

Detailed Project Report

Consultancy Services for Preparation of DPR of Delhi – Ludhiana – Amritsar - Katra Expressway having an approximate length of 600 Km (the 'Project') including spurs through BOT EPC basis (Phase-2 section from Ch.397+700 to 566+520)

Volume – I Main Report

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ABBREVIATIONS

Abbreviation	Full Form
AADT	Annual Average Daily Traffic
AAQ	Ambient Air Quality
AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
ADT	Average Daily Traffic
AIL	Aggregate Interlayer
ASI	Archaeological Survey of India
ATCC	Automatic Traffic Counter and Classifier
ATMS	Advanced Traffic Management System
AUP	Animal Underpass
BA	Borrow Area
BC	Bituminous Concrete
BIS	Bureau of Indian Standards
BOCW Act	Building & Other Construction Workers Act
BOQ	Bill of Quantity
BOT	Build Operate Transfer
C/w	Carriageway
CA	Concession Agreement
CAD	Computer Aided Design
CAGR	Cumulative Annual Growth Rate
CALA	Competent Authority Land Acquisition
CAPEX	Capital Expenditure
CB	Crash Barrier
CBR	California Bearing Ratio
CD	Cross-Drainage
CD	Consolidated Drained
CFD	Cumulative Fatigue Damage
CFI	Consolidated Fund of India
CGT	Capital Gains Tax
CMU	Corridor Management Unit
CoD	Cut-off Date
CPCB	Central Pollution Control Board
CR	Cost Ratio
CRCP	Continuously Reinforced Concrete Pavement
CRZ	Coastal Regulation Zone
CSA	Cumulative Standard Axle
CTB	Cement Treated Base
CTSB	Cement Treated Sub-base
CTVC	Classified Traffic Volume Count
CUP	Cattle Underpass
CVPD	Commercial Vehicles Per Day

Abbreviation	Full Form
CWC	Central Water Commission
CWLW	Chief Wild Life Warden
CZMP	Coastal Zone Management Plan
DBM	Dense Bituminous Macadam
DCF	Discounted Cash Flow
DEM	Digital Elevation Model
DFO	Divisional Forest Officer / Deputy Conservator of Forest
DGPS	Differential Global Positioning System
DL	Dead Load
DLC	Dry Lean Concrete
DLC	District Level Committee
DM	District Magistrate
DM	Divisional Magistrate
DPR	Detailed Project Report
DS	Disturbed Sampling
DTM	Digital Terrain Model
EAC	Expert Appraisal Committee
EC	Economic Corridor
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIRR	Equity Internal Rate of Return
EMP	Environmental Management Plan
ENPV	Economic Net Present Value
EPC	Engineering Procurement & Construction
ESA	Equivalent Standard Axles
ESAL	Equivalent Single Axle Load
ETC	Electronic Toll Collection
FCFE	Free Cash Flow to Equity
FIPL	Feedback Infra Private Limited
FO	Flyover
FOS	Factor of Safety
FR	Feeder Route
FRL	Finished Road Level
FY	Financial Year
GAD	General Arrangement Drawing
GC	Generalized Cost
GDP	Gross Domestic Product
GL	Ground Level
GoI	Government of India
GPS	Global Positioning System
GQ	Golden Quadrilateral
GR	Growth Rate

Abbreviation	Full Form
GRC	Grievance Redressal Committee
GSB	Granular Sub-base
GSDP	Gross State Domestic Product
GST	Goods and Services Tax
GTS	Great Trigonometrical Survey
GW	Ground Water
HAM	Hybrid Annuity Model
HDI	Human Development Index
HDM	Highway Development and Management
HFL	High Flood Level
HPDE	High Density Polyethylene
HS	Highway Service
HYSD	High Yield Strength Deformed
IC	Inter-Corridor
IDC	Interest During Construction
IL	Intermediate Lane
IMD	India Meteorological Department
IMU	Inertial Measurement Unit
INR	Indian Rupee
IRC	Indian Road Congress
IRR	Internal Rate of Return
IS	Indian Standard
ISA	Initial Social Assessment
ISD	Intermediate Sight Distance
IT	Information Technology
JBIC	Japan Bank for International Cooperation
kmph	Kilometre Per Hour
kmph	Kilometer Per Hour
LA	Land Acquisition
LAP	Land Acquisition Plan
LCV	Light Commercial Vehicle
LHS	Left Hand Side
LL	Liquid Limit
LMV	Light Motor Vehicle
LOS	Level of Service
LS	Lump Sum
LSD	Limit State Design
LVUP	Light Vehicular Underpass
LWL	Lowest Water Level
MAV	Multi Axle Vehicle
MCLR	Marginal Cost of Lending Rate
MDD	Maximum Dry Density

Abbreviation	Full Form
MDR	Major District Road
MIDAS	Marine Information and Data Acquisition System
MJB	Major Bridge
MNB	Minor Bridge
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoRT&H	Ministry of Road Transport and Highways
MPa	Megapascal Pressure
MR	Major Road
MSA	Million Standard Axle
MSL	Mean Sea Level
MSME	Micro, Small and Medium Enterprises
MT	Metric Ton
NBWL	National Board for Wildlife
NGO	Non-Governmental Organisation
NH	National Highway
NHAI	National Highways Authority of India
NHDP	National Highways Development Project
NOC	No Objection Certificate
NPV	Net Present Value
NRSC	National Remote Sensing Centre
NSDP	Net State Domestic Product
NS-EW	North South - East West
O&M	Operation and Maintenance
OD	Origin - Destination
ODR	Other District Road
OFC	Optical Fibre Cable
OHT	Overhead Tanks
OMC	Optimum Moisture Content
ORR	Outer Ring Road
OSMEFWC	Online Submission & Monitoring of Environmental, Forests and Wild Life Clearance
PAP	Project Affected People
PBFF	Permanent Bridge Fee Fund
PCC	Plain Cement Concrete
PCCF	Principal Chief Conservator of Forests
PCI	Per Capita Income
PCU	Passenger Car Unit
PD	Project Director
PI	Plasticity Index
PIA	Project Influence Area
PIRR	Project Internal Rate of Return
PIU	Project Implementation Unit
PL	Plastic Limit

Abbreviation	Full Form
PPP	Public Private Partnership
PQC	Pavement Quality Concrete
PROW	Proposed Right of Way
PS	Paved Shoulder
PSC	Pre Stressed Concrete
PTFE	Poly Tetra Fluoro Ethylene
PUC	Pollution Under Control
PUP	Pedestrian Underpass
PV	Present Value
PWD	Public Works Department
R&R	Rehabilitation and Resettlement
RAP	Resettlement Action Plan
RCC	Reinforced Cement Concrete
RE Wall	Reinforced Earth Wall
RF	Reserve Forest
RFCTLARR Act	The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act
RFO	Reserve Forest Officer
RFP	Request for Proposal
RHS	Right Hand Side
RO	Regional Office
ROB	Rail Over Bridge
RoW	Right of Way
RQD	Rock Quality Designations
SAIL	Steel Authority of India Limited
SBWL	State Board for Wildlife
SC	Schedule Caste
SDM	Sub-Divisional Magistrate
SEIAA	State Environment Impact Assessment Authority
SEZ	Special Economic Zone
SH	State Highway
SIDL	Superimposed Dead Load
SLS	Serviceability Limit State
SOI	Survey of India
SoR	Schedule of Rates
SP	Special Publication
SPCB	State Pollution Control Board
SPT	Standard Penetration Test
SR	State Road
ST	Schedule Tribe
SUH	Synthetic Unit Hydrograph
SV	Special Vehicle

Abbreviation	Full Form
SVUP	Small Vehicle Underpass
SW	Surface Water
TCS	Typical Cross section
TL	Trip Length
TOR	Terms of Reference
TP	Toll Plaza
TPS	Thermal Power Station
TR	Toll Rates
TT	Travel Time
UDS	Undisturbed Sampling
ULS	Ultimate Limit State
UNESCO	United Nations Educational, Scientific and Cultural Organization
VDF	Vehicle Damage Factor
VG	Viscosity Grade
VGf	Viability Gap Funding
VIDS	Video Incident Detection System
VOC	Vehicle Operating Cost
VOP	Vehicular Overpass
VOT	Value of Time
VR	Village Road
VUP	Vehicular Underpass
WACC	Weighted Average Cost of Capital
WB	World Bank
WC	Wearing Course
WGS	World Geodetic System
WIM	Weigh in Motion
WLS	Wild Life Sanctuary
WMM	Wet Mix Macadam

0 EXECUTIVE SUMMARY

0.1 Project Background

The National Highways Authority of India (NHAI) has been constituted through an Act of Parliament for faster, economical and quality Road Construction work throughout India. NHAI aims at provisioning and maintaining the national highways network to meet user expectations in the most time-bound and cost-effective manner within the strategic policy framework. The National Highways Authority of India (NHAI) is the nodal agency of Ministry of Road Transport and Highways (MORT&H), Government of India and has been entrusted with the Development of Delhi - Ludhiana - Amritsar – Katra Expressway having an approximate length of 600 Km including spurs through BOT & EPC basis.

As part of the development, MoRT&H entrusted NHAI with engagement of a Consultant to carry out the “Consultancy services for Preparation of DPR for Development of Delhi - Ludhiana - Amritsar – Katra Expressway having an approximate length of 600 Km including spurs” for project preparation. NHAI through competitive bidding has appointed M/s. Feedback Infra Private Limited for providing the required consultancy services and issued letter of Commencement of Services vide their letter No.: NHAI/Punjab/ CC/ N-1/109706 dated 11.12.2017.

The Delhi - Ludhiana - Amritsar – Katra expressway has been referred to as the Project Highway in this Report. The Project Highway starts from Kundli Manesar Palwal Expressway (KMP) in National Capital Region (NCR) and ends at Katra in Jammu & Kashmir. Section between Delhi to Gurdaspur (397.700 km) along with part of connectivity to Amritsar (Km 0.000 to Km 24.000 out of 99.033km) is taken up under Phase 1 and DPR for the same is already submitted. This report pertains to the Draft Detailed Project Report for Phase 2 which includes section from Gurudaspur (397.700 km) to Katra section.

As phase 2 development, Gurdaspur (397.700 km) to Katra (566.520 Km) has been considered. The Greenfield/ Brownfield Alignment passes through following Districts namely Gurdaspur and Pathankot in Punjab and Kathua, Samba, Jammu and Reasi districts in the union territory of Jammu and Kashmir. The Project Highway starts at design ch. 397+700 and ends at design ch. 566+520. In addition, Pathankot link from design ch. 0+000 to 12+345 is also part of phase 2. Total length of the Project Highway is 181.165Km. Total project length of Phase-2 divided into 7 civil contract packages from package-13 to package-18 and Pathankot Link. The Detailed Project Report under the contract includes the following reports in succession:

- a. Alignment options report
- b. Feasibility report
- c. Strip plan and clearances
- d. Detailed project report
- e. Bid documents and technical schedules
- f. LA & clearances report

The present report deals with the works carried out for Detailed Project Report (DPR) for Phase-2.

0.2 Project Road

The Project Highway (Phase-2 of Delhi Amritsar Katra Expressway) starts from Gurudaspur (Km 397.700) in the state of Punjab and ends at Katra (Km 566.520) in the UT of Jammu & Kashmir. The Greenfield and Brownfield Alignment of Delhi Amritsar Katra Expressway Phase-2 passes through following Districts namely Gurudaspur and Pathankot in Punjab and Kathua, Samba, Jammu and Reasi districts in the union territory of Jammu and Kashmir. The Project Highway starts at design ch. 397+700 and ends at design ch. 566+520. In addition, Pathankot link from design ch. 0+000 to 12+345 is also part of phase 2. Total length of the Project Highway is 181.165Km including Pathankot link. The key plan of the project highway is shown in figure below:

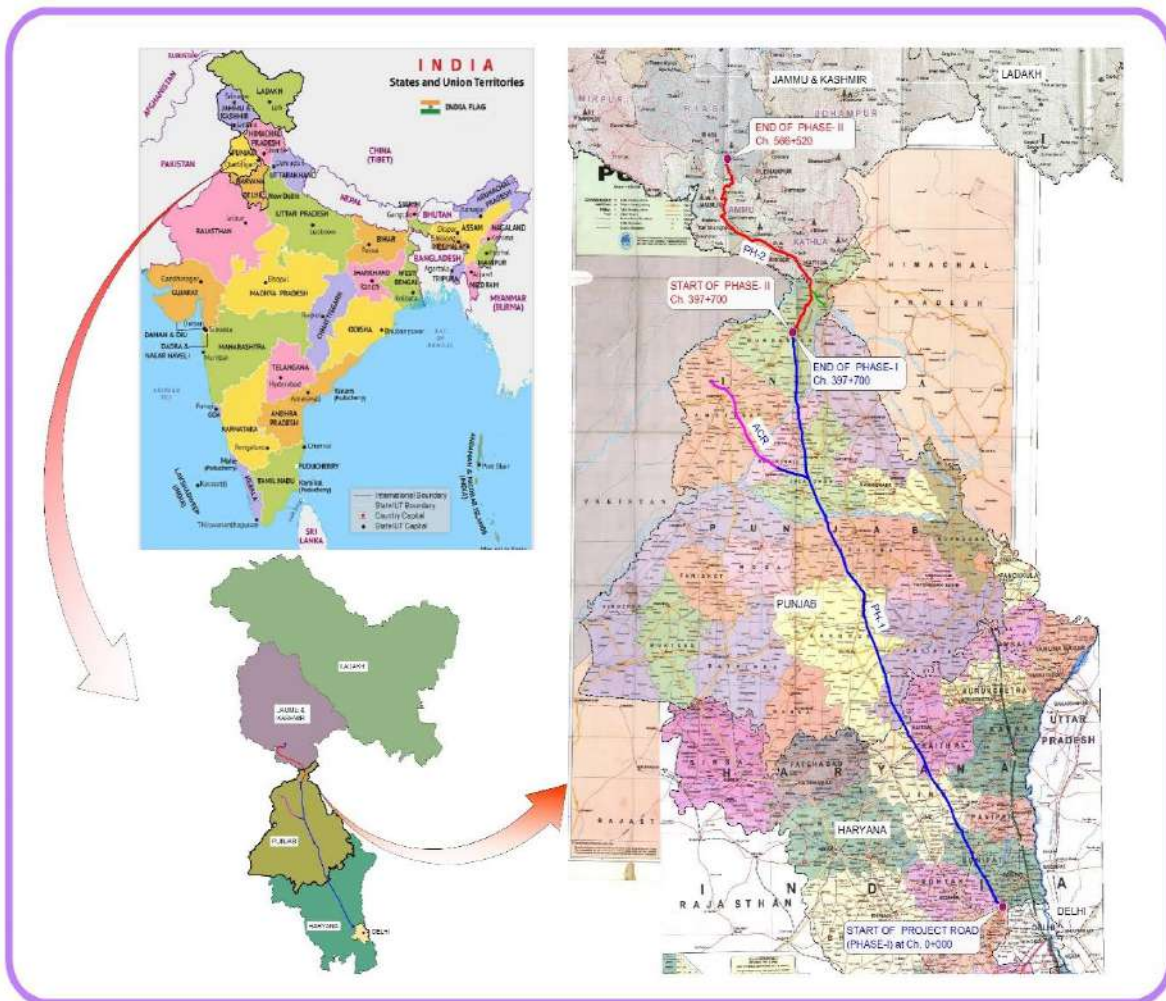


Figure 0-1: Location Map of the Project Highway

District and Tehsils (Sub-Districts) Traversed by the Proposed Alignment

The Phase 2 of the project Highway passes through 2 districts of Punjab namely Gurudaspur and Pathankot, and 4 districts of UT of Jammu and Kashmir, namely Kathua, Samba, Jammu and Reasi. It passes through 16 Tehsils i. e. Gurudaspur, Dinanagar, Pathankot, Kathua, Mahreen, Hiranagar, Ghgwal, Samba, Vijaypur, Baribrahmana, Bahu, Jammu, Nagrota, Dansal, and Katra. There is total 136 villages falling along the project alignment and the summary is given in table below:

Table 0-1: Summary of Villages along the Alignment

Sl No	State	District	Tehsil	No. of Villages
Package-13, 14,15, 17 and 18				
1	Punjab	Gurdaspur	Gurdaspur	5
			Dinanagar	4
		Pathankot	Pathankot (Green Field-10 & Brown Field-10)	13
2	J&K	Kathua	Kathua (Green Field-10 & Brown Field-10)	28
			Nagri Parole	3
			Mahreen	4
			Hiranagar	12
3	J&K	Samba	Ghgwai	5
			Samba	12
			Vijaypur	10
			Baribrahmana	1
4	J&K	Jammu	Bahu	2
			Jammu	4
			Nagrota	3
			Dansal	2
5	J&K	Reasi	Katra	9
Pathankot Link				
6	Punjab	Pathankot	Pathankot	19

Source: 3(a) Land acquisition QGIS Software.

