Y_i (mm)	$A_i \cdot Y_i$ (mm ³)
Top Flng 1	10000	505	5050000
Top Flng 2	9000	525	4725000
web	9900	247.50	2450250
	28900		1.22E+07

Area in Compression

S. No.	Area A_i (mm ²)	distance from N.A Y_i (mm)	$A_i \cdot Y_i$ (mm ³)
Bottom Flr	10000	955	9550000
Bottom Flr	0	965	0
web	18900	473	8930250
	28900		18480250

$$\begin{aligned}
 Y_1 &= \frac{\sum A_i Y_i}{\sum A_i} \\
 &= 423.02 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 Y_2 &= \frac{\sum A_i Y_i}{\sum A_i} \\
 &= 639.46 \text{ mm}
 \end{aligned}$$

$$\text{Plastic section modulus (Zp)} = A_1 \cdot Y_1 + A_2 \cdot Y_2 = 3.1E+07 \text{ mm}^3$$

Plastic Properties of Girder Excluding Full Shear Area

Assume distance of neutral axis from bottom of top flange is d.

$$d = 532.50 \text{ mm}$$

Area above neutral axis (A_1)

$$\begin{aligned}
 A_1 &= (450 \times 20 + 500 \times 20 + 20 \times d) \\
 &= 29650 \text{ mm}^2
 \end{aligned}$$

Area below neutral axis (A_2)

$$\begin{aligned}
 A_2 &= (0 \times 0 + 500 \times 20 + 20 \times (1440 - d)) \\
 &= 28150 \text{ mm}^2
 \end{aligned}$$

Moment balance about neutral axis

$$A_2 - A_1 = -1500 \text{ goal seek}$$

Area in Tension

S. No.	Area A_i (mm ²)	distance from N.A Y_i (mm)	$A_i \cdot Y_i$ (mm ³)
Top Flng 1	10000	543	5425000
Top Flng 2			
web			
	10000		5.43E+06

Area in Compression

S. No.	Area A_i (mm ²)	distance from N.A Y_i (mm)	$A_i \cdot Y_i$ (mm ³)
Bottom Flr	10000	918	9175000
Bottom Flng 2			
web			
	10000		9175000

$$\begin{aligned}
 Y_1 &= \frac{\sum A_i Y_i}{\sum A_i} \\
 &= 542.50 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 Y_2 &= \frac{\sum A_i Y_i}{\sum A_i} \\
 &= 917.50 \text{ mm}
 \end{aligned}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = 1.46\text{E}+07 \text{ mm}^3$$

ELASTIC COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER

In the negative bending region, concrete slab is ineffective in tension but longitudinal reinforcement within effective width are to be included and also sectional properties for permanent and transient load case are same as there is no effect of modular ratio

Negative flexure concrete Deck Reinforcement

Depth of Slab at Inner Girder location = 0.220 m

Provide reinforcement at top face

16 dia @ spacing 125 + 0 dia @ spacing 200

Provided Ast = 1608.50 mm²/m

Provide reinforcement at bottom face

0 dia @ spacing 200 + 0 dia @ spacing 200

Provided Ast = 0.00 mm²/m

effective width of deck slab of inner girder = 2812.5 mm

Area of reinforcement required within the effective width of inner girder at top face of deck slab

= 4523.893 mm²

Area of reinforcement required within the effective width of inner girder at bottom face of deck slab

= 0 mm²

C.g. of top layer of reinforcement from top of deck = 56 mm

C.g. of bottom layer of reinforcement from top of deck = 164 mm

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{350}{1.1} = 318.182 \text{ Mpa}$$

Calculation of the Moment of Inertia for Composite Section for Girder

SR. NO.	ELEMENT	Ai(mm ²)	ye(mm)	Aye(mm ³)	Ay ² _e (mm ⁴)	Ixx (self)(mm ⁴)	I _t = Ixx (self)+Ay ² _e
1	Steel section	57800	863.22	5.0E+07	4.3E+10	2.0E+10	6.30E+10
2	Top long. Reinf.	4524	56.00	2.5E+05	1.4E+07		1.42E+07
3	Bottom Long. Reinf.	0	164.00	0.0E+00	0.0E+00		0.00E+00
Σ		62323.9		5.0E+07			6.30E+10

Therefore N.A. from Top Fibre of Deck Slab = $\frac{5.0E+07}{6.2E+04} = 804.62 \text{ mm}$

Moment of Inertia about N.A. of the composite Section

$$I_{xx} = 2.26E+10 \text{ mm}^4$$

$$y_t = 805 \text{ mm},$$

$$y_b = 915 \text{ mm}$$

Distance between c.g. of cracked section and plate girder only

$$\bar{y} = 58.593 \text{ mm}$$

$$Z_{\text{slab}} = \frac{I_{xx}}{y_{\text{slab}}} = \frac{2E+10}{805} = 2.81E+07 \text{ mm}^3$$

$$Z_{\text{treinf.}} = \frac{I_{xx}}{y_{\text{treinf.}}} = \frac{2E+10}{749} = 3.02E+07 \text{ mm}^3$$

$$Z_{\text{tflange}} = \frac{I_{xx}}{y_t} = \frac{2E+10}{585} = 3.87E+07 \text{ mm}^3$$

$$Z_{\text{bflange}} = \frac{I_{xx}}{y_b} = \frac{2E+10}{915} = 2.47E+07 \text{ mm}^3$$

$$\text{Elastic section modulus (Ze)} = 2.47E+07 \text{ mm}^3$$

Ultimate Design of Section at Fixed End - For Shear

Critical Span	=	L1

Max Reaction at Bearing Location	=	2661.79 KN

Max Shear force for composite section	=	2661.79 KN

Material Properties

Partial Safety Factor	γ_m	=	1.10		f_y	=	350 Mpa.

Max permissible bending stress in tension or compression.

s_{bct}	=	$\frac{f_y}{\gamma_m}$	=	$\frac{350}{1.1}$	=	318.18182 Mpa

ϵ	=	$\sqrt{\frac{250}{f_y}}$	=	0.845

Average Shear Stress =	$\frac{f_y}{350}$	$\div$	γ_m	$\div$	1.1	=	318.18182 MPa

Min. Dimension Requirement

Min overall depth =	$\frac{L}{25}$	=	$\frac{22500}{25}$	=	900 mm

Overall depth Provide		=	1480 mm

Hence OK

Min Spacing =	$\frac{L}{20}$	=	$\frac{22500}{20}$	=	1125 mm

Maximum Spacing of Girder provided		=	7500 mm

Hence OK

Dimension Check

Minimum Web Thickness

a.) For vertical Stiffener

Serviceability Requirement

$\frac{d}{t_w}$	$\leq$	200 ϵ			
$\frac{d}{t_w}$	=	6.09	$<$	20.00	

Vertical Stiffener not required

b.) For horizontal Stiffener

$\frac{d}{t_w}$	$\leq$	200 ϵ	$3d \geq c \geq d$
$\frac{c}{t_w}$	$\leq$	200 ϵ	$0.74d \leq c < d$

$$\frac{d}{t_w} \leq 270\epsilon \quad c < d$$

$$t_w = \boxed{8.52} < \boxed{20.00}$$

Horizontal Stiffener not required

To avoid Flange Buckling

$$\frac{d}{t_w} \leq 345\epsilon_f^2 \quad \text{Stiffener not provided}$$

$$\frac{d}{t_w} \leq 345\epsilon_f^2 \quad c \geq 1.5 d$$

$$\frac{d}{t_w} \leq 345\epsilon_f \quad c < 1.5 d$$

$$t_w = \boxed{4.94} < \boxed{20.00}$$

Hence OK

DESIGN OF WEB FOR SHEAR :

$$\text{Max Shear force at support of composite section} = \boxed{2661.79} \text{ KN}$$

a.) Plastic Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = d * t_w \quad (\text{For Welded Section})$$

$$V_n = \boxed{5819.69} \text{ KN} > \boxed{2661.79} \text{ KN}$$

Safe in Shear

b.) Shear Buckling Design

$$\frac{d}{t_w} > 67\epsilon \quad \text{Without Stiffener}$$

$$> 67\epsilon * \sqrt{K_v/5.35} \quad \text{With Stiffener}$$

$$\frac{1440}{20} = 72.00 > 56.63$$

Hence OK

Simple Post - Critical Method

$$\begin{aligned}
 K_v &= 5.35 && \text{When stiffeners are provided only at support} \\
 &= 4.0 + 5.35/(c/d)^2 &= & \boxed{7.16} && \text{For } c/d < 1.0 \\
 &= 5.35 + 4.0/(c/d)^2 &= & \boxed{7.16} && \text{For } c/d \geq 1.0 \\
 c/d &= \boxed{1.30} \\
 K_v &= \boxed{7.16} \\
 \tau_{cr,e} &= \frac{K_v \pi^2 E}{12(1-\mu^2)(d/t_w)^2} &= & \boxed{249.51} \text{ Mpa} \\
 \lambda_w &= \sqrt{\frac{f_{yw}}{\sqrt{3} \tau_{cr,e}}} &= & \boxed{0.90} \\
 \text{i.) } \lambda_w &\leq 0.8 \\
 \tau_b &= \frac{f_{yw}}{\sqrt{3}} &= & \boxed{202.07} \text{ Mpa} \\
 \text{ii.) } 0.8 &\leq \lambda_w \leq 1.2 \\
 \tau_b &= \frac{f_{yw}}{[1-0.8(\lambda_w-0.8)] \sqrt{3}} &= & \boxed{185.92} \text{ Mpa} \\
 \text{iii.) } \lambda_w &\geq 1.2 \\
 \tau_b &= \frac{f_{yw}}{\sqrt{3} \lambda_w^2} &= & \boxed{249.51} \text{ Mpa}
 \end{aligned}$$

$$\text{Therefore, } \tau_b = \boxed{185.92} \text{ Mpa}$$

Shear force for web buckling

$$V_n = V_{cr} = A_v \tau_b = \boxed{4867.66} \text{ KN} > \boxed{2661.79} \text{ KN}$$

Safe in Buckling

ULTIMATE DESIGN OF INNER GIRDER SUBJECTED TO HOGGING MOMENT

As the Inner girder is subjected to maximum bending moment and shear force hence critical for design

Critical Span	=	L1

DESIGN STAGE I : DEAD LOAD (SELF WEIGHT, GREEN WEIGHT OF SLAB AND TEMPORARY LOAD)

Assuming the girder is laterally supported throughout the span

Max Bending Moment (Green concrete weight and temporary load) = 3610.98 kNm

Elastic section modulus (Ze)	=	2.32E+07 mm ³	
Plastic section modulus (Zp)	=	3.07E+07 mm ³	
β_b	=	1	Plastic/Compact section

If Shear force (V) is less than 0.6 times shear capacity Vd, there is no reduction in plastic bending resistance of the section. Therefore plastic bending capacity of the section is given as

Design bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_m} = \span style="border: 1px solid black; padding: 2px 10px;">9769.93 \text{ kNm}$$

If Shear force (V) is greater than 0.6 times shear capacity Vd, the bending resistance is reduced as the contribution of web to the bending gets diminished. Therefore reduced bending capacity is given as

$$M_{dv} = M_d - \beta (M_d - M_{fd}) \leq \frac{1.2 Z_e f_y}{\gamma_m}$$

$$\beta = 0.009 = (2 V/V_d - 1)^2$$

$$M_{fd} = \frac{Z_p f_y}{\gamma_m} = \span style="border: 1px solid black; padding: 2px 10px;">4645.45 \text{ kNm}$$

$$M_{dv} = \span style="border: 1px solid black; padding: 2px 10px;">9724.98 > \span style="border: 1px solid black; padding: 2px 10px;">8872.66 \text{ kNm} \quad \text{Revise Section}$$

Max Shear force for composite section

$$V = 2661.79 \text{ KN}$$

Shear Capacity of the section

$$V_d = 4867.66 \text{ KN}$$

$$V < 0.6 V_d$$

Design bending strength

$$M_d = \span style="border: 1px solid black; padding: 2px 10px;">9769.93 \text{ kNm} > 3610.98 \text{ kNm}$$

Hence OK

DESIGN STAGE II : DL+SIDL+LL

In the negative bending region, concrete slab is ineffective in tension.

Hence sectional properties and plastic moment of resistance for permanent and transient load case are same

Max . Bending Moment due to DL+SIDL = 5749.50 kN.m

Max . Bending Moment due to DL+SIDL+LL = 10006.77 kN.m

For plastic and compact stress distribution , depth $\bar{y}$

$$\bar{y} \cdot t_w \cdot 2 f_y / y_m = F_s$$

where , $F_s = f_{st} \cdot A_{st} / y_{mst}$

$A_{st} = 4523.893 \text{ mm}^2$ area of steel in deck slab at negative moment section

$f_{st} = 500 \text{ N/mm}^2$

$y_{mst} = 1.15$

F_s	=	1966910.18 N

$f_y = 350.00 \text{ N/mm}^2$

$y_m = 1.10$

$t_w = 20.00 \text{ mm}$

$\bar{y}$	=	154.54 mm

Plastic moment capacity of section

Case 1: If position of plastic neutral axis is within Web

$$M_{ph} = M_p + F_s Z$$

where, $M_p = 9769.93 \text{ kNm}$ plastic moment capacity of steel section

$$F_s = 1966.910 \text{ kN}$$

where $Z = D/2 + d_e - \bar{y}/2$

$$D = 1500.00 \text{ mm}$$

$$D/2 = 750.00 \text{ mm}$$

$$d_e = 164.00 \text{ mm}$$

$$\bar{y} = 154.54 \text{ mm}$$

$$Z = 836.73 \text{ mm}$$

$$M_{ph} = 9769.93 + 1966.9 \times 0.837$$

$$\mathbf{M_{ph} = 11415.702 \text{ kNm}}$$

Case 2: If position of plastic neutral axis is within Flange

where, $M_{ph} = F_b \cdot D/2 + F_s \cdot d_s - \frac{(F_b - F_s)^2}{F_f} \cdot \frac{t_f}{4}$

$$F_b = f_y \cdot A_s / y_m = \text{axial capacity of steel section}$$

$$A_s = 57800.00 \text{ mm}^2$$

$$F_b = 18390.9 \text{ kN}$$

$$F_s = 1966.910 \text{ kN}$$

$$d_s = 220.00 \text{ mm}$$

average $t_f = 20.00 \text{ mm}$

$$A_f = 19000.00 \text{ mm}^2$$

$$F_f = f_y \cdot A_f / y_m = 6045455 \text{ N} = 6045.455 \text{ kN}$$

$$M_{ph} = 13793.182 + 432.720 - 223.100$$

$$\mathbf{M_{ph} = 14002.802 \text{ kNm}}$$

$$D/2 - t_f = 730.00 \text{ mm}$$

$$D/2 = 750.00 \text{ mm}$$

$$\bar{y} = 154.54 \text{ mm}$$

AS $\bar{y} < D/2-t_f$ Hence Neutral axis is within Web

Hence plastic moment of resistance of composite section = 11415.702 kNm
>

10006.77 kNm
Hence OK

SUMMARY OF BENDING MOMENT CAPACITY

Load Cases	Inner Girder					
	Ultimate Bending Moment	Plastic Moment Capacity	STATUS			
Stage I : DL	3610.98	9769.93	OK			
Stage II : DL+SIDL	5749.50	11415.70	OK			
Stage III: DL+SIDL+LL	10006.77	11415.70	OK			

CHECK FOR SERVICEABILITY LIMIT STATE (MID SPAN)

SERVICEABILITY LIMIT STATE - STRESS CHECK IN INNER GIRDER AT MID-SPAN

LOCATION

For checking the stress limit, rare combination is used (As per Table 3.3, Annex B, IRC:6-2014)

Limiting Stress for Structural Steel	=	0.87 X f_y
	=	0.87 X 350
	=	304.5 MPa
Limiting Stress for Concrete	=	0.48 X f_{ck}
	=	0.48 X 40
	=	19.2 MPa

CALCULATION OF STRESS IN DL

Max Bending Moment = 1578.0 KN-m

$Z_t = 2.32E+07 \text{ mm}^3$

$Z_b = 3.10E+07 \text{ mm}^3$

Compressive Stress at top of girder = 67.9 MPa

Tensile Stress at bottom of girder = 51.0 MPa

CALCULATION OF STRESS IN SIDL

Effective width = $\frac{4500}{15}$ = 300.00 mm

Max Bending Moment = 353.5 KN-m

$Z_t = 8.72E+07 \text{ mm}^3$

$Z_b = 4.23E+07 \text{ mm}^3$

Compressive Stress at top of girder = 2.5 MPa

Tensile Stress at bottom of girder = 8.4 MPa

Compressive Stress at top of deck slab = $\frac{M}{z_t \times m}$ (for concrete section)

= $z_t \times m$

= 0.3 MPa

CASE 1: CONSIDERING LIVE LOAD AS LEADING LOAD AND TEMPERATURE AS ACCOMPANYING LOAD

CALCULATION OF STRESS IN LIVE LOAD

Effective width = $\frac{4500}{7.5}$ = 600.00 mm

Max Bending Moment due to LL = 1395.7 KN-m

$Z_t = 1.43E+08 \text{ mm}^3$

$Z_b = 4.41E+07 \text{ mm}^3$

Compressive Stress at top of girder	=	4.4 MPa
Tensile Stress at bottom of girder	=	31.7 MPa
Compressive Stress at top of deck slab	=	$\frac{M}{z_t \times m}$ (for concrete section)
	=	1.3 MPa

TOTAL STRESS AFTER STAGE III (Mpa)

Limiting Stress for Structural Steel	=	304.5 MPa
Limiting Stress for Concrete	=	19.2 MPa

	DL	SIDL	LIVE LOAD	TOTAL	
Deck Slab Top (Comp)	0.0	0.3	1.3	1.6	Safe
Girder Top (Comp)	67.9	2.5	4.4	74.8	Safe
Girder Bottom (Tensile)	51.0	8.4	31.7	91.0	Safe

TEMPERATURE AND SHRINKAGE STRESS

Load Factor Thermal load for Accompanying load	=	0.6	Rare Combination
Load Factor Ffor Shrinkage effect	=	1	Rare Combination

	Rising	Falling	Shrinkage	Rising + Shrinkage	Falling + Shrinkage
Deck Slab Top (Comp)	1.4	-0.7	-2.9	-1.6	-3.6
Girder Top (Comp)	-0.3	0.3	-39.0	-39.3	-38.7
Girder Bottom (Tensile)	2.3	-1.6	11.8	14.1	10.2

Stress Summary Considering Live load as Leading Load and Temperature load as accompanying load

	TOTAL IN SHRINKAGE (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check	TOTAL IN FALLING TEMP (MPa)	Check
Deck Slab Top (Comp)	-1.4	Safe	2.9	Safe	0.9	Safe
Girder Top (Comp)	35.8	Safe	74.5	Safe	75.1	Safe
Girder Bottom (Tensile)	102.8	Safe	93.3	Safe	89.4	Safe

CASE 2: CONSIDERING LIVE LOAD AS ACCOMPANYING LOAD AND TEMPERATURE AS LEADING LOAD

CALCULATION OF STRESS IN LIVE LOAD

$$\text{Effective width} = \frac{4500}{7.5} = 600.00 \text{ mm}$$

$$\text{Max Bending Moment} = 1046.8 \text{ KN-m}$$

$$Z_t = 1.43\text{E}+08 \text{ mm}^3$$

$$Z_b = 4.41\text{E}+07 \text{ mm}^3$$

$$\text{Compressive Stress at top of girder} = 3.3 \text{ MPa}$$

$$\text{Tensile Stress at bottom of girder} = 23.7 \text{ MPa}$$

$$\begin{aligned} \text{Compressive Stress at top of deck slab} &= \frac{M}{z_t \times m} \text{ (for concrete section)} \\ &= 1.0 \text{ MPa} \end{aligned}$$

TOTAL STRESS AFTER STAGE III (Mpa)

Limiting Stress for Structural Steel = 304.5 MPa

Limiting Stress for Concrete = 19.2 MPa

	DL	SIDL	LIVE LOAD	TOTAL	
Deck Slab Top (Comp)	0.0	0.3	1.0	1.2	Safe
Girder Top (Comp)	67.9	2.5	3.3	73.7	Safe
Girder Bottom (Tensile)	51.0	8.4	23.7	83.1	Safe

TEMPERATURE AND SHRINKAGE STRESS

Load Factor Thermal load for Accompanying load = 1 Rare Combination

	Rising	Falling	Shrinkage	Rising + Shrinkage	Falling + Shrinkage
Deck Slab Top (Comp)	2.3	-1.1	-2.9	-0.6	-4.0
Girder Top (Comp)	-0.4	0.5	-39.0	-39.5	-38.5
Girder Bottom (Tensile)	3.8	-2.6	11.8	15.6	9.1

Stress Summary Considering Live load as Leading Load and Temperature load as accompanying load

	TOTAL IN SHRINKAGE (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check
Deck Slab Top (Comp)	-1.7	Safe	3.5	Safe	0.1	Safe
Girder Top (Comp)	34.7	Safe	73.3	Safe	74.2	Safe
Girder Bottom (Tensile)	94.9	Safe	86.9	Safe	80.5	Safe

CHECK FOR SERVICEABILITY LIMIT STATE
(SUPPORT PORTION)

SERVICEABILITY LIMIT STATE - STRESS CHECK IN INNER GIRDER AT SUPPORT

LOCATION

For checking the stress limit, rare combination is used (As per Table 3.3, Annex B, IRC:6-2014)

Limiting Stress for Structural Steel	=	0.87 X f_y	
	=	0.87 X 350	
	=	304.5 N/mm ²	
Limiting stress in reinforcement	=	0.87 X $f_{y,st}$	
	=	0.87 X 500	
	=	300 N/mm ²	
f_{ck}	=	40 N/mm ²	
Flexural tensile strength of concrete	=	4.427 N/mm ²	
Tensile Stress at C.g. of Deck slab top reinf.	=	12.2 N/mm ²	Cracked

CALCULATION OF STRESS IN DL

Max Bending Moment	=	2674.8 KN-m
Zt =	3.10E+07 mm ³	
Zb =	2.32E+07 mm ³	
Tensile Stress at top of girder	=	86.4 MPa
Compressive Stress at bottom of girder	=	115.1 MPa

CALCULATION OF STRESS IN SIDL

Modular ratio	=	15 for permanent loading
Max Bending Moment	=	942.2 KN-m

Ztslab	=	2.81E+07 mm ³
Ztreinf.	=	3.02E+07 mm ³
Ztflange	=	3.87E+07 mm ³
Zbflange	=	2.47E+07 mm ³

Tensile stress at top layer of reinf.	=	31.2 N/mm ²
Tensile Stress at top of girder	=	24.3 N/mm ²
Compressive Stress at bottom of girder	=	38.1 N/mm ²

CASE 1: CONSIDERING LIVE LOAD AS LEADING LOAD AND TEMPERATURE AS ACCOMPANYING LOAD

CALCULATION OF STRESS IN LIVE LOAD

Modular ratio = 7.5 for Transient loading

Max Bending Moment due to LL = 2293.4 KN-m

Ztreinf. = $3.02\text{E}+07 \text{ mm}^3$

Ztflange = $3.87\text{E}+07 \text{ mm}^3$

Zbflange = $2.47\text{E}+07 \text{ mm}^3$

Tensile stress at top layer of reinf. = 75.8 N/mm^2

Tensile Stress at top of girder = 59.2 N/mm^2

Compressive Stress at bottom of girder = 92.7 N/mm^2

TOTAL STRESS AFTER STAGE III (Mpa)

Limiting Stress for Reinforcement = 300 N/mm^2

Limiting Stress for Structural Steel = 304.5 N/mm^2

	DL	SIDL	LIVE LOAD	TOTAL	
Tensile stress in concrete around top reinf.	0.0	2.1	10.1	12.2	
Deck Slab Top Reinf. (Tensile)	0.0	31.2	75.8	107.0	Safe
Girder Top (Tensile)	86.4	24.3	59.2	170.0	Safe
Girder Bottom (Comp)	115.1	38.1	92.7	245.9	Safe

TEMPERATURE AND SHRINKAGE STRESS

Load Factor Thermal load for Accompanying load = 0.6 Rare Combination

Load Factor FOR Shrinkage effect = 1 Rare Combination

	Rising	Falling	Shrinkage	Rising + Shrinkage	Falling + Shrinkage
Girder Top (Tensile)	-0.3	0.3	-39.0	-39.3	-38.7
Girder Bottom (Comp)	2.3	-1.6	11.8	14.1	10.2

Stress Summary Considering Live load as Leading Load and Temperature load as accompanying load

	TOTAL IN SHRINKAGE (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check	TOTAL IN FALLING TEMP (MPa)	Check
Girder Top (Tensile)	130.9	Safe	169.7	Safe	170.2	Safe
Girder Bottom (Comp)	257.7	Safe	248.2	Safe	244.3	Safe

CASE 2: CONSIDERING LIVE LOAD AS ACCOMPANYING LOAD AND TEMPERATURE AS LEADING LOAD

CALCULATION OF STRESS IN LIVE LOAD

Max Bending Moment = 1720.0 kN-m

Ztreinf. = 3.0E+07 mm³

Ztflange = 3.9E+07 mm³

Zbflange = 2.5E+07 mm³

Tensile stress at top layer of reinf. = 56.9 N/mm²

Tensile Stress at top of girder = 44.4 N/mm²

Compressive Stress at bottom of girder = 69.5 N/mm²

TOTAL STRESS AFTER STAGE III (Mpa)

Limiting Stress for Reinforcement = 300 N/mm²

Limiting Stress for Structural Steel = 304.5 N/mm²

	DL	SIDL	LIVE LOAD	TOTAL	
Tensile stress in concrete around top reinf.	0.0	2.1	7.6	9.7	
Deck Slab Top Reinf. (Tensile)	0.0	31.2	56.9	88.0	Safe
Girder Top (Tensile)	86.4	24.3	44.4	155.1	Safe
Girder Bottom (Comp)	115.1	38.1	69.5	222.7	Safe

TEMPERATURE AND SHRINKAGE STRESS

Load Factor Thermal load for Accompanying load = 1 Rare Combination

	Rising	Falling	Shrinkage	Rising + Shrinkage	Falling + Shrinkage
Girder Top (Tensile)	-0.4	0.5	-39.0	-39.5	-38.5
Girder Bottom (Comp)	3.8	-2.6	11.8	15.6	9.1

Stress Summary Considering Live load as Leading Load and Temperature load as accompanying load

	TOTAL IN SHRINKAGE (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check	TOTAL IN FALLING TEMP (MPa)	Check
Girder Top (Tensile)	116.1	Safe	154.7	Safe	155.6	Safe
Girder Bottom (Comp)	234.5	Safe	226.6	Safe	220.1	Safe

DESIGN OF PLATE GIRDER CHECK FOR DEFLECTION

SERVICEABILITY LIMIT STATE - CHECK FOR DEFLECTION

For checking the stress limit, FREQUENT combination is used

(As per Table 3.3, Annex B, IRC:6-2014)

(considering the whole superstructure)= Length = 22.50 m

According to Cl. 504.5.1 of IRC - 24-2010 the permissible deflection for

(DL + LL + SIDL) = $L/600$ = 37.500 mm

However , this restriction shall not apply if minimum in place pre camber is provided to compensate for all dead and superimposed dead load deflections.

For LL only = $L/800$ = 28.13 mm

Deflection due to DL and SIDL = 40.44 mm

Deflection due to LL(70R Wheeled) = 11.81 mm

Deflection due to LL(2 lane Class A) = 5.24 mm

Hence Deflection due to Live load = 11.81 < 28.13
O.K.Total Deflection due to dead load+Sidl = 52.25 mm > 37.50
Hence provide pre-camber in girder

DESIGN OF END CROSS
GIRDER FOR JACKING
CONDITION

Input Data

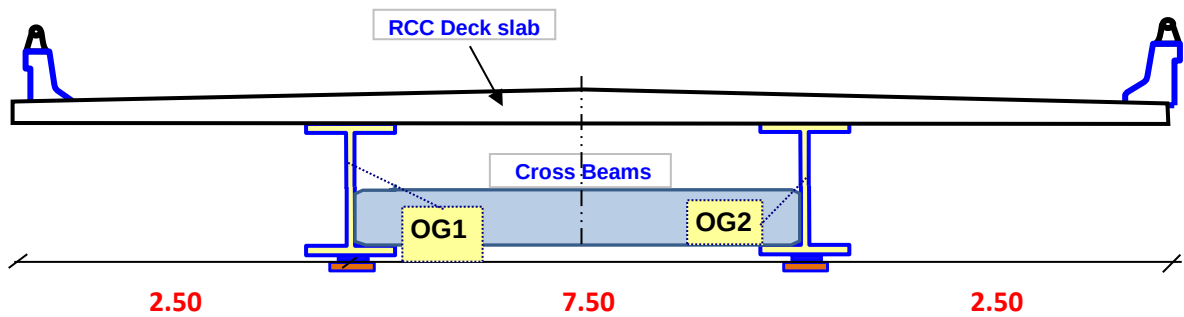
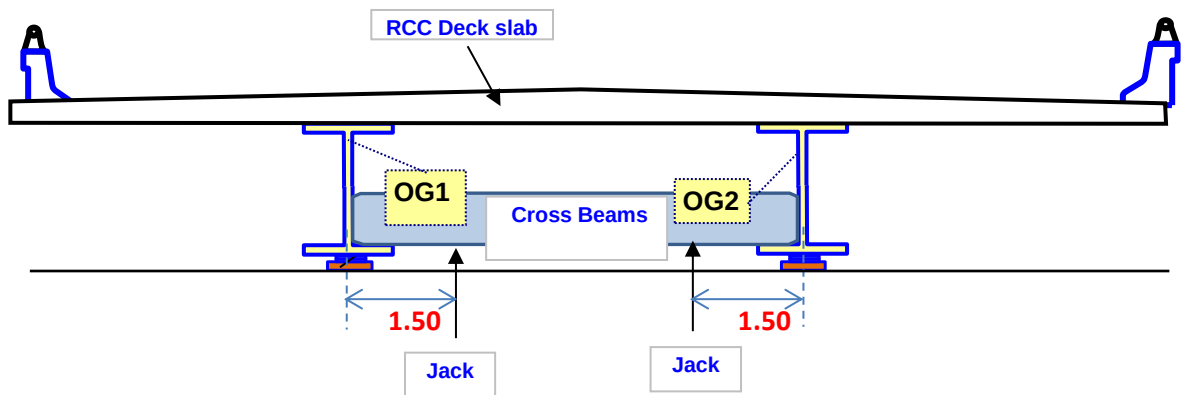


Fig. Showing End Cross Girder of Superstructure

Span	L1	=	7.50 m
Span	L2	=	2.50 m
Depth of cross girder		=	1.00 m

End cross girder has been Jacking condition



Summary of Bearing Reaction (IN KN)

	BRG1	BRG2
weigh of steel	127	127
dead load due to deck	735	735
SIDL1-Crash Barrier	131	131
SIDL2-Wearing coat	210	210
	1203	1203

Summary of Jack Force

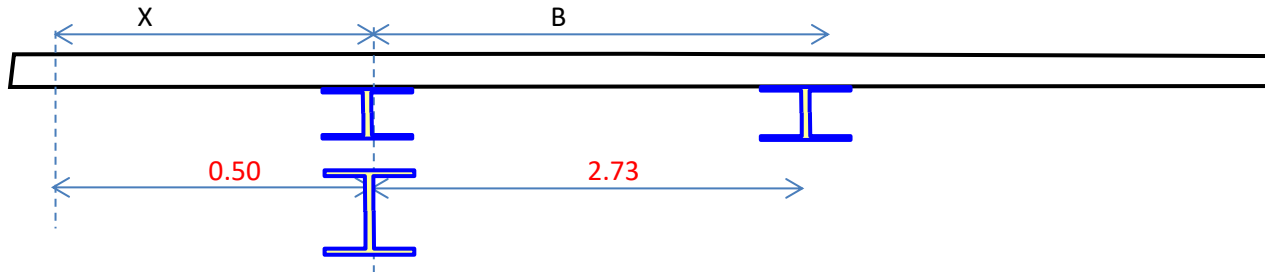
DL+SIDL1+SIDL2	1203	1203	KN

Jack Capacity	1503.75 KN	SAY	170.00 Tonne

Cross slope of superstructure	=	2.5	%
Width of kerb & RCC Railing	=	0.45	each side
Carriageway width	=	11.00	m

Overall width of bridge	=	12.00	m
Spacing of main girder.	=	7.50	m
Deck slab thickness at centre	=	0.225	m
Deck slab thickness at edge	=	0.225	m
Thick. of Deck Slab at Main L-Gir. Location	=	0.225	m
Thick. of Deck Slab at Edge L-Gir. Location	=	0.225	m

Calculation of Effective width of flanges for End Girder



B	=	2.73	m
X	=	0.50	m
Lo	=	7.50	m

$$b_{\text{eff}} = \frac{L_0}{8} + X$$

$$\frac{L_0}{8} \leq \frac{B}{2} \quad \text{and} \quad X \leq \frac{B}{2}$$

$$0.938 \leq 1.3625 \quad 0.50 \leq 1.3625$$

$$b_{\text{eff}} = 0.9375 + 0.5 = 1.438 \text{ m}$$

Dimensions of cross girder

Web plate size (without slab)	=	960 X 20	mm
Top Flange thickness Plate-1	=	300 X 20	mm
Top Flange thickness Plate-2	=	0 X 0	mm
Bottom Flange thickness Plate-1	=	300 X 20	mm
Bottom Flange thickness Plate-2	=	0 X 0	mm

PARTIAL SAFETY FACTOR

γ_m	=	1.10	For Structural Steel Against Yield Stress
γ_m	=	1.25	For Shear Connector
$\gamma_{m.st}$	=	1.15	For reinforcement

MATERIAL PROPERTIES

Grade of structural steel (Main Girders) E350	330	Mpa	plate thk <20
Grade of Secondary Members (ie rolled section)	330	Mpa	
Grade of concrete	40	M	
Type of steel	Fe 500	D	
Ultimate strength of shear connector	149	kN	For 25 mm dia Stud
Fatigue strength of shear connector	39	kN	
Ultimate strength of weld	330		
Factor of safety for shop weld	1.25	for shop welds	
	1.5	for fillet welds	

MAXIMUM FLEXURAL MOMENTS -UNDER JACKING CONDITION**from Staad-Pro Elastic analysis**

Sr. No.	Loads	Bending moment (kNm)	Load Factor- ULS	Load Factor- Rare	ULS-Bending Moment	SLS-Bending Moment
1	Self-Weight of Girder	215	1.35	1	290.25	215
2	Weight of Slab	1221	1.35	1	1648.35	1221
3	SIDL1-Crash+Railing	210	1.35	1	283.5	210
4	SIDL2-Wearing Coat	315	1.75	1.2	551.25	378
Total					2773.35	2024

MAXIMUM SHEAR FORCE -UNDER JACKING CONDITION**from Staad-Pro Elastic analysis**

Sr. No.	Loads	Shear Force (kN)	Load Factor- ULS	Load Factor- Rare	ULS-Shear Force	SLS-Shear Force
1	Self-Weight of Girder	145	1.35	1	195.75	145
2	Weight of Slab	814	1.35	1	1098.9	814
3	SIDL1-Crash+Railing	140	1.35	1	189	140
4	SIDL2-Wearing Coat	210	1.75	1.2	367.5	252
Total					1851.15	1351