0.3 Construction packages

The entire project road is divided into seven construction packages including Pathankot Link are given in Table 0.2.

Table 0-2 : Construction Packages

Sr. No.	Packages	Design Chainage (Km)		Package Start Point		Package End Point		Length of the Stretch (km)
		Start	End	Latitude	Longitude	Latitude	Longitude	
1	Package XIII	397+700	423+500	32° 01'03.62"N	75°24'05.41"E	32°12'14.91"N	75°32'14.11"E	25.800
2	Package XIV	423+500	468+100	32°12'14.91"N	75°32'14.11"E	32°28'44.25"N	75°16'44.74"E	44.600
3	Package XV	468+100	503+250	32°28'44.25"N	75°16'44.74"E	32°36'4.86"N	74°57'8.51"E	35.150
4	Package XVI	503+250	515+000	32°36'4.86"N	74°57'8.51"E	32°40'18.04"N	74°53'0.99"E	11.75
5	Package XVII	515+000	528+300	32°40'18.04"N	74°53'0.99"E	32°45'41.41"N	74°54'49.30"E	13.300
		550+900	566+520	32°52'38.27"N	74°57'18.67"E	32°59'46.06"N	74°55'43.07"E	15.62
6	Package XVIII	528+300	550+900	32°45'41.41"N	74°54'49.30"E	32°52'38.27"N	74°57'18.67"E	22.60
7	Pathankot Link	0+000	12+345	32°10'24.75"N	75°37'30.82"E	32°14'39.59"N	75°32'13.70"E	12.345
Total Length of Phase-2 including Pathankot Link (Km)								181.165

This volume deals with the Delhi Amritsar Katra Expressway Phase II, except Package-XVI which is the part of SA Infrastructure Consultants Pvt. Ltd and Package – XVIII. Details of Package – XVIII will be incorporated in the Final DPR

0.4 Land Use pattern

The land use for the Greenfield and Brownfield alignment passes through Agricultural/Barren Land and some stretch of Builtup areas.

0.5 Topographic survey

The Topographical survey has been carried out along the project alignment to provide the information in 3D. In order to have the required accuracy all Control Points and Benchmarks were established at the beginning of the topographic survey. Reference stations have been permanently established in convenient positions so that the results of survey can be verified at any time in the future. Pair of Main DGPS Control Points has been established at every 5km intervals by using DGPS survey (WGS-84), and pair of pillars has been placed at 5-km intervals. A pair of Secondary Control Points has been established at every 500m intervals which have been transferred from Main DGPS Control Points by Total Station of 1-second accuracy or by GPS itself. The procedure of topographic surveys carried out, has been described in the subsequent chapters. Ground surveys have been carried by using Drone, Total stations, DGPs and similar other survey equipment.

0.6 Material Investigations

The material survey and investigations have been conducted to assess suitability of construction material as per IRC/ MORT&H guidelines for various pavement layers and structural components. Material survey is subdivided into two activities as follows:

- Collection and testing of soil within the proposed right of way: Soil samples were collected along the proposed alignment for conducting laboratory tests and to assess the engineering properties.
- Identification of potential material sources required for construction of highway components.
 - ✓ Borrow material required for construction of Embankment/ Sub-grade
 - ✓ Aggregate source required for construction of Sub-base, WMM, DBM, BC and various grades of concrete
 - ✓ Fine aggregate (Sand/ Quarry dust) source required for construction of Sub-base, WMM, DBM, BC and various grades of concrete
 - ✓ Flyash for high embankment sections

The findings of material survey and results are elaborated in the chapter under Engineering Surveys and Investigations.

0.7 Geo-Technical Investigation

As per scope of services, technical requirements in respect of materials, workmanship and quality Geo-Technical Investigations has been carried out to know about the subsurface features and soil profiles and relevant soil and rock properties.

It also presents the details of Geotechnical explorations and engineering studies that are to be performed for the proposed Major bridges, Minor bridges, flyovers, ROB, and other grade

separators in various predetermined locations. The purpose of the explorations and studies is to identify subsurface conditions and formulate Geotechnical recommendations for design and construction.

The findings of Geo-Technical Investigation and results are elaborated in the chapter under Engineering Surveys and Investigations

0.8 Hydrological and Hydraulic Study

0.8.1 Main Objective

- The main objective of the hydrological and hydraulic study is to determine the required size of drainage structures to allow the estimated design flow of the streams to cross the road safely.
- To check whether waterway of proposed structures are sufficient to transmit the flow without risk so that appropriate decisions could be taken concerning their span arrangement.
- To estimate the peak discharge for 100-year return period flood.

0.8.2 Hydrological and Hydraulic Study for Bridges

For performing the hydrological and hydraulic analysis which essentially need the design flood of a specific return period for fixing the waterway vis-à-vis the design High Flood Level (HFL) of bridges depending upon their size and importance to ensure safety as well as economy. As per IRC 5-2015-Section I General Features of Design specify that the waterway of a bridge is to be designed for a maximum flood of 100 years return period. The following methods can be used to estimate the peak discharge for bridge sites on major and minor streams:

- a) Empirical Formulae
- b) Rational Method
- c) Synthetic Unit Hydrograph Method (Catchment Area > 25 Sq.Km)
- d) Slope Area method
- e) Catchment area basis based on existing dam data or measuring site data (wherever applicable)

0.9 Summary and Recommendations

Flood discharge estimated in four different ways should be compared & highest of these should be adopted as design discharge in general. However, the general condition laid down in IRC SP-13 has been used to fix the design discharge, that is, if the discharge obtained by one method is greater than 1.5 times the discharge obtained from the other, the design discharge should be limited to 1.5 times of the smaller one. Accordingly, the design discharge has been established for all the bridges. Based on the highest discharge HFL shall be reassessed using slope area method for the hydraulic calculation, provision of spans and scour levels.

The findings of Hydrological and Hydraulic Study and results are elaborated in the chapter under Engineering Surveys and Investigations.

Apart from the bridges over rivers, there are several locations where alignment is crossing canal/ drain of irrigation & drainage department. The span & vertical clearance is as per canal/ drain data collected from the concerned department. The required vertical clearance as per Navigational requirement is provided as per Inland Waterway Authority of India

0.10 Traffic survey and analyses

The classified volume count surveys were carried out at six locations, considering the possibility of diversion of traffic from existing alternative routes to proposed expressway. The surveys were conducted continuously for seven consecutive days for 24 hours through Automatic Traffic Counter and Classifier (ATCC) method on all locations.

The following traffic studies have been carried out for the project.

- Classified traffic volume counts for 7 days and 24 hours duration
- Origin Destination survey for 1 day

The summary of traffic survey location is given in table below:

Table 0-3: Traffic Survey Locations

Location	Start Date	End Date	Duration (days)
Classified Traffic Volume Count			
Mukarba Chowk-Panipat Section of NH-44(Near Bhagan Toll Plaza)	21/05/2018	01/05/2018	7
Kurukshetra- Ambala Section of NH-44(Near Sharifgarh)	21/05/2018	01/05/2018	7
Ludhiana-Jalandhar Section of NH-44*			-
Jalandhar-Pathankot Section of NH-44*			-
Pathankot-Jammu Section Of NH-44*			-
Amritsar - Gurdaspur Section of NH-54*			-
Gurdaspur - Pathankot Section of NH-54*			-
Hissar-Sirsa Section of NH-9*			-
Churu -Hissar Section of NH-52	10/01/2019	16/01/2019	7
Jalandhar-Amritsar Section of NH-3	11/01/2019	17/01/2019	7
Patiala-Rajpura Section Of NH-44(Near Daun Kalan)	21/05/2018	01/05/2018	7
Jammu – Domel Section of NH-44*			-
Domel – Katra	06/02/2020	12/02/2020	7
Origin–Destination			
Delhi – Panipat section (NH-44 near Baghan)	01-06-2018	02-06-2018	1
Ambala -Kurukshetra section (NH-44 near Sarifgarh)	21-05-2018	22-05-2018	1
Rajpura – Patiala (NH-07 near Daun Kalan)	24-05-2018	25-05-2018	1
Jalandhar - Ludhiana section (NH-1 near Ladhawal)	01-06-2018	02-06-2018	1
Amritsar - Jalandhar section (NH-1 near Nirajpur)	29-05-2018	30-05-2018	1
Pathankot – Jalandhar section (NH-44 near HarsaMansar)	30-05-2018	31-05-2018	1
Amritsar - Gurdaspur section (NH-54 near WaryamNagal)	28-05-2018	29-05-2018	1
Pathankot – Jammu section (NH-44 near Lakhanpur)	31-05-2018	01-06-2018	1
Hisar – Sirsa section (NH-9 near Landhari)	31-05-2018	01-06-2018	1
Hisar – Churu section (NH-52 near Lasedij)	05-06-2018	06-06-2018	1
Gurdaspur - Pathankot section (NH-54 near Ladpalwan)	16-01-2019	17-01-2019	1
Jammu – Domel Section of NH-44*	10-02-2020	11-02-2020	1

***CVC surveys at rest of locations along NH-44, NH-09 and NH-54 were not carried out as IHMCL data was available. For the purpose of OD analysis, the CVC data from the surveys carried out earlier has been used to determine the volume count according to the vehicular classification used for the present study.**

The summary of observed AADT at the survey locations are given in table below:

Table 0-4: AADT Traffic at Count Locations

Vehicle Type	Mukarba Chowk- Panipat Section of NH-44	Kurukshetra- Ambala Section of NH-44	Ludhiana-Jalandhar Section of NH-44	Jalandhar-Pathankot Section of NH-44	Pathankot-Jammu Section Of NH-44	Amritsar - Gurdaspur Section of NH-54	Gurdaspur- Pathankot section of NH-54	Patiala-Rajpura Section of NH-7	Hissar-Sirsa Section of NH-9	Churu -Hissar Section of NH-52	Jalandhar-Amritsar Section of NH-3	Jammu - Domel Section of NH-44	Domel - Katra
Car / Jeep / Van	45343	32784	27731	6335	8916	11567	7004	17469	8193	1791	21319	8934	3066
Taxi										0	478		470
Shared Jeep										24	70		0
Minibus	681	608	0	0	0	0	0	94	0	8	181	0	158
School. Bus	2437	2406	0	0	0	0	0	891	0	8	89	0	11
Govt. Bus										49	475	0	59
Pvt. Bus										58	532	0	259
Maxx/Pick-Up	2251	1424	3175	604	317	1019	671	1171	789	593	1369	866	0
LCV (4 tyre)	5595	3874	2946	811	953	427	586	605	675	167	146	888	0
LCV (6 tyre)	0	0	0	0	0	0		0	0	282	781		110
2 Axle	1044	1956	3016	2064	2187	1078	1302	417	912	203	392	2324	171
3 Axle	1773	2049	1277	1252	1298	761	1581	434	536	618	268	384	23
MAV (4 to 6 Axles)	1221	2114	643	314	743	531	1050	328	534	1565	366	235	8
MAV (> 6 Axles)	0	5	0	0	0	0	0	7	0	0	0	0	0
Others	35	0	11	4	4	2	5	0	2	0	3	8	0
Total vehicles	60380	47220	38799	11384	14418	15385	12199	21416	11641	5366	26469	14539	4335
Total PCUs	78423	69700	51147	19535	24479	21142	21951	26422	16751	12944	31827	21250	5543

Vehicle Type	Mukarba Chowk- Panipat Section of NH-44	Kurukshetra- Ambala Section of NH-44	Ludhiana-Jalandhar Section of NH-44	Jalandhar-Pathankot Section of NH-44	Pathankot-Jammu Section Of NH-44	Amritsar - Gurdaspur Section of NH-54	Gurdaspur– Pathankot section of NH-54	Patiala-Rajpura Section of NH-7	Hissar-Sirsa Section of NH-9	Churu -Hissar Section of NH-52	Jalandhar-Amritsar Section of NH-3	Jammu - Domel Section of NH-44	Domel - Katra
Non Tollable Traffic													
3-Wheeler	1535	293	1687	97	193	203	557	726	313	17	2277	130	280
2-Wheeler	9030	4001	11121	4436	8466	7043	8978	5621	2225	503	10435	1634	764
Agriculture Tractor	60	37	49	34	14	15	23	32	25	5	18	9	2
Agriculture Tractor/ Trailer	293	131	329	232	102	104	275	206	239	176	142	61	14
Cycle	182	11	87	140	195	310	157	29	26	2	351	1	3
Cycle Rickshaw	18	1	9	13	32	72	15	8	6	0	38	0	0
Animal Drawn Cart	10	0	0	0	0	0	0	0	0	1	5	0	0
Toll Exempted Car	23	73	0	0	0	0	0	49	0	2	53	0	11
Toll Exempted Bus	0	0	0	0	0	0	0	0	0	0	20	0	1
Toll Exempted LCV	8	28	0	0	0	0	0	35	0	0	28	0	1
Toll Exempted Truck	17	30	0	0	0	0	0	28	0	1	2	0	17
Total Non-Tollable (Nos.)	11176	4605	13282	4952	9002	7747	10005	6734	2834	707	13369	1835	1093
Total Non-Tollable (PCUs)	7732	3151	8863	3506	5066	4514	6427	4728	2564	1080	8603	1236	796
Grand Total (Nos.)	71556	51825	52081	16336	23420	23132	22204	28150	14475	6073	39838	16374	5428
Grand Total (PCUs)	86154	72851	60010	23041	29545	25656	28377	31150	19314	14024	40430	22485	6339

Traffic Projections on the proposed Highway

The entire expressway is divided into two phases i.e. Phase-1 from km 0+000 to Km 397+700 and Phase-2 from km 397+700 to km 566+520. Phase –1 is completely greenfield alignment and Phase-2 is the combination of greenfield and brownfield alignment. The entire expressway has been proposed as fully access controlled. The access is proposed to be provided through interchanges. Accordingly, 31 homogeneous sections have been considered, from homogeneous section 1 to 20 in Phase-1 and 21 to 31 (11 no's) in phase 2. The summary of identified homogeneous sections of phase 2 is given in table below:

Table 0-5: Traffic Homogenous Sections

Homogeneous Section	From (Km)	To (Km)	Length (Km)	Phase
21	397+700	424+557	26.857	Phase II
22	424+557	428+000	3.443	
23	428+000	438+780	10.780	
24	438+780	452+671	13.891	
25	452+671	465+798	13.127	
26	465+798	481+150	15.352	
27	481+150	486+993	5.843	
28	486+993	502+000*	15.007	
29	515+000	531+000	16.000	
30	531+000	552+000	21.000	
31	552+000	564+700**	12.700	

*DPR study from km 502 to km 515 stretch of Delhi – Katra expressway is with another consultant; **end chainage may vary depending on the final design.

The projected traffic on the Greenfield/Brownfields highway comprised the followings:

- I. **Diverted traffic** – This is traffic based on trips already made between various origin and destination points impacted by the proposed highway route.
- II. **Generated traffic** – This is the traffic based on the new trips to be generated due to development of new nodes on the proposed highway route.
- III. **Induced traffic** – This is the traffic based on the trips that were not taken earlier due to lack of desired infrastructure.