DESIGN OF END CROSS GIRDER FROM ULTIMATE LIMIT STATE METHOD

Sectional Properties

Top Flange thickness Plate-1	=	20	mm
Top Flange thickness Plate-2	=	0	mm
Bottom Flange thickness Plate-1	=	20	mm
Bottom Flange thickness Plate-2	=	0	mm
Depth of the Web Plate	=	960	mm
Thickness of the web	=	20	mm

web plate of size = **960** x **20**

Top Flange Area -

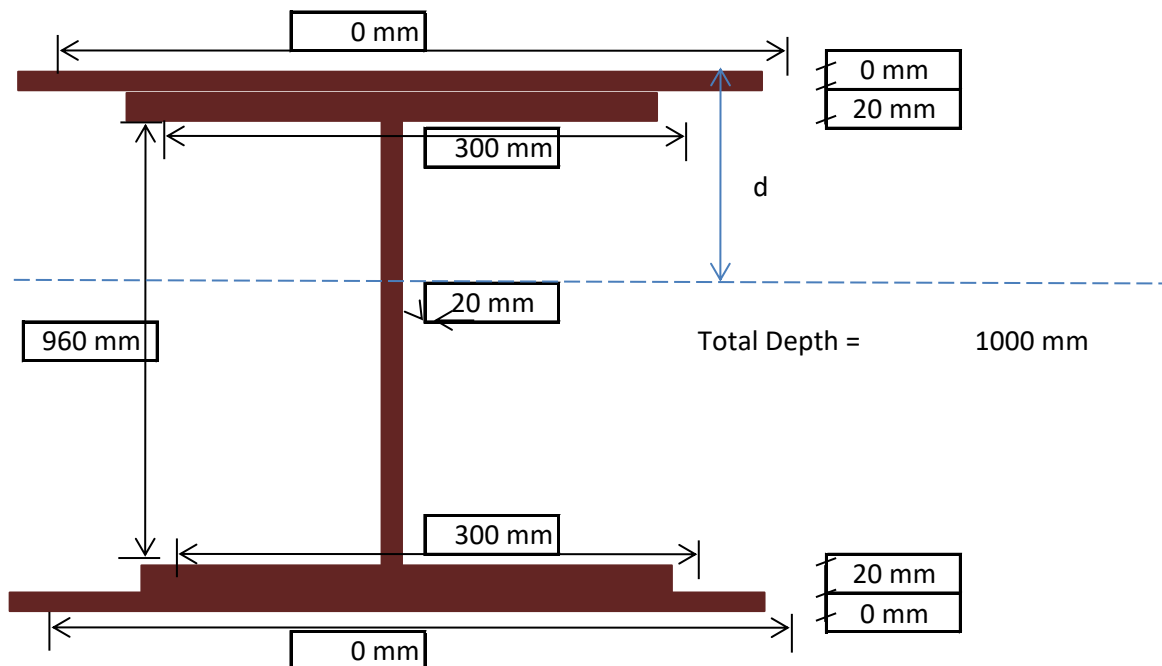
I)Top Plate-1	300	x	20	=	6000	mm ²
II) Top Plate-2	0	x	0	=	0	mm2

A_f	=	6000	mm ²

Bottom Flange Area -

I) Bottom Plate-1	300	x	20	=	6000	mm ²
II) Bottom Plate-2	0	x	0	=	0	mm ²

A_f	=	6000	mm ²

**Check for Section Class :**

Flange Class

b	=	<table><tr><td>140</td></tr></table> mm	140
140			
tf	=	<table><tr><td>20</td></tr></table> mm	20
20			
b/tf	=	7.00 Plastic	

Web Class

d	=	960
tw	=	20
d/tw	=	48.00 Plastic

Elastic Properties

SR.	ELEMENT		Ai(mm ²)	Ye (mm)	AYi	AY ² s	Ixx (self)	It =
NO.				(from top)				AY ² s + Ixx
1	Top Flange Plate-1		6000	10	60000	6.0E+05	2.0E+05	8.0E+05
2	Top Flange Plate-2		0	0	0	0.0E+00	0.0E+00	0.0E+00
3	Web		19200	500	9600000	4.8E+09	1.5E+09	6.3E+09
4	Bottom Flange Plate-1		6000	990	5940000	5.9E+09	2.0E+05	5.9E+09
5	Bottom Flange Plate-2		0	1000	0	0.0E+00	0.0E+00	0.0E+00
	Σ		31200.00		1.6E+07			1.2E+10

Therefore distance of N.A. from top fibre

$$= \frac{\Sigma A y_c}{\Sigma A} = \frac{1.6E+07}{31200.00} = 500.00 \text{ mm}$$

$$\begin{aligned} \text{M.I. About N. A.} &= 1.2E+10 - 31200.00 \times (500.00)^2 \\ I_{xx} &= 4.36E+09 \text{ mm}^4 \\ y_b &= D - y_t \\ &= 1000 - 500.00 = 500.00 \text{ mm} \\ Z_b &= \frac{I_{xx}}{y_b} = \frac{4.4E+09}{500.00} = 8.7E+06 \text{ mm}^3 \\ Z_t &= \frac{I_{xx}}{y_t} = \frac{4.4E+09}{500.00} = 8.7E+06 \text{ mm}^3 \\ \text{Elastic section modulus (Ze)} &= 8.71E+06 \text{ mm}^3 \end{aligned}$$

Plastic Properties of Girder Considering Full Shear Area

Assume distance of neutral axis from Top of top flange is d.

$$d = 500.00 \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned} A1 &= (0 \times 0 + 300 \times 20 + 20 \times (d - 0 - 20)) \\ &= 15600 \text{ mm}^2 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned} A2 &= (0 \times 0 + 300 \times 20 + 20 \times (1000 - d - 0 - 20)) \\ &= 15600 \text{ mm}^2 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = 0$$

Calculation of Effective Cross section

$$\begin{aligned} t_w &= 20.00 \text{ mm} \\ f_y &= 330 \text{ Mpa} \\ \varepsilon &= 0.87 \\ 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the compression flange} \\ 20 \varepsilon \cdot t_w &= 348.16 \text{ mm} && \text{Part adjacent to the plastic neutral axis} \\ \text{inactive portion} &= 0.00 \text{ mm} && \text{As the web is in Plastic Class} \\ &&& \text{Refer class 603.1.3} \end{aligned}$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	6000	490	2940000
Top Flng 2	0	500	0
web	9600	240.00	2304000
	15600		5.24E+06

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \boxed{336.15} \text{ mm}$$

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flr	6000	490	2940000
Bottom Flr	0	500	0
web	9600	240	2304000
	15600		5244000

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \boxed{336.15} \text{ mm}$$

$$\begin{aligned} \text{Effective Cross sectional area} &= \boxed{3.1E+04} \text{ mm}^2 \\ \text{Plastic section modulus (Zp)} &= A1*Y1 + A2*Y2 = \boxed{1.0E+07} \text{ mm}^3 \end{aligned}$$

Plastic Properties of Girder Excluding Full Shear Area

Assume distance of neutral axis from bottom of top flange is d.

$$d = \boxed{480.00} \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned} A1 &= (0 \times 0 + 300 \times 20 + 20 \times d) \\ &= 15600 \text{ mm}^2 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned} A2 &= (0 \times 0 + 300 \times 20 + 20 \times (960 - d)) \\ &= 15600 \text{ mm}^2 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = \boxed{0}$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	6000	490	2940000
Top Flng 2			
web			
	6000		2.94E+06

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = 490.00 \text{ mm}$$

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flr	6000	490	2940000
Bottom Flng 2			
web			
	6000		2940000

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = 490.00 \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = 5.88E+06 \text{ mm}^3$$

Ultimate Design of Section- For Shear

Max Shear force = 1851.15 KN

Material Properties

Partial Safety Factor γ_m = 1.10

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{330}{1.1} = \boxed{300} \text{ Mpa}$$

$$\epsilon = \sqrt{\frac{250}{f_y}} = \boxed{0.870}$$

Average Shear Stress =

$$= \frac{f_y}{330} \div \frac{\gamma_m}{1.1} = \boxed{300} \text{ MPa}$$

Min. Dimension Requirement

Min overall depth = $\frac{L}{25} = \frac{7500}{25} = \boxed{300} \text{ mm}$

Overall depth Provide = $\boxed{1000} \text{ mm}$ Hence OK

Min Spacing = $\frac{L}{20} = \frac{7500}{20} = \boxed{375} \text{ mm}$

Maximum Spacing of Girder provided = $\boxed{7500} \text{ mm}$ Hence OK

Dimension Check

Minimum Web Thickness

a.) For vertical Stiffener

Serviceability Requirement

$$\frac{d}{t_w} \leq 200\epsilon$$

$$\frac{d}{t_w} = \boxed{5.51} < \boxed{20.00}$$

Vertical Stiffener not required

b.) For horizontal Stiffener

$$\frac{d}{t_w} \leq 200\epsilon \quad 3d \geq c \geq d$$

$$\frac{c}{t_w} \leq 200\epsilon \quad 0.74d \leq c < d$$

$$\frac{d}{t_w} \leq 270\epsilon \quad c < d$$

$$t_w = \boxed{5.51} < \boxed{20.00}$$

Horizontal Stiffener not required

To avoid Flange Buckling

$$\frac{d}{t_w} \leq 345\epsilon_f^2 \quad \text{Stiffener not provided}$$

$$\frac{t_w}{d} \leq 345\epsilon_f^2 \quad c \geq 1.5 d$$

$$\frac{t_w}{d} \leq 345\epsilon_f \quad c < 1.5 d$$

$$t_w = 3.67 < 20.00$$

Hence OK

DESIGN OF WEB FOR SHEAR :

Max Shear force at support of section = 1851.15 KN

a.) Plastic Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = d * t_w \quad (\text{For Welded Section})$$

$$V_n = 3658.09 \text{ KN} > 1851.15 \text{ KN}$$

Safe in Shear

b.) Shear Buckling Design

$$\frac{d}{t_w} > 67\epsilon \quad \text{Without Stiffener}$$

$$> 67\epsilon * \sqrt{K_v/5.35} \quad \text{With Stiffener}$$

$$\frac{960}{20} = 48.00 < 58.32$$

Hence OK

Simple Post - Critical Method

$$K_v = 5.35 \quad \text{When stiffeners are provided only at support}$$

$$= 4.0 + 5.35/(c/d)^2 = 4.00 \quad \text{For } c/d < 1.0$$

$$= 5.35 + 4.0/(c/d)^2 = 5.35 \quad \text{For } c/d \geq 1.0$$

$$c/d = 0.00$$

$$K_v = 4.00$$

$$\tau_{cr,e} = \frac{K_v \pi^2 E}{12(1-\mu^2)(d/t_w)^2} = 313.82 \text{ Mpa}$$

$$\lambda_w = \sqrt{\frac{f_{yw}}{\sqrt{3} \tau_{cr,e}}} = 0.78$$

i.) $\lambda_w \leq 0.8$

$$\tau_b = \frac{f_{yw}}{1.5} = 190.53 \text{ Mpa}$$

$$\sqrt{3}$$

$$\text{ii.) } \tau_b = \frac{0.8 \lambda_w}{[1-0.8(\lambda_w-0.8)]} \times \frac{f_{yw}}{\sqrt{3}} = 193.70 \text{ Mpa}$$

$$\text{iii.) } \tau_b = \frac{1.2 f_{yw}}{\sqrt{3} \lambda_w^2} = 313.82 \text{ Mpa}$$

$$\text{Therefore, } \tau_b = 190.53 \text{ Mpa}$$

Shear force for web buckling

$$V_n = V_{cr} = A_v \tau_b = 3325.54 \text{ KN} > 1851.15 \text{ KN}$$

Safe in Buckling

Tension Field Method

$$M_{fr} = 0.25 b_f t_f^2 f_{yf} [1 - \{N_f / (b_f t_f f_{yf} / \gamma_{m0})\}]^2$$

$$M_{fr} = 9.90 \text{E}+06 \text{ Mpa} \quad \text{For top flange}$$

$$M_{fr} = 9.90 \text{E}+06 \text{ Mpa} \quad \text{For bottom flange}$$

$$s = \frac{2 (M_{fr})^{0.5}}{\sin \phi (f_{yw} t_w)^{0.5}} \leq c$$

$$s_c = 170.53 \text{ mm} \quad \text{For top flange}$$

$$s_t = 170.53 \text{ mm} \quad \text{For bottom flange}$$

$$w_{tf} = d \cos \phi + (c - s_c - s_t) \sin \phi$$

$$1552.00 \text{ mm}$$

$$\psi = 1.5 \tau_b \sin 2\phi$$

$$f_v = \frac{231.30}{[f_{yw}^2 - 3\tau_b^2 + \psi^2]^{0.5} - \psi}$$

$$0.00$$

Nominal shear resistance

$$V_n = V_{tf}$$

$$V_{tf} = [A_v \tau_b + 0.9 w_{tf} t_w f_v \sin \phi]$$

$$3658.1$$

$$V_d = \frac{V_{tf}}{\gamma_m} = 3325.5 \text{ KN} > 1851.15 \text{ KN}$$

Safe in Buckling

DESIGN OF JOINT BETWEEN FLANGE PLATE & WEB :-

$$\begin{aligned} \text{Assuming size of the fillet weld} &= 10 \text{ mm} \\ F_u &= 330 \text{ Mpa} \end{aligned}$$

The shear strength of the filled weld

$$\begin{aligned} \phi &= 0.7 \times a \times f_u / \sqrt{3} \times \gamma_{mw} \\ &= 0.707 \times 10 \times 152.42 \\ &= 1077.61 \text{ N/mm.} \end{aligned}$$

First moment of area of Flange plate @ C.G. is top plate

$$\begin{aligned} Q &= 300 \times 20 \times (500.0 - 10.0) \\ &= 2.9 \times 10^6 \text{ mm}^3 \end{aligned}$$

The shear flow is ,

$$\begin{aligned} q &= \frac{VQ}{I} \\ &= \frac{1851.2 \times 1000 \times 2.9 \times 10^6}{4.4 \times 10^9} \\ &= 1249.35 \text{ N/mm} \end{aligned}$$

providing 10 mm fillet weld whose strength is 1077.61 N/mm.
be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\begin{aligned} \text{weld length} &= \frac{1249.35 \times 1000}{2 \times 1077.61} \\ &= 579.7 \text{ mm/1000 mm Length} \end{aligned}$$

However Provide 10.00 mm fillet weld continuous throughout the length. **safe**

First moment of area of Flange plate @ C.G. is bottom plate

$$\begin{aligned} Q &= 300 \times 20 \times (500.0 - 10.0) \\ &= 2.9 \times 10^6 \text{ mm}^3 \end{aligned}$$

The shear flow is ,

$$\begin{aligned} q &= \frac{VQ}{I} \\ &= \frac{1851.2 \times 1000 \times 2.9 \times 10^6}{4.4 \times 10^9} \\ &= 1249.35 \text{ N/mm} \end{aligned}$$

Providing 8 mm weld whose strength is 1077.61 N/mm.
be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\begin{aligned} \text{weld length} &= \frac{1249.35 \times 1000}{2 \times 1077.61} \\ &= 579.7 \text{ mm/1000 mm Length} \end{aligned}$$

However Provide 10 mm fillet weld continuous throughout the length. **safe**

Fatigue check for Flange to web fillet weld

Partial Safety Factor	=	1	
Shear flow at weld location	=	1249.35	N/mm (Max. of top and bottom)
Assume Life cycle of bridge	=	2×10^6	

Uncorrected Fatigue stress range :

a.) Normal Stress Range

$$f_f = f_{fn} \sqrt[3]{5 \times 10^6 / N_{sc}}$$

$$f_{fn} = \text{92 Mpa}$$

$$f_f = 124.86 \text{ Mpa}$$

Design Fatigue strength :

Normal Stress

$$f \leq f_{fd} = \frac{\mu_r f_f}{\gamma_{mft}}$$

$$\gamma_{mft} = \text{1.25}$$

$$\mu_r = \frac{(25/t_p)^{0.25}}{1.06} \leq 1.0$$

$$f_{fd} = 105.6 \text{ Mpa}$$

Allowable Shear flow	=	2 X	0.707 X	10	X 105.6
		1493.49	N/mm		
		>		1249.35	N/mm
				Safe	

Design of Bearing Stiffener (Jacking condition)

Max factored Reaction at bearing = 1203.0 kN

Check for web buckling

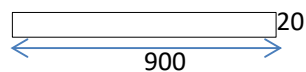
Width of bearing b_1 = 400 mm

Depth of cross section h = 1000 mm

Dispersion of load at 45° to the level

of half the depth of cross section = $b_1 + h/2$
= 900 mm

Buckling stress of web σ_b = 105.0 MPa



I_y = 600000 mm⁴

A = 18000 mm²

r_y = 5.77 mm

Buckling strength of web F_{cdw} = $(b_1 + n_1) \cdot t_w \cdot \sigma_b$
= 2731.284 kN
> 1203.0 kN

Web is safe in buckling-Hence Load Carrying not required

Check for local crushing of web

Total depth of bottom flange t_{fb} = 20.0 mm

Dispersion of load at through the flange
to the web junction at 1:2.5 slope

n_2 = $b_1 + 2.5 \cdot t_{fb}$
= 450 mm

γ_{m0} = 1.1

f_{yw} = 330 MPa

Local crushing strength of web F_{cdw} = $(b_1 + n_2) \cdot t_w \cdot f_{yw} / \gamma_{m0}$
= 5100 kN
> 1203.0 kN

Web is safe in local crushing-Hence bearing stiffener not required

ULTIMATE DESIGN OF CROSS GIRDER SUBJECTED TO BENDING MOMENT

DESIGN STAGE I : DEAD LOAD (SELF WEIGHT, GREEN WEIGHT OF SLAB AND TEMPORARY LOAD)

Assuming the girder is laterally supported throughout the span

$$\text{Max Bending Moment -DL including self weight , green weight \& temporary load} = 2773.35 \text{ kNm}$$

$$\text{Elastic section modulus (Z}_e\text{)} = 8.71\text{E}+06 \text{ mm}^3$$

$$\text{Plastic section modulus (Z}_p\text{)} = 1.05\text{E}+07 \text{ mm}^3$$

$$\beta_b = 1.00\text{E}+00$$

If Shear force (V) is less than 0.6 times shear capacity V_d, there is no reduction in plastic bending resistance of the section. Therefore plastic bending capacity of the section is given as

Design bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_m} = 3146.40 \text{ kNm}$$

If Shear force (V) is greater than 0.6 times shear capacity V_d, the bending resistance is reduced as the contribution of web to the bending gets diminished. Therefore reduced bending capacity is given as

(For Plastic and compact section)

$$M_{dv} = M_d - \beta(M_d - M_{fd}) \leq \frac{1.2 Z_e f_y}{\gamma_m}$$

$$\beta = 0.013 = (2 V/V_d - 1)^2$$

$$M_{fd} = \frac{Z_p f_y}{\gamma_m} = 1764.00 \text{ kNm}$$

$$M_{dv} = 3128.66 < 3136.44 \text{ kNm} \quad \text{Hence OK}$$

(For semicompact section)

$$M_{dv} = \frac{Z_e f_y}{\gamma_m} = 2613.70 \text{ kNm} < 3136.44 \text{ kNm} \quad \text{Hence OK}$$

Max Shear force for section

$$V = 1851.15 \text{ kN}$$

Shear Capacity of the section

$$V_d = 3325.54 \text{ kN}$$

$$\text{As the Shear force } V < 0.6 * V_d$$

Design bending strength

$$M_d = 3146.40 \text{ kNm} > 2773.35 \text{ kNm} \quad \text{Hence OK}$$

DESIGN OF SHEAR TAB

DESIGN OF CONNECTION OF X- GIRDER WITH LONGITUDINAL GIRDER

Shear force and Bending moment at connection of longitudinal girder with cross girder are

	Shear force(kN)	
Total	1851.15	

Thickness of connecting plate = 20 mm
 Thickness of member plate = 20 mm

Connection between cross member and main longitudinal member

Using High Strength Friction Grip(H.S.F.G.) Bolted joint

Nominal size of the bolt to be used = 24 mm 8.8 CLASS
 Diameter of Bolt hole = 25.5 mm
 Fy = 330 N/mm²

Shear Per Bolt = $\frac{\text{SLIP FACTOR X NUMBER OF EFFECTIVE INTERFACES X MIN. BOLT TENSION}}{\text{FACTOR OF SAFETY}}$

$$= \frac{0.5 \times 2 \times 212}{1.4} = 151.4286 \text{ KN}$$

$$\text{Bearing Per Bolt} = 24 \times 20 \times \frac{330}{1.1} = 144.00 \text{ KN}$$

$$\text{Bolt Value} = 144.00 \text{ KN}$$

$$\text{Shear Force} = 1851.15 \text{ KN}$$

$$\text{Bolt Required} = 12.86 \text{ Nos}$$

Provide 2 nos. rows
 hence required bolts in each rows = 6.428 say 8 Nos

Provide Pitch of bolts = 100 mm along length
 Provide Pitch of bolts = 75 mm along width
 edge distance of bolt = 50 mm

$$\begin{aligned} \text{Length of connecting plate to stringer web} &= 200 \text{ mm} \\ \text{Width of connecting plate to stringer web} &= 625 \text{ mm} \\ \text{Thickness of Connecting plate} &= \frac{925.58 \times 1000}{625 \times 20} \\ &= 74.046 \text{ N/mm}^2 < 330.00 \end{aligned}$$

SAFE

Connection of connecting plate with web of cross member

Using High Strength Friction Grip(H.S.F.G.) Bolted joint

Nominal size of the bolt to be used = 24 mm 8.8 CLASS
 Diameter of Bolt hole = 25.5 mm
 Fy = 330 N/mm²

Shear Per Bolt = $\frac{\text{SLIP FACTOR X NUMBER OF EFFECTIVE INTERFACES X MIN. BOLT TENSION}}{\text{FACTOR OF SAFETY}}$

$$= \frac{0.5 \times 2 \times 212}{1.4} = 151.4286 \text{ KN}$$

Bearing Per Bolt=	24	x 20 x	$\frac{330}{1.1} =$	144.00 KN
Bolt Value	=	144.00 KN		
Shear Force			=	1851.15 KN
Bolt Required	=	12.86 Nos		
Provide 8 nos. rows				
hence required bolts in each rows	=	1.607 say	2 Nos	
Provide Pitch of bolts	=	75 mm	along length	
Provide Pitch of bolts	=	100 mm	along width	
edge distance of bolt	=	50 mm		
Length of connecting plate to stringer web	=	625 mm		
Width of connecting plate to stringer web	=	200 mm		
Thickness of Connecting plate for double shear	=	$\frac{925.58 \times 1000}{625 \times 148.092}$	$\frac{1000}{10}$	
	=	148.092 N/mm ²	<	330.00
			SAFE	
Thickness of Connecting plate for single shear	=	$\frac{1851.15 \times 1000}{625 \times 148.092}$	$\frac{1000}{20}$	
	=	148.092 N/mm ²	<	330.00
			SAFE	

DESIGN OF INTERMEDIATE **CROSS GIRDER**

Input Data

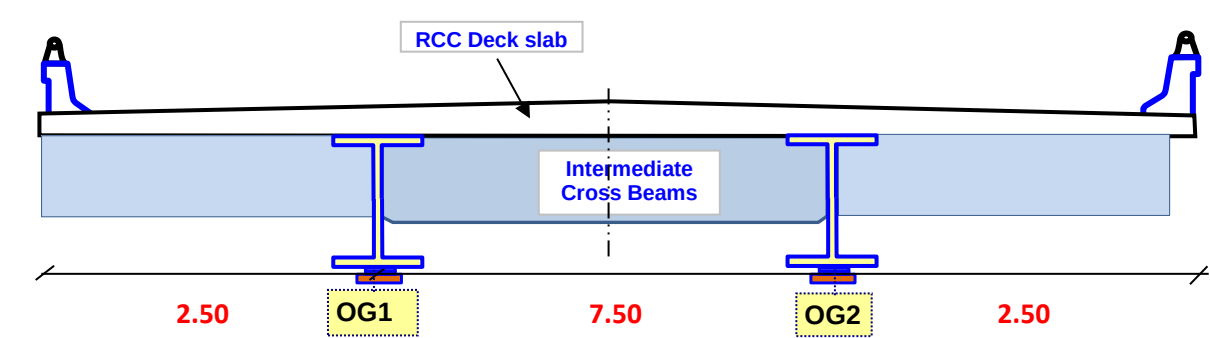


Fig. Showing Intermediate Cross Girder of Superstructure

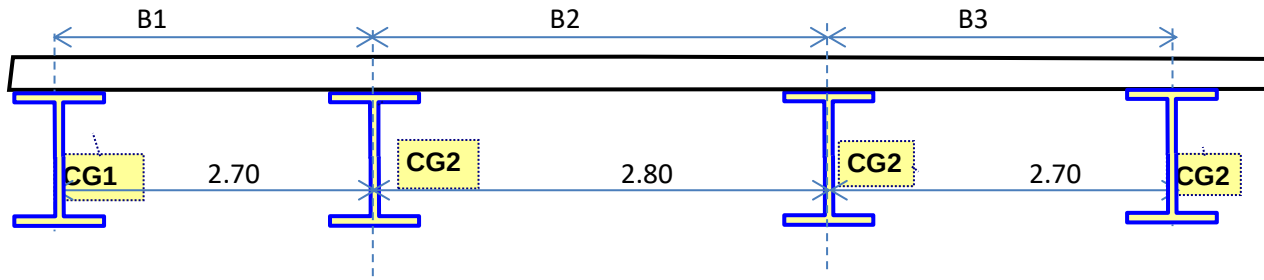
Span L1 = 7.50 m
Span L2 = 2.50 m
Depth of cross girder = 0.60 m

Calculation of Effective Span :

Effective span for Intermediate Cross Girder = $L_o = 0.8 * L1 = 7.50 \text{ m}$
Effective span for intermediate support = $L_o = 0.25 * (L1 + L2) = 2.50 \text{ m}$

Cross slope of superstructure = 2.5 %
Width of kerb & RCC Railing = 0.45 each side
Carriageway width = 11.00 m
Overall width of bridge = 12.50 m
Spacing of main girder. = 7.50 m
Deck slab thickness at centre = 0.220 m
Deck slab thickness at edge = 0.220 m
Thick. of Deck Slab at Main L-Gir. Location = 0.220 m
Thick. of Deck Slab at Edge L-Gir. Location = 0.220 m

Calculation of Effective width of flanges for Intermediate Cross Girder CG-2



Effective width of flanges :

$$b_{eff} = \frac{L_0}{4} \leq \frac{B1 + B2}{2}$$

$$B1 = 2.80$$

$$B2 = 2.70$$

Location	L_0	$L_0/4$	$(B1+B2)/2$	b_{eff}
For mid-span section	7.50	1.875	2.75	1.875
For Cantilever Portion	2.50	0.625	2.75	0.63

units in meter

1.3.3 Live Load

Dynamic Impact Factor

$$\text{Impact Factor for class A loading} = \frac{9}{13.5 + L}$$

span (m)	Class A	Class 70R	
2.50	1.50	1.25	Cantilever
7.50	1.43	1.25	

Dimensions of Intermediate Cross Girder -CG2 at Span Portion

Web plate size (without slab)	=	576 X 12	mm
Top Flange thickness Plate-1	=	200 X 12	mm
Top Flange thickness Plate-2	=	0 X 0	mm
Bottom Flange thickness Plate-1	=	200 X 12	mm
Bottom Flange thickness Plate-2	=	0 X 0	mm

PARTIAL SAFETY FACTOR

γ_m	=	1.10	For Structural Steel Against Yield Stress
γ_m	=	1.25	For Shear Connector
$\gamma_{m.st}$	=	1.15	For reinforcement

MATERIAL PROPERTIES

Grade of structural steel (Main Girders) Fe490	350	Mpa	plate thk <20 20-40 >40
	330	Mpa	
	320	Mpa	
Grade of Secondary Members (ie rolled section)	350	Mpa	
Grade of concrete	M 40		
Type of steel	HYSD Fe 500	D	
Ultimate strength of shear connector	149	kN	For 25 mm dia Stud
Fatigue strength of shear connector	39	kN	

MAXIMUM FLEXURAL MOMENTS**from Staad-Pro Elastic analysis**

Sr. No.	Loads	At Mid-Section (kNm)	AT CANTILEVER END	Max
1	Self-Weight of Girder	2.8	2.8	
2	Weight of Slab including shut	67.5	66.0	
3	SIDL1-Crash+Railing	0.0	20.0	
4	SIDL2-Wearing Coat	18.6	19.4	
5	FPLL	0.0	0.0	
6	1-70RW	253.5	37.0	
7	2-CLASS	199.5	91.2	
8	SV Load	229.5	0.0	

MAXIMUM SHEAR FORCE**from Staad-Pro Elastic analysis**

Sr. No.	Loads	AT SUPPORT
1	Self-Weight of Girder	2.22
2	Weight of Slab	60.1
3	SIDL1-Crash+Railing	0
4	SIDL2-Wearing Coat	21.7
5	FPLL	0
6	1-70RW	171.57
7	2-CLASS	138.4
8	SV Load	142.7

DESIGN OF INTERMEDIATE CROSS GIRDER (CG2) **FROM ULTIMATE LIMIT STATE METHOD**

Sectional Properties of Intermediate Cross Girder (CG2) for Mid Span Location {POSITIVE (SAGGING) BENDING REGION}

Top Flange thickness Plate-1	=	12	mm
Top Flange thickness Plate-2	=	0	mm
Bottom Flange thickness Plate-1	=	12	mm
Bottom Flange thickness Plate-2	=	0	mm
Depth of the Web Plate	=	576	mm
Thickness of the web	=	12	mm

web plate of size = **576** x **12**

Top Flange Area -

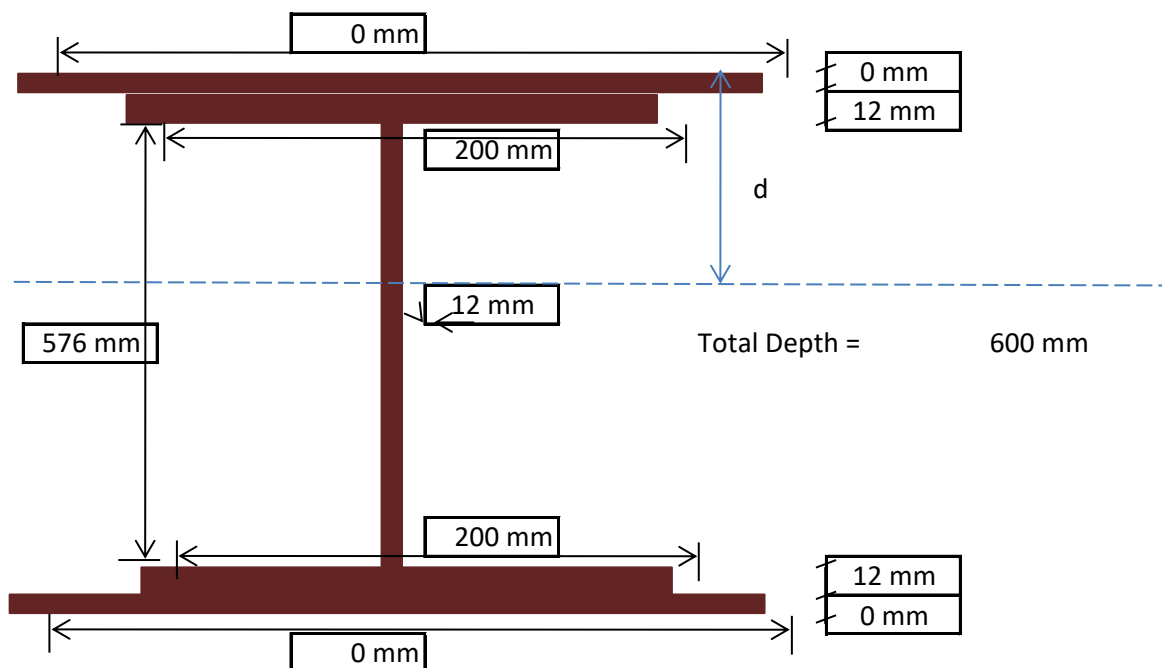
I)Top Plate-1	200	x	12	=	2400	mm ²
II) Top Plate-2	0	x	0	=	0	mm2

A_f	=	2400	mm ²

Bottom Flange Area -

I) Bottom Plate-1	200	x	12	=	2400	mm ²
II) Bottom Plate-2	0	x	0	=	0	mm ²

A_f	=	2400	mm ²



Check for Section Class :

Flange Class

b	=	<table><tr><td>94</td></tr></table> mm	94
94			
tf	=	<table><tr><td>12</td></tr></table> mm	12
12			
b/tf	=	7.83 Compact	

Web Class

d	=	576
tw	=	12
d/tw	=	48.00 Plastic

Elastic Properties

SR.	ELEMENT		Ai(mm ²)	Ye (mm)	AYi	AY ² s	Ixx (self)	It =
NO.				(from top)				AY ² s + Ixx
1	Top Flange Plate-1		2400	6	14400	8.6E+04	2.9E+04	1.2E+05
2	Top Flange Plate-2		0	0	0	0.0E+00	0.0E+00	0.0E+00
3	Web		6912	300	2073600	6.2E+08	1.9E+08	8.1E+08
4	Bottom Flange Plate-1		2400	594	1425600	8.5E+08	2.9E+04	8.5E+08
5	Bottom Flange Plate-2		0	600	0	0.0E+00	0.0E+00	0.0E+00
	Σ		11712.00		3.5E+06			1.7E+09

Therefore distance of N.A. from top fibre

$$= \frac{\Sigma A y_c}{\Sigma A} = \frac{3.5E+06}{11712.00} = \boxed{300.00} \text{ mm}$$

$$\text{M.I. About N. A.} = 1.7E+09 - 11712.00 \times (3.00E+02)^2$$

$$I_{xx} = \boxed{6.06E+08} \text{ mm}^4$$

$$y_b = \frac{D}{2} - y_t = \frac{600}{2} - 300.00 = \boxed{300.00} \text{ mm}$$

$$Z_b = \frac{I_{xx}}{y_b} = \frac{6.1E+08}{300.00} = \boxed{2.0E+06} \text{ mm}^3$$

$$Z_t = \frac{I_{xx}}{y_t} = \frac{6.1E+08}{300.00} = \boxed{2.0E+06} \text{ mm}^3$$

$$\text{Elastic section modulus (Ze)} = \boxed{2.02E+06} \text{ mm}^3$$

Plastic Properties of Girder Considering Full Shear Area

Assume distance of neutral axis from Top of top flange is d.

$$d = \boxed{250.00} \text{ mm}$$

Area above neutral axis (A1)

$$A1 = (0 \times 0 + 200 \times 12 + 12 \times (d - 0 - 12))$$

$$= 5256 \text{ mm}^2$$

Area below neutral axis (A2)

$$A2 = (0 \times 0 + 200 \times 12 + 12 \times (600 - d - 0 - 12))$$

$$= 6456 \text{ mm}^2$$

Moment balance about neutral axis

$$A2 - A1 = \boxed{1200}$$

Calculation of Effective Cross section

tw	=	12.00 mm	
fy	=	350 Mpa	
ε	=	0.85	
20 ε . tw	=	202.84 mm	Part adjacent to the compression flange
20 ε . tw	=	202.84 mm	Part adjacent to the plastic neutral axis
inactive portion	=	0.00 mm	As the web is in Plastic Class
			Refer class 603.1.3

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	2400	244	585600
Top Flng 2	0	250	0
web	2856	119.00	339864
	5256		9.25E+05

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{9.25E+05}{5256} = 176.08 \text{ mm}$$

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flr	2400	344	825600
Bottom Flr	0	350	0
web	4056	169	685464
	6456		1511064

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1511064}{6456} = 234.06 \text{ mm}$$

$$\begin{aligned} \text{Effective Cross sectional area} &= 1.2E+04 \text{ mm}^2 \\ \text{Plastic section modulus (Zp)} &= A1*Y1 + A2*Y2 = 2.4E+06 \text{ mm}^3 \end{aligned}$$

Plastic Properties of Girder Excluding Full Shear Area

Assume distance of neutral axis from bottom of top flange is d.

$$d = 288.00 \text{ mm}$$

Area above neutral axis (A1)

$$\begin{aligned} A1 &= (0 \times 0 + 200 \times 12 + 12 \times d) \\ &= 5856 \text{ mm}^2 \end{aligned}$$

Area below neutral axis (A2)

$$\begin{aligned} A2 &= (0 \times 0 + 200 \times 12 + 12 \times (576 - d)) \\ &= 5856 \text{ mm}^2 \end{aligned}$$

Moment balance about neutral axis

$$A2 - A1 = 0$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	2400	294	705600
Top Flng 2			
web			
	2400		7.06E+05

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{7.06E+05}{2400} = 294.00 \text{ mm}$$

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Flr	2400	294	705600
Bottom Flng 2			
web			
	2400		705600

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{705600}{2400} = 294.00 \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = 1.41E+06 \text{ mm}^3$$

COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER FOR PERMENANT LOAD CASE

$$\begin{aligned} \text{Effective Width of Concrete Slab For Inner Girder} \quad b_{\text{eff}} &= 1.875 \text{ m} \\ \text{Depth of Slab at Inner Girder location} &= 0.220 \text{ m} \end{aligned}$$

Modular Ratio

$$\begin{aligned} m &= 15 \text{ For Permanent loading} \\ m &= 7.5 \text{ For Transient Loading} \end{aligned}$$

For the calculation of equivalent area of deck, divide the effective width of concrete slab by modular ratio

Effective Width of Concrete Slab for Inner Girder For Permanent Loading

$$\frac{1875.00}{15.00} = 125.00 \text{ mm}$$

Calculation of the Moment of Inertia for Composite Section for Girder

SR. NO.	ELEMENT	Ai(mm ²)	ye(mm)	Aye(mm ³)	Ay ² _e (mm ⁴)	Ixx (self)(mm ⁴)	I _t = Ixx (self)+Ay ² e
1	Inner Girder	11712	520.00	6.1E+06	3.2E+09	6.1E+08	3.77E+09
2	Deck Slab	27500.0	110.00	3.0E+06	3.3E+08	1.1E+08	4.44E+08
Σ		39212.0		9.1E+06			4.22E+09

$$\text{Therefore of N.A. from Top Fibre of Deck Slab} = \frac{9.1E+06}{3.9E+04} = 232.46 \text{ mm}$$

Moment of Inertia about N.A. of the composite Section

$$\begin{aligned} &= 4.2E+09 - 3.9E+04 \times (232.4605)^2 \\ &= 2E+09 \text{ mm}^4 \\ I_{xx} &= 2.10E+09 = 2.10E+09 \text{ mm}^4 \end{aligned}$$

$$\begin{aligned} y_t &= 232 \text{ mm}, & y_b &= 588 \text{ mm} \\ Z_t &= \frac{I_{xx}}{y_t} = \frac{2E+09}{232} = 9.02E+06 \text{ mm}^3 \\ Z_b &= \frac{I_{xx}}{y_b} = \frac{2E+09}{588} = 3.57E+06 \text{ mm}^3 \end{aligned}$$

$$\text{Elastic section modulus (Ze)} = 3.57E+06 \text{ mm}^3$$

COMPOSITE SECTIONAL PROPERTIES OF INNER GIRDER FOR TRANSIENT LOAD CASE**Effective Width of Concrete Slab for Inner Girder For Transient Loading**

$$\frac{1875.00}{7.50} = 250.00 \text{ mm}$$

Calculation of the Moment of Inertia for Composite Section for Girder

SR. NO.	ELEMENT	Ai(mm ²)	ye(mm)	Aye(mm ³)	Ay ² _e (mm ⁴)	Ixx (self)(mm ⁴)	I _t = Ixx (self)+Ay ² e
1	Inner Girder	11712	520.00	6.1E+06	3.2E+09	6.1E+08	3.77E+09
2	Deck Slab	55000.0	110.00	6.1E+06	6.7E+08	2.2E+08	8.87E+08
Σ		66712		1.2E+07			4.66E+09

$$\text{Therefore of N.A. from Top Fibre of Deck Slab} = \frac{1.2E+07}{1.2E+07} = 181.98 \text{ mm}$$

$$6.7\text{E}+04$$

Moment of Inertia about N.A. of the composite Section

$$= 4.7\text{E}+09 - 6.7\text{E}+04 \times (181.9799)^2$$

$$= 2\text{E}+09 \text{ mm}^4$$

$$I_{xx} = 2\text{E}+09 = 2.45\text{E}+09 \text{ mm}^4$$

$$y_t = 182 \text{ mm},$$

$$y_b = 638 \text{ mm}$$

$$Z_t = \frac{I_{xx}}{y_t} = \frac{2\text{E}+09}{182} = 1.35\text{E}+07 \text{ mm}^3$$

$$Z_b = \frac{I_{xx}}{y_b} = \frac{2\text{E}+09}{638} = 3.84\text{E}+06 \text{ mm}^3$$

$$\text{Elastic section modulus (Ze)} = 3.84\text{E}+06 \text{ mm}^3$$

BENDING MOMENT SUMMARY AT MID SPAN

Stage I

Self weight of Girder alone

Partial Safety Factor

COMBINATIONS			
ULS	SLS		
Basic	Rare		Quasi
1.35	1.00		1.00

Max Bending Moment (Inner Girder)

=

3.79	2.81			KN-m
3.00	2.22			KN

Max Shear Force (Inner Girder)

=

Stage II

Green concrete Stage

Partial Safety Factor

Basic	Rare		Quasi
1.35	1.00		1.00

Max Bending moment (Inner Girder)

=

91.13	67.50			KN-m
81.14	60.10			KN

Max Shear Force (Inner Girder)

=

Stage III

Composite action stage

SIDL -1

Crash barrier

Partial Safety Factor

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare		Quasi	
1.35	1.00		1.00	
27.00	20.00			KN-m
0.00	0.00			KN

SIDL -2

wearing coat

Partial Safety Factor

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare		Quasi	
1.75	1.20		1.20	
33.95	23.28		0.00	KN-m
37.98	26.04		0.00	KN

Live Load Results

Foothpath live load

Partial Safety Factor

Basic		Rare	
1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

0.00	0.00	0.00	0.00	KN-m
0.00	0.00	0.00	0.00	KN

1-Lane of 70 R Wheeled Load

Impact Factor

=

Partial Safety Factor

1.25			
1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

475.31	364.41	316.88	237.66	KN-m
321.69	246.63	214.46	160.85	KN

2 lane of class A

Impact Factor

Partial Safety Factor

=	1.50			
	1.50	1.15	1.00	0.75

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

448.88	344.14	299.25	224.44	KN-m
311.40	238.74	207.60	155.70	KN

SV Load

Impact Factor

Partial Safety Factor

=	1.00			
	1.15	1	1.00	1.00

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

516.38	395.89	344.25	258.19	KN-m
321.08	246.16	214.05	160.54	KN

Live Load Combinations

Lane Reduction Factor= 1.0

2 lane of Class A + FPLL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
448.88	344.14	299.25	224.44	KN-m
311.40	238.74	207.60	155.70	KN

1 lane of 70R Wheeled + FPLL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
475.31	364.41	316.88	237.66	KN-m
321.69	246.63	214.46	160.85	KN

SV Load

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
516.38	395.89	344.25	258.19	KN-m
321.08	246.16	214.05	160.54	KN

Summary of Total Forces**DL**

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare

94.92	70.31	KN-m
84.13	62.32	KN

SIDL

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic	Rare

60.95	43.28	KN-m
37.98	26.04	KN

Governing Live loads

Max Bending moment (Inner Girder)

=

Max Shear Force (Inner Girder)

=

Basic		Rare		
516.38	395.89	344.25	258.19	KN-m
321.69	246.63	214.46	160.85	KN

Total ULS Bending Moment For Construction and Service Stages

		Basic		Rare		
		CWLL Leading	CWLL Accompanying	CWLL Leading	CWLL Accompanying	
DL+SIDL	For Inner Girder	155.87	155.87	113.59	113.59	KN-m
	During Construction Stages	155.87	155.87	113.59	113.59	KN-m
DL+SIDL+LL	For Inner Girder	672.24	551.76	457.84	371.78	KN-m
	During Service Stages	672.24	551.76	457.84	371.78	KN-m

Total ULS Shear Force For Construction and Service Stages

		Basic		Rare		
		CWLL Leading	CWLL Accompanying	CWLL Leading	CWLL Accompanying	
DL+SIDL	For Inner Girder	122.11	122.11	88.36	88.36	KN
	During Construction Stages	122.11	122.11	88.36	88.36	KN
DL+SIDL+LL	For Inner Girder	443.80	368.74	302.82	249.21	KN
	During Service Stages	443.80	368.74	302.82	249.21	KN

Ultimate Design of Sagging (Mid-Span) Region- For Shear

Max Shear force for composite section = 443.80 KN

Material Properties

$$\begin{aligned}
 \text{Partial Safety Factor } \gamma_m &= 1.10 \\
 \text{Max permissible bending stress in tension or compression.} \\
 \sigma_{bct} &= \frac{f_y}{\gamma_m} = \frac{350}{1.1} = \boxed{318.1818} \text{ Mpa} \\
 \epsilon &= \sqrt{\frac{250}{f_y}} = \boxed{0.845}
 \end{aligned}$$

$$\begin{aligned}
 \text{Average Shear Stress} &= \frac{f_y}{\gamma_m} = \frac{350}{1.1} = \boxed{318.1818} \text{ MPa}
 \end{aligned}$$

Min. Dimension Requirement

$$\begin{aligned}
 \text{Min overall depth} &= \frac{L}{25} = \frac{7500}{25} = \boxed{300} \text{ mm} \\
 \text{Overall depth Provide} &= \boxed{600} \text{ mm} \quad \text{Hence OK} \\
 \text{Min Spacing} &= \frac{L}{20} = \frac{7500}{20} = \boxed{375} \text{ mm} \\
 \text{Maximum Spacing of Girder provided} &= \boxed{7500} \text{ mm} \quad \text{Hence OK}
 \end{aligned}$$

Dimension Check

Minimum Web Thickness

a.) For vertical Stiffener

Serviceability Requirement

$$\begin{aligned}
 \frac{d}{t_w} &\leq 200\epsilon \\
 \frac{d}{t_w} &= \boxed{3.41} < \boxed{12.00} \\
 &\quad \text{Vertical Stiffener not required}
 \end{aligned}$$

b.) For horizontal Stiffener

$$\begin{aligned}
 \frac{d}{t_w} &\leq 200\epsilon & 3d \geq c \geq d \\
 \frac{c}{t_w} &\leq 200\epsilon & 0.74d \leq c < d \\
 \frac{d}{t_w} &\leq 270\epsilon & c < d \\
 \frac{d}{t_w} &= \boxed{2.52} < \boxed{12.00} \\
 &\quad \text{Horizontal Stiffener not required}
 \end{aligned}$$

To avoid Flange Buckling

$$\frac{d}{t_w} \leq 345\epsilon_f^2 \quad \text{Stiffener not provided}$$

$$\frac{t_w}{d} \leq 345\epsilon_f^2 \quad c \geq 1.5 d$$

$$\frac{t_w}{d} \leq 345\epsilon_f \quad c < 1.5 d$$

$$t_w = 1.98 < 12.00$$

Hence OK

DESIGN OF WEB FOR SHEAR :**Max Shear force at support of composite section**

$$= 443.80 \text{ KN}$$

a.) Plastic Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = d \cdot t_w \quad (\text{For Welded Section})$$

$$V_n = 1396.73 \text{ KN}$$

$$V_d = V_n / \gamma_m = 1269.75 > 443.80 \text{ KN}$$

Safe in Shear

b.) Shear Buckling Design**Simple Post - Critical Method**

$$K_v = 5.35 \quad \text{When stiffeners are provided only at support}$$

$$= 4.0 + 5.35/(c/d)^2 = 4.00 \quad \text{For } c/d < 1.0$$

$$= 5.35 + 4.0/(c/d)^2 = 5.35 \quad \text{For } c/d \geq 1.0$$

$$c/d = 0.00$$

$$K_v = 4.00$$

$$\tau_{cr,e} = \frac{K_v \pi^2 E}{12(1-\mu^2)(d/t_w)^2} = 313.82 \text{ Mpa}$$

$$\lambda_w = \sqrt{\frac{f_{yw}}{\sqrt{3} \tau_{cr,e}}} = 0.80$$

$$\text{i.) } \lambda_w \leq 0.8$$

$$\tau_b = \frac{f_{yw}}{\sqrt{3}} = 202.07 \text{ Mpa}$$

$$\text{ii.) } 0.8 \leq \lambda_w \leq 1.2$$

$$\tau_b = \frac{f_{yw}}{\sqrt{3} [1-0.8(\lambda_w-0.8)]} = 201.68 \text{ Mpa}$$

$$\text{iii.) } \lambda_w \geq 1.2$$

$$\tau_b = \frac{f_{yw}}{\sqrt{3} \lambda_w^2} = 313.82 \text{ Mpa}$$

Therefore, $\tau_b = 201.68 \text{ Mpa}$

Shear force for web buckling

$$V_n = V_{cr} = A_v \tau_b = 1267.27 \text{ KN}$$

$$V_d = V_n / \gamma_m = 1152.068 \text{ KN} > 443.80 \text{ KN}$$

Safe in Buckling

DESIGN OF JOINT BETWEEN FLANGE PLATE & WEB :-

Assuming size of the fillet weld = 8 mm

The permissible stress in the fillet weld = 131 Mpa

The shear strength of the filled weld

$$P = P_q \cdot L \cdot t$$

$$= P_q \cdot t \text{ N/mm} \quad (t = \text{Throat Thickness})$$

$$= 104.8 \times 0.707 \times 8 = 592.75 \text{ N/mm.}$$

First moment of area of Flange plate @ C.G. is top plate

$$Q = 200 \times 12 \times (300.0 - 6.0)$$

$$= 7.1E+05 \text{ mm}^3$$

The shear flow is ,

$$q = \frac{VQ}{I}$$

$$= \frac{443.8 \times 1000 \times 7.1E+05}{6.1E+08} = 516.70 \text{ N/mm}$$

providing 8 mm fillet weld whose strength is 592.75 N/mm.
be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\text{weld length} = \frac{516.70 \times 1000}{2 \times 592.75} = 435.8 \text{ mm/1000 mm Length}$$

However Provide 8.00 mm fillet weld continuous throughout the length. safe

First moment of area of Flange plate @ C.G. is bottom plate

$$Q = 200 \times 12 \times (300.0 - 6.0)$$

$$= 7.1E+05 \text{ mm}^3$$

The shear flow is ,

$$q = \frac{VQ}{I}$$

$$= \frac{443.8 \times 1000 \times 7.1E+05}{6.1E+08}$$

$$= 516.70 \text{ N/mm}$$

Providing 8 mm weld whose strength is $= 592.75 \text{ N/mm}$.
be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\text{weld length} = \frac{516.70}{2} \times \frac{1000}{592.75} = 435.8 \text{ mm/1000 mm Length}$$

However Provide 8 mm fillet weld continuous throughout the length. safe

Fatigue check for Flange to web fillet weld

$$\begin{aligned} \text{Partial Safety Factor} &= 1 \\ \text{Shear flow at weld location} &= 516.70 \text{ N/mm} \quad (\text{Max. of top and bottom}) \\ \text{Assume Life cycle of bridge} &= 2 \times 10^6 \end{aligned}$$

Uncorrected Fatigue stress range :

$$\begin{aligned} \text{a.) Normal Stress Range} \\ f_f &= f_{fn} \sqrt[3]{5 \times 10^6 / N_{sc}} \\ f_{fn} &= 92 \text{ Mpa} \\ f_f &= 124.86 \text{ Mpa} \end{aligned}$$

Design Fatigue strength :

$$\begin{aligned} \text{Normal Stress} \\ f &\leq f_{fd} = \frac{\mu_r f_f}{\gamma_{mft}} \\ \gamma_{mft} &= 1.25 \\ \mu_r &= (25/t_p)^{0.25} \leq 1.0 \\ &= 1.20 \\ f_{fd} &= 120.0 \text{ Mpa} \end{aligned}$$

$$\begin{aligned} \text{Allowable Shear flow} &= 2 \times 0.707 \times 8 \times 120.0 \\ &= 1357.54 \text{ N/mm} \\ &> 516.70 \text{ N/mm} \\ &\text{Safe} \end{aligned}$$

ULTIMATE DESIGN OF INNER GIRDER SUBJECTED TO SAGGING MOMENT

DESIGN STAGE I : DEAD LOAD (SELF WEIGHT, GREEN WEIGHT OF SLAB AND TEMPORARY LOAD)

Assuming the girder is laterally supported throughout the span

$$\text{Max Bending Moment -DL including self weight , green weight \& temporary load} = \boxed{94.92} \text{ kNm}$$

$$\text{Elastic section modulus (Z}_e\text{)} = 2.02\text{E}+06 \text{ mm}^3$$

$$\text{Plastic section modulus (Z}_p\text{)} = 2.44\text{E}+06 \text{ mm}^3$$

$$\beta_b = 1.00\text{E}+00 \text{ Plastic/Compact section}$$

If Shear force (V) is less than 0.6 times shear capacity V_d, there is no reduction in plastic bending resistance of the section. Therefore plastic bending capacity of the section is given as

Design bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_m} = \boxed{775.26} \text{ kNm}$$

If Shear force (V) is greater than 0.6 times shear capacity V_d, the bending resistance is reduced as the contribution of web to the bending gets diminished. Therefore reduced bending capacity is given as

(For Plastic and compact section)

$$M_{dv} = M_d - \beta(M_d - M_{fd}) \leq \frac{1.2 Z_e f_y}{\gamma_m}$$

$$\beta = 0.090 = (2 V/V_d - 1)^2$$

$$M_{fd} = \frac{Z_p f_y}{\gamma_m} = \boxed{449.02} \text{ kNm}$$

$$M_{dv} = \boxed{745.98} < \boxed{771.34} \text{ kNm} \quad \text{Hence OK}$$

Max Shear force for composite section

$$V = 443.80 \text{ kN}$$

Shear Capacity of the section

$$V_d = 1267.27 \text{ kN}$$

$$\text{As the Shear force } V < 0.6 * V_d$$

Design bending strength

$$M_d = \boxed{775.26} \text{ kNm} > 94.92 \text{ kNm}$$

Hence OK

DESIGN STAGE II : DL+SIDL- PERMENANT LOAD CASE

Max . Bending Moment due to DL+SIDL = 155.87 kN.m

Max permissible bending stress in tension or compression.

$$\sigma_{bct} = \frac{f_y}{\gamma_m} = \frac{350}{1.1} = \span style="border: 1px solid black; padding: 2px;">318.182 Mpa$$

Plastic moment of resistance

Position of plastic neutral axis

$$\begin{aligned} b_{eff}d_s &= 4.13E+05 \text{ mm}^2 \\ a &= \frac{(f_y/\gamma_m)}{0.36(f_{ck})} = 22.1 \\ A_s &= 11712 \text{ mm}^2 \\ A_f &= 2400 \text{ mm}^2 \\ a*A_s &= 2.59E+05 \text{ mm}^2 \\ a*A_f &= 5.30E+04 \text{ mm}^2 \\ b_{eff}d_s + 2aA_f &= 5.19E+05 \text{ mm}^2 \\ d_s &= 220 \text{ mm} \\ t_f &= 12 \text{ mm} \\ b_f &= 200 \text{ mm} \\ t_w &= 12 \text{ mm} \\ d_c &= 342.46 \text{ mm} \end{aligned}$$

$$b_{eff}d_s > a*A_s \quad \text{Neutral axis within slab}$$

$$b_{eff}d_s < a*A_s < b_{eff}d_s + 2aA_f \quad \text{Neutral axis within steel flange}$$

$$b_{eff}d_s + 2aA_f < a*A_s \quad \text{Neutral axis within web}$$

Neutral axis	Value of x_u (mm)	Moment Capacity (M_p) (Mpa)
within slab	138.020	1.47E+09
within steel flange	202.6086	1.60E+09
within web	-257.857	7.44E+08

Neutral axis within Slab of a composite section 138.02 mm depth from top of deck.

Moment of resistance M_p = 1470.09 kNm

> 155.87 kNm
Hence OK

DESIGN STAGE III : DL+SIDL+LL (TRANSIENT LOAD CASE)

Max . Bending Moment due to DL+SIDL+LL = 672.24 kNm

Final bending moment = 672.24 kNm

Plastic moment of resistance

Position of plastic neutral axis

$$\begin{aligned}
 b_{\text{eff}}d_s &= 4.13\text{E}+05 \text{ mm}^2 \\
 a &= \frac{(f_y/\gamma_m)}{0.36(f_{ck})} = 22.1 \\
 A_s &= 11712 \text{ mm}^2 \\
 A_f &= 2400 \text{ mm}^2 \\
 a*A_s &= 258788 \text{ mm}^2 \\
 a*A_f &= 53030 \text{ mm}^2 \\
 b_{\text{eff}}d_s + 2aA_f &= 518561 \text{ mm}^2 \\
 d_s &= 220 \text{ mm} \\
 t_f &= 12 \text{ mm} \\
 b_f &= 200 \text{ mm} \\
 t_w &= 12 \text{ mm} \\
 d_c &= 410.00 \text{ mm}
 \end{aligned}$$

$$b_{\text{eff}}d_s > a*A_s \quad \text{Neutral axis within slab}$$

$$b_{\text{eff}}d_s < a*A_s < b_{\text{eff}}d_s + 2aA_f \quad \text{Neutral axis in steel flange}$$

$$b_{\text{eff}}d_s + 2aA_f < a*A_s \quad \text{Neutral axis within web}$$

Neutral axis	Value of x_u (mm)	Moment Capacity (M_p) (Mpa)
within slab	138.020	1.72E+09
within steel flange	202.6086	1.86E+09
within web	-257.857	9.95E+08

Neutral axis within Slab of a composite section 138.02 mm depth from top.

Moment of resistance $M_p = 1721.78 \text{ kNm}$

$> 672.24 \text{ kNm}$
Hence OK

SUMMARY OF BENDING MOMENT CAPACITY

Load Cases	Inner Girder		
	Ultimate Bending Moment	Plastic Moment Capacity	STATUS
Stage I : DL	94.92	775.26	OK
Stage II : DL+SIDL	155.87	1470.09	OK
Stage III: DL+SIDL+LL	672.24	1721.78	OK

CHECK FOR SERVICEABILITY LIMIT STATE (MID SPAN)

SERVICEABILITY LIMIT STATE - STRESS CHECK IN INNER GIRDER AT MID-SPAN

LOCATION

For checking the stress limit, rare combination is used

(As per Table 3.3, Annex B, IRC:6-2014)

Limiting Stress for Structural Steel	=	0.87 X f_y
	=	0.87 X 350
	=	304.5 MPa
Limiting Stress for Concrete	=	0.48 X f_{ck}
	=	0.48 X 40
	=	19.2 MPa

CALCULATION OF STRESS IN DL

Max Bending Moment	=	70.3 KN-m

Z _t	=	2.02E+06 mm ³

Z _b	=	2.02E+06 mm ³

Compressive Stress at top of girder	=	34.8 MPa

Tensile Stress at bottom of girder	=	34.8 MPa

CALCULATION OF STRESS IN SIDL

Effective width	=	$\frac{1875}{15}$	=	125.00 mm

Max Bending Moment	=	43.3 KN-m

Z _t	=	9.02E+06 mm ³

Z _b	=	3.57E+06 mm ³

Compressive Stress at top of girder	=	0.3 MPa

Tensile Stress at bottom of girder	=	12.1 MPa

Compressive Stress at top of deck slab	=	$\frac{M}{z_t \times m}$ (for concrete section)
	=	0.3 MPa

CASE 1: CONSIDERING LIVE LOAD AS LEADING LOAD AND TEMPERATURE AS ACCOMPANYING LOAD**CALCULATION OF STRESS IN LIVE LOAD**

$$\text{Effective width} = \frac{1875}{7.5} = 250.00 \text{ mm}$$

$$\text{Max Bending Moment due to LL} = 344.3 \text{ KN-m}$$

$$Z_t = 1.35\text{E}+07 \text{ mm}^3$$

$$Z_b = 3.84\text{E}+06 \text{ mm}^3$$

$$\text{Compressive Stress at top of girder} = -5.3 \text{ MPa}$$

$$\text{Tensile Stress at bottom of girder} = 89.6 \text{ MPa}$$

$$\begin{aligned} \text{Compressive Stress at top of deck slab} &= \frac{M}{z_t \times m} \text{ (for concrete section)} \\ &= 3.4 \text{ MPa} \end{aligned}$$

TOTAL STRESS AFTER STAGE III (Mpa)

$$\text{Limiting Stress for Structural Steel} = 304.5 \text{ MPa}$$

$$\text{Limiting Stress for Concrete} = 19.2 \text{ MPa}$$

	DL	SIDL	LIVE LOAD	TOTAL	
Deck Slab Top (Comp)	0.0	0.3	3.4	3.7	Safe
Girder Top (Comp)	34.8	0.3	-5.3	29.7	Safe
Girder Bottom (Tensile)	34.8	12.1	89.6	136.5	Safe

TEMPERATURE AND SHRINKAGE STRESS

$$\text{Load Factor Thermal load for Accompanying load} = 0.6 \text{ Rare Combination}$$

$$\text{Load Factor Ffor Shrinkage effect} = 1 \text{ Rare Combination}$$

	Rising	Falling	Shrinkage	Rising + Shrinkage	Falling + Shrinkage
Deck Slab Top (Comp)	1.5	-0.7	-4.1	-2.6	-4.8
Girder Top (Comp)	-0.4	0.4	-54.0	-54.3	-53.6
Girder Bottom (Tensile)	1.8	-1.3	10.9	12.7	9.6

Stress Summary Considering Live load as Leading Load and Temperature load as accompanying load

	TOTAL IN SHRINKAGE (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check	TOTAL IN FALLING TEMP (MPa)	Check
Deck Slab Top (Comp)	-0.3	Safe	5.2	Safe	3.0	Safe
Girder Top (Comp)	-24.2	Safe	29.3	Safe	30.1	Safe
Girder Bottom (Tensile)	147.4	Safe	138.3	Safe	135.3	Safe

CASE 2: CONSIDERING LIVE LOAD AS ACCOMPANYING LOAD AND TEMPERATURE AS LEADING LOAD

CALCULATION OF STRESS IN LIVE LOAD

$$\text{Effective width} = \frac{1875}{7.5} = 250.00 \text{ mm}$$

$$\text{Max Bending Moment} = 258.2 \text{ KN-m}$$

$$Z_t = 1.35\text{E}+07 \text{ mm}^3$$

$$Z_b = 3.84\text{E}+06 \text{ mm}^3$$

$$\text{Compressive Stress at top of girder} = -4.0 \text{ MPa}$$

$$\text{Tensile Stress at bottom of girder} = 67.2 \text{ MPa}$$

$$\begin{aligned} \text{Compressive Stress at top of deck slab} &= \frac{M}{z_t \times m} \text{ (for concrete section)} \\ &= 2.6 \text{ MPa} \end{aligned}$$

TOTAL STRESS AFTER STAGE III (Mpa)

$$\text{Limiting Stress for Structural Steel} = 304.5 \text{ MPa}$$

$$\text{Limiting Stress for Concrete} = 19.2 \text{ MPa}$$

	DL	SIDL	LIVE LOAD	TOTAL	
Deck Slab Top (Comp)	0.0	0.3	2.6	2.9	Safe
Girder Top (Comp)	34.8	0.3	-4.0	31.1	Safe
Girder Bottom (Tensile)	34.8	12.1	67.2	114.1	Safe

TEMPERATURE AND SHRINKAGE STRESS

Load Factor Thermal load for Accompanying load = **1** Rare Combination

	Rising	Falling	Shrinkage	Rising + Shrinkage	Falling + Shrinkage
Deck Slab Top (Comp)	2.5	-1.2	-4.1	-1.6	-5.3
Girder Top (Comp)	-0.6	0.6	-54.0	-54.6	-53.3
Girder Bottom (Tensile)	3.0	-2.1	10.9	13.9	8.8

Stress Summary Considering Live load as Leading Load and Temperature load as accompanying load

	TOTAL IN SHRINKAGE (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check	TOTAL IN RISING TEMP (MPa)	Check
Deck Slab Top (Comp)	-1.2	Safe	5.3	Safe	1.7	Safe
Girder Top (Comp)	-22.9	Safe	30.4	Safe	31.7	Safe
Girder Bottom (Tensile)	125.0	Safe	117.1	Safe	112.1	Safe

DESIGN OF CAPING BEAM **UNDER BEARING**

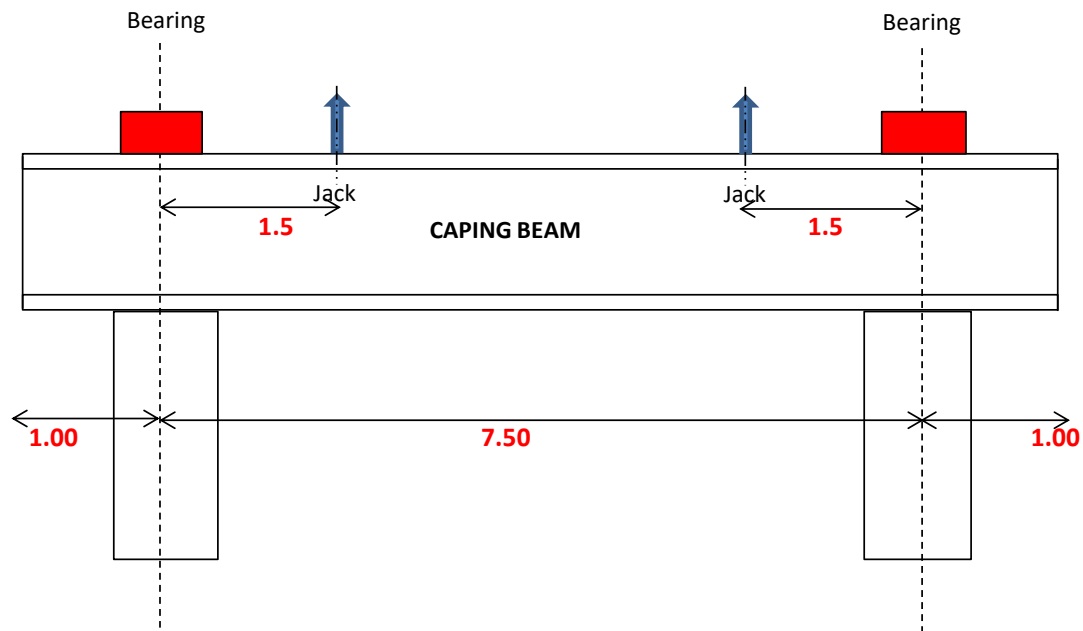
Design Data:

Fig. Typ. arrangement for Cap Beam for supporting Superstructure

Material Specification:

Grade of structural steel = E350 (As per table no. 2 of IS 2062:2006)
 Yield strength of structural steel = 330 Mpa for plate thickness between 20-40mm
 Partial Safety Factor γ_m = 1.10

Max permissible bending stress in tension or compression.

$$s_{bct} = \frac{f_y}{\gamma_m} = \frac{330}{1.1} = 300.00 \text{ Mpa}$$

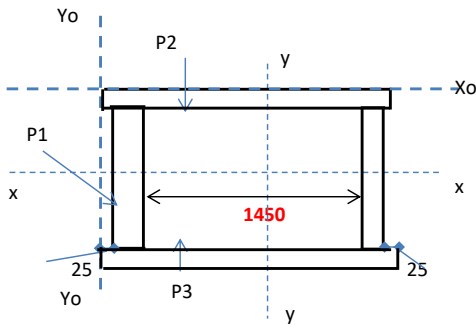
$$\epsilon = \sqrt{\frac{250}{f_y}} = 0.870$$

$$\text{Average Shear Stress} = \frac{f_y}{1.1} = \frac{330}{1.1} = 300.000 \text{ MPa}$$

MAXIMUM JACKING REACTION

From Staad Pro Analysis

Sr. No.	Loads	Left Jack Reaction (kN)	Right Jack Reaction (kN)
1	Self-Weight of Girder	317.906	317.906
2	Weight of Slab	1128.368	1128.368
3	SIDL1-Crash+Railing	367.093	367.093
4	SIDL2-Wearing Coat	257.826	257.826
	Jack Capacity	2071.193	2071.193

SECTION PROPERTIES OF CAPING BEAM

Size of Plate P1	Length =	750 mm	Thick =	25 mm
Size of Plate P2	Length =	1550 mm	Thick =	25 mm
Size of Plate P3	Length =	1550 mm	Thick =	25 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1550 mm		
Width of Member at Bottom , B	=	1550 mm		
Depth of Member , D	=	800 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	18750	37.5	400	7.03E+05	7.50E+06	2.64E+07	3.00E+09	8.79E+08	9.77E+05	3.88E+09	2.73E+07
Plate 2 Left	38750	775	12.5	3.00E+07	4.84E+05	2.33E+10	6.05E+06	2.02E+06	7.76E+09	8.07E+06	3.10E+10
Plate 3 Left	38750	775	787.5	3.00E+07	3.05E+07	2.33E+10	2.40E+10	2.02E+06	7.76E+09	2.40E+10	3.10E+10
Plate 1 Right	18750	1512.5	400	2.84E+07	7.50E+06	4.29E+10	3.00E+09	8.79E+08	9.77E+05	3.88E+09	4.29E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	115000			8.91E+07	4.60E+07	8.95E+10	3.00E+10			3.18E+10	1.05E+11

Therefore distance of N.A. , X	=	775.00 mm									
Therefore distance of N.A. , Y	=	400.00 mm	Yb	=	400.000 mm						
Ixx	=	3.18E+10	-	115000 x	160000	=	1.34E+10 mm ⁴				
Iyy	=	1.05E+11	-	115000 x	600625	=	3.59E+10 mm ⁴				
rxx	=	341.34 mm			ryy	=	558.84 mm				

PRIS	AX	0.1150	IY	0.0359	IZ	0.0134	YD	0.80	ZD	1.55	

Zxxb = Ixx / Yb	=	3.35E+07 mm ³	Zxxt = Ixx / Yt	=	3.35E+07 mm ³
Elastic section modulus (Ze)	=	3.35E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **400.00** mm

Area above neutral axis (A1) = 57500 mm² Area below neutral axis (A2) = 57500 mm²

Moment balance about neutral axis

$$A2 - A1 = \boxed{0}$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	38750	388	1.50E+07
web	18750	187.50	3.52E+06
	57500		1.85E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Fl	38750	388	1.50E+07
web	18750	188	3.52E+06
	57500		1.85E+07

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1.85E+07}{57500} = \boxed{322.28} \text{ mm}$$

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1.85E+07}{57500} = \boxed{322.28} \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = \boxed{3.71E+07} \text{ mm}^3$$

$$Ze / Zp = 9.04E-01$$

DESIGN OF CAPING BEAM UNDER JACKING CONDITION

As the the bearings are placed directly in the centre line of column, there will be no bending in capping beam in the service condition. Hence Jacking condition will govern the design of capping beam

Unsupported length of member $L_o = 7.50$ m
 Live load impact factor = 1

Sectional Properties:

$A = 1.15E-01 \text{ m}^2$ $r_{xx} = 0.341$ m
 $I_{xx} = 1.34E-02 \text{ m}^4$ $r_{yy} = 0.559$ m
 $I_{yy} = 3.59E-02 \text{ m}^4$

Results from Staad Analysis

Sr. No.	Loads	Load factors	Bending Moment , kNm	Shear Force , kN	Axial Force , kN
1	DL	1.35	1159	1495	0
3	SIDL1-Crash+Railing	1.35	275	367	0
4	SIDL2-Wearing Coat	1.75	193	258	0

ULS LOAD COMBINATION		Bending Moment , kNm	Shear Force , kN	Axial Force , kN
Normal Case - 1.35DL+1.35SIDL1+1.75SIDL2	=	2273.7	2965.2	0.00

Check for Section Class :

Welded section

Web Class

$d = 750$
 $t_w = 25$
 $d/t_w = 30$ Plastic

$\beta_b = 1.00$
 $Z_p = 3.71E+07 \text{ mm}^3$

DESIGN OF WEB FOR SHEAR :**Max Shear force**

= 2965.20 kN

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = \frac{A_v f_{yw}}{\sqrt{3} d t_w} \quad (\text{For Welded Section}) = 37500$$

$$V_n = 7144.71 \text{ kN} > 2965.20 \text{ kN}$$

Safe in Shear

As the Shear force $V < 0.6 V_d$

Design bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = \frac{11118.75}{1} \text{ KNm} > 2273.65 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 Z_e f_y}{\gamma_{m0}} = \frac{12059.06}{1} \text{ KNm}$$

DESIGN OF JOINT BETWEEN FLANGE PLATE & WEB :-

Assuming size of the fillet weld

$$\begin{aligned} f_u &= 330 \text{ Mpa} \\ \gamma_{mw} &= 1.25 \end{aligned}$$

The shear strength of the fillet weld

$$\begin{aligned} P &= 0.7 a x f_u / \sqrt{3} \gamma_{mw} \\ &= 152.420 \times 0.707 \times 8 \\ &= 862.09 \text{ N/mm.} \end{aligned}$$