Based on the above, the projected AADT and PCUs on the expressway at different homogeneous sections have been worked out, and the details are given in table below:

Table 0-6: Section wise Estimated Traffic on Project Highway

FY	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average PCUs
2018-19	18894	16945	18900	18829	18439	18439	18318	18447	21250	21250	7893	17964
2019-20	19898	17837	19901	19821	19413	19413	19286	19421	22422	22422	8372	18928
2020-21	20961	18780	20959	20871	20443	20443	20309	20451	23666	23666	8881	19948
2021-22	22084	19777	22077	21981	21533	21533	21392	21540	24983	24983	9423	21028
2022-23	23272	20832	23260	23154	22685	22685	22536	22691	26379	26379	9999	22170
2023-24	24530	21946	24511	24395	23904	23904	23748	23910	27859	27859	10611	23380
2024-25	26958	24116	26937	26808	26270	26270	26099	26278	30647	30647	11707	25703
2025-26	28219	25241	28197	28060	27500	27500	27321	27508	32112	32112	12302	26916
2026-27	29543	26422	29519	29375	28791	28791	28604	28799	33650	33650	12928	28188
2027-28	30932	27662	30907	30755	30146	30146	29950	30155	35267	35267	13588	29525
2028-29	32391	28963	32365	32204	31569	31569	31364	31578	36966	36966	14281	30929
2029-30	33711	30149	33689	33524	32866	32866	32652	32876	38476	38476	14886	32197
2030-31	35088	31385	35071	34901	34218	34218	33997	34230	40051	40051	15516	33521
2031-32	36524	32675	36512	36337	35629	35629	35399	35644	41693	41693	16174	34901
2032-33	38021	34022	38016	37836	37102	37102	36863	37119	43406	43406	16861	36341
2033-34	39584	35427	39585	39401	38639	38639	38390	38658	45192	45192	17577	37844
2034-35	40977	36689	40991	40806	40020	40020	39763	40042	46759	46759	18194	39184
2035-36	42423	38000	42451	42266	41454	41454	41188	41479	48383	48383	18833	40574
2036-37	43924	39362	43967	43781	42943	42943	42668	42971	50067	50067	19496	42017
2037-38	45482	40775	45542	45356	44490	44490	44206	44522	51812	51812	20182	43515
2038-39	47099	42243	47176	46991	46096	46096	45802	46133	53623	53623	20894	45071
2039-40	48498	43522	48598	48416	47496	47496	47194	47537	55167	55167	21499	46417
2040-41	49944	44846	50068	49889	48944	48944	48633	48990	56761	56761	22121	47809
2041-42	51439	46214	51589	51413	50442	50442	50122	50493	58404	58404	22763	49248
2042-43	52983	47629	53161	52989	51990	51990	51662	52048	60100	60100	23424	50734
2043-44	54580	49093	54786	54619	53593	53593	53255	53656	61850	61850	24106	52271

FY	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average PCUs
2044-45	56019	50423	56258	56099	55047	55047	54702	55118	63394	63394	24691	53654
2045-46	57501	51794	57776	57624	56547	56547	56193	56624	64980	64980	25290	55078
2046-47	59028	53207	59339	59197	58092	58092	57729	58177	66611	66611	25906	56544
2047-48	60600	54663	60951	60819	59685	59685	59314	59777	68286	68286	26538	58055
2048-49	62220	56166	62613	62490	61328	61328	60948	61429	70009	70009	27186	59611
2049-50	63888	57714	64326	64213	63022	63022	62632	63132	71779	71779	27851	61214
2050-51	65607	59311	66092	65990	64769	64769	64369	64887	73599	73599	28533	62866
2051-52	67378	60958	67913	67823	66571	66571	66161	66699	75470	75470	29233	64568
2052-53	69204	62657	69790	69714	68429	68429	68009	68567	77394	77394	29951	66322
2053-54	71085	64410	71726	71664	70346	70346	69914	70494	79372	79372	30689	68129
2054-55	73023	66218	73723	73676	72324	72324	71881	72483	81406	81406	31445	69992
2055-56	75021	68084	75783	75751	74365	74365	73910	74535	83498	83498	32222	71912
2056-57	77081	70008	77907	77893	76471	76471	76004	76653	85650	85650	33019	73892
2057-58	79205	71995	80099	80104	78644	78644	78165	78838	87863	87863	33837	75932
2058-59	81395	74045	82361	82385	80886	80886	80396	81094	90139	90139	34677	78037
2059-60	83653	76161	84694	84740	83201	83201	82698	83422	92480	92480	35539	80206

The thresholds for 4-lane divided interurban expressway highway is given in Table 0-7.

Table 0-7: Capacity Augmentation

FY	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average PCUs
Year when Expressway will be functional 2024-25	26958	24116	26937	26808	26270	26270	26099	26278	30647	30647	11707	25703
Threshold for Upgradation of Expressway From 4 To 6 Lanes (2052-53)	69204	62657	69790	69714	68429	68429	68009	68567	77394	77394	29951	66322

As per IRC: SP: 99-2013, the capacity of 4-lane is 65000 PCUs for peak hour flow (8%) which gets exhausted in 2052 -53. Hence, considering the IRC: SP: 099-2013, the greenfield section of expressway is to be made 4-lane and brownfield section is to be 6/4-lane

0.11 Development proposals

0.11.1 Design speed:

A design speed of 120 km per hour for plain terrain, 100 km per hour for Rolling terrain and 80 km per hour for hilly terrain has been considered for the project highway.

0.11.2 Right of Way:

The recommended minimum Right of Way is given in table below as per requirement of project:

Table 0-8: Recommended Minimum Right of Way

Section	Right of Way (ROW) in m
Rural Section	60-90
Rural sections passing through semi urban areas	45-60
Forest Area	30-60

Section wise ROW details are given in Volume – II: Part – 1 Design Report of this Detailed Project Report.

0.12 Lane Width of Carriageway

The standard lane width of the Project Corridor is 3.750 m for plain and rolling terrain and 3.5 m for hilly terrain. Project Corridor shall have two/three lane in each direction of traffic and total 4/6 lane.

0.13 Median

The median has been depressed for greenfield section and raised for brownfield section. Recommended width of median including shyness is 12m for greenfield section, 4.5m for brownfield section and 2.5 m for elevated including approaches in brownfield section. Other specifications for median are mentioned below:

1. The depressed median has suitably been designed and provision of rainwater harvesting system at suitable intervals for effective drainage of surface runoff from the median has been provided.
2. An edge strip of 0.75m width of depressed median adjacent to carriageway in either direction is paved with same specifications as of the adjacent carriageway.
3. As far as possible, the median will be of uniform width for the Project highway. However, where changes are unavoidable, a transition of 1 in 50 is provided.
4. Median is well planted to cutoff the glare coming from the vehicle traveling in opposite directions.
5. Median drains are terminated well before SVUP, LVUP, VUP with effective drainage arrangement.
6. The drainage provision at depressed median shall be suitably catered and provision of rainwater harvesting system to be made duly conceding appropriate locations for effective drainage.

7. At VUP, SVUP, LVUP and Bridge location, median wall is eliminated and slope of 1:2 has been provided; in place of median wall pitching and toe wall has been provided.

0.14 Shoulders

The shoulders on the outer side (left side of carriageway) shall be paved of 3 m wide in plane/rolling terrain and 2.5 m in hilly terrain plus 2 m wide earthen as per Section 2, Clause 2.6 of IRC: SP: 99-2013. The shoulder composition shall be as below:

- ✓ The composition and specification of the paved shoulder shall be same as that of the main carriageway.
- ✓ The earthen shoulder shall be provided with 200 mm thick layer of non-erodible/granular material for protection against erosion.

0.15 Barriers

Thrie-beam crash barrier has been provided throughout the project corridor except at structure locations. At culverts, parapet wall has been provided and at SVUP/LVUP /VUP/FO/ RoB, concrete crash barrier has been provided.

0.16 Road Junctions

Project Road crosses 51 roads of different category apart from cart tracks. Project road cross following major highways NH15/NH54, NH1A, NH-354, NH334B and SH-25 in the state of Punjab and Union Territory of Jammu & Kashmir in Phase 2. Being fully access controlled, there will be no at grade junctions. Entry/ Exit will be only from interchanges. At 9 locations interchange have been provided including Pathankot connectivity, rest all crossing will be grade separated. Locations of proposed interchanges are given in table below:

Table 0-9: Details of Proposed Interchanges along the Alignment

Interchange . No.	Chainage	Type of Interchange	Road crossing
1	424+557	Trumpet	NH-54/ Start of Kathua Bypass
2	428+100	Trumpet	Pathankot Link
3	438+780	Rotary with ramps	MDR [Kathua-Keerian Gandial road]
4	451+671	Double Trumpet	NH-44/ End of Kathua Bypass
5	465+798	Rotary with ramps	MDR [Chak Dyala – Hiranagar Road]
6	481+150	Double Trumpet	NH-44/ Start of Sambha Bypass
7	486+993	Rotary with ramps	Industrial Road in Sambha Bypass
8	552+260	Rotary with ramps	NH-44 and NH-144
9	563+545	Trumpet	Katra Bus Stand Link

Note: Culverts of size 1x2x2 are proposed at every closed loop in Interchange except Rotary type

0.17 Proposed Connecting Roads, Service Road and Slip Road

At some locations connecting road has been provided to connect nearby tracks to optimise the number of SVUP along the project road. Generally, access has been provided to all crossroad, in case 2 or more earthen roads cross the proposed expressway in close vicinity

in that case access has been provided to one road and rest are joined to underpass by connecting road outside the PROW. Service roads have been provided wherever it will be required due to severance of existing facility. The service roads shall be connected to nearest existing crossroads and grade-separator for the convenience of local population. Slip roads are provided as interchange locations. The details of locations where connecting road have been provided are given in the table below:

Table 0-10: List of Proposed Connecting Roads

Connecting Road in Package-13,14 &15:

Sl. No.	Design Chainage (Km)		Side (LHS/RHS)	Length (M)
	From	To		
1	424+140	424+430	LHS	290
2	424+100	424+440	RHS	340
3	427+290	427+330	LHS	40
4	427+290	427+420	RHS	130
5	429+290	429+370	RHS	80
6	431+520	431+710	RHS	190
7	432+520	432+630	LHS	110
8	436+210	436+300	RHS	90
9	450+500	450+680	RHS	180
10	451+360	451+480	LHS	120
11	451+380	451+490	RHS	110
12	468+940	468+980	RHS	40

Connecting Road in Package-17:

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)
	From	To		
1	524+000	424+200	LHS	220
2	562+070	562+280	LHS	210
3	562+280	562+550	Below Viaduct	270
4	564+320	564+450	LHS	130
5	RHS of Expressway between km 566+200 to km 566+520 followed existing road alignment.			766
6	Connect to Katra Market to Round about near Katra Bus Stand/ Katra Railway Station.			315

Service Road: Service Road is provided at locations shown below on both side of expressway.

Service road in Pkg-13, 14 & 15.

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Remarks
	From	To			
1	397+700	422+440	Both	24740	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)
2	423+280	423+500	Both	220	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Remarks
	From	To			
3	423+500	424+600	Both	1100	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)
4	453+038	463+400	Both	10362	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)
5	471+300	479+800	Both	8500	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)
6	490+700	499+630	Both	8930	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)
7	500+700	503+200	Both	2500	Lane width 2x7m + (Shyness + Paved shoulder as per TCS)

Package 17: -

Service road along Main Alignment of Expressway for Kunjwani to Sidhra Section

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Width of Service Road (m) (Lane Width + Shoulder Width)
	From	To			
1	515+000	522+500	Both	7500	As per TCS
2	522+500	522+800	LHS	300	As per TCS
3	522+800	522+950	Both	150	As per TCS
4	522+950	523+160	LHS	210	As per TCS
5	523+160	523+690	Both	530	As per TCS
6	523+960	524+750	Both	790	As per TCS
7	524+930	525+440	Both	510	As per TCS
8	525+680	526+280	Both	600	As per TCS
9	526+550	527+870	Both	1320	As per TCS
10	527+870	528+120	LHS	250	As per TCS
11	528+120	528+300	Both	180	As per TCS

Service Road on RHS which is split from Main Alignment towards existing road for Kunjwani to Sidhra Section.

Sl. No.	Design Chainage of RHS Service Road (Km)		Side	Length (m)	Width of Service Road (m) (Lane Width + Shoulder Width)
	From	To			
1	522+470	522+710	RHS	240	As per TCS
2	522+910	523+150	RHS	240	As per TCS
3	523+690	524+230	RHS	540	As per TCS
4	524+950	525+380	RHS	430	As per TCS

Sl. No.	Design Chainage of RHS Service Road (Km)		Side	Length (m)	Width of Service Road (m) (Lane Width + Shoulder Width)
	From	To			
5	525+660	526+350	RHS	690	As per TCS
6	526+860	527+250	RHS	390	As per TCS
7	528+540	528+920	RHS	380	As per TCS

Ramps (Function as LHS Service Road) to connect LHS Service Road which is terminated due to follow existing road alignment for Kunjwani to Sidhra Section.

Sl. No.	Ramps Chainage (Km)		Design Length (m)	Width of Service Road (m) (Lane Width + Shoulder Width)	Remarks
	From	To			
1	0+000	0+360	360	As per TCS	Ramp-1 between Expressway Chainage Km 522+500 to 522+860 on RHS
2	0+000	0+600	600	As per TCS	Ramp-2 between Expressway Chainage Km 523+690 to 523+960
3	0+000	0+466	466	As per TCS	Ramp-3 between Expressway Chainage Km 524+750 to 524+930
4	0+000	0+645	645	As per TCS	Ramp-4 between Expressway Chainage Km 525+440 to 525+680
5	0+000	0+461	461	As per TCS	Ramp-5 between Expressway Chainage Km 526+280 to 526+550

Service Road along Main Alignment of Expressway for Domel to Katra Section

Sl. No.	Design Chainage (Km)		Side (LHS/RHS)	Length (m)	Width of Service Road (m) (Lane Width + Shoulder Width)
	From	To			
1	550+900	552+220	Both	1320	As per TCS
2	552+330	552+420	LHS	90	As per TCS
3	552+420	555+470	Both	3050	As per TCS
4	555+470	555+650	RHS	180	As per TCS
5	555+650	555+980	Both	330	As per TCS
6	555+980	556+390	RHS	410	As per TCS
7	556+390	559+640	Both	3250	As per TCS
8	559+640	559+850	RHS	210	As per TCS
9	559+850	560+000	Both	150	As per TCS
10	560+000	560+250	RHS	250	As per TCS
11	560+250	560+910	Both	660	As per TCS

Ramps (Function as LHS Service Road) to connect LHS Service Road which is terminated due to follow existing road alignment for Domel to Katra Section.

Sl. No.	Ramps Chainage (Km)		Design Length (m)	Width of Service Road (m) (Lane Width + Shoulder Width)	Remarks
	From	To			
1	0+000	0+286	286	As per TCS	Ramp-1 between Expressway Chainage Km 555+470 to 555+650
2	0+000	0+582	582	As per TCS	Ramp-2 between Expressway Chainage Km 555+980 to 556+390
3	0+000	0+243	243	As per TCS	Ramp-3 between Expressway Chainage Km 559+640 to 559+850
4	0+000	0+300	300	As per TCS	Ramp-4 between Expressway Chainage Km 560+000 to 560+250

Service Road in Pathankot Link Road:

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Remarks
	From	To			
1	1+050	5+750	Both sides	4700	Excluding Tapering Length
2	6+950	9+290	Both sides	2340	
3	11+290	11+930	Both sides	640	

Slip Roads: Slip Road provided at given below locations.

Slip Roads in Package 13, 14 & 15: -

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Remarks
	From	To			
1	397+700	399+970	Both	2230	5.5m
2	411+100	411+800	Both	700	5.5m
3	424+060	424+430	Both	740	5.5m
4	453+640	454+020	Both	760	5.5m
5	454+690	455+080	Both	780	5.5m
6	456+100	456+660	Both	1120	5.5m
7	462+880	463+430	Both	1100	5.5m
8	472+800	473+290	Both	980	5.5m
9	475+200	476+450	Both	1250	5.5m
10	490+100	491+160	Both	2120	5.5m
11	495+540	497+540	Both	2000	5.5m
12	501+340	501+670	Both	330	5.5m
13	502+300	503+260	LHS	960	5.5m

Slip Roads in Package 17: -

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Remarks
	From	To			
1	515+760	515+970	Both sides	210	
2	520+150	520+200	Both sides	50	Ramp for Exit from Expressway
3	521+250	521+300	RHS	50	Ramp for Entry to Expressway
4	523+340	523+390	LHS	50	Ramp for Entry to Expressway

Slip Roads in Pathankot Link Road: -

Sl. No.	Design Chainage (Km)		Side (LHS/RHS]	Length (m)	Remarks
	From	To			
1	9+900	9+980	Both sides	80	Excluding Tapering Length
2	10+078	10+400	Both sides	322	
3	0+000	1+020	Both sides	1020	Along NH-44 (Pathankot-Jalandhar Road) at start point of Project Road

Ramps from km 9+980 towards NH-54 on both directions in Pathankot Link Road: -

Sl. No.	Ramp Chainage (Km)		Length (m)	Remarks
	From	To		
1	0+080	0+340	260	Ramps provided to connect NH-54 on both directions.
2	0+080	0+320	240	

0.18 Nallah training

Nallah training/ river training is provided at locations where the water body is running parallel to the project highway within RoW. Nallah/River training is done with the lined canal of equivalent width of the nallah/ drain.

0.19 Way side Amenities/ Service Areas

In the project highway one smaller amenity of 200m x 300m and bigger amenity of 400m x 600m are provided alternatively at 25Km interval. Big size amenity is provided with subway/ SVUP to enable the vehicle/ user to pass on the opposite side highway amenity. There is one small highway amenity and one big amenity in this package.

Big size way side amenity: Wayside amenities is a part of the Highway and is provided with the minimum facilities such as Parking areas (Trucks, Buses, Cars, Mini Buses), Fuel Station and garage for minor repair, Hotel/ Motel, Trauma Center, Rest Areas, Fast Food Centre, Travel Information Facilities, Toilets and Bath Facilities, space for Maintenance staff & Vehicle Service Station, Dormitory, Helipad, Generator room/ solar system area, Play Area & security personnel, Separate area Truck parking facilities is provided in this way side amenity for truck parker. Truck parker to have separate Dhaba, Water Kiosk, weighing bridge, Motel, Toilet facility, Garage / workshop/ service centre.

Small size way side amenity: Toilet facilities and kiosks with smaller parking area, fuel station, water kiosk and restaurants are provided within 0.8 hectares of area.