First moment of area of Flange plate @ C.G. is

top plate

$$\begin{aligned} Q &= 1550 \times 25 \times (400.0 - 12.5) \\ &= 1.5E+07 \text{ mm}^3 \end{aligned}$$

The shear flow is ,

$$\begin{aligned} q &= \frac{VQ}{I} \\ &= \frac{2965.2 \times 1000 \times 1.5E+07}{1.3E+10} \\ &= 3322.97 \text{ N/mm} \end{aligned}$$

$$\text{the shear flow on each web side} = \frac{3322.97}{4} = 830.74 \text{ N/mm.}$$

Providing 8 mm fillet weld whose strength is 862.09 N/mm. to be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\begin{aligned} \text{weld length} &= \frac{3322.97 \times 1000}{4 \times 862.09} \\ &= 963.6 \text{ mm/1000 mm Length} \end{aligned}$$

However Provide 8.00 mm fillet weld continuous throughout the length. safe

First moment of area of Flange plate @ C.G. is

bottom plate

$$\begin{aligned} Q &= 1550 \times 25 \times (400.0 - 12.5) \\ &= 1.5E+07 \text{ mm}^3 \end{aligned}$$

The shear flow is ,

$$\begin{aligned} q &= \frac{VQ}{I} \\ &= \frac{2965.2 \times 1000 \times 1.5E+07}{1.3E+10} \\ &= 3322.97 \text{ N/mm} \end{aligned}$$

$$\text{the shear flow on each web side} = \frac{3322.97}{4} = 830.74 \text{ N/mm.}$$

Providing 8 mm fillet weld whose strength is 862.09 N/mm.
be used at both faces, then the required length of weld for 1000 mm length of girder is ,

$$\text{weld length} = \frac{3322.97}{4} \times \frac{1000}{862.09} = 963.6 \text{ mm/1000 mm Length}$$

However Provide 8 mm fillet weld continuous throughout the length. **safe**

Fatigue check for Flange to web fillet weld

Partial Safety Factor = 1

Shear flow at weld location = 553.83 N/mm (Max. of top and bottom)

Assume Life cycle of bridge $N_{sc} = 2 \times 10^6$

Uncorrected Fatigue stress range :

a.) Normal Stress Range

$$f_f = f_{fn} \sqrt[3]{5 \times 10^6 / N_{sc}}$$

$$f_{fn} = 103 \text{ Mpa} \quad \text{Load carrying weld}$$

$$f_f = 139.79 \text{ Mpa}$$

Design Fatigue strength :

Normal Stress

$$f \leq f_{fd} = \frac{\mu_r f_f}{\gamma_{mft}}$$

$$\gamma_{mft} = 1.35$$

$$\mu_r = (25/t_p)^{0.25} \leq 1.0$$

$$= 1.000$$

$$f_{fd} = 103.6 \text{ Mpa}$$

Allowable Shear flow = $1 \times 0.707 \times 8 \times 103.6$

$$585.68 \text{ N/mm} > 553.83 \text{ N/mm}$$

Safe

DESIGN OF SPANDREL **COLUMN**

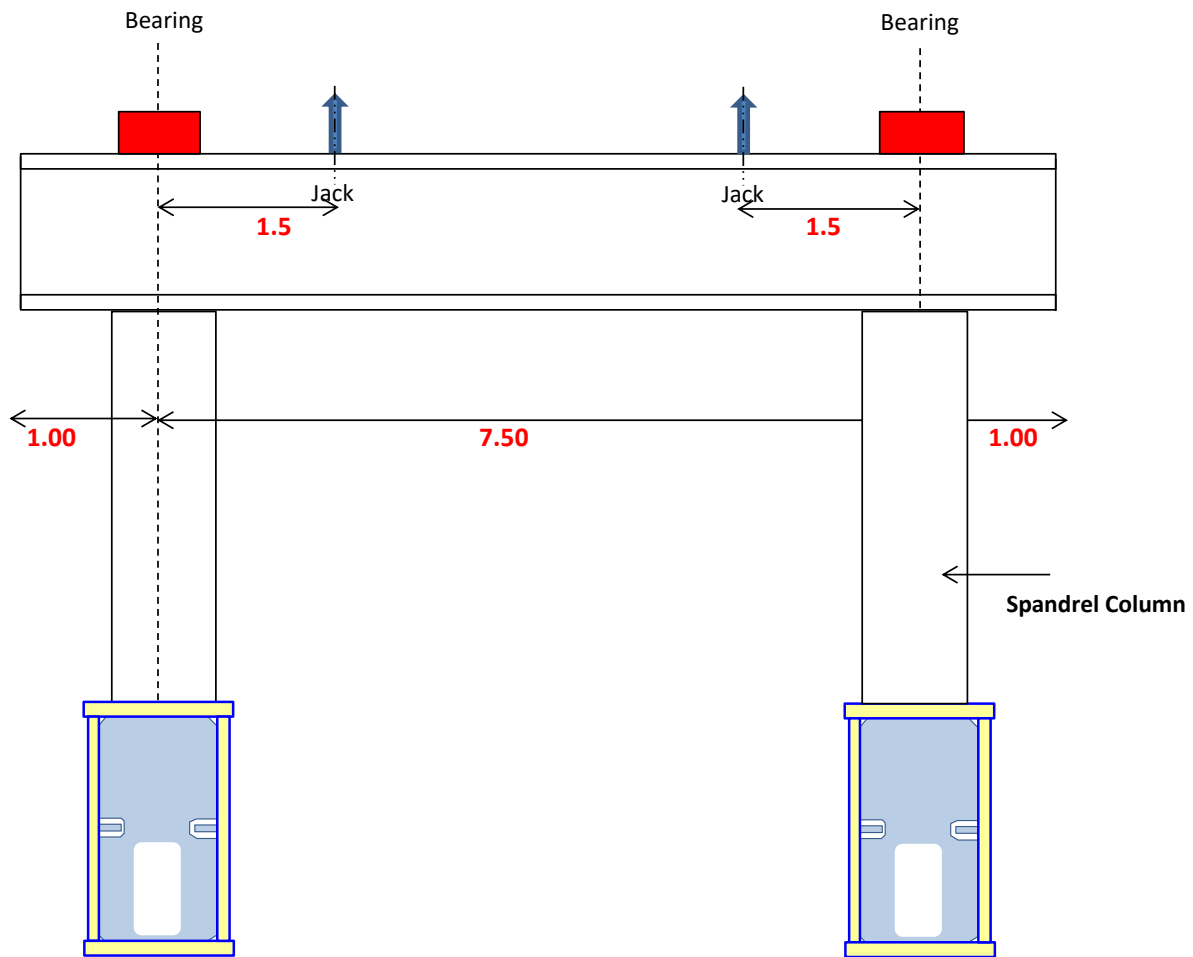
Design Data:

Fig. Typ. arrangement for Cap Beam for supporting Superstructure

Material Specification:

Grade of structural steel	=	E350	(As per table no. 2 of IS 2062:2006)
Yield strength of structural steel	=	330	Mpa for plate thickness between 20-40mm
Partial Safety Factor γ_m	=	1.10	

Max permissible bending stress in tension or compression.

$$s_{bct} = \frac{f_y}{\gamma_m} = \frac{330}{1.1} = 300.00 \text{ Mpa}$$

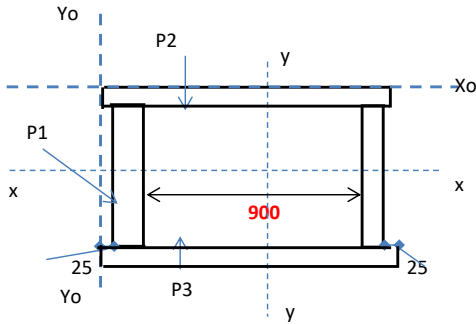
$$\epsilon = \sqrt{\frac{250}{f_y}} = 0.870$$

$$\begin{aligned} \text{Average Shear Stress} &= \frac{f_y}{1.1} \\ &= \frac{330}{1.1} = 300.000 \text{ MPa} \end{aligned}$$

$$\text{The permissible stress in the fillet weld} = 108.000 \text{ Mpa}$$

MAXIMUM COLUMN REACTION**From Staad Pro Analysis**

Sr. No.	Loads	Axial (KN)	Bending Moment (Mxx)	Bending Moment (Myy)	Shear Force FY (KN)	Shear Force FZ (KN)
1	Self-Weight of Girder	617.645	191.048	11.427	8.658	2.142
2	Weight of Slab	1207.479	120.217	4.014	5.448	0.82
3	SIDL1-Crash+Railing	350.89	44.907	3.235	2.035	0.697
4	SIDL2-Wearing Coat	274.435	35.265	2.509	1.598	0.542
5	FPLL	242.889	32.935	53.795	2.65	10.449
6	1-70RW	570.648	393.128	71.464	18.567	13.618
7	2-CLASS A	556.307	545.918	54.031	25.214	10.123
8	Seismic Force	166.359	440.747	204.466	44.538	36.158
9	Wind Force	685.555	153.921	602.194	14.547	107.251

SECTION PROPERTIES OF SPANDREL COLUMN

Size of Plate P1	Length =	650 mm	Thick =	25 mm
Size of Plate P2	Length =	1000 mm	Thick =	25 mm
Size of Plate P3	Length =	1000 mm	Thick =	25 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1000 mm		
Width of Member at Bottom , B	=	1000 mm		
Depth of Member , D	=	700 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo ²	Ayo ²	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo ² , mm ⁴	Iyy + Axo ² , mm ⁴
Plate 1 Left	16250	37.5	350	6.09E+05	5.69E+06	2.29E+07	1.99E+09	5.72E+08	8.46E+05	2.56E+09	2.37E+07
Plate 2 Left	25000	500	12.5	1.25E+07	3.13E+05	6.25E+09	3.91E+06	1.30E+06	2.08E+09	5.21E+06	8.33E+09
Plate 3 Left	25000	500	687.5	1.25E+07	1.72E+07	6.25E+09	1.18E+10	1.30E+06	2.08E+09	1.18E+10	8.33E+09
Plate 1 Right	16250	962.5	350	1.56E+07	5.69E+06	1.51E+10	1.99E+09	5.72E+08	8.46E+05	2.56E+09	1.51E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	82500			4.13E+07	2.89E+07	2.76E+10	1.58E+10			1.69E+10	3.17E+10

Therefore distance of N.A. , X	=	500.00 mm									
Therefore distance of N.A. , Y	=	350.00 mm	Yb	=	350.000 mm						
Ixx	=	1.69E+10 -	82500 x			122500 =		6.84E+09 mm ⁴			
Iyy	=	3.17E+10 -	82500 x			250000 =		1.11E+10 mm ⁴			
rxx	=	287.99 mm				ryy	=	367.14 mm			

PRIS	AX	0.0825	IY	0.0111	IZ	0.0068	YD	0.70	ZD	1.00	

Zxxb = Ixx / Yb	=	1.95E+07 mm ³	Zxxt = Ixx / Yt	=	1.95E+07 mm ³
Elastic section modulus (Ze)	=	1.95E+07 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **350.00** mm

Area above neutral axis (A1) = 41250 mm² Area below neutral axis (A2) = 41250 mm²

Moment balance about neutral axis

$$A2 - A1 = 0$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	25000	338	8.44E+06
web	16250	162.50	2.64E+06
	41250		1.11E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Fl	25000	338	8.44E+06
web	16250	163	2.64E+06
	41250		1.11E+07

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1.11E+07}{41250} = 268.56 \text{ mm}$$

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{1.11E+07}{41250} = 268.56 \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = 2.22E+07 \text{ mm}^3$$

$$Ze / Zp = 8.82E-01$$

DESIGN OF END VERTICAL MEMBER

Unsupported length of member	Lx	=	21.45 m
	LY	=	6.00 m
Live load impact factor		=	1

Sectional Properties:

A	=	8.25E-02 m ²	rxx	=	0.288 m
Ixx	=	6.84E-03 m ⁴	ryy	=	0.367 m
Iyy	=	1.11E-02 m ⁴			

ULS LOAD COMBINATION		Axial Force , kN	Bending Moment(Mxx or Mzz) , kNm	Bending Moment (Myy) , kNm	Shear Force FY (KN)	Shear Force FZ (KN)
Load Factor						
Self-Weight of Girder	1.35	833.8	257.9	15.4	11.7	2.9
Weight of Slab	1.35	1630.1	162.3	5.4	7.4	1.1
SIDL1-Crash+Railing	1.35	473.7	60.6	4.4	2.7	0.9
SIDL2-Wearing Coat	1.75	480.3	61.7	4.4	2.8	0.9
With Leading LL						
FPLL	1.5	364.3	49.4	80.7	4.0	15.7
1-70RW	1.5	856.0	589.7	107.2	27.9	20.4
2-CLASS A	1.5	834.5	818.9	81.0	37.8	15.2
Seismic Force	1.5	249.5	661.1	306.7	66.8	54.2
Wind Force	0.9	617.0	138.5	542.0	13.1	96.5
With Accompanying LL						
FPLL	1.15	279.3	37.9	61.9	3.0	12.0
1-70RW	1.15	656.2	452.1	82.2	21.4	15.7
2-CLASS A	1.15	639.8	627.8	62.1	29.0	11.6
Seismic Force	1.5	249.5	661.1	306.7	66.8	54.2
Wind Force	1.5	1028.3	230.9	903.3	21.8	160.9
Load Combination						
DL+SIDL+LL	Leading LL	4638.2	1410.8	217.5	66.4	42.0
DL+SIDL+LL+EQ	Leading LL	4887.7	2071.9	524.2	133.2	96.2
DL+SIDL+LL+WL	Leading LL	5255.2	1549.4	759.5	79.5	138.5
DL+SIDL+LL	Accompanying LL	4353.4	1208.2	173.7	56.6	33.6
DL+SIDL+LL+EQ	Accompanying LL	4603.0	1869.3	480.4	123.4	87.8
DL+SIDL+LL+WL	Accompanying LL	5631.3	2100.2	1383.6	145.3	248.7
Maximum		5631.3	2100.2	1383.6	145.3	248.7

Check for Section Class :

Web Class

d = **650**tw = **25****d/tw** = **26 Plastic**

$$\beta_b = 1.00E+00$$

$$Z_p = 2.22E+07 \text{ mm}^3$$

DESIGN OF WEB FOR SHEAR :

$$\text{Max Shear force} = 248.68 \text{ KN}$$

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3} d t_w} \quad (\text{For Welded Section}) = 32500$$

$$V_n = 6192.08 \text{ KN} > 248.68 \text{ KN}$$

Safe in Shear

$$\text{As the Shear force } V < 0.6 V_d$$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 6646.88 \text{ KNm}$$

$$6646.88 > 2100.23 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 Z_e f_y}{\gamma_{m0}} = 7037.68 \text{ KNm}$$

$$6646.88 < 7037.68 \text{ KNm}$$

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 6646.88 \text{ KNm}$$

$$6646.88 > 1383.64 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 Z_e f_y}{\gamma_{m0}} = 7037.68 \text{ KNm}$$

$$6646.88 < 7037.68 \text{ KNm}$$

Axial Force Capacity of Section along X-X axis

$$\text{Design Axial Force} = 5631.3187 \text{ KN} \quad \text{Compressive Force}$$

$$\text{Effective length } 1 * L_x = 21.45 \text{ m}$$

$$\text{Minimum Radius of gyration, } r_{xx} = 0.288 \text{ m}$$

$$\text{Slenderness ratio} = \frac{k L_{xx}}{r_{xx}} = 74.48 < 180$$

SAFE

$$E = 2.0E+05 \text{ MPa}$$

$$f_{cc} = \frac{\pi^2 E}{\lambda^2} = 355.8$$

$$\lambda = \sqrt{\frac{(KL/r_x)^2}{\frac{f_y}{f_{cc}}}} = 0.963$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.621$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 1.093$$

$$b/t_f = 40 \quad h/t_w = 26$$

$$\alpha = 0.34 \quad \text{Maximum of buckling class 'b along z-z & b along y-y' as per Table 4}$$

$$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 186.2 \text{ MPa}$$

Design Strength of member, p_{dx}

$$P_{dx} = A_e * f_{cdx} = 15360.24 \text{ KN} > 5631.32 \text{ KN} \quad \text{OK}$$

Axial Force Capacity of Section along Y-Y axis

Design Axial Force = 5631.3187 KN Compressive Force

Effective length $1 * L_y = 6.00 \text{ m}$ Minimum Radius of gyration, $r_{yy} = 0.367 \text{ m}$ Slenderness ratio = $\frac{kL_{yy}}{r_{yy}} = 16.34 < 180$ **SAFE** $E = 2.0E+05 \text{ MPa}$

$$f_{cc} = \frac{\pi^2 E}{(KL/r_y)^2} = 7390.8$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.211$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.996$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.524$$

$$\alpha = 0.34 \quad \text{Maximum of buckling class 'b along z-z & b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 298.8 \text{ MPa}$$

Design Strength of member, P_{dy}

$$P_{dy} = A_e \cdot f_{cdy} = 24650.83 \text{ KN} > 5631.32 \text{ KN} \quad \text{OK}$$

Check for Section Strength

as per clause 510.3.1.1 of IRC:24-2010

$$\frac{N}{N_d} + \frac{M_y}{M_{yd}} + \frac{M_z}{M_{zd}} \leq 1.0$$

$$\text{where, } M_z = M_x \quad \& \quad M_{zd} = M_{zd}$$

$$\frac{5631.32}{15360.24} + \frac{1383.64}{6646.88} + \frac{2100.23}{6646.88} =$$

$$0.367 + 0.208 + 0.316 = 0.891 < 1$$

SAFE**Check for Overall stability of member for combined axial and bending moment**

As per Clause 510.3.2.2 of IRC:24-2010 -

$$P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + KLT \cdot M_z / M_{dz} \leq 1.0$$

$$P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$$

$$P = 5631.32 \text{ KN}$$

$$P_{dy} = 24650.83 \text{ KN}$$

$$P_{dx} = P_{dz} = 15360.24 \text{ KN}$$

$$M_z = M_x = 2100.23 \text{ kNm} \quad M_y = 1383.64 \text{ kNm}$$

$$M_{dz} = M_{dx} = 6646.88 \text{ kNm} \quad M_{dy} = 6646.88 \text{ kNm}$$

$$K_z = 1 + (\lambda_z - 0.2) \cdot P / P_{dz} \leq (1 + 0.8 P / P_{dz})$$

$$\lambda_z = 0.96$$

$$K_z = 1.280 \leq 1.293 \quad \text{OK}$$

$$\Psi_z = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.03 \text{ from staad}$$

$$C_{mz} = 0.6 + 0.4 \Psi_z = 0.612 \geq 0.4 \quad \text{SAFE}$$

$$K_y = 1 + (\lambda_y - 0.2) \cdot P / P_{dy} \leq (1 + 0.8 P / P_{dy})$$

$$\lambda_y = 0.21$$

$$K_y = 1.003 \leq 1.183 \quad \text{OK}$$

$$\Psi_y = \frac{\text{Min End moment}}{\text{Max End moment}} = -0.26 \text{ from staad}$$

$$C_{my} = 0.6 + 0.4 \Psi_y = 0.50 \geq 0.4 \quad \text{SAFE}$$

$$\text{Generally } C_{MLT} = C_{mz} = 0.61$$

$$K_{LT} = 1 - (0.1 \lambda_{LT} \cdot n_y) / (C_{mLT} - 0.25) \geq 1 - (0.1 n_y) / (C_{mLT} - 0.25)$$

$$n_y = P/P_y = 0.228$$

$$\lambda_{LT} = 0.729$$

$$K_{LT} = 0.954 \geq 0.937 \text{ OK}$$

Check: $P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$

$$= \frac{5631.32}{24650.83} + \frac{1.003 \times 0.496 \times 1383.64}{6646.88} + \frac{0.954 \times 2100.23}{6646.88}$$

$$= 0.228 + 0.104 + 0.301$$

$$= 0.633 \leq 1 \text{ OK}$$

Check: $P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$

$$= \frac{5631.32}{15360.24} + \frac{0.602 \times 0.496 \times 1383.64}{6646.88} + \frac{0.783 \times 2100.23}{6646.88}$$

$$= 0.367 + 0.062 + 0.247$$

$$= 0.676 \leq 1 \text{ OK}$$

DESIGN OF ARCH RIBS

Material Specification:

Grade of structural steel	=	E450	(As per table no. 2 of IS 2062:2006)
Yield strength of structural steel	=	430	Mpa for plate thickness between 20-40mm
Partial Safety Factor γ_m	=	1.10	

Max permissible bending stress in tension or compression.

$$s_{bct} = \frac{f_y}{\gamma_m} = \frac{430}{1.1} = 390.91 \text{ Mpa}$$

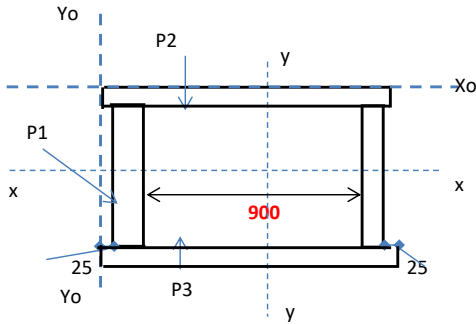
$$\epsilon = \sqrt{\frac{250}{f_y}} = 0.762$$

$$\text{Average Shear Stress} = \frac{f_y}{\gamma_m} = \frac{430}{1.1} = 390.91 \text{ MPa}$$

$$\text{The permissible stress in the fillet weld} = 108.00 \text{ Mpa}$$

MAXIMUM COLUMN REACTION**From Staad Pro Analysis**

Sr. No.	Loads	Axial (KN)	Bending Moment (Mxx)	Bending Moment (Myy)	Shear Force FY (KN)	Shear Force FZ (KN)	
1	Self-Weight of Girder	8348.37	3495.14	8.71	168.72	0.90	Compresion
2	Weight of Slab	6627.03	1912.35	5.94	182.02	0.07	Compresion
3	SIDL1-Crash+Railing	1980.09	828.30	14.92	150.57	6.92	Compresion
4	SIDL2-Wearing Coat	1549.27	647.16	11.67	117.72	5.41	Compresion
5	FPLL	1348.00	564.98	10.16	102.60	4.71	Compresion
6	1-70RW	1178.94	6624.26	9.56	269.81	5.92	Compresion
7	2-CLASS A	1148.21	7896.13	3.73	313.36	2.13	Compresion
8	Seismic Force	-5605.39	12611.65	668.50	768.18	91.62	Tension
9	Wind Force	-10746.27	1788.24	1882.13	320.85	279.91	Tension

SECTION PROPERTIES OF ARCH RIBS

Size of Plate P1	Length =	2300 mm	Thick =	25 mm
Size of Plate P2	Length =	1000 mm	Thick =	50 mm
Size of Plate P3	Length =	1000 mm	Thick =	50 mm
Size of top plate	Length =	0 mm	Thick =	0 mm
Size of bottom plate	Length =	0 mm	Thick =	0 mm
Width of Member at top , B	=	1000 mm		
Width of Member at Bottom , B	=	1000 mm		
Depth of Member , D	=	2400 mm		

Element	A ,mm ²	xo = c.g. @ Yo-Yo	yo = c.g. @ Xo-Xo	Axo	Ayo	Axo2	Ayo2	Ixx , mm ⁴	Iyy , mm ⁴	Ixx+ Ayo2 , mm ⁴	Iyy + Axo2 , mm ⁴
Plate 1 Left	57500	37.5	1200	2.16E+06	6.90E+07	8.09E+07	8.28E+10	2.53E+10	2.99E+06	1.08E+11	8.39E+07
Plate 2 Left	50000	500	25	2.50E+07	1.25E+06	1.25E+10	3.13E+07	1.04E+07	4.17E+09	4.17E+07	1.67E+10
Plate 3 Left	50000	500	2375	2.50E+07	1.19E+08	1.25E+10	2.82E+11	1.04E+07	4.17E+09	2.82E+11	1.67E+10
Plate 1 Right	57500	962.5	1200	5.53E+07	6.90E+07	5.33E+10	8.28E+10	2.53E+10	2.99E+06	1.08E+11	5.33E+10
Top plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bottom plate	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	215000			1.08E+08	2.58E+08	7.83E+10	4.48E+11			4.98E+11	8.67E+10

Therefore distance of N.A. , X	=	500.00 mm									
Therefore distance of N.A. , Y	=	1200.00 mm	Yb	=	1200.000 mm						
Ixx	=	4.98E+11 -	215000 x		1440000 =			1.89E+11 mm ⁴			
Iyy	=	8.67E+10 -	215000 x		250000 =			3.29E+10 mm ⁴			
rxx	=	937.04 mm			ryy	=		391.41 mm			

PRIS	AX	0.2150	IY	0.0329	IZ	0.1888	YD	2.40	ZD	1.00	

Zxxb = Ixx / Yb	=	1.57E+08 mm ³	Zxxt = Ixx / Yt	=	1.57E+08 mm ³
Elastic section modulus (Ze)	=	1.57E+08 mm ³			

Plastic Properties

Assume distance of neutral axis from Top of top flange is d. = **1200.00** mm

Area above neutral axis (A1) = 107500 mm² Area below neutral axis (A2) = 107500 mm²

Moment balance about neutral axis

$$A2 - A1 = \boxed{0}$$

Area in Compression

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Top Flng 1	50000	1175	5.88E+07
web	57500	575.00	3.31E+07
	107500		9.18E+07

Area in Tension

S. No.	Area Ai (mm ²)	distance from N.A Yi (mm)	Ai*Yi (mm ³)
Bottom Fl	50000	1175	5.88E+07
web	57500	575	3.31E+07
	107500		9.18E+07

$$Y1 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{9.18E+07}{107500} = \boxed{854.07} \text{ mm}$$

$$Y2 = \frac{\sum A_i Y_i}{\sum A_i} = \frac{9.18E+07}{107500} = \boxed{854.07} \text{ mm}$$

$$\text{Plastic section modulus (Zp)} = A1*Y1 + A2*Y2 = \boxed{1.84E+08} \text{ mm}^3$$

$$Ze / Zp = 8.57E-01$$

DESIGN OF END VERTICAL MEMBER

Unsupported length of member	Lx	=	15.00 m
	LY	=	15.00 m
Live load impact factor		=	1

Sectional Properties:

A	=	2.15E-01 m ²	rxx	=	0.937 m
Ixx	=	1.89E-01 m ⁴	ryy	=	0.391 m
Iyy	=	3.29E-02 m ⁴			

ULS LOAD COMBINATION		Axial Force , kN	Bending Moment(Mxx or Mzz) , kNm	Bending Moment (Myy) , kNm	Shear Force FY (KN)	Shear Force FZ (KN)
Load Factor						
Self-Weight of Girder	1.35	11270.3	4718.4	11.8	227.8	1.2
Weight of Slab	1.35	8946.5	2581.7	8.0	245.7	0.1
SIDL1-Crash+Railing	1.35	2673.1	1118.2	20.1	203.3	9.3
SIDL2-Wearing Coat	1.75	2711.2	1132.5	20.4	206.0	9.5
With Leading LL						
FPLL	1.5	2022.0	847.5	15.2	153.9	7.1
1-70RW	1.5	1768.4	9936.4	14.3	404.7	8.9
2-CLASS A	1.5	1722.3	11844.2	5.6	470.0	3.2
Seismic Force	1.5	-8408.1	18917.5	1002.8	1152.3	137.4
Wind Force	0.9	-9671.6	1609.4	1693.9	288.8	251.9
With Accompanying LL						
FPLL	1.15	1550.2	649.7	11.7	118.0	5.4
1-70RW	1.15	1355.8	7617.9	11.0	310.3	6.8
2-CLASS A	1.15	1320.4	9080.6	4.3	360.4	2.5
Seismic Force	1.5	-8408.1	18917.5	1002.8	1152.3	137.4
Wind Force	1.5	-16119.4	2682.4	2823.2	481.3	419.9
Load Combination						
DL+SIDL+LL	Leading LL	29391.5	22242.5	89.9	1506.7	36.1
DL+SIDL+LL+EQ	Leading LL	20983.5	41160.0	1092.7	2659.0	173.5
DL+SIDL+LL+WL	Leading LL	19719.9	23851.9	1783.8	1795.5	288.0
DL+SIDL+LL	Accompanying LL	28507.1	19281.1	83.0	1361.1	32.3
DL+SIDL+LL+EQ	Accompanying LL	20099.0	38198.6	1085.8	2513.4	169.8
DL+SIDL+LL+WL	Accompanying LL	3979.6	40881.0	3909.0	2994.7	589.6
Maximum		29391.5	22242.5	3909.0	2994.7	589.6
		20983.5	41160.0			

Check for Section Class :

Web Class

d	=	2300
tw	=	25

d/tw = 92 Compact

$$\beta_b = 1.00E+00$$

$$Z_p = 1.84E+08 \text{ mm}^3$$

DESIGN OF WEB FOR SHEAR :

$$\text{Max Shear force} = 2994.67 \text{ KN}$$

Shear Capacity

$$V_n = V_p = \frac{A_v f_{yw}}{\sqrt{3}}$$

$$A_v = d \cdot t_w \quad (\text{For Welded Section}) = 115000$$

$$V_n = 28549.97 \text{ KN} > 2994.67 \text{ KN}$$

Safe in Shear

$$\text{As the Shear force } V < 0.6 \cdot V_d$$

Design bending strength in x-x direction

$$M_{dz} \text{ or } M_{dx} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 71780.7 \text{ KNm}$$

$$71780.7 > 22242.53 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_{ex} \cdot f_y}{\gamma_{m0}} = 73795.49 \text{ KNm}$$

$$71780.7 < 73795.49 \text{ KNm}$$

SAFE

Design bending strength-Y-Y direction

$$M_{dy} = \frac{\beta_b Z_p f_y}{\gamma_{m0}} = 71780.7 \text{ KNm}$$

$$71780.7 > 3908.97 \text{ KNm}$$

Hence OK

$$\text{where } \frac{1.2 \cdot Z_{ey} \cdot f_y}{\gamma_{m0}} = 73795.49 \text{ KNm}$$

$$71780.7 < 73795.49 \text{ KNm}$$

Axial Force Capacity of Section along X-X axis

Design Axial Force = 29391.548 KN Compressive Force

Effective length = 9.75 m

Minimum Radius of gyration , rxx = 0.937 m

Slenderness ratio = $\frac{kL_{xx}}{r_{xx}}$ = 10.41 < 250
SAFE

E = 2.0E+05 MPa

$f_{cc} = \frac{\pi^2 E}{(KL/rx)^2} = 18232.1$

$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = 0.154$

$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 1.024$

$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.500$

b/tf = 20 h/tw = 92

$\alpha = 0.49$ Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4

$f_{cd,x} = \frac{\chi f_y}{\gamma_{m0}} = 400.2 \text{ MPa}$

Design Strength of member, pdx

$P_{dx} = A_e * f_{cdx} = 86051.48 \text{ KN} > 29391.55 \text{ KN}$

OK

Axial Force Capacity of Section along Y-Y axis

Design Axial Force = 29391.5482 KN Compressive Force

Effective length = 9.75 m

Minimum Radius of gyration , ryy = 0.391 m

Slenderness ratio = $\frac{kL_{yy}}{r_{yy}}$ = 24.91 < 250
SAFE

E = 2.0E+05 MPa

$f_{cc} = \frac{\pi^2 E}{(KL/rx)^2} = 3181.2$

$$\lambda = \sqrt{\frac{(KL/ry)^2}{f_y/f_{cc}}} = 0.368$$

$$\chi = \frac{1}{(\Phi + (\Phi^2 - \lambda^2)^{0.5})} = 0.914$$

$$\Phi = 0.5(1 + \alpha(\lambda - 0.2) + \lambda^2) = 0.609$$

$$\alpha = 0.49 \quad \text{Maximum of buckling class 'c' along z-z & b along y-y' as per Table 4}$$

$$f_{cd,y} = \frac{\chi f_y}{\gamma_{m0}} = 357.4 \text{ MPa}$$

Design Strength of member, p_{dy}

$$P_{dy} = A_e \cdot f_{cdy} = 76842.57 \text{ KN} > 29391.55 \text{ KN} \quad \text{OK}$$

Check for Section Strength

as per clause 510.3.1.1 of IRC:24-2010

$$\frac{N}{N_d} + \frac{M_y}{M_{yd}} + \frac{M_z}{M_{zd}} \leq 1.0$$

where , $M_z = M_x$ & $M_{zd} = M_{zd}$

$$N_d = A_g \cdot F_y / \gamma_{m0} = 8.40E+07 \text{ N} = 84045.45 \text{ KN}$$

Case 1 : Max compression with corresponding moment

$$\frac{29391.55}{84045.45} + \frac{3908.97}{71780.68} + \frac{22242.53}{71780.68} = 0.350 + 0.054 + 0.310 = 0.714 < 1 \quad \text{SAFE}$$

Case 2 : Max moment with corresponding compression

$$\frac{20983.46}{84045.45} + \frac{3908.97}{71780.68} + \frac{41160.01}{71780.68} = 0.250 + 0.054 + 0.573 = 0.878 < 1 \quad \text{SAFE}$$

Check for Overall stability of member for combined axial and bending moment

As per Clause 510.3.2.2 of IRC:24-2010 -

$$P/P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + KLT \cdot M_z / M_{dz} \leq 1.0$$

$$P/P_{dx} + 0.6K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$$

Case 1 : Max compression with corresponding moment

$$P = 29391.55 \text{ KN}$$

$$\begin{aligned}
 p_{dy} &= 76842.57 \text{ KN} \\
 p_{dx} = p_{dz} &= 86051.48 \text{ KN} \\
 M_z = M_x &= 22242.53 \text{ kNm} & M_y &= 3908.97 \text{ kNm} \\
 M_{dz} = M_{dx} &= 71780.68 \text{ kNm} & M_{dy} &= 71780.68 \text{ kNm}
 \end{aligned}$$

$$K_z = 1 + (\lambda_z - 0.2) \cdot P / P_{dz} \leq (1 + 0.8 P / P_{dz})$$

$$\begin{aligned}
 \lambda_z &= 0.15 \\
 K_z &= 0.984 \leq 1.273 \quad \boxed{\text{OK}}
 \end{aligned}$$

$$\Psi_z = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \text{ from staad}$$

$$C_{mz} = 0.6 + 0.4 \Psi_z = 0.800 \geq 0.4 \quad \boxed{\text{SAFE}}$$

$$K_y = 1 + (\lambda_y - 0.2) \cdot P / P_{dy} \leq (1 + 0.8 P / P_{dy})$$

$$\begin{aligned}
 \lambda_y &= 0.37 \\
 K_y &= 1.064
 \end{aligned}$$

$$\Psi_y = \frac{\text{Min End moment}}{\text{Max End moment}} = 0.50 \text{ from staad}$$

$$C_{my} = 0.6 + 0.4 \Psi_y = 0.80 \geq 0.4 \quad \boxed{\text{SAFE}}$$

$$\text{Generally } C_{MLT} = C_{mz} = 0.80$$

$$K_{LT} = 1 - (0.1 \lambda_{LT} \cdot n_y) / (C_{mLT} - 0.25) \geq 1 - (0.1 n_y) / (C_{mLT} - 0.25)$$

$$n_y = P / P_y = 0.382$$

$$\lambda_{LT} = 0.154$$

$$K_{LT} = 0.989 \geq 0.930 \quad \boxed{\text{OK}}$$

$$\text{Check: } P / P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$$

$$= \frac{29391.55}{76842.57} + \frac{1.064 \times 0.800 \times 3908.97}{71780.68} + \frac{0.989 \times 22242.53}{71780.68}$$

$$= 0.382 + 0.046 + 0.307$$

$$= 0.735 \leq 1 \quad \boxed{\text{OK}}$$

$$\text{Check: } P / P_{dx} + 0.6 K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$$

$$= \frac{29391.55}{86051.48} + \frac{0.638 \times 0.800 \times 3908.97}{71780.68} + \frac{0.787 \times 22242.53}{71780.68}$$

$$= 0.342 + 0.028 + 0.244$$

$$= 0.613 \leq 1 \quad \boxed{\text{OK}}$$

Case 2 : Max moment with corresponding compression

P	=	20983.46	KN				
p _{dy}	=	76842.57	KN				
p _{dx} = p _{dz}	=	86051.48	KN				
M _z = M _x	=	41160.01	kNm	M _y	=	3908.97	kNm
M _{dz} =M _{dx}	=	71780.68	kNm	M _{dy}	=	71780.68	kNm

$$K_z = 1 + (\lambda_z - 0.2) \cdot P / P_{dz} \leq (1 + 0.8 P / P_{dz})$$

λ_z	=		$\leq$	1.0	
K _z	=	0.989	$\leq$	1.195	OK

Ψ_z	=	$\frac{\text{Min End moment}}{\text{Max End moment}}$	=	0.50	from staad

C _{mz}	=	0.6 + 0.4 Ψ_z	=	0.800	$\geq$	0.4	SAFE

$$K_y = 1 + (\lambda_y - 0.2) \cdot P / P_{dy} \leq (1 + 0.8 P / P_{dy})$$

λ_y	=	OK
K _y	=	1.046

Ψ_y	=	$\frac{\text{Min End moment}}{\text{Max End moment}}$	=	0.50	from staad

C _{my}	=	0.6 + 0.4 Ψ_y	=	0.80	$\geq$	0.4	SAFE

Generally	$C_{MLT} = C_{mz}$	=	0.80

$$K_{LT} = 1 - (0.1 \lambda_{LT} \cdot n_y) / (C_{mLT} - 0.25) \geq 1 - (0.1 n_y) / (C_{mLT} - 0.25)$$

n_y	=	P / P _y	=	0.273

λ_{LT}	=	0.154

K _{LT}	=	0.992	$\geq$	0.950	OK

Check: $P / P_{dy} + K_y \cdot C_{my} \cdot M_y / M_{dy} + K_{LT} \cdot M_z / M_{dz} \leq 1.0$

=	$\frac{20983.46}{76842.57} +$	$\frac{1.046 \times 0.800 \times 3908.97}{71780.68} +$	$\frac{0.992 \times 41160.01}{71780.68}$

=	0.273	+	0.046	+	0.569

=	0.888	$\leq$	1	OK

Check: $P / P_{dx} + 0.6 K_y \cdot C_{my} \cdot M_y / M_{dy} + K_z \cdot C_{mz} \cdot M_z / M_{dz} \leq 1.0$

=	$\frac{20983.46}{86051.48} +$	$\frac{0.627 \times 0.800 \times 3908.97}{71780.68} +$	$\frac{0.791 \times 41160.01}{71780.68}$

=	0.244	+	0.027	+	0.454

= **0.725** ≤ 1 OK

**DETAILED DESIGN OF CAST IN SITU DECK SLAB OVER
GIRDER**

DESIGN OF RCC DECK SLAB

Deck is designed as a continuous slab of one metre width supported over longitudinal girders.

Dimesnions of Deck Slab

Total deck width	=	12 m
slab thickness	=	220 at free edge
Cross slope of deck slab	=	2.5 %
slab thicness	=	220 at centre of deck
Slab Thickness	=	220 mm at girder location
Total Width of Slab	=	12 m

CALCULATION OF DEAD LOAD & SUPERIMPOSED DEAD LOAD

1. Deck slab

Self weight of slab	=	5.500 kN/m ²

2. Wearing coat 50 thick + additional load

Load = 2.0 kN/m ²	with start and end offset of 0.5m

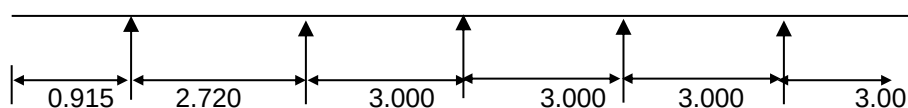
3. Crash barrier

load = 8.0 kN/m

4. PCC Profile Correction

Thk	=	0.000 m at edge	0 kN/m ²
		0.000 m at median	0 kN/m ²
load=	0 kN/m ²		

IDEALIZATION OF DECK SLAB



Load Factors (As per IRC:6-2017)

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

Loads	Basic Combination
Dead Load+SIDL except wearing course	1.350
Wearing Course only	1.750
CWLL and Associate load and FPLL(Service)	1.500

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL excluding surfacing	1.000	1.00	1.00
Surfacing	1.200	1.20	1.20
Shrinkage Creep Effect	1.000	1.00	1.00
CWLL and Associate load and FPLL	1.000	0.75	0.00

CALCULATION OF EFFECTIVE WIDTH AND LOAD INTENSITY FOR CRITICAL LOAD POSITIONS



As per IRC: 21, clause 305.16.2

$$b_{ef} = \alpha \cdot a \cdot (1 - a/l_o) + b_1 \quad (\text{for solid slab spanning in one direction})$$

$$= 1.2 a + b_1 \quad (\text{for solid slab cantilever})$$

b_{ef} = effective width of slab

l_o = effective span = 2.275 m

a = distance of c.g. of conc. load from nearer support

b_1 = breadth of concentration area of the load i.e. the dimension of tyre over road surface in the direction at right angle to span plus twice the thickness of wearing coat

α = a constant having the values depending upon ratio b/l_o

$$= 2.6$$

Average Thickness of Profile Correction = 0.000 m

Thickness of wearing coat = 65 mm

Thickness of deck slab = 220 mm

Effective depth of deck slab = 174 mm

Contact width perpendicular to span = 250 mm

Contact width parallel to span = 500 mm

Distance between two loads perpendicular to span = 1.2 m

Thickness of Web of girder = 0.000 m

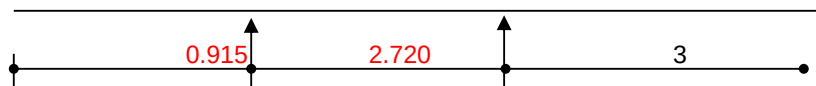
Top Flange width of girder = 0.00 m

Effective support length from centre of web = 0.000 m

Concentrated load = 57 kN

$$b_1 = 0.25 + 0.065 \times 2 = 0.38 \text{ m}$$

Loading **1 One lane CI A** (Cantilever Moment)

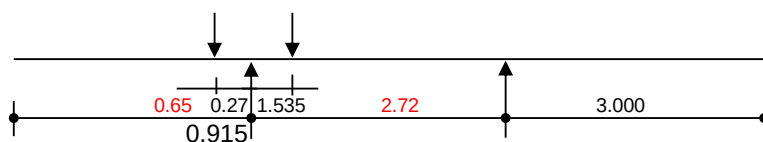


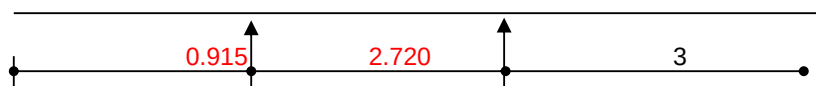
Length of dispersion along the span =

$$0.5 + 2 \times (0.065 + 0.174 + 0.000) = 0.978 \text{ m}$$

Load Nos.	Load (kN)	a (m)	b _{ef} (m)	b _{ef1} (m)	b _{eff2} (m)	Load (kN/m ²)
1	57	0.265	0.698	0.698	0.978	83.50
2	57	1.535	1.678	1.439	0.978	40.5

$b_{ef1} = (b_{ef} + 1.2)/2$, if $b_{ef} > 1.2$



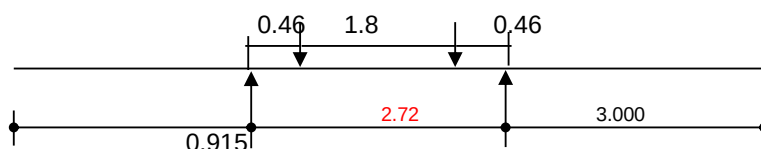
Loading 1 One lane CI A (sagging Moment)

Length of dispersion across the span =

$$0.25 + 2 \times (0.065 + 0.174 + \quad) = 0.728 \text{ m}$$

Load Nos.	Load (kN)	a (m)	bef (m)	bef1 (m)	bef2 (m)	Load (kN/m ²)
1	57	0.460	1.722	1.461	0.728	53.60
2	57	0.460	1.722	1.461	0.728	53.6

bef1 = (bef+1.2)/2, if bef > 1.2

**CLASS 70R LOADING**

Max. load on a wheel = $\frac{200}{4} = 50 \text{ kN}$

Max. tyre pressure = 5.273 kg/cm^2

Contact width parallel to span = 410 mm

Contact area = $\frac{5000}{5.273} = 948 \text{ cm}^2$

= 94823 mm^2

Contact width perpendicular to span = $\frac{94823}{410} = 231 \text{ mm}$

Distance between two loads perpendicular to span = 1.22 m

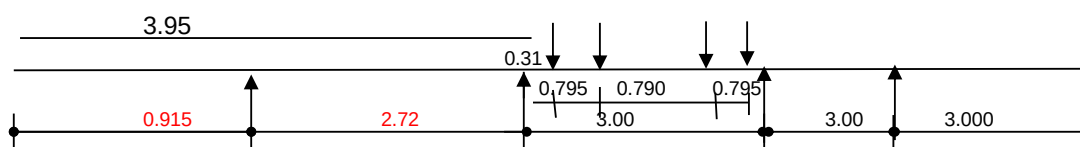
b1 = $0.231 + 0.065 \times 2 = 0.361 \text{ m}$

Loading 1 M type (for maximum sagging moment)

Length of dispersion along the span = 0.888 m

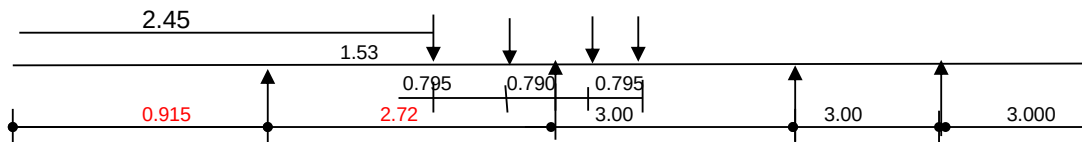
Load Nos.	Load (kN)	a (m)	bef (m)	bef1 (m)	bef2(m)	Load (kN/m ²)
1	50	0.310	1.057	1.057	0.842	56.2
2	50	1.105	1.839	1.529	0.793	41.3
3	50	1.105	1.839	1.529	0.793	41.3
4	50	0.31	1.057	1.057	0.842	56.2

bef1 = (bef+1.22)/2, if bef > 1.22

**Loading 2 M type (Inner Support Hogging Moment)**

Length of dispersion along the span = 0.888 m

Load Nos.	Load (kN)	a (m)	bef (m)	bef1 (m)	beff2(m)	Load (kN/m ²)
1	50	1.190	1.837	1.528	0.842	38.9
2	50	0.395	1.210	1.210	0.793	52.1
3	50	0.395	1.210	1.210	0.793	52.1
4	50	1.190	1.837	1.528	0.842	38.9

$$bef1 = (bef + 1.22)/2, \text{ if } bef > 1.22$$
**IRC Class SV Loading**

Hogging

Contact width parallel to span = 450 mm
 Contact width perpendicular to span = 274 mm

Length of dispersion across the span , b1 = 0.404 m

Length of dispersion along the span = 0.928 m

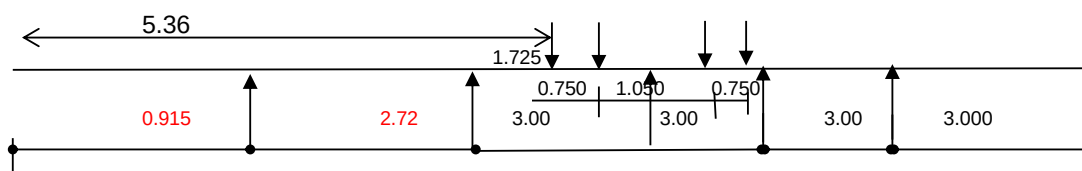
Maximum weight of single axle = 180.00 KN

nos. of wheel considered under each axle = 4.00

Weight shared by each wheel = 45.00 KN

Distance betn two axle perpendicular to span = 1.5 m

Load Nos.	Load (kN)	a (m)	bef (m)	bef1 (m)	beff2(m)	Load (kN/m ²)
1	45	1.275	1.861	1.681	0.839	31.9
2	45	0.525	1.454	1.454	0.839	36.9
3	45	0.525	1.454	1.454	0.839	36.9
4	45	1.275	1.861	1.681	0.839	31.9

**IRC Class SV Loading**

Sagging

Contact width parallel to span = 1200 mm
 Contact width perpendicular to span = 274 mm

Length of dispersion across the span , b1 = 0.404 m

Length of dispersion along the span = 1.678 m

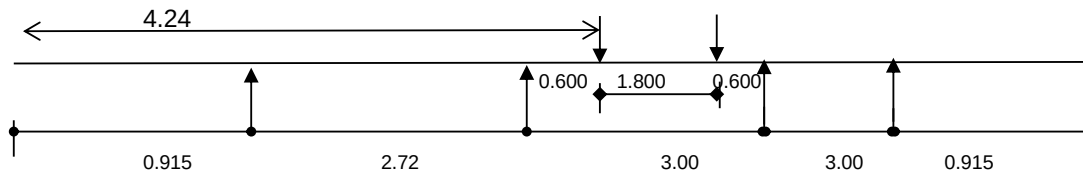
Maximum weight of single axle = 180.00 KN

nos. of wheel considered under each axle = 2.00

Weight shared by each wheel = 90.00 KN

Distance betn two axle perpendicular to span = 1.5 m

Load Nos.	Load (kN)	a (m)	bef (m)	bef1 (m)	Load (kN/m ²)
1	90	0.60	1.553	1.526	35.1
2	90	1.20	1.878	1.689	31.8



Material Specification

Concrete Grade	=	M 40	
Characteristic Compressive	=	40.00	Mpa at 28 days
Design Compressive strength of Concrete, fcd	=	17.87	Mpa at 28 days (0.67/1.5 * fck) - Refer Fig 6.5 of IRC : 112-2011
Tensile strength of concrete , fctm	=	3.03	MPa
Strain at reaching Characteristic Strength, ϵ_{c2}	=	0.02	
Ultimate Strain, ϵ_{cu2}	=	0.035	
Modulus of Elasticity of Concrete (Ec)	=	3.16E+04	N/mm ² (5000 x sqrt (fck)
Ecm	=	3.33E+04	N/mm ²
Steel Grade	=	Fe 500	D (HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500	Mpa
Design Yield Strength of Reinforcement, fyd	=	434.78	Mpa (1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	2.00E+05	Mpa
Dry weight of Concrete	=	25	kN/m ³
Dry unit weight of soil	=	20	kN/m ³
Permissible Crack Width	=	0.3	mm - For Moderate Exposure Condition
Maximum compressive stress in concrete under rare combination	=	0.48 fck	(Refer Clause 12.2.1 of IRC:112-2011)
	=	19.2	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Staad Results:

Load Cases	Moment (kNm/m)			Shear Forces at deff from Support Face (kN/m)	
	Cantilever Portion	Intermediate Support	Intermediate Span	Cantilever Portion	Intermediate Support
DL+SIDL excluding Wearing Coat	0.000	5.210	2.660	0.000	10.300
Wearing Coat	0.000	1.540	0.785	0.000	3.030
Class A	0.000	0.000	0.000	0.000	0.000
Class 70R Wheel	0.000	29.100	30.300	0.000	64.000
SV Loading	0.000	24.000	19.400	0.000	47.100

shear reduction factor = 0.000

Impact Factor for Cantilever Span = 1.5 For Span < 3 m (Fig 5 of IRC: 6-2014)

Impact Factor for Continuous Span = 1.25 For Span < 9 m (Clause 208.3 of IRC: 6-2014)

Note: No impact factor shall be applied on SV loading

Factored Forces For Design of Deck Slab

Load Cases	Load Factor	Moment (kNm/m)			Shear Forces at deff from Support Face (kN/m)	
		Cantilever Portion	Intermediate Support	Intermediate Span	Cantilever Portion	Intermediate Support
DL+SIDL excluding Wearing Coat	1.350	0.000	7.034	3.591	0.000	13.905
Wearing Coat	1.750	0.000	2.695	1.374	0.000	5.303
Class A	1.500	0.000	0.000	0.000	0.000	0.000
Class 70R Wheel	1.500	0.000	54.563	56.813	0.000	120.000
SV Loading	1.150	0.000	27.600	22.310	0.000	54.165
Total =		0.000	64.291	61.777	0.000	139.208

Support Reinforcement Calculation:

Thickness of slab = 220 mm at Interior span

Thickness of slab = 220 mm (at cantilever)

Clear Cover to outer steel = 40 mm

Maximum Diameter of Reinforcement = 12 mm

Effective Depth Provided (d_{eff}) = 174 mm

Design bending moment = 64.29 kNm/m

M_{ulim} = 0.165 x f_{ck} x b x d² = 64.29 kNm/m (Equation derived based on IRC:112-2011)

Effective Depth of Cap Required (d_{req}) = $\sqrt{\frac{64.29 \times 1000000}{0.165 \times 40.00}}$

Effective Depth of Cap Required (d_{req}) = 98.697 mm

Total Depth Required (D_{req}) = 144.70 mm

Total Depth Provided (D_{prov}) = 220.00 mm

OK

R = M_{RD} / (b d²) = 2.12

Design Moment of Resistance M_{RD} = 0.87 f_y A_{st} * (d - (λ x_u / 2))

64.29 = 0.87 f_y A_{st} * (d - (λ x_u / 2))

$$\begin{aligned}\eta &= 1 \\ f_{cd} &= 17.84 \text{ N/mm}^2 \\ f_y &= 500 \text{ N/mm}^2 \\ \lambda &= 0.8\end{aligned}$$

$$M_{RD} = 0.87 f_y A_{st} \left(d - \frac{0.87 f_y A_{st}}{b \cdot n \cdot f_{cd}} \right)$$

Area of Steel Required, $A_{st_{red}}$ = 907.0448 mm²/m

$$A_{st_{req}} = 907.0448 \text{ mm}^2/\text{m}$$

Minimum Longitudinal Reinforcement :

$$\begin{aligned}\text{As. Min} &= 0.26 \times \frac{f_{ctm}}{f_y} \times b \cdot d \quad \text{- Refer Eq. 16.5.1.1 \& 16.6.1.1 of IRC: 112-2011} \\ \text{Whichever is higher} &\text{ OR } 0.0015 \times b \cdot d \quad \text{-Refer Clause 16.9 of IRC:112-2011'} \\ b &= 1000.00 \text{ mm} \\ d &= 174.00 \text{ mm} \\ \text{Ast min} &= 274.09 \text{ mm}^2/\text{m} \\ \text{Governing Reinf. Ast} &= 907.04 \text{ mm}^2/\text{m}\end{aligned}$$

Provide 12 mm dia @ 100 mm c/c + 0 mm dia @ 100 mm c/c

Area provided=	1130.97 mm ² /m	>	907.04 mm ² /m	OK
Percentage of Steel (pt%)	=		0.65 %	

Maximum Spacing of Bars : as per Clause 16.6.1.1 of IRC:112-2011

$$\begin{aligned}S_{max} &= 2h = 348.00 \\ \text{OR} &= 250.00 \text{ mm} \quad \text{whichever is max}\end{aligned}$$

Provided Spacing is less than Smax, Hence OK

Moment of Resistance of Section corresponding to Provided Ast

$$\begin{aligned}M_{RD} &= 0.87 f_y A_{st} \left(d - \frac{0.87 f_y A_{st}}{b \cdot n \cdot f_{cd}} \right) \\ &= 78.82 \text{ kNm} > 64.29 \text{ kNm}\end{aligned}$$

SAFE

Distribution reinforcement:

Effective Depth in Long. Direction = 163 mm

As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least 20 % of the main reinforcement

$$\frac{20.00}{100.00} \times 1130.97 = 226.1947 \text{ mm}^2/\text{m}$$

Provide 10 dia bar 200 mm c/c at Trans direction in top face. (Providing = 392.69908 mm²)

Span Reinforcement Calculation:

$$\begin{aligned}\text{Clear Cover to outer steel} &= 40 \text{ mm} \\ \text{Maximum Diameter of Reinforcement} &= 12 \text{ mm} \\ \text{Effective Depth Provided (deff)} &= 174 \text{ mm} \\ \text{Design bending moment} &= 61.78 \text{ kNm/m} \\ \text{Mult} &= 0.165 \times f_{ck} \times b \times d^2 = 61.78 \text{ kNm/m} \\ \text{Effective Depth of Cap Required (dreq)} &= \text{SQRT} \left(\frac{61.78 \times 1000000}{0.165 \times 40.00 \times 1000} \right) \\ \text{Effective Depth of Cap Required (dreq)} &= 96.7481 \text{ mm} \\ \text{Total Depth Required (Dreq)} &= 142.75 \text{ mm} \\ \text{Total Depth Provided (Dprov)} &= 220.00 \text{ mm} \\ R = Mu/(b d^2) &= 2.04\end{aligned}$$

OK

Ast Required:

$$M_{RD} = 0.87 f_y A_{st} * (d - (0.87 * f_y * A_{st} / (b * n * f_{cd} * 2)))$$

$$\text{Area of Steel Required, } A_{st_{red}} = 869.112 \text{ mm}^2/\text{m}$$

$$A_{st_{req}} = 869.112 \text{ mm}^2/\text{m}$$

Minimum Longitudinal Reinforcement :

$$A_{s, \text{Min}} = 0.26 \times \frac{f_{ctm}}{f_{yk}} \times b \cdot d \quad \text{- Refer Eq. 16.5.1.1 \& 16.6.1.1 of IRC: 112-2011}$$

Whichever is higher OR $= 0.0015 \times b \cdot d$ -Refer Clause 16.9 of IRC:112-2011'

$$b = 1000.00 \text{ mm}$$

$$d = 174.00 \text{ mm}$$

$$A_{st \text{ min}} = 274.09 \text{ mm}^2/\text{m}$$

$$\text{Governing Reinf. Ast} = 869.11 \text{ mm}^2/\text{m}$$

Provide 12 mm dia @ 100 mm c/c + 0 mm dia @ 100 mm c/c

Area provided=	1130.97 mm ² /m	>	869.11 mm ² /m	OK
Percentage of Steel (pt%)	=	0.65	%	

Maximum Spacing of Bars : as per Clause 16.6.1.1 of IRC:112-2011

$$S_{max} = 2h = 348.00$$

OR $= 250.00 \text{ mm}$ whichever is max

Provided Spacing is less than Smax, Hence OK

Moment of Resistance of Section corresponding to Provided Ast

$$M_{RD} = 0.87 f_y A_{st} * (d - (0.87 * f_y * A_{st} / (b * n * f_{cd} * 2)))$$

$$= 78.82 \text{ kNm} > 61.78 \text{ kNm}$$

SAFE

Distribution reinforcement:

Effective Depth in Long. Direction = 165 mm

As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least 20 % of the main reinforcement

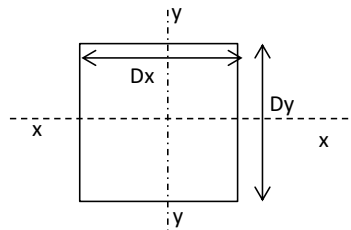
$$\frac{20.00}{100.00} \times 1130.97 = 226.1946711 \text{ mm}^2/\text{m}$$

Provide 10 dia bar 200 direction in top face. (Providing = 392.699 mm²)

Stress Check of Deck Slab**Design Forces in Rare Combination**

Load Cases	Load Factors	Moments (kNm/m)		
		Cantilever Portion	Intermediate Support	Intermediate Span
DL+SIDL excluding Wearing Coat	1.0	0.00	5.21	2.66
Wearing Coat	1.2	0.00	1.54	0.79
Class A	1.0	0.00	0.00	0.00
Class 70R Wheel	1.0	0.00	36.38	37.88
SV Loading	1.0	0.00	24.00	19.40
			43.13	41.32

Maximum Support moment (M _{xx})	=	43.125	kNm/m
Maximum compressive stress in concrete under rare combination	=	19.2	N/mm ²
Maximum tensile stress in steel under rare combination	=	300	N/mm ²

Section Properties of Uncracked Section:

width of section (D _x)	=	1000.00	mm
Depth of Section (D _y)	=	220.00	mm
Gross Cross sectional area (A _g)	=	220000	mm ²
Gross Moment of Inertia I _{gxx}	=	8.87E+08	mm ⁴
Gross Moment of Inertia I _{gyy}	=	1.83E+10	mm ⁴

Calculation of Modular Ratio:

Perimeter of section (u)	=	2440	mm
2 A _c /u	=	180.328	mm
For Dry atmospheric condition			
Creep coeff.	=	1.48	
E _{ceff}	=	1.34E+04	

Modular Ratio (m)	=	E _c / E _{ceff}	=	14.87

Details of Reinforcements:

at Support	12 mm dia @ 100 mm c/c		
	0 mm dia @ 100 mm c/c		
Total Ast provided	=	1130.97	mm ² /m
pt = A _{st} /(b*D)	=	0.0065	
effective cover	=	46	mm
C.g. Of Tension steel from N.A. (y)	=	64.00	mm
Area of concrete, A _c = (A _g - A _{st})	=	218869.03	mm ²
Transformed Area of Section A _{st} T	=	235690.1538	mm ²
Transformed M.O.I (I _{xx})	=	8.87E+08 + 64266869.8	
	=	9.52E+08	mm ⁴
Section modulus (Z _{xx})	=	I _{xx} / (D _y /2)	
	=	8650910.938	mm ³
Bending stress (M / Z _{xx})	=	4.985	N/mm ²
Tensile strength of concrete , f _{ctm}	=	3.03	N/mm ²

Cracked**Sectional Properties of Cracked Section:**

Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.

Effective Depth deff (d _y)	=	174.00	mm
Depth of neutral axis (y _b)	=	k * d _y	
where , k	=	sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	
	=	0.3535	
Depth of Neutral axis from Extreme compression face(y _b)	=	61.5160	mm
Depth of Neutral axis from Extreme Tension face(y _t)	=	158.4840	mm

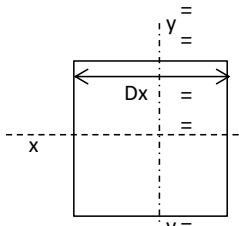
Depth of Neutral axis from c.g. Of tesion steel (ys)	=	112.4840 mm		
Cracked Moment of Inertia (Ixxcr)	=	$Dx * (k * dy)^3 / 3 + m Ast * (dy - k * dy)^2$		
	=	2.9043E+08 mm ⁴		
Maximum compressive stress in concrete=	$Mxx / Ixxcr * yb$	=	9.13 N/mm ²	< 19.2 SAFE
Maximum Tensile stress in steel=	$m * Mxx / Ixxcr * ys$	=	248.42 N/mm ²	< 300 SAFE

Crack Width Calculation of Deck Slab

Design Forces in Quasi-Permanent Combination		Moments (kNm/m)		
Load Cases	Load Factors	Cantilever Portion	Intermediate Support	InterMeediate Span
DL+SIDL excluding Wearing Coat	1	0	5.21	2.66
Wearing Coat	1.20	0	1.54	0.785
Class A	0	0	0	0
Class 70R Wheel	0	0	0	0
SV Loading	0	0	0	0
			6.75	3.45
Maximum Support moment (Mxx)			=	6.75 kNm/m

Section Properties of Uncracked Section:

width of section (Dx)	=	1000.00 mm
Depth of Section (Dy)	=	220.00 mm
Gross Cross sectional area (Ag)	=	220000 mm ²
Gross Moment of Inertia Igxx	=	8.87E+08 mm ⁴
Gross Moment of Inertia Igyy	=	1.83E+10 mm ⁴



	=	2440 mm
	=	180.328 mm

Calculation of Modular Ratio:

Perimeter of section (u)				
2 Ac/u				
For Dry atmosperic condition				
Creep coeff.				
Eceff	=	$\frac{E_{cm}}{(1 + \phi)}$	=	1.34E+04
Modular Ratio (m)	=	E_c / E_{ceff}	=	14.87

Details of Reinforcements:

at Support	12 mm dia @ 100 mm c/c			
	0 mm dia @ 100 mm c/c			
Total Ast provided			=	1130.97 mm ² /m
pt = Ast/(b*D)			=	0.0065
effective cover			=	46 mm
C.g. Of Tension steel from N.A. (y)			=	64.00 mm
Area of concrete, Ac = (Ag- Ast)			=	218869.03 mm ²
Transformed Area of Section AstT		Ac + m Ast	=	235690.1538 mm ²
Transformed M.O.I (Ixx)	Igxx+(m-1).Ast . y^2		=	8.87E+08 + 64266869.8
			=	9.52E+08 mm ⁴
Section modulus (Zxx)			=	Ixx / (Dy/2)
			=	8650910.938 mm ³
Bending stress (M/ Zxx)			=	0.780 N/mm ²
Tensile strength of concrete , fctm			=	3.03 N/mm ²

Uncracked**No need to check for Crack width as the section is uncracked****Sectional Properties of Cracked Section:**

Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.

Effective Depth deff (dy)	=	174.00 mm
Depth of neutral axis (yb)	=	k * dy
where , k	=	$\frac{\sqrt{2 p_t m + (p_t m)^2}}{2} - p_t m$
	=	0.3535
Depth of Neutral axis from Extreme compression face(yb)	=	61.5160 mm
Depth of Neutral axis from Extreme Tension face(yt)	=	158.4840 mm
Depth of Neutral axis from c.g. Of tesion steel (ys)	=	112.4840 mm
Cracked Moment of Inertia (Ixxcr)	=	$Dx * (k * dy)^3 / 3 + m Ast * (dy - k * dy)^2$
	=	2.9043E+08 mm ⁴

Maximum compressive stress in concrete=	$M_{xx}/I_{xxcr} * y_b$	=	1.43 N/mm ²	<	19.2	SAFE
Maximum Tensile stress in concrete=	$M_{xx}/I_{xxcr} * y_t$	=	3.68 N/mm ²	>	3.03	
Maximum Tensile stress in steel=	$m * M_{xx}/I_{xxcr} * y_s$	=	38.88 N/mm ²	<	300	SAFE

Crack Width Check in Deck Slab

Depth	=	220.00 mm
Maximum Dia of Tension Reinf.	=	12.00 mm
Effective width , d _{eff}	=	174.00 mm
Area of Steel on Tension, A _{st}	=	1130.97 mm ² / m

Check for crack width : Refer Clause 12.3.4 of IRC:112-2011

$$W_k = S_{r \max} (\epsilon_{sm} - \epsilon_{cm})$$

Where, S_{r max} = maximum crack spacing
 ϵ_{sm} = mean strain in the reinforcement
 ϵ_{cm} = mean strain in concrete between cracks

Below Formula For Calculation of S_{r max} is applicable if the spacing between the reinf. is less or equal to 5*(c+ ϕ /2) = 230.00 mm

Provided Spacing of Reinf. On tension face = 100.00 mm **Hence OK**

$$S_{r \max} = 3.4 c + \frac{0.425 k_1 k_2 \phi}{\rho_{p \text{ eff}}}$$

Clear Cover , c	=	40 mm
Diameter of Main Bar , ϕ	=	12 mm
Coefficient , k ₁	=	0.8 for Deformed bars
Coefficient , k ₂	=	0.5 for Bending
Depth of Neutral axis	=	61.52 mm

$$\rho_{p \text{ eff}} = A_s / A_{c \text{ eff}}, \text{ where } A_{c \text{ eff}} = \text{effective area of concrete in tension surrounding the reinf.}$$

$$h_{c \text{ eff}} = \text{Min of } 2.5 (D_y - d_y), D_y - y_b/3, D_y/2 = 110.00 \text{ mm}$$

$$A_{c \text{ eff}} = D_x * h_{c \text{ eff}} = 1000.00 \times 110.00 = 1.10 \text{E}+05 \text{ mm}^2$$

$$\rho_{p \text{ eff}} = 0.010$$

S_{r max}	=	136.00 +	198.41	=	334.41 mm

$$(\epsilon_{sm} - \epsilon_{cm}) = \frac{\sigma_{sc} - k_t f_{ct \text{ eff}} (1 + \alpha_e \rho_{p \text{ eff}})}{E_s}$$

Where ,

$$\text{Stress in the tension reinf.} = \sigma_{sc} = 38.883 \text{ N/mm}^2 \text{ from Rare Combination}$$

$$k_t = 0.50$$

$$\text{Tensile strength of concrete} = f_{ct \text{ eff}} = f_{ctm} = 3.03 \text{ Mpa}$$

$$\alpha_e = \frac{E_s}{E_{cm}} \text{ where , } E_s = 2.00 \text{E}+05 \text{ N/mm}^2, E_{cm} = 3.33 \text{E}+04 \text{ N/mm}^2$$

$$\alpha_e = 6.00$$

$$0.6 \sigma_{sc} / E_s = 0.0001$$

$$(\epsilon_{sm} - \epsilon_{cm}) = \frac{38.88 - 156.40}{2.00 \text{E}+05} = -0.00059$$

W_k	=	0.04 mm	<0.3mm,SAFE

STAAD ANALYSIS FOR DECK SLAB DESIGN

STAAD PLANE ANALYSIS FOR DESIGN OF SLAB (DL+SIDL+CWLL)

PAGE NO. 1

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*****
*                               *
*      STAAD.Pro CONNECT Edition      *
*      Version  21.00.01.12          *
*      Proprietary Program of        *
*      Bentley Systems, Inc.         *
*      Date=    JUN 10, 2020         *
*      Time=    19:31:20             *
*                               *
*****

```

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1. STAAD SPACE
INPUT FILE: D:\MISC\CDPL\Chamba Bridge\Design\Deck Slab\Staad\Deck Slab.STD
2. START JOB INFORMATION
3. ENGINEER DATE 02-JULY-2015
4. END JOB INFORMATION
5. INPUT WIDTH 79
6. UNIT METER KN
7. JOINT COORDINATES
8. 2 0.915 0 0; 3 4.015 0 0; 4 7.115 0 0; 5 10.215 0 0; 6 13.315 0 0
9. 7 16.415 0 0; 8 0 0 0
10. MEMBER INCIDENCES
11. 2 2 3; 3 3 4; 4 4 5; 5 5 6; 6 6 7; 7 8 2
12. DEFINE MATERIAL START
13. ISOTROPIC CONCRETE
14. E 3.33E+007
15. POISSON 0.17
16. DENSITY 25
17. ALPHA 1E-005
18. DAMP 0.05
19. END DEFINE MATERIAL
20. MEMBER PROPERTY INDIAN
21. 2 TO 7 PRIS YD 0.25 ZD 1
22. CONSTANTS
23. MATERIAL CONCRETE ALL
24. SUPPORTS
25. 2 TO 7 PINNED
26. *****
27. LOAD 1 SELF WEIGHT OF SLAB
28. SELFWEIGHT Y -1
29. MEMBER LOAD
30. 2 TO 7 UNI GY -1.28
31. *****
32. LOAD 2 WEARING COAT
33. MEMBER LOAD
34. 2 TO 7 UNI GY -2
35. *****
36. *LOAD 3 1 LANE CLASS-A
37. *MEMBER LOAD

```


38. *7 UNI GY -90.7 0.396 1

STAAD SPACE

-- PAGE NO. 2

39. *2 UNI GY -90.7 0 0.404

40. *2 UNI GY -37.5 1.196 2.204

41. *****

42. LOAD 4 1-LANE 70-WHEEL (MAX SAGGING MOMENT)

43. MEMBER LOAD

44. 2 UNI GY -49.43 3.02425 3.1

45. 3 UNI GY -49.43 0 0.79575

46. 3 UNI GY -39.72 0.75875 1.55125

47. 3 UNI GY -39.72 1.54875 2.34125

48. 3 UNI GY -49.43 2.30425 3.1

49. 4 UNI GY -49.43 0 0.0757

51. *****

52. LOAD 5 70R WHEEL (MAX HOGGING MOMENT)

53. MEMBER LOAD

54. 2 UNI GY -36.06 1.47425 2.34575

55. 2 UNI GY -51.64 2.30875 3.10125

56. 3 UNI GY -51.64 -0.001 0.79125

57. 3 UNI GY -36.06 0.754 1.62575

59. *****

60. LOAD 6 SV LOAD (MAX HOGGING MOMENT)

61. MEMBER LOAD

62. 3 UNI GY -29.55 1.0905 1.9595

63. 3 UNI GY -35.03 1.8405 2.7095

64. 4 UNI GY -35.03 0.0905 0.9595

65. 4 UNI GY -29.55 0.8405 1.7095

67. *****

68. LOAD 7 SV LOAD (MAX SAGGING MOMENT)

69. MEMBER LOAD

70. 3 UNI GY -32.9 2.881 3.100

71. 4 UNI GY -32.9 0 1.519

72. 4 UNI GY -29.58 1.581 3.10

73. 5 UNI GY -29.58 0 0.220

75. *****

76. PERFORM ANALYSIS

PROBLEM STATISTICS

NUMBER OF JOINTS	7	NUMBER OF MEMBERS	6
NUMBER OF PLATES	0	NUMBER OF SOLIDS	0
NUMBER OF SURFACES	0	NUMBER OF SUPPORTS	6

Using 64-bit analysis engine.

SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

ORIGINAL/FINAL BAND-WIDTH= 6/ 6/ 24 DOF
 TOTAL PRIMARY LOAD CASES = 6, TOTAL DEGREES OF FREEDOM = 24
 TOTAL LOAD COMBINATION CASES = 0 SO FAR.
 SIZE OF STIFFNESS MATRIX = 1 DOUBLE KILO-WORDS
 REQD/AVAIL. DISK SPACE = 12.0/ 275081.8 MB

STAAD SPACE

-- PAGE NO. 3

***WARNING - INSTABILITY AT JOINT 8 DIRECTION = MX
 PROBABLE CAUSE SINGULAR-ADDING WEAK SPRING
 K-MATRIX DIAG= 6.0406302E+05 L-MATRIX DIAG= -1.1641532E-10 EQN NO 22
 ***NOTE - VERY WEAK SPRING ADDED FOR STABILITY

NOTE STAAD DETECTS INSTABILITIES AS EXCESSIVE LOSS OF SIGNIFICANT DIGITS
 DURING DECOMPOSITION. WHEN A DECOMPOSED DIAGONAL IS LESS THAN THE
 BUILT-IN REDUCTION FACTOR TIMES THE ORIGINAL STIFFNESS MATRIX DIAGONAL,
 STAAD PRINTS A SINGULARITY NOTICE. THE BUILT-IN REDUCTION FACTOR
 IS 1.000E-09

THE ABOVE CONDITIONS COULD ALSO BE CAUSED BY VERY STIFF OR VERY WEAK
 ELEMENTS AS WELL AS TRUE SINGULARITIES.

77. PRINT MEMBER FORCES
 STAAD SPACE

-- PAGE NO. 4

MEMBER END FORCES STRUCTURE TYPE = SPACE

ALL UNITS ARE -- KN METE (LOCAL)

MEMBER LOAD JT AXIAL SHEAR-Y SHEAR-Z TORSION MOM-Y MOM-Z

2	1	2	0.00	10.51	0.00	0.00	0.00	3.15
		3	0.00	12.84	0.00	0.00	0.00	-6.76
2	2	0.00	2.79	0.00	0.00	0.00	0.84	
		3	0.00	3.41	0.00	0.00	0.00	-1.80
4	2	0.00	-6.66	0.00	0.00	0.00	0.00	
		3	0.00	10.40	0.00	0.00	0.00	-20.78
5	2	0.00	7.90	0.00	0.00	0.00	-0.00	
		3	0.00	64.39	0.00	0.00	0.00	-29.09
6	2	0.00	-2.17	0.00	0.00	0.00	0.00	
		3	0.00	2.17	0.00	0.00	0.00	-6.73
7	2	0.00	1.19	0.00	0.00	0.00	-0.00	
		3	0.00	-1.19	0.00	0.00	0.00	3.69
3	1	3	0.00	11.94	0.00	0.00	0.00	6.76
		4	0.00	11.41	0.00	0.00	0.00	-5.94
2	3	0.00	3.17	0.00	0.00	0.00	1.80	
		4	0.00	3.03	0.00	0.00	0.00	-1.58
4	3	0.00	70.19	0.00	0.00	0.00	20.78	
		4	0.00	71.44	0.00	0.00	0.00	-22.73
5	3	0.00	62.92	0.00	0.00	0.00	29.09	
		4	0.00	9.43	0.00	0.00	0.00	-4.75
6	3	0.00	15.21	0.00	0.00	0.00	6.73	
		4	0.00	40.91	0.00	0.00	0.00	-25.15
7	3	0.00	-6.01	0.00	0.00	0.00	-3.69	
		4	0.00	13.22	0.00	0.00	0.00	-15.74
4	1	4	0.00	11.76	0.00	0.00	0.00	5.94

```

      5  0.00  11.58  0.00  0.00  0.00  0.00  -5.66
2    4  0.00   3.12  0.00  0.00  0.00  0.00   1.58
      5  0.00   3.08  0.00  0.00  0.00  0.00  -1.50
4    4  0.00  12.94  0.00  0.00  0.00  0.00  22.73
      5  0.00  -9.20  0.00  0.00  0.00  0.00   5.93
5    4  0.00   1.93  0.00  0.00  0.00  0.00   4.75
      5  0.00  -1.93  0.00  0.00  0.00  0.00   1.25
6    4  0.00  47.09  0.00  0.00  0.00  0.00  25.15
      5  0.00   9.03  0.00  0.00  0.00  0.00  -4.44
7    4  0.00  48.87  0.00  0.00  0.00  0.00  15.74
      5  0.00  46.04  0.00  0.00  0.00  0.00 -15.33

5  1  5  0.00  11.04  0.00  0.00  0.00   5.66
      6  0.00  12.30  0.00  0.00  0.00  0.00  -7.61
2    5  0.00   2.93  0.00  0.00  0.00  0.00   1.50
      6  0.00   3.27  0.00  0.00  0.00  0.00  -2.02
STAAD SPACE                                -- PAGE NO.  5

```

MEMBER END FORCES STRUCTURE TYPE = SPACE

ALL UNITS ARE -- KN METE (LOCAL)

MEMBER LOAD JT AXIAL SHEAR-Y SHEAR-Z TORSION MOM-Y MOM-Z

```

4    5  0.00  -2.39  0.00  0.00  0.00  -5.93
      6  0.00   2.39  0.00  0.00  0.00  -1.46
5    5  0.00  -0.50  0.00  0.00  0.00  -1.25
      6  0.00   0.50  0.00  0.00  0.00  -0.31
6    5  0.00   1.78  0.00  0.00  0.00   4.44
      6  0.00  -1.78  0.00  0.00  0.00   1.09
7    5  0.00  12.39  0.00  0.00  0.00  15.33
      6  0.00  -5.88  0.00  0.00  0.00   3.61

6  1  6  0.00  14.13  0.00  0.00  0.00   7.61
      7  0.00   9.22  0.00  0.00  0.00   0.00
2    6  0.00   3.75  0.00  0.00  0.00   2.02
      7  0.00   2.45  0.00  0.00  0.00  -0.00
4    6  0.00   0.47  0.00  0.00  0.00   1.46
      7  0.00  -0.47  0.00  0.00  0.00   0.00
5    6  0.00   0.10  0.00  0.00  0.00   0.31
      7  0.00  -0.10  0.00  0.00  0.00   0.00
6    6  0.00  -0.35  0.00  0.00  0.00  -1.09
      7  0.00   0.35  0.00  0.00  0.00  -0.00
7    6  0.00  -1.16  0.00  0.00  0.00  -3.61
      7  0.00   1.16  0.00  0.00  0.00   0.00

7  1  8  0.00   0.00  0.00  0.00  0.00  -0.00
      2  0.00   6.89  0.00  0.00  0.00  -3.15
2    8  0.00   0.00  0.00  0.00  0.00   0.00
      2  0.00   1.83  0.00  0.00  0.00  -0.84
4    8  0.00  -0.00  0.00  0.00  0.00  -0.00
      2  0.00   0.00  0.00  0.00  0.00  -0.00
5    8  0.00   0.00  0.00  0.00  0.00   0.00
      2  0.00   0.00  0.00  0.00  0.00   0.00
6    8  0.00   0.00  0.00  0.00  0.00  -0.00

```

	2	0.00	-0.00	0.00	0.00	0.00	-0.00
7	8	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	-0.00	0.00	0.00	0.00	0.00

***** END OF LATEST ANALYSIS RESULT *****

78. FINISH

Annexure-I : Steel Quantity**Steel Quantity for 180 m open spandrel Steel arch**

	=	Weight (KN)
Arch	=	6526.828
Arch Bracing	=	940.635
Spandrel Column	=	1065.473
Cap Beam	=	549.5
Superstructure	=	2762.372
Column Tie	=	32.932
Total		11877.74

Consider	20% extra for waste	=	1453	Ton	say	1500 Ton
Plan area of truss		=	190 x		12.5 =	2375 sqm
Steel required		=	1500 /		2375 =	0.63 T/sqm
					=	632 kg/sqm

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)
PRISMATIC STEEL	386.72	6526.828

TOTAL =	6526.828	

TOTAL VOLUME OF PRISMATIC STEEL SECTIONS = 83.14 CUBIC METE

***** END OF DATA FROM INTERNAL STORAGE *****

1780. STEEL TAKE OFF LIST 97 TO 290 5432 TO 5625
 (ARCH SPAN 180.0M WITH TWIN RIBS)-12.0M WIDE FOR DL & SI -- PAGE NO. 42

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)
ST PIP3556H	1371.01	940.635

TOTAL =	940.635	

***** END OF DATA FROM INTERNAL STORAGE *****

1781. STEEL TAKE OFF LIST 291 TO 304 5626 TO 5641
 (ARCH SPAN 180.0M WITH TWIN RIBS)-12.0M WIDE FOR DL & SI -- PAGE NO. 43

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)
PRISMATIC STEEL	164.52	1065.473

TOTAL =	1065.473	

TOTAL VOLUME OF PRISMATIC STEEL SECTIONS = 13.57 CUBIC METE

***** END OF DATA FROM INTERNAL STORAGE *****

1782. STEEL TAKE OFF LIST 305 TO 360

(ARCH SPAN 180.0M WITH TWIN RIBS)-12.0M WIDE FOR DL & SI -- PAGE NO. 44

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)
PRISMATIC STEEL	56.00	549.500

TOTAL =	549.500	

TOTAL VOLUME OF PRISMATIC STEEL SECTIONS = 7.00 CUBIC METE

***** END OF DATA FROM INTERNAL STORAGE *****

WARNING- One or more lines are too long and will be split into 2 lines.

This may not work for all commands. Please check.

1784. STEEL TAKE OFF LIST 539 TO 552 595 TO 608 2975 TO 2986 3023 TO 3034 3335 TO -
(ARCH SPAN 180.0M WITH TWIN RIBS)-12.0M WIDE FOR DL & SI -- PAGE NO. 45

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)

1785. 3346 3383 -
1786. 3384 TO 3394 3695 TO 3706 3743 TO 3754 4055 TO 4066 4103 TO 4114 4415 TO 4426 -
1787. 4463 TO 4474 4775 TO 4786 4823 TO 4834 5159 TO 5172 5215 TO 5228 511 TO 524 -
1788. 623 TO 636 2951 TO 2962 3047 TO 3058 3311 TO 3322 3407 -
1789. 3408 TO 3418 3671 TO 3682 3767 TO 3778 4031 TO 4042 4127 TO 4138 4391 TO 4402 -
1790. 4487 TO 4498 4751 TO 4762 4847 TO 4858 5131 TO 5144 5243 TO 5256 -
1791. 651 TO 660 791 TO 800 3181 TO 3190 3541 TO 3550 3901 TO 3910 4261 -
1792. 4262 TO 4270 4621 TO 4630 4981 TO 4990 5401 TO 5410 -
1793. 671 TO 680 691 TO 700 711 TO 720 731 TO 740 751 TO 760 -
1794. 771 TO 780 3081 TO 3090 3101 TO 3110 3121 TO 3130 3141 TO 3150 3161 TO 3170 -
1795. 3441 TO 3450 3461 TO 3470 3481 TO 3490 3501 TO 3510 3521 TO 3530 -
1796. 3801 TO 3810 3821 TO 3830 3841 TO 3850 3861 TO 3870 3881 TO 3890 -

1797. 4161 TO 4170 4181 TO 4190 4201 TO 4210 4221 TO 4230 4241 TO 4250 -
 1798. 4521 TO 4530 4541 TO 4550 4561 TO 4570 4581 TO 4590 4601 TO 4610 -
 1799. 4881 TO 4890 4901 TO 4910 4921 TO 4930 4941 TO 4950 4961 TO 4970 -
 1800. 5281 TO 5290 5301 TO 5310 5321 TO 5330 5341 TO 5350 5361 TO 5370 -
 1801. 5381 TO 5390

Tapered	MembNo:	511	375.00	522.221
Tapered	MembNo:	539	375.00	1730.925
Tapered	MembNo:	651	617.10	509.226

 TOTAL = 2762.372

***** END OF DATA FROM INTERNAL STORAGE *****

1803. STEEL TAKE OFF LIST 5411 TO 5431
 (ARCH SPAN 180.0M WITH TWIN RIBS)-12.0M WIDE FOR DL & SI -- PAGE NO. 46

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)

In Steel Takeoff the density of steel is assumed for members with no density.

 TOTAL = 0.000

***** END OF DATA FROM INTERNAL STORAGE *****

1804. STEEL TAKE OFF LIST 5642 TO 5649
 (ARCH SPAN 180.0M WITH TWIN RIBS)-12.0M WIDE FOR DL & SI -- PAGE NO. 47

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)

ST PIP3556H	48.00	32.932

 TOTAL = 32.932

**DESIGN OF PIER P3 & P4 WITH PILE
FOUNDATION SUPPORTING SPANDREL
ARCH**

Detailed Design of Substructure & Pile Foundation

Span Arrangement

Left Span			Right Span		
c/c distance between Bearing - Left Span	=	23.800 m	c/c distance between Bearing -Right Span	=	23.800 m
projection beyond CL of brg.-Left support	=	0.575 m	projection beyond CL of brg.-Left support	=	0.575 m
projection beyond CL of brg.-Right support	=	0.575 m	projection beyond CL of brg.-Right support	=	0.575 m
Total Length of Left Span	=	24.950 m	Total Length of Right Span	=	24.950 m
Expansion Gap	=	50.000 mm	Expansion Gap	=	50.000 mm
c/c distance between Expansion Gap - Left Span	=	25.00 m	c/c distance bet. Expansion Gap - Right Span	=	25.00 m
Coeff. Of friction for Pot-PTFE bearing for Left Side	=	0.05	Coeff. Of friction for Pot-PTFE bearing for Right Side	=	0.05
Congestion Factor	=	1.000	Congestion Factor	=	1.000
Type of Superstructure	=	Composite Steel Plate Girder	Type of Superstructure	=	Composite Steel Plate Girder
Radius of Curvature	=	0.000 m			

Angle of Skew

= 0 Degrees

Cos 0	=	1.000	Sin 0	=	0.000	tan 0	=	0.000

Calculation of Impact Factor

AS per IRC 6:2014, Clause 208.2

Impact Factor - 70 RW		=	1.241	Superstructure	Impact Factor - 70 RW		=	1.241	Superstructure
Impact Factor -Class A	{1+9/(13.5+L)}	=	1.241	Superstructure	Impact Factor -Class A	{1+9/(13.5+L)}	=	1.241	Superstructure
Impact Factor - 70 RW		=	1.241	Bearing	Impact Factor - 70 RW		=	1.241	Bearing
Impact Factor -Class A		=	1.241	Bearing	Impact Factor -Class A		=	1.241	Bearing
Impact Factor - 70 RW		=	1.121	Pier Cap	Impact Factor - 70 RW		=	1.121	Pier Cap
Impact Factor -Class A		=	1.121	Pier Cap	Impact Factor -Class A		=	1.121	Pier Cap

Bearings

Type of Bearing	=	SPHERICAL BEARING	Type of Bearing	=	SPHERICAL BEARING
No of Bearings/Pedestral	=	2	No of Bearings/Pedestral	=	2
C/C Distance of Bearing in Transverse Direction=	7.500m	(Skew)	C/C Distance of Bearing in Transvers	=	7.500m (Skew)

Details of Superstructures and Salient Reduced Levels's (RL's)

LEFT SIDE SPAN

Deck level at Median edge	=	1198.000 m
Deck level at outer edge	=	1197.856 m
Deck level at center line of bridge	=	1198.000 m
Soffit Level	=	1196.215 m
Pier Cap Top Level	=	1196.309 m
Bearing Level	=	1196.309 m
C/C of span	=	23.800 m
Max Depth of Superstructure	=	1.720 m

RIGHT SIDE SPAN

Deck level at Median Edge	=	1198.000 m
Deck level at outer edge	=	1197.856 m
Deck level at center line of bridge	=	1198.000 m
Soffit Level	=	1196.215 m
Pier Cap Top Level	=	1196.309 m
Bearing Level	=	1196.759 m
C/C of span	=	23.800 m
Max Depth of Superstructure	=	1.720 m

Depth of Bearing+Pedestal 1	=	0.450 m	Bearing Plate	=	0.00 m
Depth of Bearing+Pedestal 2	=	0.450 m	Depth of Bearing+Pedestal 1	=	0.450 m
Depth of Bearing+Pedestal 3	=	0.000 m	Depth of Bearing+Pedestal 2	=	0.450 m
Depth of Bearing+Pedestal 4	=	0.000 m	Depth of Bearing+Pedestal 3	=	0.000 m
Depth of Bearing+Pedestal 5	=	0.000 m	Depth of Bearing+Pedestal 4	=	0.000 m
Depth of Bearing+Pedestal 6	=	0.000 m	Depth of Bearing+Pedestal 5	=	0.000 m
Depth of Bearing+Pedestal 7	=	0.000 m	Depth of Bearing+Pedestal 6	=	0.000 m
Distance of nearest girder from c.l. of bridge	=	3.750 m	Depth of Bearing+Pedestal 7	=	0.000 m
Depth of Bow string arch	=	0.000 m	Distance of nearest girder from c.l. of bridge	=	3.750 m
			Depth of Bow string arch	=	0.000 m

Common For Both Span

Pier Cap Bottom Level	=	1194.709 m	Thickness of Wearing Coat	=	0.065 m
Pier Shaft Top Level	=	1194.709 m	Camber slope	=	2.50 %
Pier Shaft Bottom Level	=	1142.500 m	Width of Carriageway	=	11.5 m
GL/FL/LBL/Cross road level	=	1142.500 m	Total Width of Superstructure	=	12.5 m
Pile Cap Top Level	=	1142.500 m	Nos. of Lane for design purpose	=	3 LANE
Pile Cap Bottom Level	=	1132.500 m	Dia of Pile	=	1.20 m
Pile Tip Level	=	1112.500 m	Depth of Pile Cap	=	10.00 m
			Length of Pile	=	20.00 m
Rock level	=	1117.500 m	Nos of Pile in Longitudinal Side in one	=	5 Nos
			Nos of Pile in Transverse Side in one	=	4 Nos
			Wedge over girder	=	0 m
			Cross girder depth below centre girder	=	0.000 m

C.G OF CRASH Barrier From Deck Top	=	0.447 m	C.G OF CRASH Barrier From Deck T	=	0.447 m
C.G OF Wearing Course from Deck Top	=	0.033 m			

Dimensions of Substructure & Foundation**(i) Pier Cap****Along L-L Axis**

Width of Uniform Portion	=	2.500 m Right
Width of Uniform Portion	=	2.500 m Skew
Width of Cap at Bottom	=	2.300 m Right
Height of Uniform depth	=	0.800 m
Height of triangular portion	=	0.800 m

Along T-T Axis

Length of Uniform Portion	=	11.000 m Right
Length of Uniform Portion	=	11.000 m Skew
Length of Varying Portion at bottom	=	10.500 m Skew

		SPAN-LEFT		SPAN-Right		Expansion Gap		
C/C distance of Bearing along L-L	=	-2.270	+	0.000	+	0.000	=	-2.270 m
C/C distance of Bearing along T-T	=	7.500 m	(Straight)	7.500m	(Skew)			
C.G. of pier cap about centre line of	=	-2.270 m						

(ii) Pier Shaft

Shape of Pier shaft	=	Rectangular						
Width/Dia of pier shaft	=	2.000 m	No of Pier	=	2	c/c distance between Piers	=	7.500
Length/Dia. of Pier	=	3.000 m						
cut water portion(semi-circular)	=	0.000 m	0.0000			Height of Pier shaft	=	52.209 m

Length / Dia of pier = 0.000 m
 C.G. of pier shaft about centre line c = -2.270 m

(iii) Pile Cap

along L-L Axis

Projection of Pile Cap on Left Side of Pier = 6.950 m
 Projection of Pile Cap on Right Side of Pier = 6.950 m
 Distance Between Piles Centre in Longitudinal Direction = 3.600 m
 Projection of Pile Cap from C/L of piles in longitudinal direction = 0.750 m
 Length of Pile Cap in Longitudinal Direction = 15.900 m
 Top width of pile cap in long. Direction = 5.788
 Top width of pile cap in trans. Direction = 12.300
 Thickness of pile cap one end = 10.000
 Thickness of pile cap on another end = 2.000

along T-T Axis

Projection of Pile Cap on Footpath Side of Pier = 3.750 m
 Projection of Pile Cap on Median Side of Pier = 3.750 m
 Distance Between Piles Centre in Transverse Direction = 4.500 m
 Projection of Pile Cap from C/L of piles in Transverse direction = 0.750 m
 Projection of Pile Cap from C/L of piles in Transverse direction = 0.750 m
 Length of Pile Cap in Transverse Direction = 15.000 m

Design Data & Material Specification

For Pier and Pier Cap

Conc Grade = M 35
 Characteristic Compressive Strength of Concrete, f_{ck} = 35.00 Mpa at 28 days
 Design Compressive strength of Concrete, f_{cd} = 15.63 Mpa at 28 days (0.67/1.5 * f_{ck})
 Tensile strength of concrete, f_{ctm} = 2.77 MPa
 Strain at reaching Characteristic Strength, ϵ_{c2} = 0.02
 Ultimate Strain, ϵ_{cu2} = 0.035
 Modulus of Elasticity of Concrete (E_c) = 29580.40 N/mm² (5000 x sqrt (f_{ck}))
Steel Grade = Fe 500 D (HYSD Steel)
 Yield Strength of Reinforcement, f_y or f_{yk} = 500 Mpa
 Design Yield Strength of Reinforcement, f_{yd} = 434.78 Mpa (1/1.15 * f_y)
 Modulus of Elasticity of Steel (E_s) = 200000.00 Mpa
 Dry weight of Concrete = 25 kN/m³
 Dry unit weight of soil = 20 kN/m³
 Permissible Crack Width = 0.3 mm - For Moderate Exposure Condition

For Pile and Pile Cap

Conc Grade = M 35
 Characteristic Compressive Strength of Concrete, f_{ck} = 35.00 Mpa at 28 days
 Design Compressive strength of Concrete, f_{cd} = 15.63 Mpa at 28 days (0.67/1.5 * f_{ck})
 Tensile strength of concrete, f_{ctm} = 2.77 MPa
 Strain at reaching Characteristic Strength, ϵ_{c2} = 0.02
 Ultimate Strain, ϵ_{cu2} = 0.035
 Modulus of Elasticity of Concrete (E_c) = 29580.40 N/mm² (5000 x sqrt (f_{ck}))
Steel Grade = Fe 500 D (HYSD Steel)
 Yield Strength of Reinforcement, f_y or f_{yk} = 500 Mpa
 Design Yield Strength of Reinforcement, f_{yd} = 434.78 Mpa (1/1.15 * f_y)
 Modulus of Elasticity of Steel (E_s) = 200000.00 Mpa

Type of Soil = 1 Hard or Rocky Strata

Maximum compressive stress in concrete

(Refer Clause 12.2.1 of IRC:112-2011)

under rare combination = 16.8 N/mm²
 Under Quasi-Permanent Combination = 12.6 N/mm²
 Maximum tensile stress in steel = 300 N/mm²

Clear Cover to Reinforcement

Cover for pier shaft = 50 mm
 Cover for pile cap and pile shaft = 75 mm

Seismic Data:

Seismic Zone	=	5		
Z =Zone factor	=	0.36		
I =Importance factor	=	1.2	for important bridges	
R =Response Reduction factor	=	3	in Longitudinal direction	For substructure except pier cap
	=	3	In Transverse direction	For substructure except pier cap
	=	3	For Pier Cap/Beam	
Vertical load capacity of pile (Normal Case)	=	6500 KN	Assumed	-Refer IS 2911: Part I/Section 3, Clause 5.9
Vertical load capacity of pile (Wind Case)	=	8775 KN	multiplied by 1.35%	factor will vary from 1.25 to 1.50%
Vertical load capacity of pile (Seismic Case)	=	8775 KN	multiplied by 1.35%	
Horizontal load capacity of pile (Normal Case)	=	650.0 KN	Assumed	

CALCULATION OF DEAD LOAD , SIDL , CWLL**Dead Load Reaction from Superstructure Analysis**

		LHS		Trans. Ecce. (m) skew		RHS		Trans. Ecce. (m) skew
DL reaction on Bearing1	=	585.94	kN	3.750	DL reaction on Bearing	585.94	kN	3.750
DL reaction on Bearing2	=	585.94	kN	-3.750	DL reaction on Bearing	585.94	kN	-3.750
DL reaction on Bearing3	=	0.00	kN	0.000	DL reaction on Bearing	0.00	kN	0.000
DL reaction on Bearing4	=	0.00	kN	0.000	DL reaction on Bearing	0.00	kN	0.000
DL reaction on Bearing5	=	0.00	kN	0.000	DL reaction on Bearing	0.00	kN	0.000
DL reaction on Bearing6	=	0.00	kN	0.000	DL reaction on Bearing	0.00	kN	0.000
DL reaction on Bearing7	=	0.00	kN	0.000	DL reaction on Bearing	0.00	kN	0.000
Total DL Reaction	=	1171.875	kN	0.000	Total DL Reaction	1171.875	kN	0.000

SIDL Reaction from Superstructure Analysis (without Wearing Course)

		LHS		Trans. Ecce. (m)		RHS		Trans. Ecce. (m)
SIDL reaction on Bearing1	=	125.000	kN	3.750	SIDL reaction on Beari	125.000	kN	3.750
SIDL reaction on Bearing2	=	125.000	kN	-3.750	SIDL reaction on Beari	125.000	kN	-3.750
SIDL reaction on Bearing3	=	0.000	kN	0.000	SIDL reaction on Beari	0.000	kN	0.000
SIDL reaction on Bearing4	=	0.000	kN	0.000	SIDL reaction on Beari	0.000	kN	0.000
SIDL reaction on Bearing5	=	0.000	kN	0.000	SIDL reaction on Beari	0.000	kN	0.000
SIDL reaction on Bearing6	=	0.000	kN	0.000	SIDL reaction on Beari	0.000	kN	0.000
SIDL reaction on Bearing7	=	0.000	kN	0.000	SIDL reaction on Beari	0.000	kN	0.000
Total SIDL Reaction	=	250.000	kN	0.000	Total SIDL Reaction	250.000	kN	0.000

Reaction due to Wearing Coat from Superstructure Analysis

		LHS		Trans. Ecce. (m)		RHS		Trans. Ecce. (m)
WC reaction on Bearing1	=	156.250	kN	3.750	WC reaction on Bearin	156.250	kN	3.750
WC reaction on Bearing2	=	156.250	kN	-3.750	WC reaction on Bearin	156.250	kN	-3.750
WC reaction on Bearing3	=	0.000	kN	0.000	WC reaction on Bearin	0.000	kN	0.000
WC reaction on Bearing4	=	0.000	kN	0.000	WC reaction on Bearin	0.000	kN	0.000
WC reaction on Bearing5	=	0.000	kN	0.000	WC reaction on Bearin	0.000	kN	0.000
WC reaction on Bearing6	=	0.000	kN	0.000	WC reaction on Bearin	0.000	kN	0.000
WC reaction on Bearing7	=	0.000	kN	0.000	WC reaction on Bearin	0.000	kN	0.000
TOTAL REACTION (WC)	=	312.500	kN	0.000	TOTAL REACTION (V	312.500	kN	0.000

FPLL reaction on Bearing1	=	0.0	kN	FPLL reaction on Bearin	0.000	kN
FPLL reaction on Bearing2	=	0.0	kN	FPLL reaction on Bearin	0.000	kN
FPLL reaction on Bearing3	=	0.0	kN	FPLL reaction on Bearin	0.000	kN
FPLL reaction on Bearing4	=	0.0	kN	FPLL reaction on Bearin	0.000	kN
Total FPLL reaction	=	0.000	kN	Total FPLI	=	0.000 kN

Reduction Factor = 1.0 (For a 2 Lane carriageway) - Refer Clause 205 of IRC: 6-2014

Maximum Live load Reaction from Superstructure Analysis**From Annexure-I****MAXIMUM REACTION CASE:** Reduction Factor = 0.9

1-70R + 1-CLASS A

Total Reaction on LHS brg.	1058.52 kN	and Corresponding Transverse moment	1005.60 kNm
Total Reaction on RHS brg.	291.48 kN	and Corresponding Transverse moment	276.90 kNm

MAXIMUM TRASVERSE MOMENT CASE:

Reduction Factor = 1

1-70R

Total Reaction on LHS brg.	808.87 kN	and Corresponding Transverse moment	2552.00 kNm
Total Reaction on RHS brg.	191.13 kN	and Corresponding Transverse moment	603.00 kNm

Arch Support Reaction-ULS

C.G. of Arch base from C.G. of footing

From Staad Pro Analysis

= 2.80

L/C	Force-X kN	Force-Y kN	Force-Z kN	Moment-X kN-m	Moment-Y kN-m	Moment-Z kN-m	
100	38902	38140	0	3	-3	-9463	1.0DL + 1.00SIDL + 1.00WC
101	74325	57714	-6718	5857	-13701	-75281	LOAD 101 - 1.35DL + 1.35SIDL + 1.75WC
102	49535	40995	-10643	88110	-107353	-54418	LOAD 102 - 1.35DL + 1.35SIDL + 1.75WC + 0.9WL + 0.9TH
103	66252	57665	-10666	89820	-109508	-86911	LOAD 103 - 1.35DL + 1.35SIDL + 1.75WC - 0.9WL + 0.9TH
104	49535	40995	-10643	88110	-107353	-54418	LOAD 104 - 1.35DL + 1.35SIDL + 1.75WC + 1.5WL + 0.9TH
105	66252	57665	-10666	89820	-109508	-86911	LOAD 105 - 1.35DL + 1.35SIDL + 1.75WC - 1.5WL + 0.9TH
106	55228	46271	3733	6345	7509	25452	LOAD 106 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 (EQL + 0.3EQT + 0.3EQ
107	-43050	46170	3740	6353	7583	40893	LOAD 107 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 (EQL + 0.3EQT + 0.3EQ
108	-45538	44044	3819	8155	9683	36772	LOAD 108 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 (0.3EQL + EQT + 0.3EQ
109	52704	44112	3811	8114	9568	-25724	LOAD 109 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 (0.3EQL + EQT + 0.3EQ
110	-37388	44133	42	902	1209	22469	LOAD 110 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 (0.3EQL + 0.3EQT + EQ
111	46612	44162	41	886	1119	-5327	LOAD 111 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 (0.3EQL + 0.3EQT + EQ
112							LOAD 112 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 WL (DOWNWARD)+
113							LOAD 113 - 1.35DL + 1.35SIDL + 1.75WC + 1.5 WL (UPWARD)+0.9TI

Arch Support Reaction-ULS

C.G. of Arch base from C.G. of footing

From Staad Pro Analysis

= 2.80 m

IN Long. Direction

= 0.00 m

In trasverse direction

	Force-X kN	Force-Y kN	Force-Z kN	Moment-X kN-m (MT)	Moment-Y kN-m	Moment-Z kN-m (ML)
Normal Case	74325.21	57713.97	6717.95	5856.84	13700.68	75280.89
Seismic Case	55228.16	46270.77	3819.27	8154.57	9682.72	40893.46
Wind Case	66251.57	57664.63	10665.63	89820.26	109508.29	86910.77

Computation of volumes of Subsoil Components**i) Bearing Pedestal**

Left Span :

Pedestal 1	=	0.450 x	0.800 x	0.800 =	0.2880 m ³	Trans. Ecc 3.750
Pedestal 2	=	0.450 x	0.800 x	0.800 =	0.2880 m ³	-3.750
					0.5760 m ³	0.000

Right Span :

Pedestal 1	=	0.450 x	0.800 x	0.800 =	0.2880 m ³	3.750
Pedestal 2	=	0.450 x	0.800 x	0.800 =	0.2880 m ³	-3.750
					0.5760 m ³	0.000

ii) Seismic Arrestor

Left Span:

Long. Arrestor	=	0.3716 m ³				Nos. 2
Transverse arrestor	=	0.500 x	0.725 x	1.025 =	0.3716 m ³	2
						0

Right Span:

Long. Arrestor	=	0.500 x	0.725 x	1.025 =	0.3716 m ³	2
Transverse Arrestor	=	0.500 x	0.725 x	1.025 =	0.3716 m ³	2

(iii) Pier Cap

$$\begin{aligned}
 \text{Volume 1} &= 11.000 \times 2.500 \times 0.800 = 42.640 \text{ m}^3 \\
 &+ 2.400 \times \left(\frac{11.000 + 10.500}{2} \right) \times 0.800 \\
 \text{Volume 2 due to additional height of cap} &= 0.000 \times 1.250 \times 11.000 = 0.000 \text{ m}^3 \\
 \text{Long. Eccentricity due to additional weight of cap} &= 1.250 - 0.625 = -0.625 \text{ m}
 \end{aligned}$$

(iv) Pier Shaft

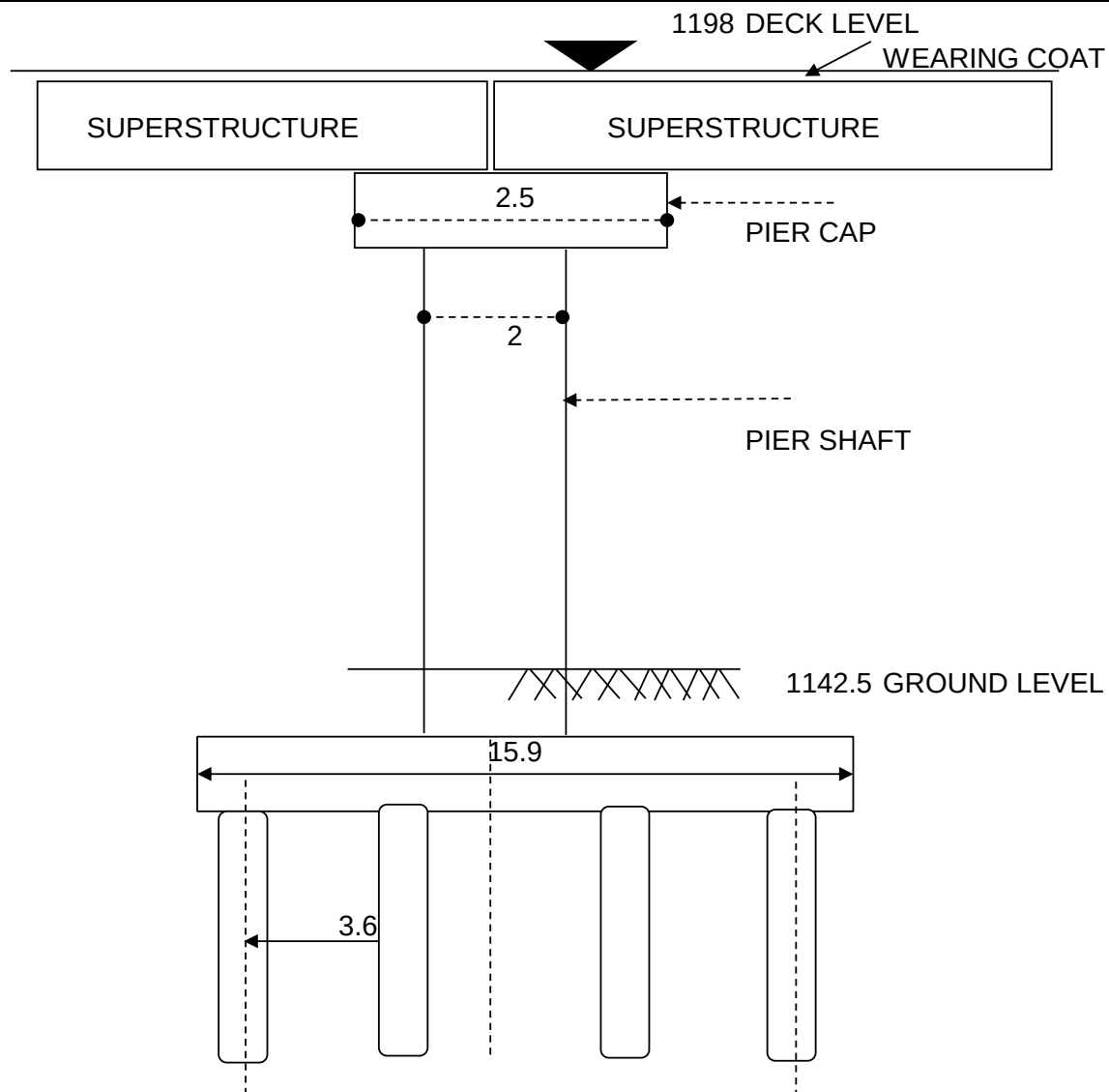
$$\text{Volume of Pier Shaft} = 2.000 \times 2.00 \times 3.000 \times 52.209 = 626.505 \text{ m}^3$$