Following are the locations of amenities:

S. No.	Start (Km)	End (Km)	Side	Type of facility	Area
1	439+350	439+600	Both side	Road user facility	4 Ha +4 Ha
2	467+675	467+925	LHS side	Road user facility	4 Ha
3	469+225	469+475	RHS side	Road user facility	4.0 Hect
4	487+010	487+420	RHS side	Road user facility	9.7 Hect
5	552+600	552+870	RHS side	Road user facility	2.15 Hect

0.20 Retaining wall/ toe wall:

Retaining wall toe wall are provided where embankment height is more than 8m. These locations are found mostly at the bridge approach or localised depressed locations.

0.21 Road Lighting:

Road lighting are provided at all major/ minor bridges/ toll plaza's, amenities/ subways and junctions. The specification of road lighting is as per IRC SP 99.

0.22 Structures

Grade separated structures are proposed for intersections with National highways, State highways, Major District Roads (MDRs), Other District Roads (ODRs), Village Roads (VRs) and Railway Line. These structures include Interchanges, ROB's, Flyovers / VOPs, VUPs, LVUPs, SVUPs.

Structures have been provided at river/ nalla/ pond/ tank/ stream/ canal crossings. These are Major Bridges (MJB), Minor bridges (MNB), Box culverts. The summary of proposed structures is given in table below:

Table 0-11: List of Proposed Structures

Sl. No.	Type of structures	Numbers
Package-13		
1	RoB	0
2	Interchange	0
3	Flyover	5
4	Major Bridge	1
5	Major Bridge cum VUP	0
6	Major Bridge cum LVUP	0
7	Major Bridge cum SVUP	0
8	Minor Bridge	3
9	Minor Bridge cum LVUP	0
10	Minor Bridge cum SVUP	2
11	MNB cum VUP	0
12	VUP	11
13	LVUP	1

Sl. No.	Type of structures	Numbers
14	SVUP	0
15	Viaduct	0
16	Culvert	63
17	Culverts on loop & Ramps	0
18	Structures on Loops of Interchange (VUP & VOP)	0
19	Additional culvert	26
Total		112
Package-14		
1	RoB	1
2	Interchange	2
3	Flyover	1
4	Major Bridge	7
5	Major Bridge cum VUP	1
6	Major Bridge cum LVUP	0
7	Major Bridge cum SVUP	0
8	Minor Bridge	17
9	Minor Bridge cum LVUP	5
10	Minor Bridge cum SVUP	4
11	MNB cum VUP	2
12	VUP	4
13	LVUP	16
14	SVUP	5
15	Elevated	3
16	Viaduct	1
17	Aqueduct	1
18	Culvert	103
19	Culverts on loop & Ramps	18
20	Structures on Loops and Ramps (MNB, VUP & VOP)	7
21	Additional culverts	45
Total		243
Package-15		
1	RoB	2
2	Interchange	0
3	Flyover	2
4	Major Bridge	8
5	Major Bridge cum VUP	1
6	Major Bridge cum LVUP	0
7	Major Bridge cum SVUP	0
8	Minor Bridge	21
9	Minor Bridge cum LVUP	1
10	Minor Bridge cum SVUP	6

Sl. No.	Type of structures	Numbers
11	MNB cum VUP	0
12	VUP	5
13	LVUP	5
14	SVUP	3
15	Elevated	6
16	Viaduct	0
17	Culvert	55
18	Culverts on loop & Ramps	8
19	Structures on Loops and Ramps (VUP & VOP)	3
20	Additional culverts	35
Total		161
Package-17		
1	RoB	2
2	RUB	1
3	ROB cum Elevated	1
4	Interchange	1
5	Interchange cum Viaduct	1
6	Flyover	4
7	Major Bridge	1
8	Major Bridge cum VUP	1
9	Major Bridge cum LVUP	0
10	Major Bridge cum SVUP	0
11	Minor Bridge	15
12	Minor Bridge cum LVUP	1
13	Minor Bridge cum SVUP	0
14	MNB cum VUP	0
15	VUP	4
16	VOP	1
17	LVUP	4
18	SVUP	2
19	Viaduct	13
20	Viaduct cum MJB	1
21	Culvert	93
22	Culverts on loop & Ramps	1
23	Structures on Loops and Ramps (VUP)	1
24	Additional culverts	35
Total		182
Pathankot Link		
1	ROB	1
2	Interchange	0
3	Flyover	2

Sl. No.	Type of structures	Numbers
4	Special Structure	0
5	Major Bridge	2
6	Major Bridge cum LVUP	1
7	Major Bridge cum SVUP	1
8	Major Bridge cum VUP	1
9	Minor Bridge	1
10	Minor Bridge cum LVUP	0
11	Minor Bridge cum SVUP	0
12	Minor Bridge cum VUP	0
13	VUP	3
14	LVUP	3
15	SVUP	4
16	Viaduct	0
17	Culvert	31
18	Structures on Loops of Interchange (MNB & VUP)	0
19	Culverts on Loops of Interchange	0
20	Additional culverts	12
Total		62

Details of Structure proposals are elaborated under Design Report.

0.23 Pavement Design

The Greenfield/Brownfield expressway has been designed as per the guidelines of IRC: 37-2018 – “Guidelines for the design of flexible pavements”. The rigid pavement is designed as per the guidelines of IRC: 58-2015 – “Guidelines for the design of rigid pavements for highways”.

0.23.1 Design life

As per clause 4.3.1 of IRC: 37-2018, a design life of 30 years has been considered for flexible pavement design of main carriageway. Similarly, as per clause 4.3.1 of IRC: 37-2018, a design life of 20 years has been considered for Pathankot Link, service road (NH). 30 years design life is considered for Rigid pavement design.

0.23.2 Design CBR

Based on Laboratory test results of identified borrow area soil, the available CBR varies between 6.90% and 12.0%. The effective design CBR (%) Adopted for Current project road 12%.

0.23.3 Recommended Pavement Design:

The summary of recommended flexible pavement crust composition for main carriageway including ramps is given in table below.

Table 0-12: Recommended Pavement Design for Main Carriageway and Ramps

Homogeneous Sections		21	22 to 31	Pathankot Link
Section (Ch.)	From	397.700	424.557	0.000
	To	424.557	566.520	13.700
Lane Configuration		6,4-Lane	6,4-Lane	4-Lane
Adopted MSA		200	150	50
Effective Design CBR (%)		12	12	12
Grade of Bitumen		VG40		
Proposed Crust Composition (mm)	SMA	50	50	40
	DBM	115	100	70
	WMM	150	150	150
	CTSB	250	250	200
	Total	565	550	460

The summary of recommended flexible pavement crust composition for proposed service road carriageway along the proposed expressway is given in table below.

Table 0-13 : Recommended Pavement Design for Service Road

Homogeneous Sections		21	22 to 31	Pathankot Link
Section (Ch.)	From	397.700	424.557	0.000
	To	424.557	566.520	13.700
Adopted MSA		85	50	10
Effective Design CBR (%)		12	12	12
Grade of Bitumen		VG-40		VG30
Proposed Crust Composition (mm)	SMA/BC	40	40	40
	DBM	90	70	50
	WMM	150	150	150
	CTSB	200	200	200
	Total	480	460	440

The summary of recommended flexible pavement crust composition for proposed Slip Road section along the proposed expressway is given in table below.

Homogeneous Sections		21 to 31
Section (Ch.)	From	Proposed Sections wherever required. (from Km 397.700 to Km 566.520)
	To	
Adopted MSA		10
Grade of Bitumen		VG30
Proposed Crust Composition (mm)	BC	40
	DBM	50
	WMM	150
	CTSB	200
	Total	440

Similarly, Rigid Pavement is considered for the proposed toll plaza/booth locations of the project road and the proposed crust composition is given in table below:

Table 0-13: Recommended Pavement Design for Toll Plaza/Booths

Pavement Crust Composition	Thickness (mm)
PQC	300
DLC	150
GSB	150
Total	600

0.24 Preliminary Environmental Assessment

Environmental impact assessment is an integral part of any green-field road project and is mandatory for project environment clearances. The preliminary environmental assessment is carried out to identify critical issues to be addressed in detail during subsequent stages of the project. The assessment is based on existing policy, legal and administrative framework considering the applicable environmental legislations, regulations and guidelines.

The proposed alignment mostly follows 'plain' and 'rolling' terrain. The elevation varies from from ~259 m above MSL to ~837 m above MSL at different locations. Average elevation of the project stretch is ~374 m above MSL. Broadly the Land use forms identified around the proposed corridor includes Agricultural Land and Barren Land. Project alignment is also passing through the ecologically protected area at few locations.

The proposed alignment is not passing through any protected area in Punjab State. However, in in UT of J&K, the proposed alignment is passing through Bahu Conservation Reserve, Ramnagar Wildlife Sanctuary and Nandini Wildlife Sanctuary. Therefore, wildlife clearance shall be obtained under Wildlife (Protection) Act, 1972. Further, the proposed alignment is also traversing through Reserve Forests at few locations and the Strip Forests alongside roads, canals and railway lines declared as Protected Forests, hence, there will be diversion of forest land and necessary clearances shall be obtained as per requirements under Forest (Conservation) Act, 1980.

For drawing up the baseline status of existing environment, Ambient Air Quality, Ambient Noise Level, Surface & Ground Water Quality and Soil Quality monitoring conducted at representative locations along the proposed expressway. Ambient Air Quality monitoring conducted at a frequency of twice a week for one season at each monitoring station adopting a 24-hours schedule. Complete Baseline monitoring results will discuss under EIA report. Flora and fauna study along the project expressway will be undertaken during the Environmental Impact Assessment (EIA) study.

The detailed environmental surveys and clearances to be procured from the statutory authorities are under progress. The impact assessments will be detailed in Environmental Impact Assessment (EIA) report which also contemplates the positive impacts and mitigation measures

0.25 Initial Social Impact Assessment

The proposed alignment traverses through 2 districts of Punjab namely Gurudaspur and Pathankot, and 4 districts of UT of Jammu and Kashmir, namely Kathua, Sambha, Jammu and Reasi. It traverses through a total of 16 tehsils (3 nos. in Punjab State & 13 nos. in UT of Jammu & Kashmir) and 117 villages (22nos. in Punjab state and 95nos. in Jammu & Kashmir state) along the project corridor. The assessment is based on existing policy, legal and administrative framework considering the applicable social legislations, regulations and guidelines.

Total land required for the proposed project is about 698.0103 Ha which includes 143.6362 Ha Government land and 554.3741 Ha of Private land. In total, 136 villages (19 villages in Pathankot Link, 22 in Punjab Section & 95 in Jammu & Kashmir Section) will be affected due to land acquisition.

During the census survey in addition to structures that belong to titleholders, large number of encroachers and squatters were also enumerated along the proposed alignment. Based on the social survey data, a total no. of 2452 structures i.e., 2297 private structures and 155 CPR/Religious properties would be affected due to implementation of the project. Out of 2452, 17 structures are in Pathankot link, 108 structures are in Gurdaspur district, 107 structures are in Pathankot district, 1363 structures are in Samba district, 632 structures are in Kathua district, 155 structures are in Jammu district and 70 structures are in Reasi district jurisdiction.

Table 1-15: Detail of Tehsils and Villages along the Proposed Alignment

SI No	State	District	Tehsil	No. of Villages
Package-13, 14,15, 17 and 18				
1	Punjab	Gurdaspur	Gurdaspur	5
			Dinanagar	4
		Pathankot	Pathankot (Green Field-10 & Brown Field-10)	13
2	J&K	Kathua	Kathua (Green Field-10 & Brown Field-10)	28
			Nagri Parole	3
			Mahreen	4
			Hiranagar	12
3	J&K	Samba	Ghgwai	5
			Samba	12
			Vijaypur	10
			Baribrahmana	1
4	J&K	Jammu	Bahu	2
			Jammu	4
			Nagrota	3
			Dansal	2
5	J&K	Reasi	Katra	9
Package - Pathankot Link				
6	Punjab	Pathankot	Pathankot	19

Source: 3a Draft Notification

0.26 Cost Estimate

The unit rates for each construction items have been arrived by using the latest available “**Schedule of Rates (SOR): (Highways Department & PWD Department) for Punjab and UT of Jammu & Kashmir**”. The detailed analysis has been carried out as per **Standard Data Book of Ministry of Road Transport & Highways (MORTH)** for deriving unit rates of items of Road and Bridge works.

The input rates of Bitumen, Emulsion, Cement and Steel have been taken from market. The rates plant, machinery, labour and other materials like metal, sand etc. have been taken from latest available SOR of Punjab and UT of Jammu & Kashmir. The basic rates for each construction items have been analysed on the basis of material study, the prices of construction materials collected from various sources and on the anticipated distance between source and the site of work. For items where rates are not available in SOR, the rates have been adopted as per previous experience of the consultant or on the present market rates.

The detailed cost estimate is given in a separate volume. The summary of package wise project cost has been worked and shown in the following table:

Table 0-14: Abstract of Cost Estimate

Abstract of Cost of Package – 13: Km 397.700 to Km 423.500

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	49,40,321
2	Earth Work	67,64,28,478
3	Granular Subbase Courses and Base Courses (Non-Bituminous)	62,19,46,085
4	Bituminous and Rigid Pavement Courses	1,51,00,47,964
5	Culverts	18,18,43,936
6	Bridges	
	a) Minor Bridges	18,66,10,466
	b) Major Bridges	9,65,63,455
	c) FO, ROB	56,22,40,389
	d) VUP/PUP	29,06,60,879
	e) RE Wall	1,10,94,77,338
	f) FOB	1,26,09,420
7	Drainage & Protective Works	19,03,41,311
8	Junctions	3,84,08,068
9	Traffic signs, Road markings and other road appurtenances	51,39,48,846
10	Miscellaneous Works	16,30,55,280
11	Maintenance of roads	1,46,21,256
12	Toll Plaza	7,98,78,366
13	Environmental Plan	2,25,69,894
	Civil Cost	6,27,61,91,751
	12% GST on Civil Cost	75,31,43,010
	Utility Shifting	62,57,78,191
	Total Civil Cost	7,65,51,12,953
	Cost Per Km in Crores (On Civil Cost)	24
	Cost Per Km in Crores (On Total Civil Cost)	30
	Supervision Charges of Utility Shifting	1,56,44,455
	GST @ 18% on Supervision Charges	28,16,002
	Land Acquisition, Resettlement and Rehabilitation Cost	41,94,00,000
	Other Preconstruction Expenses (EMP Cost)	22,16,00,000

Abstract of Cost of Package – 14: Km 423.500 to km 468.100

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	1,33,45,051
2	Earth Work	1,65,07,28,620
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	85,36,68,511
4	Bituminous and Rigid Pavement Courses	1,70,86,83,008
5	Culverts	1,11,47,26,228
6	Bridges	
	a) Minor Bridges	1,21,01,82,881
	b) Major Bridges	3,27,89,07,771
	c) FO, ROB	1,86,20,98,618
	d) VUP/PUP	39,11,90,398
	e) RE Wall	2,02,38,00,501
7	Drainage & Protective Works	26,35,07,553
8	Junctions	0
9	Traffic signs, Road markings and other road appurtenances	80,42,39,028
10	Miscellaneous Works	41,79,93,670
11	Maintenance of roads	0
12	Toll Plaza	37,24,68,204
13	Environmental Plan	3,91,60,592
	Civil Cost	16,00,47,00,634
	12% GST on Civil Cost	1,92,05,64,076
	Utility Shifting	18,02,30,000
	Total Civil Cost	18,10,54,94,711
	Cost Per Km in Crores (On Civil Cost)	35.88
	Cost Per Km in Crores (On Total Civil Cost)	40.60
	Supervision Charges of Utility Shifting	45,05,750
	<u>GST @ 18% on Supervision Charges</u>	8,11,035
	Land Acquisition, Resettlement and Rehabilitation Cost	11,41,72,00,00
	Other Preconstruction Expenses (EMP Cost)	19,66,00,00

Abstract of Cost of Package – 15: Km 468.100 to Km 503.250

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	1,94,58,706
2	Earth Work	1,15,87,42,721
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	87,64,74,238
4	Bituminous and Rigid Pavement Courses	1,36,73,11,403
5	Culverts	47,58,97,863
6	Bridges	
	a) Minor Bridges	90,54,98,146
	b) Major Bridges	1,38,78,92,776
	c) FO, ROB	5,05,98,81,367

Sr. No.	Particulars	Amount (INR)
	d) VUP/PUP	31,09,89,109
	e) RE Wall	1,35,61,43,008
7	Drainage & Protective Works	60,00,69,083
8	Junctions	3,60,55,974
9	Traffic signs, Road markings and other road appurtenances	59,08,20,554
10	Miscellaneous Works	47,67,60,000
11	Maintenance of roads	0
12	Toll Plaza	88,10,98,419
13	Environmental Plan	3,08,19,210
	Civil Cost	15,53,39,12,57
	12% GST on Civil Cost	1,86,40,69,509
	Utility Shifting	34,75,99,000
	Total Civil Cost	17,74,55,81,08
	Cost Per Km in Crores (On Civil Cost)	44.26
	Cost Per Km in Crores (On Total Civil Cost)	50.56
	Supervision Charges of Utility Shifting	86,89,975
	<u>GST @ 18% on Supervision Charges</u>	15,64,196
	Land Acquisition, Resettlement and Rehabilitation Cost	8,53,20,00,000
	Other Preconstruction Expenses (EMP Cost)	16,01,00,000

Abstract of Cost of Package – 17: Km 515.000 to Km 528.300 (Kunjwani to Sidhra Section) and Km 550.900 to Km 566.520 (Domel to Katra Section)

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	3,06,73,026
2	Earth Work	56,18,08,156
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	63,32,21,780
4	Bituminous and Rigid Pavement Courses	1,32,19,67,808
5	Culverts	63,20,48,140
6	Bridges	
	a) Minor Bridges	88,69,47,060
	b) Major Bridges	52,56,48,335
	c) FO, ROB	5,96,88,10,906
	d) VUP/PUP	28,79,36,394
	e) RE Wall	1,06,32,55,041
	f) FOB	0
7	Drainage & Protective Works	1,06,31,86,228
8	Junctions	8,49,46,425
9	Traffic signs, Road markings and other road appurtenances	51,26,87,766
10	Miscellaneous Works	47,97,69,811
11	Maintenance of roads	2,11,84,071
12	Toll Plaza	0

Sr. No.	Particulars	Amount (INR)
13	Environmental Plan	56,89,966
	Civil Cost	14,07,97,80,914
	12% GST on Civil Cost	1,68,95,73,710
	Utility Shifting	85,35,34,750
	Total Civil Cost	16,62,28,89,373
	Cost Per Km in Crores (On Civil Cost)	48.69
	Cost Per Km in Crores (On Total Civil Cost)	57.48
	Supervision Charges of Utility Shifting	21338369
	<u>GST @ 18% on Supervision Charges</u>	3840906
	Land Acquisition, Resettlement and Rehabilitation Cost	7996400000
	Other Preconstruction Expenses (EMP Cost)	34815600

Abstract of Cost of Pathankot Link Road: Km 0.000 to Km 12.345

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	15,83,653
2	Earth Work	69,36,55,707
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	24,15,52,955
4	Bituminous and Rigid Pavement Courses	26,78,30,809
5	Culverts	24,95,89,963
6	Bridges	
	a) Minor Bridges	2,43,43,723
	b) Major Bridges	77,02,26,963
	c) FO, ROB	35,81,40,538
	d) VUP/PUP	13,35,43,019
	e) RE Wall	25,61,65,526
	f) FOB	
7	Drainage & Protective Works	17,68,40,927
8	Junctions	1,78,27,714
9	Traffic signs, Road markings and other road appurtenances	20,49,49,750
10	Miscellaneous Works	5,90,10,240
11	Maintenance of roads	0
12	Toll Plaza	6,67,57,344
13	Environmental Plan	87,66,126
	Civil Cost	3,53,07,84,957
	12% GST on Civil Cost	42,36,94,195
	Utility Shifting	11,54,10,151
	Total Civil Cost	4,06,98,89,303
	Cost Per Km in Crores (On Civil Cost)	28.60
	Cost Per Km in Crores (On Total Civil Cost)	32.97
	Supervision Charges of Utility Shifting	28,85,254
	<u>GST @ 18% on Supervision Charges</u>	5,19,346

Sr. No.	Particulars	Amount (INR)
	Land Acquisition, Resettlement and Rehabilitation Cost	2,49,04,00,000
	Other Preconstruction Expenses (EMP Cost)	6,55,00,000

0.27 Economic Analysis

The objective of the cost benefit economic analysis is to identify and quantify the benefits and costs associated with the project (Delhi Katra Expressway), in order to select the optimum solution along with the economic viability in terms of its likely investment return potential.

Strategy 1: In the HDM model analysis, this “Do Minimum Scenario” alternative will form the base strategy against which all other strategies will be compared. Phase-2 of Delhi – Katra Expressway from Gurudaspur to Katra is the combination of green field and brownfield alignment, catering the present existing traffic of brownfield alignment has been considered as base case.

Strategy 2: This is the scenario of construction of combination of Greenfield and Brownfield Expressway of 6/4 Lane Configuration with service road in brownfield sections.

This strategy forms a ‘With Project’ alternative and is compared to ‘Without Project’ alternative. By comparing the above alternatives, the net agency costs and net user costs and finally net project benefits, associated with the project during its analysis period are calculated, for the improvement option in order to arrive at Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV).

0.28 Economic Analysis Summary

The project road is economically viable and further, sensitivity analysis has been carried out. The sensitivity analysis is given in table below:

Table 0-15: Sensitivity Analysis

Details	EIRR (%)	NPV (Rs. million)
Base Case	15.9	19460.95
Case I	14.3	12682.65
Case II	14.0	9790.72
Case III	12.6	3012.42

The project road is economically viable for the proposed construction of combination of Greenfield and Brownfield 4/6 lane Expressway, considering their positive values of feasibility criteria (EIRR and ENPV) both at normal scenario and at worst scenario under sensitivity analysis. In the normal scenario, the project has 15.9% and even at the worst-case scenario (i.e. Base Costs plus 15% and Base Benefits minus 15%) the EIRR is 12.6% and are found much above the required (12%) minimum level. This indicates the necessity of project road from the economy point of view and recommended for construction.

0.29 Financial Analysis

A financial model has been prepared for the financial analysis of the Project Highway on BOT mode. The analysis has been carried out for the following two options:

- i) Option 1A: Without VGF
- ii) Option 1B: With VGF of 40%

The results of the financial model on BOT mode are given in table below:

Table 0-16: Financial Analysis BOT Summary

For Package 13

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	702.93	702.93
Total Project Cost (TPC)	839.40	827.66
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	40%
Project IRR	5.66%	5.73%
Equity IRR	3.05%	14.72%
Conclusion	Not Viable	Not Viable

For Package 14

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	1792.53	1792.53
Total Project Cost (TPC)	2132.66	2105.50
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	40%
Project IRR	5.51%	5.57%
Equity IRR	2.74%	14.31%
Conclusion	Not Viable	Not Viable

For Package 15

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	1739.80	1739.80
Total Project Cost (TPC)	2070.04	2060.91
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	14%
Project IRR	9.58%	9.58%
Equity IRR	10.83%	15.19%
Conclusion	Not Viable	Not Viable

For Package 17

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	1576.94	1576.94
Total Project Cost (TPC)	1876.27	
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	29%
Project IRR	3.70%	3.77%
Equity IRR	Negative	15.35%
Conclusion	Not Viable	Not Viable

From the above results obtained from financial analysis are as following

- 1 Packages 13 and 14 are not viable on BOT Toll even with 40% VGF
- 2 Packages 15 and 17 are not viable on BOT Toll mode without VGF, however with VGF of 14% & 29% the viability is achieved respectively.
- 3 though with VGF, packages 15 & 17 yield target EIRR of 15% but the PIRR could not achieve WACC (Weighted Average Cost of Capital = 8.37%).

Even with the maximum allowable limit of VGF, i.e 40%, the project gives an E-IRR below the target E-IRR of 15% for package 13 & 14. However, with VGF package 15 & 17 are viable but unable to achieve target WACC. Hence it would not be accepted by the private party. The project is, therefore, unviable on BOT Toll mode.

The best suited mode of procurement for this project would be EPC (Engineering Procurement and Construction) or Hybrid Annuity Model (HAM). For ease of decision

for the authority, we have analysed the project packages on Hybrid Annuity Model in the next section.

1 PROJECT BACKGROUND

The National Highways Authority of India (NHAI) has been constituted through an Act of Parliament for faster, economical and quality Road Construction work throughout India. The National Highways Authority of India (NHAI) is the nodal agency of Ministry of Road Transport and Highways (MORT&H), Government of India and has been entrusted with the Development of Delhi - Ludhiana - Amritsar – Katra Expressway having an approximate length of 600 Km including spurs through BOT& EPC basis.

As part of the development, MoRT&H entrusted NHAI with engagement of a consultant to carry out the “Consultancy services for Preparation of DPR for Development of Delhi - Ludhiana - Amritsar – Katra Expressway having an approximate length of 600 Km including spurs” for project preparation. NHAI through competitive bidding has appointed M/s. Feedback Infra Private Limited for providing the required consultancy services and issued letter of Commencement of Services vide their letter No.: NHAI/Punjab/ CC/ N-1/109706 dated 11.12.2017.

The Delhi - Ludhiana - Amritsar – Katra expressway has been referred to as the Project Highway in this Report. The Project Highway starts from Kundli Manesar Palwal Expressway (KMP) in National Capital Region (NCR) and ends at Katra in Jammu & Kashmir. Section between Delhi to Gurdaspur (397.700 km) along with part of connectivity to Amritsar (Km 0.000 to Km 24.000 out of 99.033km) is taken up under Phase 1 and DPR for the same is already submitted. This report pertains to the Draft Detailed Project Report for Phase 2 which includes section from Gurudaspur (397.700 km) to Katra section.

As phase 2 development, Gurdaspur (397.7 km) to Katra has been considered. The Greenfield/ Brownfield Alignment passes through following Districts namely Gurdaspur and Pathankot in Punjab and Kathua, Samba, Jammu and Reasi districts in the union territory of Jammu and Kashmir. The Project Highway starts at design ch. 397+700 and ends at design ch. 566+520. In addition, Pathankot link from design ch. 0+000 to 12+345 is also part of phase 2. Total length of the Project Highway is 181.165Km.

The key plan of the project highway is shown in figure below:

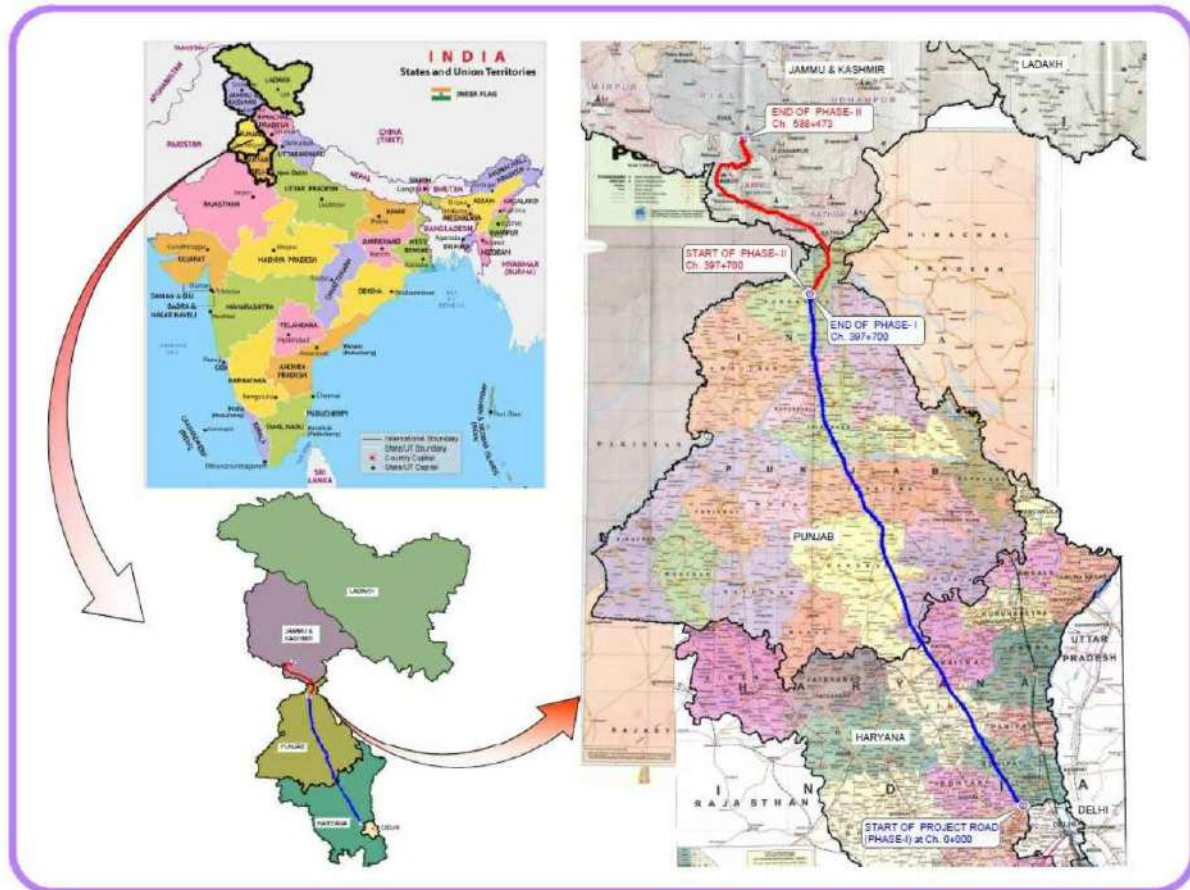


Figure 1-1: Location Map of the Project Highway

1.1 Project Objectives

The objective of the project is to establish the technical, economic and financial viability of the project with the aim of easing traffic, shortening travel time and distance; developing a World Class Infrastructure. Further, the aim of the project is to boost the Road Infrastructure for faster connectivity between Delhi and Katra via Ludhiana and Amritsar and facilitating the Development of Commercial Areas, Educational, Eco-Tourism, Agriculture Advancement, Automobile Sectors etc. The study been carried forward by considering the following factors:

1.1.1 Provide efficient, faster and better connectivity

The project will not only connect the two major O-D points of Delhi and Katra but also important towns of Haryana, Punjab and Jammu & Kashmir. It will also provide a faster and better connectivity to the important cities in the vicinity of the proposed expressway through development of spur routes and/ or development of existing roads.

1.1.2 Improve efficiency of traffic movements

- a. The proposed alignment will provide maximum design flexibility to meet current and future traffic needs.

- b. The project follows a combination of crow-flight and brownfield alignment to allow for a near-perfect geometry with shortest distance and resulting in savings in travel time, fuel and total transportation cost.
- c. Each kilometre saved in transportation will help the farmers to access the markets at a lower cost and thereby reduced logistics cost will be passed-on to the end consumer (citizen) who will be hugely benefitted.
- d. The Proposed Highway will provide faster movement of perishable goods like fruits, vegetables, dairy and poultry products thereby reducing the wastages and increasing production.

1.1.3 Boost Economic Development

- The proposed Phase II alignment of Delhi – Amritsar – Katra Expressway traverses through the District of Gurdaspur and Pathankot in Punjab state and Kathua, Samba, Jammu and Reasi districts in the union territory of Jammu and Kashmir. The expressway would act as potential for development of new areas and wealth creation for these less developed / backward Districts.
- The project would trigger economic activity along the highway with opportunities for new occupations and trade.

1.1.4 Minimise Social Impact

The proposed alignment will minimize the impact / effect on the number of habitations through combination of greenfield and brownfield alignment.

1.1.5 Minimize environmental impact

While fixing the alignment, utmost care has been taken to avoid Wildlife Sanctuaries and National Parks as per the MoEF&CC Guidelines. Also, every effort has been made to reduce acquisition of Forest Land.

1.1.6 Provide for Cost-effective development

- The highway should avoid acquisition of developed areas and as far as possible pass through undeveloped / barren land to minimize cost of land acquisition and associated cost of utility shifting.
- The highway should be easy to construct and maintain.

Additionally, the NHA Circular No. NHA / Planning/EC/DPR/2016/110986 dated 03.01.2018 on policy for design of full access control Expressway gives the following objective for planning and design of Economic Corridors:

- **Ensure hierarchical functioning of the main highway and service roads.**
- **Maximise capacity of every component of NH system.**
- **Remove conflicting movements by way of full access control along entire corridor.**
- **Achieve average speed of 100 Kmph for passenger vehicle and 80 kmph for commercial vehicles.**

1.2 Scope of Work

The scope of work for the project highway covers the following major tasks:

- Review of all available reports and published information about the project highway and the project influence area.
- Environmental and Social Impact Assessment, including social related to cultural properties, natural habitats, involuntary resettlement etc.