(v) Pile Cap

$$\text{Volume} = 10.844 \times 13.650 \times 6.00 = 888.124 \text{ m}^3$$

(vi) Volume of Overburden Earth Over Pile Cap

$$\text{Volume of earthfill over pile cap} = (148.0206 - 12.0) \times 0.000 = 0.000 \text{ m}^3$$

FIGURE SHOWING SALIENT FEATURE OF PIER AND FOUNDATION

Possible Load Combination

1	COMB 1: DL+SIDL-Normal Dry Case	NORMAL CASE
2	COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case	
3	COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case	
4	COMB 4 : DL+SIDL -one Span Dislodege Normal case	
5	COMB 5 : COMB 2 + WL -Normal Dry Case	WIND CASE
6	COMB 6: COMB 3 + WL -Wind Dry Case	
7	COMB 7 : DL+SIDL+WL -one Span Dislodege Wind case	
8	COMB 8 : COMB 1 + EQ-L -Seismic Dry Case	SEISMIC CASE
9	COMB 9 : COMB 1 + EQ-T -Seismic Dry Case	
10	COMB 10 : COMB 2 + EQ-L -Seismic Dry Case	
11	COMB 11 : COMB 2 + EQ-T -Seismic Dry Case	
12	COMB 12 : COMB 3 + EQ-L -Seismic Dry Case	
13	COMB 13 : COMB 3 + EQ-T -Seismic Dry Case	
14	COMB 14 : DL+SIDL+EQ-L -one Span Dislodege Seismic case	
15	COMB 15 : DL+SIDL+EQ-T -one Span Dislodege Seismic case	

Load Factors:**Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State**

Loads	Normal Case	Seismic Case
Dead Load+SIDL , Back Fill except wearing course	1.350	1.35
SIDL (Wearing Course only)	1.750	1.75
CWLL (Service)	1.500	0.20
CWLL (Construction)	1.350	1.00
Wind Load-accompanying	0.900	-
Seismic Effect (during service)		1.50
Seismic Effect (during construction)		0.75

Table B.3 Partial Safety Factor For Verification of Serviceability Limit State

Loads	Rare Case	Frequent Combination	Quasi-Permanent Combination
Dead Load+SIDL	1.00	1.00	1.00
Surfacing	1.20	1.20	1.20
CWLL	1.00	0.75	0.00
Wind Load	0.60	0.50	0.00

Table B.4 Partial Safety Factor For Design of Foundation

Loads	Normal Case	Seismic Case
Dead Load+SIDL except wearing course	1.350	1.35
SIDL (Wearing Course only)	1.750	1.75
CWLL (Service)	1.500	0.75
CWLL (Construction)	1.350	1.00
Wind Load	0.900	-
Seismic Effect (during service)		1.50
Seismic Effect (during construction)		0.75

Seismic coefficient Calculation

(As Per IRC:6-2017 , Clause 219)

Horizontal Seismic Force For Zone - 5

F_{eq} = Seismic forces to be resisted
 F_{eq} = $A_h \times (\text{Dead load} + \text{Appropriate Live load})$
 A_h = horizontal seismic coefficient

$$= \frac{\left(\frac{Z}{2} \right) \left(\frac{S_a}{g} \right)}{\left(\frac{R}{I} \right)}$$

Z	=	Zone factor	=	0.36	
I	=	Importance factor	=	1.20	
R	=	Response reduction factor	=	3.0	in Longitudinal direction
			=	3.0	In Transverse direction
			=	3.0	For Pier Cap/Beam

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \frac{D}{1000F}^{1/2}$$

D = appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

D = 2343.75 + 500 + 625.000 = 3468.75 KN

$$F = \frac{6 E I}{x^2(3L-x)}$$

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction

= 53.715 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction

= 54.905 m

Pier Cap Top Level - Pile Top Level

= 53.809 m

Dimensions of Abutment Shaft

Width	=	3.00	m	Number of pier	=	2
Thickness	=	2.00	m	spacing between	=	7.5

Moment of Inertia , I_{long} = 3.000 m^4

Moment of Inertia , I_{tran} = 175.500 m^4

E_{cm} = 3.231E+07 kN/m^2

Longitudinal Direction

Force	=	1.8713	KN
D	=	3468.75	KN
T	=	2.723	sec

Transverse Direction

Force	=	105.945	KN
D	=	3738.750	KN
T	=	0.376	sec

Hard or Rocky Strata

S_a/g = 0.367

S_a/g = 2.500

For Substructure except pier cap

Seismic Coeff. In Longitudinal Direction = 0.026

Seismic Coeff. In Transverse Direction = 0.180

For Pier Cap

Seismic Coeff. In Longitudinal Direction = 0.026

Seismic Coeff. In Transverse Direction = 0.180

Summary of Horizontal and Vertical Sismic Coeff.

For Design of Substructure

For Substructure excluding pier cap

Ah	=	0.026	in Longitudinal direction
Ah	=	0.180	In Transverse direction
Av	=	0.120	In Vertical Direction

only for Pier Cap

Ah	=	0.026
Ah	=	0.180
Av	=	0.120

For Design of Foundation

Ah	=	0.036
Ah	=	0.243
Av	=	0.162

Ah	=	0.036
Ah	=	0.243
Av	=	0.162

During Construction ,
Importance factor = **1.00**

Summary of Horizontal and Vertical Sismic Coeff. In Dislodge Case

For Design of Substructure

For Substructure excluding pier cap

Ah	=	0.022
Ah	=	0.150
Av	=	0.100

only for Pier Cap

Ah	=	0.022
Ah	=	0.150
Av	=	0.100

For Design of Foundation

Ah	=	0.030
Ah	=	0.203
Av	=	0.135

Ah	=	0.030
Ah	=	0.203
Av	=	0.135

Horizontal Force (HL) AT Bearings in Ultimate Limit State

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing -

SPHERICAL BEARING

Left Span

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1171.88	1.35	1.35	1582.03	1582.03
SIDL except wc	=	250.00	1.35	1.35	337.50	337.50
WC	=	312.50	1.75	1.75	546.88	546.88
FPLL	=	0.00	1.5	0.2	0.00	0.00
CWLLmax- Reaction case	=	0.00	1.5	0.2	0.00	0.00
Transv. Moment Case	=	0.00	1.5	0.2	0.00	0.00
CWLLmin	=	0.00	1.5	0.2	0.00	0.00

Right Span

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1171.88	1.35	1.35	1582.03	1582.03
SIDL except wc	=	250.00	1.35	1.35	337.50	337.50
WC	=	312.50	1.75	1.75	546.88	546.88
FPLL	=	0.00	1.5	0.2	0.00	0.00
CWLLmax- Reaction case	=	1058.52	1.5	0.2	1587.79	211.70
CWLLmax- Reaction case	=	0.00	1	0	0.00	0.00
CWLLmax- Transv. Moment Case	=	808.87	1.5	0.2	1213.31	161.77
CWLLmin	=	191.13	1.5	0.2	286.69	38.23
CWLLmin	=	0.00	1	0	0.00	0.00

1-70R + 1-CLASS A

SV LOAD

1-70R

SV LOAD

COMB 1: DL+SIDL-Normal Dry Case**From Left Span**

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

From Right Span

$$F_h = 0 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case 1-70R + 1-CLASS AFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 0.00) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to braking} = 0.2 \times (0.00) + 0.05 \times (0.00) = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 286.69) = 0.05 \times 2753.10 = 137.65 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	137.65	14.33
123.32	-137.65	-14.33

Maximum Net Horizontal Force = 14.33 kN**COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case** SV LOADFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 0.00) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to braking} = 0.2 \times (0.00) + 0.05 \times (0.00) = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 0.00) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN**COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case****Maximum Net Horizontal Force = 14.33 kN****COMB 4 : DL+SIDL -one Span Dislodge Normal case****Maximum Net Horizontal Force = 137.65 kN****COMB 5 : COMB 2 + WL -Normal Dry Case**From Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to wind} = 84.682 \text{ kN} \times \text{Load factor } 0.9 = 0.000$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 6: COMB 3 + WL -Wind Dry Case

Maximum Net Horizontal Force = 0.00 kN

COMB 7 : DL+SIDL+WL -one Span Dislodge Wind case

From Right Span

$$\begin{aligned}
 F_h \text{ due to wind} &= 84.682 \text{ kN} \times \text{Load factor } 0.9 = 0.000 \\
 \mu R &= 0.05 \times (1582.03 + 337.50 + 546.88) \\
 &= 0.05 \times 2466.41 \\
 &= 123.32 \text{ kN} \\
 F_h/2 + \mu R &= 123.320 \text{ kN} \\
 F_h - \mu R &= -123.320 \text{ kN}
 \end{aligned}$$

Maximum Net Horizontal Force = 123.32 kN

COMB 8 : COMB 1 + EQ-L -Seismic Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 0.05 \times (1582.03 + 337.50 + 546.88) \\
 &= 0.05 \times 2466.41 \\
 &= 123.32 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 F_h \text{ due to seismic} &= 0.000 \times (2343.75 + 500.00 + 625.00) \\
 &= 0.000 \times 3468.750 \times \text{Load factor } 1.50 \\
 &= 0.00 \\
 \mu R &= 0.05 \times (1582.03 + 337.50 + 546.88) \\
 &= 0.05 \times 2466.41 \\
 &= 123.32 \text{ kN}
 \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 9 : COMB 1 + EQ-T -Seismic Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 123.32 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 F_h \text{ due to seismic} &= 0.3 \times 0.00 = 0.000 \text{ kN} \\
 \mu R &= 123.32
 \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 10 : COMB 2 + EQ-L -Seismic Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\begin{aligned} \mu R &= 0.05 \times (\text{DL} \quad \text{SIDL} \quad \text{WC} \quad \text{LL (min)}) \\ &= 0.05 \times (1582.03 + 337.50 + 546.88 + 0.00) \\ &= 123.32 \text{ kN} \end{aligned}$$

From Right Span

$$F_h \text{ due to seismic} = 0.00 \text{ kN}$$

$$F_h \text{ due to braking} = 0.2 \times 0 = 0 \text{ kN}$$

$$\text{Total } F_h = 0.00 \text{ kN}$$

$$\begin{aligned} \mu R &= 0.05 \times (\text{DL} \quad \text{SIDL} \quad \text{WC} \quad \text{LL (min)}) \\ &= 0.05 \times (1582.03 + 337.50 + 546.88 + 38.225) \\ &= 125.23 \text{ kN} \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	125.23	1.91
123.32	-125.23	-1.91

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 11 : COMB 2 + EQ-T -Seismic Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to seismic} = 0.30 \times 0.00 = 0.0 \text{ kN}$$

$$F_h \text{ due to braking} = 0.00 \text{ kN}$$

$$\text{Total } F_h = 0.00 \text{ kN}$$

$$\mu R = 125.23 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	125.23	1.91
123.32	-125.23	-1.91

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 12 : COMB 3 + EQ-L -Seismic Dry Case

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 13 : COMB 3 + EQ-T -Seismic Dry Case

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 14 : DL+SIDL+EQ-L -one Span Dislodge Seismic caseFrom Right Span

$$F_h \text{ due to seismic} = 0.000 \times (\text{DL} \quad \text{SIDL} \quad \text{WC})$$

$$= 0.000 \times 3468.75 = 0.00$$

$$= 0.00 \text{ kN}$$

$$\text{Maximum Net Horizontal Force} = 65.04 \text{ kN} \quad 0.75 \text{ factor have been considered IRC}$$

COMB 15 : DL+SIDL+EQ-T -one Span Dislodge Seismic caseFrom Right Span

$$F_h \text{ due to seismic} = 0.3 \times 0.00 = 0.000 \text{ kN}$$

$$\text{Maximum Net Horizontal Force} = 65.04 \text{ kN} \quad 0.75 \text{ factor have been considered IRC}$$

Horizontal Force (HL) AT Bearings For Design of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing

-

SPHERICAL BEARING

Left Span

Lloads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1171.88	1.35	1.35	1582.03	1582.03
SIDL except wc	=	250.00	1.35	1.35	337.50	337.50
WC	=	312.50	1.75	1.75	546.88	546.88
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Right Span

Lloads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1171.88	1.35	1.35	1582.03	1582.03
SIDL except wc	=	250.00	1.35	1.35	337.50	337.50
WC	=	312.50	1.75	1.75	546.88	546.88
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	1058.52	1.5	0.75	1587.79	793.89
CWLLmax-Transv. Moment Case	=	808.87	1.5	0.75	1213.31	606.66
CWLLmin	=	191.13	1.5	0.75	286.69	143.34

COMB 1: DL+SIDL-Normal Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 0.05 \times (\text{DL} + \text{SIDL} + \text{WC}) \\
 &= 0.05 \times (1582.03 + 337.50 + 546.88) \\
 &= 123.32 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 F_h &= 0 \text{ kN} \\
 \mu R &= 0.05 \times (\text{DL} + \text{SIDL} + \text{WC}) \\
 &= 0.05 \times (1582.03 + 337.50 + 546.88) \\
 &= 123.32 \text{ kN}
 \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 0.00) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to braking} = 0.2 \times (0.00) + 0.05 \times (0.00) = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 286.69) = 0.05 \times 2753.10 = 137.65 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	137.65	14.33
123.32	-137.65	-14.33

Maximum Net Horizontal Force = 14.33 kN

COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case

Maximum Net Horizontal Force = 14.33 kN

COMB 4 : DL+SIDL -one Span Dislodge Normal case

Maximum Net Horizontal Force = 123.32 kN

COMB 5 : COMB 2 + WL -Normal Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to wind} = 84.682 \text{ kN} \times \text{Load factor } 0.9 = 0.000$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 6: COMB 3 + WL -Wind Dry Case

Maximum Net Horizontal Force = 0.00 kN

COMB 7 : DL+SIDL+WL -one Span Dislodge Wind caseFrom Right Span

$$F_h \text{ due to wind} = 84.682 \text{ kN} \times \text{Load factor } 0.90 = 0.000$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

$$F_h/2 + \mu R = 123.320 \text{ kN}$$

$$F_h - \mu R = -123.320 \text{ kN}$$

Maximum Net Horizontal Force = 123.32 kN

COMB 8 : COMB 1 + EQ-L -Seismic Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to seismic} = 0.000 \times (2343.75 + 500.00 + 625.00) = 0.000 \times 3468.750 = 0.00$$

Load factor 1.50

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 9 : COMB 1 + EQ-T -Seismic Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to seismic} = 0.3 \times 0.00 = 0.000 \text{ kN}$$

$$\mu R = 123.32$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	123.32	0.00
123.32	-123.32	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 10 : COMB 2 + EQ-L -Seismic Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 0) = 0.05 \times 2466.41 = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to seismic} = 0.00$$

$$F_h \text{ due to braking} = 0.2 \times 0 + 0.05 \times 0 = 0 \text{ kN}$$

$$\text{Total } F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1582.03 + 337.50 + 546.88 + 38.225) = 0.05 \times 2504.63 = 125.23 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	125.23	1.91
123.32	-125.23	-1.91

Maximum Net Horizontal Force = 1.91 kN

COMB 11 : COMB 2 + EQ-T -Seismic Dry CaseFrom Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 123.32 \text{ kN}$$

From Right Span

$$F_h \text{ due to seismic} = 0.30 \times 0.00 = 0.00 \text{ kN}$$

$$F_h \text{ due to braking} = 0.00 \text{ kN}$$

$$\text{Total } F_h = 0.00 \text{ kN}$$

$$\mu R = 125.23 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-123.32	125.23	1.91
123.32	-125.23	-1.91

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 12 : COMB 3 + EQ-L -Seismic Dry Case

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 13 : COMB 3 + EQ-T -Seismic Dry Case

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 14 : DL+SIDL+EQ-L -one Span Dislodge Seismic case

From Right Span

$$F_h \text{ due to seismic} = 0.000 \times (2343.75 + 500.00 + 625.00) = 0.000 \times 3468.75 = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1171.88 + 250.00 + 312.50) = 0.05 \times 1734.38 = 86.72 \text{ kN}$$

$$F_h/2 + \mu R = 86.719 \text{ kN}$$

$$F_h - \mu R = -86.719 \text{ kN}$$

$$F_h = 0.00 \text{ kN}$$

Load factor 0.75

$$\text{Maximum Net Horizontal Force} = 65.04 \text{ kN} \quad 0.75 \text{ factor have been considered IRC}$$

COMB 15 : DL+SIDL+EQ-T -one Span Dislodge Seismic case

From Right Span

$$F_h \text{ due to seismic} = 0.3 \times 0.00 = 0.000 \text{ kN}$$

$$\mu R = 86.72 \text{ kN}$$

$$F_h/2 + \mu R = 86.719 \text{ kN}$$

$$F_h - \mu R = -86.719 \text{ kN}$$

$$F_h = 0.000 \text{ kN}$$

Load factor 0.75

$$\text{Maximum Net Horizontal Force} = 65.04 \text{ kN} \quad 0.75 \text{ factor have been considered IRC}$$

Horizontal Force (HL) AT Bearings For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Left Span

Lloads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1171.88	1	1	1171.88	1171.88
SIDL except wc	=	250.00	1	1	250.00	250.00
WC	=	312.50	1	1	312.50	312.50
FPLL	=	0.00	1	1	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	1	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1	1	0.00	0.00
CWLLmin	=	0.00	1	1	0.00	0.00

Right Span

Lloads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1171.88	1	1	1171.88	1171.88
SIDL except wc	=	250.00	1	1	250.00	250.00
WC	=	312.50	1	1	312.50	312.50
FPLL	=	0.00	1	1	0.00	0.00
CWLLmax-Reaction case	=	1058.52	1	1	1058.52	1058.52
CWLLmax-Reaction case	=	0.00	1	0	0.00	0.00
CWLLmax-Transv. Moment Case		808.87	1	1	808.87	808.87
CWLLmin	=	191.13	1	1	191.13	191.13
CWLLmin	=	0.00	1	0	0.00	0.00

1-70R + 1-CLASS A

SV LOAD

1-70R

SV LOAD

COMB 1: DL+SIDL-Normal Dry Case

From Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1171.88 + 250.00 + 312.50) = 0.05 \times 1734.38 = 86.72 \text{ kN}$$

From Right Span

$$F_h = 0 \text{ kN}$$

$$\mu R = 0.05 \times (1171.88 + 250.00 + 312.50) = 0.05 \times 1734.38 = 86.72 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case

1-70R + 1-CLASS A

From Left Span

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (1171.88 + 250.00 + 312.50 + 0.00) = 0.05 \times 1734.38 = 86.72 \text{ kN}$$

From Right Span

$$F_h \text{ due to braking} = 0.2 \times (0.00) + 0.05 \times (0.00) = 0.00 \text{ kN}$$

$$\begin{aligned} \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50 + 191.13) \\ &= 0.05 \times 1925.50 \\ &= 96.28 \text{ kN} \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	96.28	9.56
86.72	-96.28	-9.56

$$\text{Maximum Net Horizontal Force} = 9.56 \text{ kN}$$

COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case SV LOADFrom Left Span

$$\begin{aligned} F_h &= 0.00 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50 + 0.00) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN} \end{aligned}$$

From Right Span

$$F_h \text{ due to braking} = 0.2 \times (0.00) + 0.05 \times (0.00) = 0.00 \text{ kN}$$

$$\begin{aligned} \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50 + 0.00) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN} \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

$$\text{Maximum Net Horizontal Force} = 0.00 \text{ kN}$$

COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case

$$\text{Maximum Net Horizontal Force} = 9.56 \text{ kN}$$

COMB 4 : DL+SIDL -one Span Dislodege Normal case

$$\text{Maximum Net Horizontal Force} = 86.72 \text{ kN}$$

COMB 5 : COMB 2 + WL -Normal Dry CaseFrom Left Span

$$\begin{aligned} F_h &= 0.00 \text{ kN} \\ \mu R &= 86.72 \text{ kN} \end{aligned}$$

From Right Span

$$\begin{aligned} F_h \text{ due to wind} &= 84.682 \text{ kN} \times \text{Load factor } 1.00 = 0.000 \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN} \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

$$\text{Maximum Net Horizontal Force} = 0.00 \text{ kN}$$

COMB 6: COMB 3 + WL -Wind Dry Case

$$\text{Maximum Net Horizontal Force} = 0.00 \text{ kN}$$

COMB 7 : DL+SIDL+WL -one Span Dislodege Wind caseFrom Right Span

$$\begin{aligned} F_h \text{ due to wind} &= 84.682 \text{ kN} \times \text{Load factor } 1 = 0.000 \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \end{aligned}$$

$$\begin{aligned}
 &= 0.05 \times 1734.38 \\
 &= 86.72 \text{ kN} \\
 F_h/2 + \mu R &= 86.719 \text{ kN} \\
 F_h - \mu R &= -86.719 \text{ kN}
 \end{aligned}$$

Maximum Net Horizontal Force = 86.72 kN

COMB 8 : COMB 1 + EQ-L -Seismic Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 0.05 \times (DL + SIDL + WC) \\
 &= 0.05 \times (1171.88 + 250.00 + 312.50) \\
 &= 86.72 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 F_h \text{ due to seismic} &= 0.0000 \times (DL + SIDL + WC) \\
 &= 0.00 \times (2343.75 + 500.00 + 625.00) \\
 &= 0.00 \\
 \mu R &= 0.05 \times (DL + SIDL + WC) \\
 &= 0.05 \times (1171.88 + 250.00 + 312.50) \\
 &= 86.72 \text{ kN}
 \end{aligned}$$

Load factor 1.00

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 9 : COMB 1 + EQ-T -Seismic Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 86.72 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 F_h \text{ due to seismic} &= 0.3 \times 0.00 = 0.000 \text{ kN} \\
 \mu R &= 86.72
 \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 10 : COMB 2 + EQ-L -Seismic Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 0.05 \times (DL + SIDL + WC + LL(\min)) \\
 &= 0.05 \times (1171.88 + 250.00 + 312.50 + 0) \\
 &= 86.72 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 F_h \text{ due to seismic} &= 0.00 \\
 F_h \text{ due to braking} &= 0.2 \times 0 + 0.05 \times 0 = 0 \text{ kN} \\
 \text{Total } F_h &= 0.00 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 \mu R &= 0.05 \times (DL + SIDL + WC + LL(\min)) \\
 &= 0.05 \times (1171.88 + 250.00 + 312.50 + 38.23) \\
 &= 88.63 \text{ kN}
 \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	88.63	1.91
86.72	-88.63	-1.91

Maximum Net Horizontal Force = 1.91 kN

COMB 11 : COMB 2 + EQ-T -Seismic Dry Case

From Left Span

$$\begin{aligned}
 F_h &= 0.00 \text{ kN} \\
 \mu R &= 86.72 \text{ kN}
 \end{aligned}$$

From Right Span

$$\begin{aligned}
 \text{Fh due to seismic} &= 0.30 \times 0.00 = 0.0 \text{ kN} \\
 \text{Fh due to braking} &= 0.00 \text{ kN} \\
 \text{Total Fh} &= 0.00 \text{ kN} \\
 \mu R &= 88.63 \text{ kN}
 \end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	88.63	1.91
86.72	-88.63	-1.91

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 12 : COMB 3 + EQ-L -Seismic Dry Case

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 13 : COMB 3 + EQ-T -Seismic Dry Case

$$\text{Maximum Net Horizontal Force} = 1.91 \text{ kN}$$

COMB 14 : DL+SIDL+EQ-L -one Span Dislodge Seismic case

$$\begin{aligned}
 \text{From Right Span} \quad \text{Fh due to seismic} &= 0.000 \times (\text{DL } 2343.75 + \text{SIDL } 500.00 + \text{WC } 625.00) \\
 &= 0.00 \times 3468.750 = 0.00 \text{ kN} \\
 &= 0.00 \text{ kN} \\
 \mu R &= 0.05 \times (\text{DL } 1171.88 + \text{SIDL } 250.00 + \text{WC } 312.50) \\
 &= 0.05 \times 1734.38 \\
 &= 86.72 \text{ kN} \\
 \text{Fh}/2 + \mu R &= 86.719 \text{ kN} \\
 \text{Fh} - \mu R &= -86.719 \text{ kN} \\
 \text{Fh} &= 0.00 \text{ kN}
 \end{aligned}$$

Load factor **0.50**

$$\text{Maximum Net Horizontal Force} = 86.72 \text{ kN}$$

COMB 15 : DL+SIDL+EQ-T -one Span Dislodge Seismic case

$$\begin{aligned}
 \text{From Right Span} \quad \text{Fh due to seismic} &= 0.3 \times 0.00 = 0.000 \text{ kN} \\
 \mu R &= 86.72 \text{ kN} \\
 \text{Fh}/2 + \mu R &= 86.719 \text{ kN} \\
 \text{Fh} - \mu R &= -86.719 \text{ kN} \\
 \text{Fh} &= 0.000 \text{ kN}
 \end{aligned}$$

$$\text{Maximum Net Horizontal Force} = 86.72 \text{ kN}$$

Horizontal Force (HL) AT Bearings For Serviciilty Limit State

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - SPHERICAL BEARING

Left Span

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1171.88	1	1	1	1171.88	1171.88	1171.88
SIDL except wc	=	250.00	1	1	1	250.00	250.00	250.00
WC	=	312.50	1	1	1	312.50	312.50	312.50
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Right Span

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1171.88	1	1	1	1171.88	1171.88	1171.88
SIDL except wc	=	250.00	1	1	1	250.00	250.00	250.00
WC	=	312.50	1	1	1	312.50	312.50	312.50
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	1058.52	1	0.75	0	1058.52	793.89	0.00
CWLLmax-Transv. Moment Case		808.87	1	0.75		808.87	606.66	0.00
CWLLmin	=	191.13	1	0.75	0	191.13	143.34	0.00

COMB 1: DL+SIDL-Normal Dry Case**-Rare Combination****From Left Span**

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (DL + SIDL + \text{Wearing Course})$$

$$= 0.05 \times (1171.88 + 250.00 + 312.50)$$

$$= 86.72 \text{ kN}$$

From Right Span

$$F_h = 0 \text{ kN}$$

$$\mu R = 0.05 \times (DL + SIDL + WC)$$

$$= 0.05 \times (1171.88 + 250.00 + 312.50)$$

$$= 86.72 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN**COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal -Rare Combination****From Left Span**

$$F_h = 0.00 \text{ kN}$$

$$\mu R = 0.05 \times (DL + SIDL + WC + LL \text{ min})$$

$$= 0.05 \times (1171.88 + 250.00 + 312.50 + 0.00)$$

$$= 86.72 \text{ kN}$$

From Right Span

$$F_h \text{ due to braking} = 0.2 \times (0.00) + 0.05 \times (0.00)$$

$$= 0.00 \text{ kN}$$

$$\begin{aligned}\mu R &= 0.05 \times (1171.88 + 250.00 + 312.50 + 191.13) \\ &= 0.05 \times 1925.50 \\ &= 96.28 \text{ kN}\end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	96.28	9.56
86.72	-96.28	-9.56

Maximum Net Horizontal Force = 9.56 kN

COMB 3: DL+SIDL + LL(Max Transverse Moment) -N_i -Rare Combination

Maximum Net Horizontal Force = 9.56 kN

COMB 5 : COMB 2 + WL -Normal Dry Case -Rare Combination

From Left Span

$$\begin{aligned}F_h &= 0.00 \text{ kN} \\ \mu R &= 86.72 \text{ kN}\end{aligned}$$

From Right Span

$$\begin{aligned}F_h \text{ due to wind} &= 84.682 \text{ kN} \times \text{Load factor } 0.60 = 0.000 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN}\end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 6: COMB 3 + WL -Wind Dry Case -Rare Combination

Maximum Net Horizontal Force = 0.00 kN

FREQUENT COMBINATION

COMB 1: DL+SIDL-Normal Dry Case

FREQUENT COMBINATION

From Left Span

$$\begin{aligned}F_h &= 0.00 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN}\end{aligned}$$

From Right Span

$$\begin{aligned}F_h &= 0 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN}\end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal FREQUENT COMBINATION

From Left Span

$$\begin{aligned}F_h &= 0.00 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50 + 0.00) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN}\end{aligned}$$

From Right Span

$$\begin{aligned}F_h \text{ due to braking} &= 0.2 \times (0.00) + 0.05 \times (0.00) \\ &= 0.00 \text{ kN}\end{aligned}$$

$$\begin{aligned}\mu R &= 0.05 \times (1171.88 + 250.00 + 312.50 + 143.34) \\ &= 0.05 \times 1877.72 \\ &= 93.89 \text{ kN}\end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	93.89	7.17
86.72	-93.89	-7.17

Maximum Net Horizontal Force = 7.17 kN

COMB 3: DL+SIDL + LL(Max Transverse Moment) -N FREQUENT COMBINATION

Maximum Net Horizontal Force = 7.17 kN

COMB 5 : COMB 2 + WL -Normal Dry Case

FREQUENT COMBINATION

From Left Span

$$\begin{aligned}F_h &= 0.00 \text{ kN} \\ \mu R &= 86.72 \text{ kN}\end{aligned}$$

From Right Span

$$F_h \text{ due to wind} = 84.682 \text{ kN} \times \text{Load factor } 0.50 = 0.000 \text{ kN}$$

$$\mu R = 86.72 \text{ kN}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

COMB 6: COMB 3 + WL -Wind Dry Case

FREQUENT COMBINATION

Maximum Net Horizontal Force = 0.00 kN

1. Normal Case - (DL+SIDL)-Quasi-Permanent Combination

From Left Span

$$\begin{aligned}F_h &= 0.00 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN}\end{aligned}$$

From Right Span

$$\begin{aligned}F_h &= 0 \text{ kN} \\ \mu R &= 0.05 \times (1171.88 + 250.00 + 312.50) \\ &= 0.05 \times 1734.38 \\ &= 86.72 \text{ kN}\end{aligned}$$

Free Brg	Fix Brg	Net Horizontal Force
-86.72	86.72	0.00
86.72	-86.72	0.00

Maximum Net Horizontal Force = 0.00 kN

2. Normal One Span Dislodged Case - (DL+SIDL)-Quasi-Permanent Combination

Left Span Dislodge

Maximum Horizontal Force

$$\mu R = 86.72 \text{ kN}$$

Centrifugal Force Calculation

As per clause 212 of IRC:6-2017

CENTRIFUGAL FORCE	C	=	$\frac{W V^2}{127 R}$	
			Normal Case	Seismic Case
Design Speed	V	=	60.00 kmph	60.00 kmph
Live Load	W	=	135.00 t	27.00 t
Radius of Curvature	R	=	0.00 m	0.00 m
CENTRIFUGAL FORCE	C	=	0.00 t	0.00 t
		=	0.00 kN	0.00 kN

Calculation of Vertical Reaction Due to Braking Force

Braking Force	=	$0.2 \times (1000) +$	$0.05 \times (554.00)$
	=	227.7 kN	
		Deck Lvl. At Centre of Bridge	Soffit Level
C.g. Of Force	=	$1.2 + (1198.000 -$	$1196.215)$
	=	2.99 m	
Moment due to Braking Force	=	679.68 kNm	
Span	=	23.8 m	
Vertical Reaction	=	28.558 kN	Upward
	=	-28.558 kN	Downward

Wind Calculation (As Per Clause 209 of IRC:6-2017)

basic wind speed = 39 m/s (As per IRC 6:2017 , Fig. 10)

Maximum Height of Bridge from Ground Surface = 55.5 m
As per Table 4 of IRC 6:2017

Basic wind speed = 33 m/s
 $V_z = 33.77 \text{ m/s}$
 $P_z = 683.57 \text{ N/m}^2$

modified value of Hourly mean wind speed and wind pressure for this bridge are as per below

$V_{z,\text{design}} = V_z \times 1.18 = 39.91 \text{ m/s}$
 $P_{z,\text{design}} = P_z \times 1.40 = 954.74 \text{ N/m}^2$

Design Wind Force on Superstructure

$F_T = P_z \times A_1 \times G \times C_d$ as per IRC 6:2017, Caluse 209.3.3

Where , $P_z = 954.74 \text{ N/m}^2$

Area (A1) in Elevation**Left Side Span**

Span Length = 25.000 m
 Depth of superstructure = 1.720 m
 Crash Barrier = 1.150 m
 Area A1 = 71.750 m²

Right Side Span

Span Length = 25.000 m
 Depth of superstructure = 1.720 m
 Anticrash Railing = 1.150 m
 Area A1 = 71.750 m²

Gust factor , G = 2.0 as per Clause 209.3.3

Left Span**Composite Steel Plate Girder**

Drag Coeff. $C_d = 2 \times (1 + c / (20 d))$
 $c = 7.5$
 $d = 1.720$
 $C_d = 2.436$

RightSpan**Composite Steel Plate Girder**

Drag Coeff. $C_d = 2 \times (1 + c / (20 d))$
 $c = 7.5$
 $d = 1.720$
 Drag Coeff. $C_d = 2.436$

FT = 166875.49 N from Left span
 N acting at Level = 1197.65 m
 Parallel to Span FT sin (θ) = 0.00 N acting at Level = 1196.759 m
 Perpendicular to span FT cos (θ) = 166875.49 N acting at Level = 1197.65 m

FT = 166875.49 N from Right Span
 acting at 1197.65 m
 Parallel to Span FT sin (θ) = 0.00 N acting at Level = 1196.759 m
 Perpendicular to span FT cos (θ) = 166875.49 N acting at Level = 1197.65 m

Wind Force on Live Load

Drag Coeff. $C_d = 1.200$
 Exposed Area A1 = 25.000 x 3 = 75.000 m²
 FT = 171853.19 N

AS per clause 209.3.4

Longitudinal Wind Force

FL =	25%	FT =	41718.874 N	from Left span
Parallel to Span		FL cos (θ) =	41718.87 N acting at Level =	1196.759 m
Perpendicular to span		FL sin (θ) =	0.00 N acting at Level =	1197.65 m
FL =	25%	FT =	84682.170 N	from Right Span +live load
Parallel to Span		FL cos (θ) =	84682.17 N acting at Level =	1196.759 m
Perpendicular to span		FL sin (θ) =	0.00 N acting at Level =	1197.65 m

Total Wind Force in Longitudinal Direction	FL =	FT sin (θ)	+	FL cos (θ)	from Left span
	=	0.00	+	41718.87	
	=	41718.87 N acting at Level =			1196.759 m
	FL =	FT sin (θ)	+	FL cos (θ)	from Right Span
	=	0.00	+	84682.17	
	=	84682.17 N acting at Level =			1196.76 m
Total Wind Force in Transverse Direction	FT =	FT cos (θ)	+	-FL sin (θ)	from Left span
	=	166875.49	+	0.0	
	=	166875.49 N acting at Level =			1197.650 m
	FT =	FT cos (θ)	+	-FL sin (θ)	from Right Span
	=	166875.49	+	0.0	
	=	166875.49 N acting at Level =			1197.650 m
	Toatl FT =	333750.99	N acting at Level =		1197.650 m

Upward / Downward Wind Vertical Load (Fv)