- Public Consultation, including consultation with communities located along the road, NGOs working in the area, other stake-holders and relevant Government Departments at all the different stages of assignment (such as inception stage, feasibility stage, preliminary design stage and once final designs are concretized).
- Detailed Reconnaissance Survey.
- Identification of possible alternative alignments for Greenfield Highway along with improvements in the existing alignment, if any bypassing congested locations with alternatives, evaluation of different alternatives comparison on techno-economic and other considerations and recommendations regarding most appropriate option.
- Traffic Studies including Traffic Surveys, Axle Load Survey and Demand Assessment/ Forecasting over the next 30 Years.
- Inventory and Road Condition Surveys for the spurs (existing road), existing road portions other than the proposed Greenfield Highway.
- Inventory and condition surveys for spurs (existing road) for bridges, cross-drainage structures, other Structures, river Bank training/ Protection works and drainage provisions.
- Detailed Topographic Surveys with Lidar Technique by using drone and total station with minimum engineering grade system or any other better technology having output accuracy not less than:

- i. **As specified in IRC: SP-19**
- ii. **Total Station**
- iii. **GPS/DGPS**

- Sub-grade characteristics and strength: investigation of required sub-grade and sub- soil characteristics and strength for road and embankment design and sub soil investigation for spurs (existing road)
- Identification of sources of construction materials
- Detailed design of road, its cross sections, horizontal and vertical alignment and design of embankment of height more than 6m and also in poor soil conditions and where density consideration require, even lesser height embankment. Detailed design of structures preparation of GAD and construction drawings and cross-drainage structures and underpasses etc.
- Identification of the Type and the Design of Intersections
- Identification and Design of Grade Separated Interchanges
- Value analysis/ value engineering and project costing
- Economic and Financial Analysis
- Contract packaging and implementation schedule
- Strip plan indicating the scheme for schedule for LA: reports documents and drawings arrangement of estimates for cutting/ transplanting of trees and shifting of utilities from the concerned department
- To find out financial viability of project for implementation and suggest the preferred mode on which the project is to be taken up
- Preparation of detailed project report, cost estimate, approved for construction Drawings, rate analysis, detailed bill of quantities, bid documents for execution of civil works through budgeting resources
- Design of toll plaza and identification of their numbers and location and office cum residential complex including working drawings
- Design of weighing stations, parking areas and road side amenities
- Any other user-oriented facility en-route toll facility
- Tie-in of on-going/sanctioned works of MORT&H/ NHAI/ other agencies

- Preparation of social plans for the project affected people as per policy of the lending agencies/ Govt. of India R&R Policy

1.3 Contract Packages

The entire project highway is divided into 5 construction packages and details are given in table below;

Sr. No.	Packages	Design Chainage (Km)		Package Start Point		Package End Point		Length of the Stretch (km)
		Start	End	Latitude	Longitude	Latitude	Longitude	
1	Package XIII	397+700	423+500	32° 01'03.62"N	75°24'05.41"E	32°12'14.91"N	75°32'14.11"E	25.800
2	Package XIV	423+500	468+100	32°12'14.91"N	75°32'14.11"E	32°28'44.25"N	75°16'44.74"E	44.600
3	Package XV	468+100	503+250	32°28'44.25"N	75°16'44.74"E	32°36'4.86"N	74°57'8.51"E	35.150
4	Package XVI	503+250	515+000	32°36'4.86"N	74°57'8.51"E	32°40'18.04"N	74°53'0.99"E	11.75
5	Package XVII	515+000	528+300	32°40'18.04"N	74°53'0.99"E	32°45'41.41"N	74°54'49.30"E	13.300
		550+900	566+520	32°52'38.27"N	74°57'18.67"E	32°59'46.06"N	74°55'43.07"E	15.62
6	Package XVIII	528+300	550+900	32°45'41.41"N	74°54'49.30"E	32°52'38.27"N	74°57'18.67"E	22.60
7	Pathankot Link	0+000	12+345	32°10'24.75"N	75°37'30.82"E	32°14'39.59"N	75°32'13.70"E	12.345
Total Length of Phase-2 including Pathankot Link (Km)								181.165

This volume deals with the Delhi Amritsar Katra Expressway Phase II, except Package-XVI which is the part of SA Infrastructure Consultants Pvt. Ltd and Package – XVIII. Details of Package – XVIII will be incorporated in the Final DPR.

1.4 Schedule of Deliverables

As per Terms of Reference of Contract Agreement, the activities to be carried out for the project are split into eight (8) stages as given below:

Table 1-1: Schedule of Deliverables

S. No.	Stage	Key Activities	Report/Deliverable
1	Inception	Project planning and mobilization	Inception Report and QAP
2	Feasibility	Alignment finalization, Preliminary Surveys	Alignment Options Report and Feasibility Report
3	LA and Clearances-I	LA, utilities identification; creation of draft notifications and proposals	Strip Plan, LA Report (3a, 3A), Clearances and Utility Shifting Proposals
4	DPR	Detailed design of highway, preparation of detailed project report with drawings	Draft DPR Report, Final DPR Report, documents and drawings
5	Technical Schedules	Preparation of Bid Documents and Technical Schedules	Civil Works Contract Agreement and Schedules
6	(i) LA II	Land Acquisition Process, obtaining final utilities estimates and required clearances	JMS and 3D Report, Final Project Clearances and Utilities Report
	(ii) Project Clearances		
7	LA III - Award Determination	Land Acquisition Award Determination	3G Report
8	LA IV – Possession	Obtaining Possession of land	Land Possession Report

This Report intends to cover Stage-4, Detailed Project Report.

1.5 Structure of the Detailed Project Report

The entire Detailed Project Report is divided into following volumes and appendices:

Volume-I:	Main Report Appendix to Main Report
Volume-II:	Design Report Part-1: Highway & Pavement Design Part-2: Highway Structures Design
Volume-III:	Material Report
Volume-IV:	Environmental Assessment Report including Environmental Management Plan (EMP) & Resettlement Action Plan (RAP)
Volume-V:	Technical Specifications
Volume-VI:	Rate Analysis
Volume-VII:	Cost Estimate
Volume-VIII:	Bill of Quantities
Volume-IX:	Drawings Part-A: Highway Drawings Part-B: Structures

2 SOCIO ECONOMIC PROFILE OF THE PROJECT AREA

2.1 Socio-economic Profile and Social Impacts

The project Phase II, being discussed under this chapter concerns the Punjab and Jammu and Kashmir section of the proposed Delhi Amritsar-Katra Expressway from Gurdaspur (Km 397+700) to Katra section (Km 566+520) and the Pathankot Link from Km. 0.000 to Km. 12.345. The project is planned as 4 lanes highway expandable to 8 lanes with provision of service road for future. To understand the socio-economic profile of project area, the socio-economic information of affected families of both structures and land was collected through the socio-economic survey (SES) and census survey. The total number of project affected households are 2604 in respectively and project affected persons are 10455 in both the state. The proposed alignment traverses through two districts of Punjab State viz. Gurdaspur and Pathankot and four districts of Jammu & Kashmir Union Territory viz. Kathua, Samba, Jammu and Reasi

The extent of social impacts includes the losses to land, structures and livelihood. In addition to this, the project will impact government and common property resources (CPRs) properties. These impacts have been discussed in this section of the report.

2.2 Loss of Structure in the Sub-project

During the census survey in addition to structures that belong to titleholders, large number of encroachers and squatters were also enumerated along the proposed alignment. Based on the social survey data, a total of 2452 structures (17 in Pathankot Link, 108 in Gurdaspur, 107 in Pathankot, 632 in Kathua, 1363 in Samba, 155 in Jammu & 70 in Reasi) would be affected due to the development of the proposed expressway. Out of 2452 affected structures, 2297 are private structures and 155 are government, religious & CPR's structures. Annexures are attached in Volume-IV (RAP). The details of the same are depicted in **Table 2.1**.

Table 2-1: Loss of Structures in Punjab State and J&K(UT)

State	Districts	Private Structures	CPR/Religious Structure	Total
Punjab	Pathankot (Spur)	17	0	17
	Gurdaspur	103	5	108
	Pathankot	96	11	107
Jammu & Kashmir	Kathua	576	56	632
	Samba	1311	52	1363
	Jammu	136	19	155
	Reasi	58	12	70
Total		2297	155	2452

Source: Census and Socio-economic Survey, 2021

2.3 Type of Affected Structures (Private)

Based on the social survey data it was found that, 2297 private structures are going to be affected due to the proposed project in all six districts of Punjab and J&K. Out of 2297 affected structures, 250 are private residential properties, 1451 structures are

used commercially, 238 structures are residential cum commercial and 358 are other private structures i.e. boundary wall and sheds. The details of the same are depicted in (Table: 2.2).

Table 2-2: Type of Affected Structures

State	Districts	Private Structures				Total
		Residential	Commercial	Residential cum commercial	Others	
Punjab	Pathankot (Spur)	7	3	0	7	17
	Gurdaspur	35	64	0	4	103
	Pathankot	12	79	5	0	96
Jammu & Kashmir	Kathua	80	315	74	107	576
	Samba	79	890	125	217	1311
	Jammu	20	77	20	19	136
	Reasi	17	23	14	4	58
Total		250	1451	238	358	2297

Source: Census and Socio-economic Survey, 2021

2.4 Typology of Affected Structures

The construction type of structures being affected in the project area are categorised into 3 major types, such as temporary (Kuchha), semi-permanent (Semi-Pucca) and permanent (Pucca) structures. It was observed that among the affected structures most of the structures, i.e., more than 81.16% are pucca structures. Out of 2452 structures, 1990 structures are permanent, 239 structures are semi-permanent, and 223 structures are of temporary in nature. The details of type of constructions of the affected structures are summarized in the **Table 2.3**

Table 2-3: Typology of Affected Structures in Punjab State and J&K(UT)

State	Districts	Permanent	Semi-Permanent	Temporary	Total
Punjab	Pathankot (Spur)	11	0	6	17
	Gurdaspur	91	3	14	108
	Pathankot	91	0	16	107
Jammu & Kashmir	Kathua	487	97	48	632
	Samba	1142	106	115	1363
	Jammu	118	18	19	155
	Reasi	50	15	5	70
Total		1990	239	223	2452

Source: Census and Socio-economic Survey, 2021

2.5 Social Stratification of Affected Families

The social stratification of the affected families in the Punjab state and J&K (UT) shows dominance of general caste with 64.36% (1676) followed by scheduled caste (SC) with 10.91% (284), other backward class (OBC) with 9.29% (242) and scheduled tribe (ST) with 1.77% (46). 356 project affected family were not available or did not participate in social impact assessment study.

The detail of social grouping in the project affected districts of both the states is presented in the **Table 2.4**

Table 2-4: Social Stratification of Affected Families

State	Districts	General	OBC	SC	ST	NA	Total	%
Punjab	Pathankot (Spur)	-	-	-	-	17	17	0.65
	Gurdaspur	-	-	-	-	103	103	3.96
	Pathankot	-	-	-	-	96	96	3.69
Jammu & Kashmir	Kathua	500	88	85	5	30	708	27.19
	Samba	1024	142	178	25	110	1479	56.80
	Jammu	104	11	14	13	0	142	5.45
	Reasi	48	1	7	3	0	59	2.27
Total		1676	242	284	46	356	2604	100
%		64.36	9.29	10.91	1.77	13.67	100	

Source: Census & Socio-economic Survey, 2021

2.6 Monthly Income of the Affected Families

The survey attempted to find the annual income of the affected families from all sources. Since most of them did not reveal their exact income during social survey due to different reasons, it was tried to assess the approximate income in different ranges. During the census cum socio-economic surveys incomes of the households were recorded.

Annual Income as revealed by the PAHs during socio-economic survey has been analysed. This information helps in assessing family's financial condition. The income level of the affected households in Above Rs. 2,40,001 per annum category is (35.22%) and (14.25%) families earn below Rs. 60,000 per annum. Details of Project Affected Household's annual income is presented in **table 2-5**.

Table 2-5: Income Categorisation of the Affected Families in Punjab State and J&K(UT)

S. No.	Annual Income	Number of PAH	Percentage
1	Below 60,000	371	14.25
2	Between 60,001 to 1,20,000	324	12.44

S. No.	Annual Income	Number of PAH	Percentage
3	Between 1,20,001 to 1,80,000	354	13.59
4	Between 1,80,001 to 2,40,000	269	10.33
5	Above 2,40,001	790	35.22
6	NA	369	14.17
Total		2604	100

Source: Census & Socio-economic Survey, 2021

2.7 Gender wise Distribution of Sample Population along the Proposed Alignment

The population profile of project affected area is presented in **Table 2.6**. The project affected population of the affected area is 10455, out of which 5535 are male and 4920 are female. It is found that the sex ratio is 889 with male population.

Table 2-6: Affected Persons by Gender

State	District	PAHs	%	PAPs (Gender wise)				Total Affected PAPs	%
				Male	%	Female	%		
Punjab	Pathankot (Spur)	17	0.65	-	-	-	-	-	-
	Gurdaspur	103	3.96	-	-	-	-	-	-
	Pathankot	96	3.69	-	-	-	-	-	-
Jammu & Kashmir	Kathua	708	27.19	1969	18.83	1669	15.96	3638	34.80
	Samba	1479	56.80	3151	30.14	2877	27.52	6028	57.66
	Jammu	142	5.45	245	2.34	239	2.29	484	4.63
	Kathua	59	2.27	170	1.63	135	1.29	305	2.92
Total		2604	100	5535	52.94	4920	47.06	10455	100

Source: Census & Socio-economic Survey, 2021

2.8 Educational Status of Affected Population

Table 2-7 presents the educational level of persons, wherein majority of them were found to be literate. The findings of census cum socio-economic survey reveals that literacy rate is highest in Secondary level i.e. 61.50 % followed by graduate (16.22%) and primary (9.91%).

Table 2-7: Educational Status of Project Affected Persons in Punjab State and J&K(UT)

S. No.	Indicators (Literacy Rate / Educational Level)	Total Persons	%age	Gender Disaggregated Information			
				Male	%age	Female	%age
1	Illiterate	622	6.72	242	2.56	380	4.10
2	Illiterate (Read & Write)	197	2.13	86	0.91	111	1.20
3	Primary (Class 1-5)	918	9.91	407	4.30	511	5.52

S. No.	Indicators (Literacy Rate / Educational Level)	Total Persons	%age	Gender Disaggregated Information			
				Male	%age	Female	%age
4	Secondary (Class 6-12)	5694	61.50	3139	33.19	2555	27.59
5	Graduate	1502	16.22	834	8.82	668	7.21
6	Technical	201	2.17	137	1.45	64	0.69
7	Vocational	119	1.29	49	0.52	70	0.76
8	NA	6	0.06	3	0.03	3	0.03
Total		9259	100	4897	51.77	4362	47.11

Source: Census & Socio-economic Survey, 2021 Note: *Not Applicable includes children below or equal to three (6) years

2.9 Occupational Pattern of Affected Population

During the survey it was attempted to know the types of occupation of the project affected persons. The **Table 2.8** shows that majority of the PAPs in Punjab state and UT of J&K are engaged with agricultural activities. Since majority of the PAPs are engaged in agricultural activities the project area's economic life is mostly dependent on agriculture.

3062 constitute working population and 3778 represent the non- working population. Occupation-wise analysis of working and non-working group population is shown in **Table 2-8 & 2-9**. Majority of the affected population is engaged in business activities.

Table 2-8: Occupational Pattern of Affected Population in Punjab State and J&K(UT)

S. No.	Occupation	Distribution of PAPs in working population	%	Distribution of PAPs by Gender			
				Male	%	Female	%
1	Agricultural Labourer	66	2.16	66	2.16	0	0.00
2	Cultivator	97	3.17	95	3.10	2	0.07
3	Business/Trade	1055	34.45	1025	33.47	30	0.98
4	Govt. Employee	868	28.35	777	25.38	91	2.97
5	Non Agri. Labour	205	6.69	135	4.41	70	2.29
6	Private Service	286	9.34	245	8.00	41	1.34
7	Self Employed/Artisan	481	15.71	440	14.37	41	1.34
8	Others	304	9.93	246	8.03	58	1.89
Total		3062	100	2729	89.12	333	10.88

Source: Census & Socio-economic Survey, 2021

PAPs not in income earning pursuits have been shown in the following **Table 2-9**

Table 2-9: Distribution of PAPs not in any Income Earning activities

S. No.	Occupation	Total Number of PAPs in non-working population	%age	Project Affected PAPs by Gender			
				Male	%age	Female	%age
1	Not in Workforce*	1304	34.52	242	6.41	1062	28.11
2	Household Work	1287	34.07	91	2.41	1196	31.66
3	Unemployed	1150	30.44	248	6.56	902	23.88
4	NA	37	0.98	24	0.64	13	0.34
Total		3778	100	605	16.01	3173	83.99

Source: Census & Socio-economic Survey, 2021

2.10 Population Distribution Based on Age

The analysis of the census data shows, 10455 persons will get affected due to the project implementation. A significant percentage of population between 15-59 age category is (57.59%) followed by (15.71%) of 59 & above age group. The following **Table no. 2-10** shows the population in the project area, disaggregated by age

Table 2-10: Population Distribution Based on Age of PAPs in Punjab State and J&K (UT)

S. No.	Age Group	PAPs	Percentage	Gender Disaggregated Population			
				Male	%	Female	%
1	<06	1196	11.44	650	6.22	546	5.22
2	06-15	1595	15.26	861	8.24	734	7.02
3	15-59	6021	57.59	3217	30.77	2804	26.82
4	59 & above	1643	15.71	807	7.72	836	8.00
Total		10455	100	5535	52.94	4920	47.06

Source: Census & Socio-economic Survey, 2021

2.11 Public Consultation

Public Consultations or community participation is an integral part and process of any projects which involves resettlement or rehabilitation issues. It helps to incorporate valuable local level community and affected family's suggestions and perceptions of development. In the process, stakeholders get the opportunity to address issues, which are resolved after making appropriate integrated changes in design and alternative finalization. The stakeholders become aware of the development schemes and at the same time influence and share to control over these initiatives, decisions and resources. Community consultations also facilitate to avoid confrontation to the project development, which is otherwise likely to occur.

2.12 Objectives of Public Consultations

The overall objectives of the consultation program in preparing RAP were to disseminate project information and to incorporate public and affected persons views in Resettlement and Action Plans, which are guided by specific objectives like:

- 1 Awareness amongst stakeholders by disclosing the components of the RAP as per the RTFCTLARRA, 2013 compensation provisions of First and Second Schedule, though acquisition of land will be carried out in accordance with the NHAI Act.
- 2 Improvement in project design minimising potential conflicts and delays in implementation.
- 3 Facilitate development of appropriate and acceptable entitlement options.
- 4 Reduce problems of institutional co-ordination.
- 5 Make the R&R process transparent and reduce conflicts.
- 6 Increase APs commitment, ensure effectiveness and sustainability of the income restoration strategies, and improve coping mechanisms.
- 7 Creating sense of belongingness among the stakeholders.

2.13 Identification of the stakeholders

The stakeholders are all the people getting affected by the project or are responsible for the project, whether directly or indirectly. The community participation programmes in social assessment ensured that information is disseminated to all the affected persons and other stakeholders in appropriate ways. The information dissemination is carried out in the vernacular language, detailing about the main project features and the entitlement framework. Due consideration has also been given to address the views of the vulnerable groups.

Certain issues conditioned the participation of the stakeholders, as follows:

- 1 Who might be affected (positively or negatively) by the proposed development?
- 2 Who are voiceless for whom special efforts may have to be made?
- 3 Who are representatives of those likely to be affected?
- 4 Who is responsible for what is intended?
- 5 Who can make what is intended more effective through their participation or less effective by their non-participation or outright opposition?
- 6 Who can contribute financial and technical resources?
- 7 Whose behaviour has to change for the effort to succeed?

Both primary and secondary stakeholders were identified, based on the above criteria. They were invited to take part in the consultation series and were solicited to participate in planning and implementation of the R&R programme.

Primary stakeholders included those affected negatively or positively by the project, like the APs, project beneficiaries and project implementing agencies. Secondary stakeholders included other individuals and groups, with an interest in the project, viz., the MoRTH, the highway users, the NHAI, etc.

2.14 Disclosure of Project Information

The sharing of information is essential for sustainable development. It stimulates public debate on and broadens understanding of development issues and enhances transparency and accountability in the development process. It also strengthens public support to improve the lives of people, facilitates collaboration among the many parties involved in development, and improves the quality of projects and programs. It is now accepted everywhere that the expanded access to information by the public will enhance the dialogue on development and make an important contribution to efforts to reduce poverty and promote sustainable development. In this development project the disclosure of project information (during the feasibility stage) to the public in general and to the people who are likely to be impacted negatively in particular have been done by way of consultation process. During the consultation session it was observed that the local people are aware of this project through local newspaper, published from time to time.

2.15 Consultations for Determining Principle

The consultation process is not only targeted at project information dissemination to the people, but another important aspect covered is determining of principle for formulating an entitlement framework and eligibility policy for the project. The consultation process throws light of the people's expectations, aspirations etc. from the project as well as their expectations in terms of compensation and assistance from the project in case of adverse impacts.

2.16 Participants at different levels

The extent or the likely level of adverse impacts was one of the major criteria in deciding locations for public consultation sessions. The consultation programme has been tiered and conducted at several levels, such as:

- 1 Heads of the families, likely to be impacted
- 2 Members of the families, likely to be impacted
- 3 Clusters of APs
- 4 Villagers
- 5 Village Council/Town Council/Panchayats
- 6 Local voluntary organisations and CBOs/NGOs
- 7 Government agencies and departments

2.17 Levels of Consultation

The enactment of the participation and consultations with the stakeholders has been done at different levels throughout the project preparation stage. The Public

Consultation was carried out at various stages of project preparation: Social Screening stage, Feasibility stage and Detailed Stage.

2.18 Consultation during Project Preparation

The Census/Survey Team carried out consultations through Focus Group Discussions (FGDs) and meetings with the APs as well as the general public in the project area. FGDs were conducted primarily in settlements with problems of traffic congestion, dense informal/squatter settlement, close junctions and road intersections, and concentration of APs. During the survey, intensive discussion and consultation meetings were conducted with large number of APs in nearly every affected village wherein policy related issues; displacements and other related issues were discussed. Suggestions and comments by APs were incorporated in the project design as well as the policy measures for resettlement management. Public discussions were conducted at important points, where people could assemble in large numbers. Local administration members were contacted to inform the people. The team also had informal meetings with village head, panchayat and other district level government officials, leaders of local level organization /association, trucker's association, and village women groups. The detailed summary of public consultations has been explained in Vol. IV (RAP).

2.19 Plan for further Consultation in the Project

The effectiveness of the R&R program is directly related to the degree of continuing involvement of those affected by the project. Several additional rounds of consultations with APs will form part of the further stages of project preparation and implementation. A local NGO will be entrusted with the task of conducting these consultations during RAP implementation, which will involve agreements on compensation, assistance options, and entitlement package and income restoration measures suggested for the sub-project. The consultation will continue throughout the project implementation. The following set of activities will be undertaken for effective implementation of the Plan:

In case of any change in engineering alignment planning, the APs and other stakeholders will be consulted in selection of proposed expressway alignment for minimization of resettlement impacts, development of mitigation measures etc.

Together with the NGO, the Project Implementation Unit (PIU) will conduct information dissemination sessions in the project area and solicit the help of the local community/ leaders and encourage the participation of the AP's in Plan implementation.

During the implementation of RAP, NGO will organize public meetings, and will appraise the communities about the progress in the implementation of project works, including awareness regarding expressway construction.

Consultation and focus group discussions will be conducted with the vulnerable groups like women, SC, ST, and OBC's to ensure that the vulnerable groups understand the process and their needs are specifically taken into consideration.

To make reasonable representation of women in the project planning and implementation they will be specifically involved in consultation.

2.20 Information Disclosure

To keep more transparency in planning and for further active involvement of APs and other stakeholders the project information will be disseminated through disclosure of resettlement planning documents. The EA will submit the following documents to MORTH for disclosure on MoRTH's/NHAI website:

- 1 The final resettlement action plan endorsed by the EA after the census of affected families/persons has been completed;
- 2 An updated resettlement action plan, will be prepared at the time of project implementation, as necessary; and
- 3 The resettlement monitoring reports.

The EA will provide relevant resettlement information, including information from the above-mentioned documents in a timely manner, in an accessible place and in a form and language(s) understandable to affected persons/families and other stakeholders. A resettlement information leaflet containing information on compensation, entitlement and resettlement management adopted for the project will be made available in local language and distributed to APs.

3 ENGINEERING SURVEY & INVESTIGATIONS

3.1 GENERAL

The main objective of the consultancy service is to establish the technical, economical, and financial viability of the project and prepare detailed project report for 4/6 lane access control Greenfield/ brownfield Highway and other details as per the 'Terms of Reference' and guidelines given in IRC publications specially IRC:SP:99-2013 (IRC:SP:84-2019 for Pathankot link).

Following are the various engineering surveys and investigations which have been carried out.

- Reconnaissance survey
- Structure Inventory & Condition Survey
- Road Inventory
- Pavement Investigation
- Subgrade Investigation
- Material Investigation
- Topographic Survey
- Geotechnical Investigation
- Hydraulic and Hydrological Investigations

This chapter brings out the salient features in respect of the major field studies and investigations.

3.2 RECONNAISSANCE SURVEY

The main objective of reconnaissance survey is to examine the general characteristics of the area for the purpose of identifying cost effective and feasible alignment for further investigations and detailing. Prior to taking up the ground reconnaissance survey, following maps and secondary data, pertaining to project influence area, were collected and studied:

- Maps and topo sheets published by Survey of India.
- Road Development Plan for Tehsils and Districts.
- Khasra Maps (Village Maps) of the preliminary identified alignment
- Google Image.
- All fieldwork involving topographic surveys and engineering investigations were primarily based on the information obtained from the reconnaissance survey.

The reconnaissance survey has been taken up immediately after getting the in-principle approval of the preferred alignment for the project stretch. As a part of the reconnaissance, the team visited the site and approached the proposed alignment. The desk study was also carried out simultaneously on Google maps/ Survey of India Topographic Maps and various minor realignments were proposed/discussed and have been considered. During the reconnaissance visit, attempts were made to collect the development plans and secondary data from the related departments from site. These include:

- Data on existing land use
- Data on existing material sources

3.2.1 Walking the Alignment

The preferred alignment was selected/ in principally approved by MORT&H as it avoided wildlife sanctuary, reserve forest, ponds; environmentally sensitive areas and had the desired geometrics of the highway. At most location square crossings to railway lines, National/State highways; major rivers have been achieved. It has been ensured to follow the guidelines of respective authorities and the alignment avoids habitations/ villages/ densely populated settlement. Adequate space for proposed interchanges at the intersection with major highways and wayside amenities at regular interval has been considered.

3.2.2 HT Tower/ HT Line found during reconnaissance survey

The HT Towers / HT lines observed within RoW along the preferred alignment are listed in Table below and many of these require to be shifted/ raised considering the profile of proposed expressway.

Table 3-1: List of HT Tower/ HT Line

DKE Phase-II summary for Utility EHT Towers/HT Lines Re-location					
Sl. No.	Chainage		HT TOWER		REMARKS
	Stating	Ending	LHS	RHS	
1	397+700	398+000	-	1	HT Line Crossing @ CH:397+710
2	398+000	399+000	-	-	HT Line Crossing @ CH:398+675
3	399+000	400+000	-	-	
4	402+000	403+000	1	-	HT Line Crossing @ CH:402+465
5	403+000	404+000	-	-	
6	404+000	405+000	-	-	
7	405+000	406+000	2	-	HT Line Crossing @ CH:405+865
					HT Line Crossing @ CH:405+940
8	406+000	407+000	-	-	HT Line Crossing @ CH:406+820
9	407+000	408+000	-	-	
10	408+000	409+000	-	1	HT Line Crossing @ CH:408+820
11	409+000	410+000	-	-	
12	410+000	411+000	1	-	HT Line Crossing @ CH:410+060
13	411+000	412+000	1	-	HT Line Crossing @ CH:411+020
					HT Line Crossing @ CH:411+920
14	412+000	413+000	-	-	HT Line Crossing @ CH:412+740
15	413+000	414+000	-	-	
16	414+000	415+000	-	-	
17	415+000	416+000	1	1	HT Line Crossing @ CH:415+490
18	416+000	417+000	-	-	HT Line Crossing @ CH:416+020
19	417+000	418+000	-	-	
20	420+000	421+000	-	-	HT Line Crossing @ CH:420+900

DKE Phase-II summary for Utility EHT Towers/HT Lines Re-location					
Sl. No.	Chainage		HT TOWER		REMARKS
	Stating	Ending	LHS	RHS	
21	421+000	422+000	-	-	
22	422+000	423+000	-	-	
23	423+000	423+500	-	1	HT Line Crossing @ CH:423+280 HT Line Crossing @ CH:423+355
24	423+500	424+000	-	-	
25	424+000	425+000	-	1	HT Line Crossing @ CH:424+770
26	425+000	426+000	-	-	HT Line Crossing @ CH:425+920
27	426+000	427+000	-	-	
28	427+000	428+000	-	-	HT Line Crossing @ CH:427+750
29	430+000	431+000	-	-	
30	431+000	432+000	-	-	HT Line Crossing @ CH:431+590
31	432+000	433+000	-	-	
32	433+000	434+000	-	-	HT Line Crossing @ CH:433+385
33	456+000	457+000	1	-	
34	457+000	458+000	-	-	
35	470+000	471+000	-	1	HT Line Crossing @ CH:470+385
36	471+000	472+000	-	-	
37	476+000	477+000	1	-	HT Line Crossing @ CH:476+880
38	477+000	478+000	-	-	
39	478+000	479+000	-	-	
40	479+000	480+000	-	-	HT Line Crossing @ CH:479+735
41	480+000	481+000	-	-	HT Line Crossing @ CH:480+795
42	481+000	482+000	-	-	
43	484+000	485+000	-	-	
44	485+000	486+000	-	-	HT Line Crossing @ CH:485+855
45	494+000	495+000	1	1	HT Line Crossing @ CH:494+925
46	495+000	496+000	3	2	HT Line Crossing @ CH:495+360 HT Line Crossing @ CH:495+370 HT Line Crossing @ CH:495+425
47	498+000	499+000	-	-	
48	499+000	500+000	1	1	HT Line Crossing @ CH:499+355
49	514+000	515+000	-	-	-
50	515+000	516+000	-	-	-
51	516+000	517+000	-	-	-
52	517+000	518+000	-	-	-
53	518+000	519+000	-	-	-
54	519+000	520+000	-	-	-

DKE Phase-II summary for Utility EHT Towers/HT Lines Re-location					
Sl. No.	Chainage		HT TOWER		REMARKS
	Stating	Ending	LHS	RHS	
55	520+000	521+000	-	-	-
56	521+000	522+000	-	-	HT Line Crossing @ CH:521+622
					HT Line Crossing @ CH:521+694
					HT Line Crossing @ CH:521+717
57	522+000	523+000	-	-	HT Line Crossing @ CH:522+943
58	523+000	524+000	-	-	-
59	524+000	525+000	-	-	-
60	525+000	526+000	-	-	-
61	526+000	527+000	-	-	HT Line Crossing @ CH:526+195
62	527+000	528+000	-	-	HT Line Crossing @ CH:527+461
					HT Line Crossing @ CH:527+557
					HT Line Crossing @ CH:527+937
63	528+000	529+000	-	-	-
64	529+000	530+000	-	-	-
65	530+000	531+000	-	-	-
66	531+000	532+000	-	-	HT Line Crossing @ CH:531+213
67	532+000	533+000	-	-	-
68	533+000	534+000	-	-	-
69	534+000	535+000	-	-	-
70	535+000	536+000	-	-	-
71	536+000	537+000	-	-	-
72	537+000	538+000	-	-	HT Line Crossing @ CH:537+156
73	538+000	539+000	-	-	-
74	539+000	540+000	-	-	HT Line Crossing @ CH:539+161
					HT Line Crossing @ CH:539+170
75	540+000	541+000	-	-	HT Line Crossing @ CH:540+226
76	541+000	542+000	-	-	-
77	542+000	543+000	-	-	-
78	543+000	544+000	-	-	HT Line Crossing @ CH:543+995
79	544+000	545+000	-	-	HT Line Crossing @ CH:544+673
80	545+000	546+000	-	-	-
81	546+000	547+000	-	-	HT Line Crossing @ CH:546+913
					HT Line Crossing @ CH:546+923
82	547+000	548+000	-	-	HT Line Crossing @ CH:547+025
83	548+000	549+000	-	-	HT Line Crossing @ CH:548+626
84	549+000	550+000	-	-	HT Line Crossing @ CH:549+129
					HT Line Crossing @ CH:549+139

DKE Phase-II summary for Utility EHT Towers/HT Lines Re-location					
Sl. No.	Chainage		HT TOWER		REMARKS
	Stating	Ending	LHS	RHS	
85	550+000	551+000	-	-	-
86	551+000	552+000	-	-	-
87	552+000	553+000	-	-	-
88	553+000	554+000	-	-	-
89	554+000	555+000	-	-	-
90	555+000	556+000	-	-	HT Line Crossing @ CH:555+190
					HT Line Crossing @ CH:555+211
91	556+000	557+000	-	-	-
92	557+000	558+000	-	-	-
93	558+000	559+000	-	-	-
94	559+000	560+000	-	-	-
95	560+000	561+000	-	-	-
96	561+000	562+000	-	-	-
97	562+000	563+000	-	-	HT Line Crossing @ CH:562+739
					HT Line Crossing @ CH:562+867
98	563+000	564+000	-	-	-
99	564+000	END	-	-	-
TOTAL			13	10	
			23		

3.2.3 Forest along the Alignment

Proposed alignment is crossing the protected forest (road side/ canal side plantation declared as forest) at many locations in Punjab state and reserve forest & protected area (Wildlife Sanctuary and conservation reserve) in union territory of Jammu.

The exact length of affected forest area along the proposed alignment will be measured during joint inspection with forest department.