Fv =	Pz x	A3 x	G x	CL	as per IRC 6:2014, Caluse 209.3.5
Where ,	A3	=	Area in Plan (m2)	=	12.5 x 25.00
				=	312.500 m ² from Left span
			A3	=	12.5 x 25.00
				=	312.5 m ² from Right Span
			CL	=	0.75
			Fv	=	223767.2 N from Left span
				=	-223767.2 N Upward
			Fv	=	223767.2 N from Right Span
				=	-223767.2 N upwrad

Design Wind Force on Substructure

AS per clause 209.4 , IRC 6:2014

Pier Cap

F _T =	Pz x	A2 x	G x	Cd	
Projected area of cap in elevation	A2	=	3.840 m ²		
	H	=	1.600 m		
	b	=	2.500 m		
	d	=	11.000 m		
	H/b	=	0.640	&	d/b= 4.40
Correspo to H/b and d/b ratio fro Table 6	Cd	=	0.800		
	FT	=	5865.9 N		
Parallel to Span	FT sin (θ)	=	0.0 N acting at Level =		1195.5 m
Perpendicular to span	FT cos (θ)	=	5865.9 N acting at Level =		1195.5 m

Pier Shaft

Projected area of shaft in elevation	A2	=	104.418 m ²		
	H	=	52.209 m		
	b	=	2 m		
	d	=	3.000 m		
	H/b	=	26.1	& d/b=	1.50
	Cd	=	2.0	For rectangular section	
	FT	=	398766.2 N		
Parallel to Span	FT sin (θ)	=	0.0 N acting at Level =		1168.604 m
Perpendicular to span	FT cos (θ)	=	398766.2 N acting at Level =		1168.604 m

Calculation of Forces For Foundation Base Pressure Check

Pile Cap Bottom Lvl = 1132.50 Bearing top Level = 1196.31 m

COMB 1: DL+SIDL-Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL (kN)	FT (kN)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MT = PxeT
Superstructure-Left Span										
Dead Load	1			1171.875			-2.870	0.000	-3363.281	0.000
SIDL except Wearing Course	1			250.000			-2.870	0.000	-717.500	0.000
Wearing Course	1			312.500			-2.870	0.000	-896.875	0.000
Superstructure-Right Span										
Dead Load	1			1171.875			-1.670	0.000	-1957.031	0.000
SIDL except Wearing Course	1			250.000			-1.670	0.000	-417.500	0.000
Wearing Course	1			312.500			1.670	0.000	521.875	0.000
Bearing Pedestal : Left Span	1	25	0.576	14.400			-2.870	0.000	-41.328	0.000
Bearing Pedestal : Right Span	1	25	0.576	14.400			-1.670	0.000	-24.048	0.000
Seismic arrestor: Left Span										
Long. Arrestor	1	25	0.743	18.578			0.000	0.000	0.000	0.000
Transverse arrestor	1	25	0.743	18.578			0.000	0.000	0.000	0.000
Seismic arrestor: Right Span										
Long. Arrestor	1	25	0.743	18.578			-1.670	0.000	-31.025	0.000
Transverse arrestor	1	25	0.743	18.578			0.000	0.000	0.000	0.000
Substructure										
Pier Cap	1	25	42.640	1066.000			0.000	0.000	0.000	0.000
Additional weight of cap	1	25	0.000	0.000			-2.270	0.000	0.000	0.000
Pier Shaft	1	25	626.505	15662.625			-2.270	0.000	-35554.159	0.000
Pile Cap	1	25	888.124	22203.090			0.000	0.000	0.000	0.000
Earth fill on pile cap	1	20	0.000	0.000			0.000	0.000	0.000	0.000
Net Horizontal Force at Bearing					0.000	0.000			0.000	0.000
ARCH REACTION				42751.089	55055.711	4976.257	2.800	0.000	119703.050	0.000
									55763.624	4338.400
Total				85254.667	55055.711	4976.257			77222.178	0.000

COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL (kN)	FT (kN)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MT = PxeT
Forces from Case 1 except horizontal forces due to superstructure				85254.667	55055.711	4976.257			77222.178	0.000
CWLL from left span	1			0.00			-2.870		0.000	0.000
CWLL(MAX) with Braking	1			1087.083			-1.670		-1815.429	1005.599
Vertical Reaction					9.556	0.000			609.776	0.000
Net Horizontal Force at Bearing										
Total				86341.750	55065.267	4976.257			76016.525	1005.599

COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	FL (kN)	FT (kN)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MT = PxeT
Forces from Case 1 except horizontal forces due to superstructure				85254.667	55055.711	4976.257			77222.178	0.000
CWLL from left span	1			0.00			-2.870		0.000	0.000
CWLL(MAX) with Braking	1			837.432			-1.670		-1398.512	2551.997
Vertical Reaction					9.556	0.000			609.776	0.000
Net Horizontal Force at Bearing										
Total				86092.099	55065.267	4976.257			76433.442	2551.997

COMB 4 : DL+SIDL -one Span Dislodge Normal case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	FL (kN)	FT (kN)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MT = PxeT
Superstructure-Right Span										
Dead Load	1			1171.875			-1.670	0.000	-1957.031	0.000
SIDL except Wearing Course	1			250.000			-1.670	0.000	-417.500	0.000
Wearing Course	1			312.500			1.670	0.000	521.875	0.000
Bearing Pedestal : Right Span	1	25	0.576	14.400			-1.670	0.000	-24.048	0.000
Seismic arrestor	1			74.313			0.000	0.000	0.000	0.000
Substructure										
Pier Cap	1	25	42.640	1066.000			0.000	0.000	0.000	0.000
Additional weight of cap	1	25	0.000	0.000			-2.270	0.000	0.000	0.000
Pier Shaft	1	25	626.505	15662.625			-2.270	0.000	-35554.159	0.000
Pile Cap	1	25	888.124	22203.090			0.000	0.000	0.000	0.000
Earth fill on pile cap	1	20	0.000	0.000			0.000	0.000	0.000	0.000
Net Horizontal Force at Bearing					86.719	0.000			5533.415	0.000
ARCH REACTION				42751.089	55055.711	4976.257	2.800	0.000	119703.050	0.000
									55763.624	4338.400
Total				83505.892	55142.430	4976.257			143569.227	4338.400

COMB 5 : COMB 2 + WL -Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	FL (kN)	FT (kN)	C.g. of Force (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	Long. Moment		Trans. Moment	
										ML = PxeL	ML due to FL	MT = PxeT	MT due to FT
Superstructure-Left Span													
Dead Load				1171.875				-2.870	0.000	-3363.281		0.000	
SIDL except Wearing Course				250.000				-2.870	0.000	-717.500		0.000	
Wearing Course				312.500				-2.870	0.000	-896.875		0.000	
CWLL				0.000				-2.870	0.000	0.000		0.000	
Superstructure-Right Span													
Dead Load				1171.875				-1.670	0.000	-1957.031		0.000	
SIDL except Wearing Course				250.000				-1.670	0.000	-417.500		0.000	
Wearing Course				312.500				1.670	0.000	521.875		0.000	
CWLL				1087.083				1.670	0.000	1815.429		2551.997	
Bearing Pedestal : Left Span				14.400				-2.870	0.000	-41.328		0.000	
Bearing Pedestal : Right Span				14.400				-1.670	0.000	-24.048		0.000	
Seismic arrestor				74.313				0.000	0.000	0.000		0.000	

Substructure													
Pier Cap				1066.000	0.000	5.866	1195.509	0.000	0.000	0.000	0.00	0.000	369.60
Additional weight of cap				0.000				-2.270	0.000	0.000		0.000	
Pier Shaft				15662.625	0.000	398.766	1168.604	-2.270	0.000	-35554.159	0.00	0.000	14397.21
Pile Cap				22203.090				0.000	0.000	0.000		0.000	
Earth fill on pile cap				0.000				0.000	0.000	0.000		0.000	
Wind Load					0.000	333.751	1197.650				0.000		21743.877
Wind Down from Left Span				223.767				-2.870		-642.212			
Wind down from Right Span				223.767				-1.670		-373.691			
Wind UP from Left Span				-223.767				-2.870		642.212			
Wind UP from Right Span				-223.767				-1.670		373.691			
ARCH REACTION				38443.089	44167.715	0.000		2.800	0.000	107640.648	57940.5135	0.000	59880.176
Total				Down	82481.283	44167.715	738.383			65990.326	57940.513	2551.997	96390.862
				Up	81586.215					68022.132			

COMB 6: COMB 3 + WL -Wind Dry CaseHence Design forces will same as **Load Combination 5**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL (kN)	FT (kN)	C.g. of Force (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	Long. Moment		Trans. Moment	
										ML = Px eL	ML due to FL	MT = Px eT	MT due to FT
Total			down	82481.283	44167.715	738.383				65990.326	57940.513	2551.997	96390.862
			UP	81586.215						68022.132			

COMB 7 : DL+SIDL+WL -one Span Dislodge Wind case**Left Span Dislodge**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL (kN)	FT (kN)	C.g. of Force (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	Long. Moment		Trans. Moment	
										ML = Px eL	ML due to FL	MT = Px eT	MT due to FT
Superstructure-Right Span													
Dead Load	1			1171.875				-1.670	0.000	-1957.031		0.000	
SIDL except Wearing Course	1			250.000				-1.670	0.000	-417.500		0.000	
Wearing Course	1			312.500				1.670	0.000	521.875		0.000	
Bearing Pedestal : Left Span				14.400				-2.870	0.000	-41.328		0.000	
Bearing Pedestal : Right Span				14.400				-1.670	0.000	-24.048		0.000	
Seismic arrestor				74.313				0.000	0.000	0.000		0.000	
Substructure													
Pier Cap	1	25	42.640	1066.000	0.000	5.866	1195.509	0.000	0.000	0.000	0.00	0.000	369.60
Additional weight of cap				0.000				-2.270	0.000	0.000		0.000	
Pier Shaft	1	25	626.505	15662.625	0.000	398.766	1168.604	-2.270	0.000	-35554.159	0.00	0.000	14397.21
Pile Cap	1	25	888.124	22203.090				0.000	0.000	0.000		0.000	
Earth fill on pile cap	1	20	0.000	0.000				0.000	0.000	0.000		0.000	
Wind Load	1				86.719	333.751	1197.65				5533.41504		21743.877
Wind down from Right Span				223.767				-1.670		-373.691			
Wind UP from Right Span				-223.767				-1.670		373.691			
ARCH REACTION				38443.089	44167.715	0.000	0.000	2.800	0.000	107640.648	57940.513	0.000	59880.176
Total				Down	79436.058	44254.434	738.383	3561.763		69794.766	63473.929	0.000	96390.862
				UP	78988.524					70542.148			

COMB 8 : COMB 1 + EQ-L -Seismic Dry Case**For Substructure Excluding Pier Cap**

Seismic Effect Factor = **1**
 $\alpha_h = 0.036$ in Longitudinal direction
 $\alpha_h = 0.243$ In Transverse direction
 $\alpha_v = 0.162$ In Vertical Direction

For Pier Cap

$\alpha_h = 0.036$ in Longitudinal direction
 $\alpha_h = 0.243$ In Transverse direction
 $\alpha_v = 0.162$ In Vertical Direction

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	Long. Moment			Trans. Moment	
											ML = Px eL	MLs due to FL	MLs due to Fv	MT = Px eT	MTs due to FT
Superstructure-Left Span															
Dead Load	1			1171.875		85.430	56.953	1197.362	-2.270	0.000	-2660.156		-129.284	0.000	5541.112
SIDL except Wearing Course	1			250.000		18.225	12.150	1198.447	-2.270	0.000	-567.500		-27.581	0.000	1201.886
Wearing Course	1			312.500		22.781	15.188	1198.033	-2.270	0.000	-709.375		-34.476	0.000	1492.912
Superstructure-Right Span															
Dead Load	1			1171.875		85.430	56.953	1197.362	-2.270	0.000	-2660.156		-129.284	0.000	5541.112
SIDL except Wearing Course	1			250.000		18.225	12.150	1198.447	-2.270	0.000	-567.500		-27.581	0.000	1201.886
Wearing Course	1			312.500		22.781	15.188	1198.033	-2.270	0.000	-709.375		-34.476	0.000	1492.912
Bearing Pedestal : Left Span				14.400					-2.870	0.000	-41.328			0.000	
Bearing Pedestal : Right Span				14.400					-1.670	0.000	-24.048			0.000	
Seismic Arrestor				74.313					0.000	0.000	0.000			0.000	
Substructure															
Pier Cap	1	25	42.640	1066.000	38.052	77.711	51.808	1195.509	0.000	0.000	0.000	2397.589	0.000	0.000	4896.498
Additional weight of cap				0.000	0.000	0.000	0.000	1195.509	-2.270	0.000	0.000	0.000		0.000	0.000
Pier Shaft	1	25	626.505	15662.625	559.089	1141.805	761.204	1168.604	-2.270	0.000	-35554.159	20185.569	-1727.932	0.000	41224.169
Pile Cap	1	25	888.124	22203.090	792.556	1618.605	1079.070	1137.500	0.000	0.000	0.000	3962.781		0.000	8093.026
Earth fill on pile cap	1	20	0.000	0.000					0.000	0.000	0.000			0.000	
Net Horizontal Force at Bearing					0.000	0.000						0.000			0.000
ARCH REACTION				30847.178	36818.773	2546.181			2.800	0.000	86372.098	27262.310		0.000	5436.383
TOTAL				73350.755	38208.470	5637.175	2060.663				42878.500	53808.249	-2110.612	0.000	76121.897
							-2060.663						2110.612		

COMB 9 : COMB 1 + EQ-T -Seismic Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load (P) kN.	FL = $0.3 \times \alpha_h \times P$ (kN)	FT = $\alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	Long. Moment			Trans. Moment	
											ML = Px eL	MLs due to FL	MLs due to Fv	MT = Px eT	MTs due to FT
Superstructure-Left Span															
Dead Load	1			1171.875		284.766	56.953	1197.362	-2.270	0.000	-2660.156		-129.284	0.000	18470.373
SIDL except Wearing Course	1			250.000		60.750	12.150	1198.447	-2.270	0.000	-567.500		-27.581	0.000	4006.287
Wearing Course	1			312.500		75.938	15.188	1198.033	-2.270	0.000	-709.375		-34.476	0.000	4976.374
Superstructure-Right Span															
Dead Load	1			1171.875		284.766	56.953	1197.362	-2.270	0.000	-2660.156		-129.284	0.000	18470.373
SIDL except Wearing Course	1			250.000		60.750	12.150	1198.447	-2.270	0.000	-567.500		-27.581	0.000	4006.287
Wearing Course	1			312.500		75.938	15.188	1198.033	-2.270	0.000	-709.375		-34.476	0.000	4976.374
Bearing Pedestal : Left Span				14.400					-2.870	0.000	-41.328			0.000	
Bearing Pedestal : Right Span				14.400					-1.670	0.000	-24.048			0.000	
Seismic Arrestor				74.313					0.000	0.000	0.000			0.000	

Substructure															
Pier Cap	1	25	42.640	1066.000	11.416	259.038	51.808	1195.509	0.000	0.000	0.000	719.277	0.000	0.000	16321.661
Additional weight of cap				0.000	0.000	0.000	0.000	1195.509	-2.270	0.000	0.000	0.000	0.000	0.000	0.000
Pier Shaft	1	25	626.505	15662.625	167.727	3806.018	761.204	1168.604	-2.270	0.000	-35554.159	6055.671	-1727.932	0.000	137413.897
Pile Cap	1	25	888.124	22203.090	237.767	5395.351	1079.070	1137.500	0.000	0.000	0.000	1188.834		0.000	26976.754
Earth fill on pile cap	1	20	0.000	0.000					0.000	0.000	0.000			0.000	
Net Horizontal Force at Bearing					0.000	0.000						0.000			0.000
ARCH REACTION				30847.178	36818.773	2546.181	0.000	0.000	2.800	0.000	86372.098	27262.310	0.000	0.000	5436.383
TOTAL				73350.755	37235.682	12849.494	2060.663				42878.500	35226.092	-2110.612	0.000	241054.763
							-2060.663								2110.612

COMB 10 : COMB 2 + EQ-L -Seismic Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MLs due to FL	MLs due to Fv	MT = PxeT	MTs due to FT
Forces from Case 8 except horizontal forces due to superstructure				73350.755	38208.470	5637.175	2060.663				42878.500	53808.249	-2110.612	0.000	76121.897
CWLL from left span	1			0.000		0.000	0.000	1199.200	-2.870	0.000	0.000		0.000	0.000	0.000
CWLL(MAX) with Braking	1			217.417		15.850	10.566	1199.200	-1.670		-363.086		-17.646	1005.599	1057.173
Vertical Reaction					1.911	0.000						121.955			0.000
Net Horizontal Force at Bearing															
Total				73568.172	38210.382	5653.025	2071.229				42515.415	53930.204	-2128.258	1005.599	77179.070
							-2071.229								2128.258

COMB 11 : COMB 2 + EQ-T -Seismic Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $0.3 \times \alpha_h \times P$ (kN)	FT = $\alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MLs due to FL	MLs due to Fv	MT = PxeT	MTs due to FT
Forces from Case 9 except horizontal forces due to superstructure				73350.755	37235.682	12849.494	2060.663				42878.500	35226.092	-2110.612	0.000	241054.763
CWLL from left span	1			0.000		0.000	0.000	1199.200	-2.870	0.000	0.000		0.000	0.000	0.000
CWLL(MAX) with Braking	1			217.417		52.832	10.566	1199.200	-1.670		-363.086		-17.646	1005.599	3523.910
Vertical Reaction					1.911	0.000						121.955			0.000
Net Horizontal Force at Bearing															
Total				73568.172	37237.594	12902.327	2071.229				42515.415	35348.047	-2128.258	1005.599	244578.673
							-2071.229								2128.258

COMB 12 : COMB 3 + EQ-L -Seismic Dry Case

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = $\alpha_h \times P$ (kN)	FT = $0.3 \times \alpha_h \times P$ (kN)	Fv = $0.3 \times \alpha_v \times P$ (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = PxeL	MLs due to FL	MLs due to Fv	MT = PxeT	MTs due to FT
Forces from Case 8 except horizontal forces due to superstructure				73350.755	38208.470	5637.175	2060.663				42878.500	53808.249	-2110.612	0.000	76121.897
CWLL from left span	1			0.000		0.000	0.000	1199.200	-2.870	0.000	0.000		0.000	0.000	0.000
CWLL(MAX) with Braking	1			167.486		12.210	8.140	1199.200	-1.670		-279.702		-13.594	2551.997	814.391
Vertical Reaction					1.911	0.000						121.955			0.000
Net Horizontal Force at Bearing															
Total				73518.242	38210.382	5649.385	2068.802				42598.798	53930.204	-2124.205	2551.997	76936.288
							-2068.802								2124.205

COMB 13 : COMB 3 + EQ-T -Seismic Dry Case

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load (P) kN.	FL = 0.3x ah x P (kN)	FT = ah x P (kN)	Fv = 0.3 x av x P (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = Px eL	MLs due to FL	MLs due to Fv	MT = Px eT	MTs due to FT
Forces from Case 9 except horizontal forces due to superstructure				73350.755	37235.682	12849.494	2060.663				42878.500	35226.092	-2110.612	0.000	241054.763
CWLL from left span	1			0.000		0.000	0.000	1199.200	-2.870	0.000	0.000		0.000	0.000	0.000
CWLL(MAX) with Braking	1			167.486		40.699	8.140	1199.200	-1.670		-279.702		-13.594	2551.997	2714.637
Vertical Reaction					1.911	0.000						121.955			
Net Horizontal Force at Bearing															0.000
Total				73518.242	37237.594	12890.194	2068.802				42598.798	35348.047	-2124.205	2551.997	243769.400
							-2068.802						2124.205		

Note: In Seismic Condition , Seismic Effect becomes 50%

$$= 0.5$$

COMB 14 : DL+SIDL+EQ-L -one Span Dislodge Seismic case

Left Span Dislodge

COMB 14 : DL+SIDL+EQ-L -one Span Dislodge Seismic case											Left Span Dislodge			Long. Moment			Trans. Moment	
Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = q _h x P (kN)	FT = 0.3 x q _h x P (kN)	Fv = 0.3 x a _v x P (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	ML = Px _e L	MLs due to FL	MLs due to Fv	MT = Px _e T	MTs due to FT			
Superstructure-Right Span																		
Dead Load	1			1171.875		42.715	28.477	1197.362	-2.270	0.000	-2660.156		-64.642	0.000	2770.556			
SIDL except Wearing Course	1			250.000		9.113	6.075	1198.447	-2.270	0.000	-567.500		-13.790	0.000	600.943			
Wearing Course	1			312.500		11.391	7.594	1198.033	-2.270	0.000	-709.375		-17.238	0.000	746.456			
Bearing Pedestal : Right Span				14.400					-1.670	0.000	-24.048			0.000				
Seismic Arrestor				74.313					0.000	0.000	0.000			0.000				
Substructure																		
Pier Cap	1	25	42.640	1066.000	19.026	38.856	25.904	1195.509	0.000	0.000	0.000	1198.794	0.000	0.000	2448.249			
Additional weight of cap				0.000	0.000	0.000	0.000	1195.509	-2.270	0.000	0.000	0.000		0.000	0.000			
Pier Shaft	1	25	626.505	15662.625	279.545	570.903	380.602	1168.604	-2.270	0.000	-35554.159	10092.785	-863.966	0.000	20612.084			
Pile Cap	1	25	888.124	22203.090	396.278	809.303	539.535	1137.500	0.000	0.000	0.000	1981.390		0.000	4046.513			
Earth fill on pile cap	1	20	0.000	0.000					0.000	0.000	0.000			0.000				
Net Horizontal Force at Bearing					86.719	0.000						5533.415			0.000			
ARCH REACTION				30847.178	36818.773	2546.181	0.000	0.000	2.800	0.000	86372.098	27262.310	0.000	0.000	5436.383			
TOTAL				71601.980	37600.341	4028.460	988.186				46856.860	46068.695	-959.636	0.000	36661.185			
							-988.186								959.636			

COMB 15 : DL+SIDL+EQ-T -one Span Dislodge Seismic case**Left Span Dislodge**

Loads	Load Factor	Unit Weights (kN/m ³)	Volume (m ³)	Vertical Load(P) kN.	FL = 0.3 x α_h x P (kN)	FT = α_h x P (kN)	Fv = 0.3 x α_v x P (kN)	C.g. of Force in Trans. (m)	Long. Ecc. (eL) (m)	Transv. Ecc. (eT) (m)	Long. Moment			Trans. Moment	
											ML = PxeL	MLs due to FL	MLs due to Fv	MT = PxeT	MTs due to FT
Superstructure-Right Span															
Dead Load	1			1171.875		142.383	28.477	1197.362	-2.270	0.000	-2660.156		-64.642	0.000	9235.187
SIDL except Wearing Course	1			250.000		30.375	6.075	1198.447	-2.270	0.000	-567.500		-13.790	0.000	2003.144
Wearing Course	1			312.500		37.969	7.594	1198.033	-2.270	0.000	-709.375		-17.238	0.000	2488.187
Bearing Pedestal : Right Span				14.400					-1.670	0.000	-24.048			0.000	
Seismic Arrestor				74.313					0.000	0.000	0.000			0.000	
Substructure															
Pier Cap	1	25	42.640	1066.000	5.708	129.519	25.904	1195.509	0.000	0.000	0.000	359.638	0.000	0.000	8160.830
Additional weight of cap				0.000	0.000	0.000	0.000	1195.509	-2.270	0.000	0.000	0.000		0.000	0.000
Pier Shaft	1	25	626.505	15662.625	83.863	1903.009	380.602	1168.604	-2.270	0.000	-35554.159	3027.835	-863.966	0.000	68706.948
Pile Cap	1	25	888.124	22203.090	118.883	2697.675	539.535	1137.500	0.000	0.000	0.000	594.417		0.000	13488.377
Earth fill on pile cap	1	20	0.000	0.000					0.000	0.000	0.000			0.000	
Net Horizontal Force at Bearing					86.719	0.000						5533.415			0.000
ARCH REACTION				30847.178	36818.773	2546.181	0.000	0.000	2.800	0.000	86372.098	27262.310	0.000	0.000	5436.383
TOTAL				71601.980	37113.947	7487.111	988.186				46856.860	36777.616	-959.636	0.000	109519.056
							-988.186						959.636		

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = **1.00** x 0.00 = 0.00 KN
 Transverse Moment due to C.F. = 0.000 x (1199.200 - 1132.500) = 0.00 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = **1.00** x 0.00 = 0.000 KN
 Transverse Moment due to C.F. = 0.000 x (1199.200 - 1132.500) = 0.000 kNm

Summary of Forces at Pile Cap Bottom For Stability of Foundation

CASE	LOAD COMBINATION		P (kN)	ML (kNm)	MT (kNm)	FL (kN)	FT (kN)	Resultant Force
Normal Case	COMB 1: DL+SIDL-Normal Dry Case		85254.7	77222.2	0.0	55055.71	4976.26	55280.14
	COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case		86341.7	76016.5	1005.6	55065.27	4976.26	55289.66
	COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case		86092.1	76433.4	2552.0	55065.27	4976.26	55289.66
	COMB 4 : DL+SIDL -one Span Dislodge Normal case		83505.9	143569.2	4338.4	55142.43	4976.26	55366.51

Wind Case	COMB 5 : COMB 2 + WL -Normal Dry Case	Down	82481.3	123930.8	98942.9	44167.72	738.38	44173.89
		Up	81586.2	125962.6	98942.9			
	COMB 6: COMB 3 + WL -Wind Dry Case	Down	82481.3	123930.8	98942.9	44167.72	738.38	44173.89
		Up	81586.2	125962.6	98942.9			
	COMB 7 : DL+SIDL+WL -one Span Dislodege Wind case	Down	79436.1	133268.7	96390.9	44254.43	738.38	44260.59
		Up	78988.5	134016.1	96390.9			
Seismic Case	COMB 8 : COMB 1 + EQ-L -Seismic Dry Case	Down	75411.4	94576.1	76121.9	38208.47	5637.18	38622.08
		Up	71290.1	98797.4	76121.9			
	COMB 9 : COMB 1 + EQ-T -Seismic Dry Case	Down	75411.4	75994.0	241054.8	37235.68	12849.49	39390.42
		Up	71290.1	80215.2	241054.8			
	COMB 10 : COMB 2 + EQ-L -Seismic Dry Case	Down	75639.4	94317.4	78184.7	38210.38	5653.02	38626.29
		Up	71496.9	98573.9	78184.7			
	COMB 11 : COMB 2 + EQ-T -Seismic Dry Case	Down	75639.4	75735.2	245584.3	37237.59	12902.33	39409.50
		Up	71496.9	79991.7	245584.3			
	COMB 12 : COMB 3 + EQ-L -Seismic Dry Case	Down	75587.0	94404.8	79488.3	38210.38	5649.39	38625.75
		Up	71449.4	98653.2	79488.3			
	COMB 13 : COMB 3 + EQ-T -Seismic Dry Case	Down	75587.0	75822.6	246321.4	37237.59	12890.19	39405.53
		Up	71449.4	80071.0	246321.4			
	COMB 14 : DL+SIDL+EQ-L -one Span Dislodege Seismic case	Down	72590.2	91965.9	36661.18	37600.34	4028.46	37815.53
		Up	70613.8	93885.2	36661.18			
	COMB 15 : DL+SIDL+EQ-T -one Span Dislodege Seismic case	Down	72590.2	82674.8	109519.06	37113.95	7487.11	37861.61
		Up	70613.8	84594.1	109519.06			

Calculation of Reaction at Pile**Arrangement of Vertical Pile Shaft**

Nos. of Piles = 20 Nos.

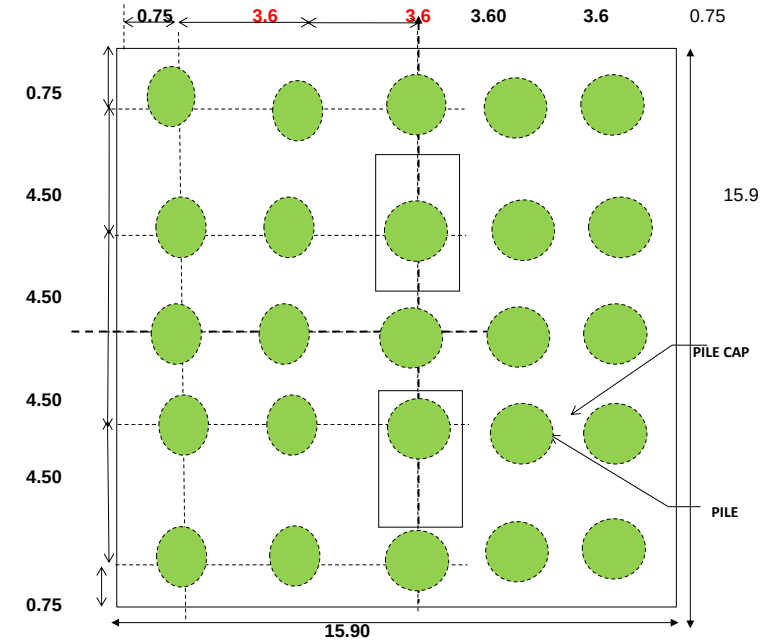
Pile No	rLs	rTs
1	7.200	6.750
2	7.200	2.250
3	7.200	-2.250
4	7.200	-6.750
5	3.600	6.750
6	3.600	2.250
7	3.600	-2.250
8	3.600	-6.750
9	0.000	6.750
10	0.000	2.250
11	0.000	-2.250
12	0.000	-6.750
13	-3.600	6.750
14	-3.600	2.250
15	-3.600	-2.250
16	-3.600	-6.750

Pile No	rLs	rTs
17	-7.200	6.750
18	-7.200	2.250
19	-7.200	-2.250
20	-7.200	-6.750
0	0.000	0.000
1	0.000	0.000
2	0.000	0.000
3	0.000	0.000
4	0.000	0.000
5	0.000	0.000

L S
e p
f a
t n

$$\begin{aligned}\Sigma rLs^2 &= 505.440 \text{ m}^2 \\ \Sigma rTs^2 &= 460.688 \text{ m}^2\end{aligned}$$

$$\text{Load on each pile} = \frac{P}{n} + \frac{MLs \cdot rLs}{\Sigma rL^2} + \frac{MTs \cdot rTs}{\Sigma rT^2}$$



LOADS ON EACH PILE

CASE	LOAD COMBINATION	Design Forces at Bottom of Cap			Load on Each Pile Top							
		P	ML	MT	P1	P2	P3	P4	P5	P6	P7	P8
Normal Case	COMB 1: DL+SIDL-Normal Dry Case	85255	77222	0	5363	5363	5363	5363	4813	4813	4813	4813
	COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case	86342	76017	1006	5415	5405	5395	5385	4873	4863	4854	4844
	COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case	86092	76433	2552	5431	5406	5381	5356	4886	4861	4837	4812
	COMB 4 : DL+SIDL -one Span Dislodege Normal case	83506	143569	4338	6284	6242	6199	6157	5261	5219	5177	5134
Wind Case	COMB 5 : COMB 2 + WL -Normal Dry Case	82481	123931	98943	7339	6373	5406	4440	6456	5490	4524	3557
	Up	81586	125963	98943	7323	6357	5390	4424	6426	5460	4493	3527
	COMB 6: COMB 3 + WL -Wind Dry Case	82481	123931	98943	7339	6373	5406	4440	6456	5490	4524	3557
	Up	81586	125963	98943	7323	6357	5390	4424	6426	5460	4493	3527
	COMB 7 : DL+SIDL+WL -one Span Dislodege Wind case	79436	133269	96391	7283	6341	5399	4457.9	6333	5392	4450	3509
	Up	78989	134016	96391	7271	6329	5388	4446.2	6316	5375	4433	3492
Seismic Case	COMB 8 : COMB 1 + EQ-L -Seismic Dry Case	75411	94576	76122	6233	5490	4746	4002	5560	4816	4072	3329
	Up	71290	98797	76122	6087	5344	4600	3857	5384	4640	3896	3153
	COMB 9 : COMB 1 + EQ-T -Seismic Dry Case	75411	75994	241055	8385	6030	3676	1321	7844	5489	3135	780
	Up	71290	80215	241055	8239	5884	3530	1175	7668	5313	2959	604
	COMB 10 : COMB 2 + EQ-L -Seismic Dry Case	75639	94317	78185	6271	5507	4744	3980	5599	4836	4072	3308
	Up	71497	98574	78185	6125	5361	4597	3833	5423	4659	3895	3131
	COMB 11 : COMB 2 + EQ-T -Seismic Dry Case	75639	75735	245584	8459	6060	3661	1263	7920	5521	3122	723
	Up	71497	79992	245584	8313	5914	3515	1116	7743	5344	2945	546
	COMB 12 : COMB 3 + EQ-L -Seismic Dry Case	75587	94405	79488	6289	5512	4736	3959	5616	4840	4064	3287
	Up	71449	98653	79488	6142	5366	4590	3813	5440	4663	3887	3110
	COMB 13 : COMB 3 + EQ-T -Seismic Dry Case	75587	75823	246321	8469	6062	3656	1250	7929	5522	3116	710
	Up	71449	80071	246321	8322	5916	3510	1104	7752	5346	2940	534
	COMB 14 : DL+SIDL+EQ-L -one Span Dislodege Seismic case	72590	91966	36661	5477	5119	4761	4402	4822	4464	4105	3747
	Up	70614	93885	36661	5405	5047	4689	4331	4737	4378	4020	3662
	COMB 15 : DL+SIDL+EQ-T -one Span Dislodege Seismic case	72590	82675	109519	6412	5342	4272	3203	5823	4753	3683	2614
	Up	70614	84594	109519	6340	5271	4201	3131	5738	4668	3598	2529

Load on Each Pile Top										
CASE	LOAD COMBINATION	Max Reaction	Min Reaction	Max Reaction	Check For Vertical Capacity	Min Reaction	Check For Uplift Capacity	Resultant Force	Max	Check For Horizontal Capacity
Normal Case	COMB 1: DL+SIDL-Normal Dry Case	5363	5363	6284	SAFE	5356	SAFE	2764	2768	
	COMB 2: DL+SIDL + LL(Maximum Reaction) -Normal Dry Case	5415	5385					2764		
	COMB 3: DL+SIDL + LL(Max Transverse Moment) -Normal Dry Case	5431	5356					2764		
	COMB 4 : DL+SIDL -one Span Dislodege Normal case	6284	6157					2768		
Wind Case	COMB 5 : COMB 2 + WL -Normal Dry Case	7339	4440	7339	SAFE	4424	SAFE	2209	2213	
	Down	7323	4424							
	COMB 6: COMB 3 + WL -Wind Dry Case	7339	4440					2209		
	Down	7323	4424							
Seismic Case	COMB 7 : DL+SIDL+WL -one Span Dislodege Wind case	7283	4458	8469	SAFE	1104	SAFE	2213	1970	
	Down	7271	4446							
	Up									
	COMB 8 : COMB 1 + EQ-L -Seismic Dry Case	6233	4002					1931		
	Down	6087	3857							
	Up									
	COMB 9 : COMB 1 + EQ-T -Seismic Dry Case	8385	1321					1970		
	Down	8239	1175							
	Up									
	COMB 10 : COMB 2 + EQ-L -Seismic Dry Case	6271	3980					1931		
	Down	6125	3833							
	Up									
	COMB 11 : COMB 2 + EQ-T -Seismic Dry Case	8459	1263					1970		
	Down	8313	1116							
	Up									
	COMB 12 : COMB 3 + EQ-L -Seismic Dry Case	6289	3959					1931		
	Down	6142	3813							
	Up									
	COMB 13 : COMB 3 + EQ-T -Seismic Dry Case	8469	1250					1970		
	Down	8322	1104							
	Up									
	COMB 14 : DL+SIDL+EQ-L -one Span Dislodege Seismic case	5477	4402					1891		
	Down	5405	4331							
	Up									
	COMB 15 : DL+SIDL+EQ-T -one Span Dislodege Seismic case	6412	3203					1893		
	Down	6340	3131							
	Up									

Numbers of Raker piles

Raker pile shall be provided to cater longitudinal horizontal force (Fx)

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⁴
 692.081 KN