3.2.4 Reconnaissance survey for Hydrological study along the project corridor (13th Jan 2020 to 15th Feb 2020 to 20th Feb 2020)

The site visit was undertaken by the Hydrologist and structural engineer. Objective of the visit was to identify the sexisting parallel structures for the proposed major/minor bridges (if located nearby) and collection of dimensional details of existing canals/ drains at site for designing the waterway, assessment of HFL from local enquiry and marking on structure. The project road crosses various important canal/ drain and rivers as mentioned below:

Table 3-2: Hydrological study along the project corridor upto Gurdaspur

Sl. No.	Location (Ch.)	Name of River/ Canal/ Drain	Remarks
1.	437+153.6	Ravi River	Side Protection with stone pitching (wired mess) on U/S and D/S side. Bridge provided on Interstate connecting road (Punjab– Jammu) is of 27x44.0m (Total bridge length 1.188 Km). Above water level vertical clearance is 8m
2.	454+359	Ujh River	Old bridge on LHS and new Bridge on RHS with 1.5m level difference. Carriageway on LHS is 7m and in RHS its 7.5m. Span of the bridge is 1x13+37.2x15+1x13. Vertical clearance above Bed is 8m.
3.	493+743	Devak river	Old bridge on LHS side and new bridge on RHS. Span of bridge is 20x20.4m, 1x20.4m, 1x20.4m & 1x20.4m.



Ch. 437+153.6: Ravi River



Ch. 437+153.6: Ravi River



Ch. 454+359: Ujh River



Ch. 454+359: Ujh River



Ch. 473+445: River Bein



Ch. 473+445: River Bein

3.3 Structure Inventory & Condition Survey

3.3.1 General

A detailed condition survey along with visual inspection of existing structures has been carried out by the concerned key professionals to assess and ascertain the existing condition of the Bridges and other Cross drainage structures. Inventory of bridges has been prepared based on the condition survey, which consists of recording relevant technical data for each bridge.

Existing road consists of 7 Major Bridges, 40 Minor Bridges, 2 Flyovers, 2 VUPs, 88 Box culverts, 51 Pipe culverts and 5 Slab Culverts.

3.3.2 Major Bridges

There are Major Bridges in the project road. The superstructures are generally PSC I-Beam, RCC T Beam, RCC I Girder, RCC Solid Slab and RCC Box; whereas substructures are RCC Wall, pier supported on open, Well & Pile Foundation.

Most of the Major Bridges are in fair condition, with some requiring repair & rehabilitation to slab, railing or parapet wall and damaged wearing coat. These bridges are proposed to be retained with widening & some bridges require reconstruction.

Some photographs of Major bridges are shown below:

	
Major Bridge at Ch. 454+359	Major Bridge at Ch. 460+836
	
Major Bridge at Ch. 462+111	Major Bridge at Ch. 473+445
	
Major Bridge at Ch. 477+308	Major Bridge at Ch. 498+276
	
Major Bridge at Ch. 493+743	

3.3.3 Minor Bridges

There are Minor Bridges in the project road. The superstructures are generally PSC I Girder, RCC T-Beam, RCC I Girder, RCC Solid & RCC Box; whereas substructures are RCC Wall supported on Open, RCC Box Foundation.

Most of the Minor Bridges are in fair condition, with some requiring repair & rehabilitation to slab, railing or parapet wall and damaged wearing coat. These bridges are proposed to be retained with widening & some bridges require reconstruction.

Some photographs of Minor bridges are shown below:



Minor Bridge at Ch. 399+965



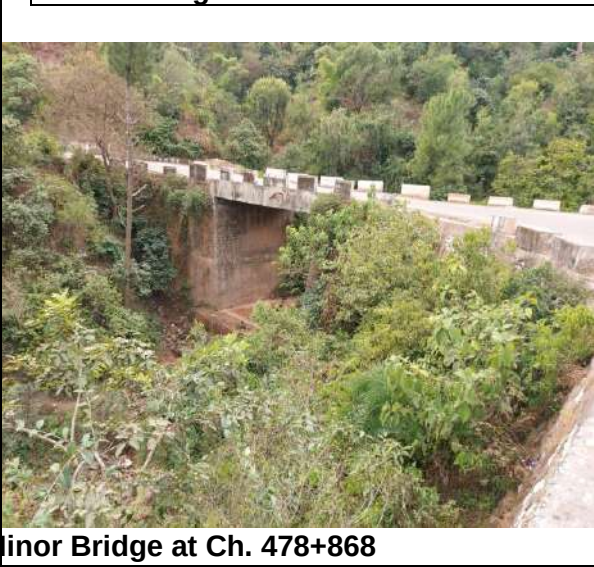
Minor Bridge at Ch. 411+575



Minor Bridge at Ch. 414+942



Minor Bridge at Ch. 456+679

	
Minor Bridge at Ch. 456+969	Minor Bridge at Ch. 458+441
	
Minor Bridge at Ch. 478+868	Minor Bridge at Ch. 521+920
	
Minor Bridge at Ch. 478+868	

3.3.4 Flyovers

There are Flyovers in the project road. The superstructure is PSC Girder whereas substructures is of RCC Box supported on raft. Both Flyovers are in fair condition. The Flyovers are proposed to be retained with widening. Some photographs of Flyovers are shown below:



Flyover at Ch. 398+135



Flyover at Ch. 399+610

3.3.5 Vehicular Underpass

There are VUP's in the project road. The structures are RCC Box. Both the VUP's are in fair condition. The VUP's are proposed to be retained with widening. Some photographs of VUP's are shown below:



3.3.6 Culvert

There are Box culverts, Pipe culverts and Slab Culverts in the project road.

Most of the Culverts are in fair condition, with some requiring repair & rehabilitation to slab, railing or parapet wall and damaged wearing coat. These culverts are proposed to be retained with widening.

Poor maintenance has led to improper functioning of the culverts. Adequate maintenance of culverts in many areas can result in proper functioning of the culverts.

The common defects that have been observed in the culverts are as follows:

- 1 Parapet /handrail cracked or broken in some cases.**
- 2 Vegetation growth on part of the structural element.**
- 3 Vent way choked condition due to accumulation of waste and garbage.**
- 4 Bed flooring absent or damaged in many cases.**
- 5 Reinforcement exposed.**

Some photographs of Culverts are shown below:





The detailed structure inventory data is given as **Annexure 3.1**.

3.3.7 Road Inventory by Using NSV

Road inventory survey has been carried out with NSV Vehicle at 100m intervals along the project road to collect details of all the features of the existing road and pavement. The following aspects have essentially been covered:

- Terrain
- Land use (built-up / agricultural / forest / industrial / barren)
- Village / Town
- Formation width
- Carriageway width - (type / width / condition)
- Shoulder (type / width / condition)
- Embankment height
- Submergence history if any
- Details and configuration of major junctions.
- Details of crossroads
- Location of sharp curves
- List of important structures like temples, petrol pumps, weigh bridges, schools / colleges, passenger shelters, dhabas, major buildings, industrial areas etc.
- Location of water bodies (lakes & reservoir etc.)
- Existing Right of way
- Existing bus shelters
- Culverts, bridges, and other structures (type, size & span arrangement)
- Roadside arboriculture
- Existing tree plantations
- Existing utility services on either side within ROW
- General drainage condition

This data has been taken into consideration for preliminary design (duly augmented by topographical survey). The detailed Road Inventory is given In **Annexure 3.2 to 3.5**. Summary of Road inventory is given below.

3.3.8 Pavement Width & Shoulder

Pavement width varies between 7m to 12.5m in all sections from Km 397+000 to 569+430, except for few toll plaza locations where the width is more than 12m. The shoulders are mostly paved in the sections and the width varies between 1m to 3m, however in most of the sections it is around 1.5m.

3.3.9 Type of Carriageway

The Road section from 397+000 to 554+580 is Four Lane, except for section between 421+950 to 422+380 & 547+350 to 547+600 where it is more than 4-Lane due to toll plaza. Also, the stretch between 554+400.5 to 569+430 is Two Lane.

3.3.10 Type of Pavement

The Pavement is both BT (Bituminous) & CC (Cement concrete) in Section-1 from 397+000 to 424+310. Whereas in sections 2, 3 & 4 pavement is mostly Bituminous from 453+000 to 502+000. From 539+500 to 554+580 in section-5 the pavement is both BT (Bituminous) & CC (Cement concrete). However, in section 6 from 554+400 till 567+430 it is mostly BT (Bituminous).

3.3.11 Terrain

The terrain is mostly Plain and rolling with hilly terrain towards the end in section 5 & 6.

3.3.12 Median

The raised median in section 1-5 (Km 397+000 till 554+580) lies between 1.5 to 5 meters. Section 6 is of Two-lane configuration without median.

3.3.13 Drain Type

The side drain is Opened-Lined drain in section-1 from 403+330 to 424+310. Section-2, 3 & 4 mostly have covered-lined drain except for some locations with opened lined drain. However, sections 5 & 6 have opened-lined drain with some stretches with covered lined drains.

3.3.14 Bus Bay/Shelter Locations

The details of bus shelters/Bay project roads are given Table below.

Table 3-3: Details of Bus bay/Shelters

Starting Chainage	Direction	Way Side Amenity
408+290	Increasing	Bus Shelter
421+580	Increasing	Bus Shelter
417+170	Decreasing	Bus Shelter
408+470	Decreasing	Bus Shelter
403+510	Decreasing	Bus Shelter
453+490	Increasing	Bus Shelter
455+260	Increasing	Bus Shelter
456+510	Increasing	Bus Shelter
458+180	Increasing	Bus Shelter
459+620	Increasing	Bus Shelter
458+250	Decreasing	Bus Shelter
456+590	Decreasing	Bus Shelter
453+550	Decreasing	Bus Shelter
472+530	Increasing	Bus Shelter
479+130	Increasing	Bus Shelter
471+060	Decreasing	Bus Shelter
490+410	Increasing	Bus Shelter
496+510	Increasing	Bus Shelter
496+600	Decreasing	Bus Shelter
490+380	Decreasing	Bus Shelter
540+701	Increasing	Bus Shelter
540+711	Decreasing	Bus Shelter

3.4 Pavement Investigations

Pavement investigations have been carried out for existing carriageway along the project highway. The following investigations have been carried out to know the remaining life and riding quality of the existing pavement.

- Pavement Condition Survey using Net work Survey vehicle (NSV)
- Roughness Test using Net work Survey vehicle (NSV)
- Falling weight deflectometer Test (FWD)

3.4.1 Pavement Condition Survey by using NSV

Pavement condition survey to include pavement (surface distress type and extent) shoulder and Embankment & drainage.

The Pavement Condition Survey has been carried out with the objective to assess the distress in pavement surface, shoulders and in embankment.

The following details have been collected from the Pavement Condition survey:

- 1 Cracking - % of pavement area affected.

- 2 Ravelling - % of pavement area affected.
- 3 Potholing - % of pavement area affected.
- 4 Patching - % of pavement area affected.
- 5 Edge Break - Length in meters.
- 6 Rut Depth - in mm.

The detailed pavement condition survey is presented as **Annexure 3.2** and the summary of pavement condition survey is given in Table below.

Table 3-4: Summary of Pavement Condition Survey

Chainage (km)		Pavement Condition (LHS)		(RHS)	
From	To	L1	L2	R1	R2
397.000	398.000	Poor	Poor	Poor	Poor
398.000	399.000	Poor	Poor	Poor	Poor
399.000	400.000	Poor	Poor	Poor	Poor
400.000	401.000	Poor	Poor	Good	Good
401.000	402.000	Poor	Poor	Good	Good
402.000	403.000	Poor	Poor	Poor	Poor
403.000	404.000	Poor	Poor	Poor	Poor
404.000	405.000	Poor	Poor	Poor	Poor
405.000	406.000	Poor	Poor	Poor	Poor
406.000	407.000	Poor	Poor	Poor	Poor
407.000	408.000	Poor	Good	Poor	Poor
408.000	409.000	Poor	Poor	Poor	Poor
409.000	410.000	Poor	Poor	Poor	Poor
410.000	411.000	Poor	Poor	Poor	Fair
411.000	412.000	Poor	Poor	Poor	Poor
412.000	413.000	Poor	Poor	Poor	Poor
413.000	414.000	Poor	Poor	Poor	Poor
414.000	415.000	Poor	Poor	Poor	Poor
415.000	416.000	Poor	Poor	Poor	Poor
416.000	417.000	Poor	Fair	Poor	Poor
417.000	418.000	Poor	Good	Poor	Poor
418.000	419.000	Poor	Good	Poor	Poor
419.000	420.000	Good	Poor	Poor	Poor
420.000	421.000	Poor	Poor	Poor	Poor
421.000	422.000	Poor	Poor	Poor	Poor
422.000	423.000	Poor	Fair	Fair	Fair
423.000	424.000	Poor	Poor	Good	Good
424.000	424.300	Poor	Poor	Good	Good
Green Field-Kathua, Pathankot and Lakhanpur Combined Bypass					
453.000	454.000	Poor	Poor	Good	Good
454.000	455.000	Fair	Fair	Good	Good
455.000	456.000	Poor	Poor	Good	Good

Chainage (km)		Pavement Condition (LHS)		(RHS)	
From	To	L1	L2	R1	R2
456.000	457.000	Poor	Poor	Good	Good
457.000	458.000	Poor	Poor	Good	Good
458.000	459.000	Poor	Poor	Good	Good
459.000	460.000	Poor	Poor	Good	Good
460.000	461.000	Poor	Poor	Good	Good
461.000	462.000	Poor	Poor	Good	Good
462.000	463.000	Poor	Fair	Good	Good
463.000	464.000	Poor	Fair	Good	Good
Green Field-Chak Dayala Bypass & Realignment for ROB					
468.000	469.000	Poor	Poor	Good	Good
469.000	470.000	Fair	Fair	Good	Good
470.000	471.000	Poor	Fair	Good	Good
471.000	472.000	Poor	Good	Good	Good
472.000	473.000	Poor	Good	Good	Good
473.000	474.000	Poor	Fair	Good	Good
474.000	475.000	Poor	Poor	Good	Good
475.000	476.000	Poor	Poor	Good	Good
476.000	477.000	Poor	Poor	Good	Good
477.000	478.000	Poor	Fair	Good	Good
478.000	479.000	Poor	Good	Good	Good
479.000	480.000	Poor	Good	Good	Good
Samba Bypass					
490.000	491.000	Poor	Poor	Good	Good
491.000	492.000	Poor	Poor	Good	Good
492.000	493.000	Poor	Poor	Good	Good
493.000	494.000	Good	Good	Good	Good
494.000	495.000	Fair	Fair	Good	Good
495.000	496.000	Good	Good	Good	Good
496.000	497.000	Good	Good	Good	Good
497.000	498.000	Good	Good	Good	Good
498.000	499.000	Good	Good	Good	Good
499.000	500.000	Good	Good	Good	Good
500.000	501.000	Good	Good	Good	Good
501.000	502.000	Good	Good	Good	Good
503.000 to 514 SA Infra Data to be used					
539.500	540.000	Poor	Poor	Good	Good
540.000	541.000	Poor	Poor	Good	Fair
541.000	542.000	Fair	Fair	Good	Poor
542.000	543.000	Poor	Poor	Good	Fair
543.000	544.000	Poor	Poor	Fair	Poor
544.000	545.000	Poor	Poor	Poor	Fair

Chainage (km)		Pavement Condition (LHS)		(RHS)	
From	To	L1	L2	R1	R2
545.000	546.000	Fair	Fair	Good	Poor
546.000	547.000	Fair	Poor	Good	Fair
547.000	548.000	Good	Fair	Good	Good
548.000	549.000	Good	Good	Good	Good
549.000	550.000	Good	Good	Good	Good
550.000	551.000	Good	Good	Good	Good
551.000	552.000	Good	Good	Good	Good
552.000	553.000	Good	Good	Good	Good
553.000	554.000	Fair	Good	Good	Fair
554.000	555.000	Good	Good	Fair	Good
555.000	556.000	Poor	-	Fair	-
556.000	557.000	Good	-	Fair	-
557.000	558.000	Fair	-	Fair	-
558.000	559.000	Poor	-	Fair	-
559.000	560.000	Good	-	Good	-
560.000	561.000	Good	-	Good	-
561.000	562.000	Good	-	Good	-
562.000	563.000	Good	-	Fair	-
563.000	564.000	Good	-	Fair	-
564.000	565.000	Fair	-	Good	-
565.000	566.000	Poor	-	Poor	-
566.000	567.000	Poor	-	Fair	-
567.000	568.000	Poor	-	Good	-
568.000	569.000	Fair	-	Fair	-

3.4.2 Roughness Survey by NSV

The Network Survey Vehicle is based on the latest survey techniques utilizing Laser, Global Positioning System and Video image processing tools etc. The Survey Vehicle is used for automatic collection of road inventory and pavement condition related data required for Road Asset Management, Pavement Maintenance Management System and Road Safety Audit Related Studies.

The system is capable of collecting the following information at Highway Speeds:

- Longitudinal profiling (International Roughness Index)
- Transverse profiling (Rut Depth)
- Road Geometry Data (cross slope, gradient, curvature)
- GPS coordinates (X, Y, Z) viz. longitude, latitude & altitude
- Video imaging for Roadside furniture / Road Assets
- Video imaging for Pavement Surface Distresses

The NSV Profilometer instrument is shown in figure below.

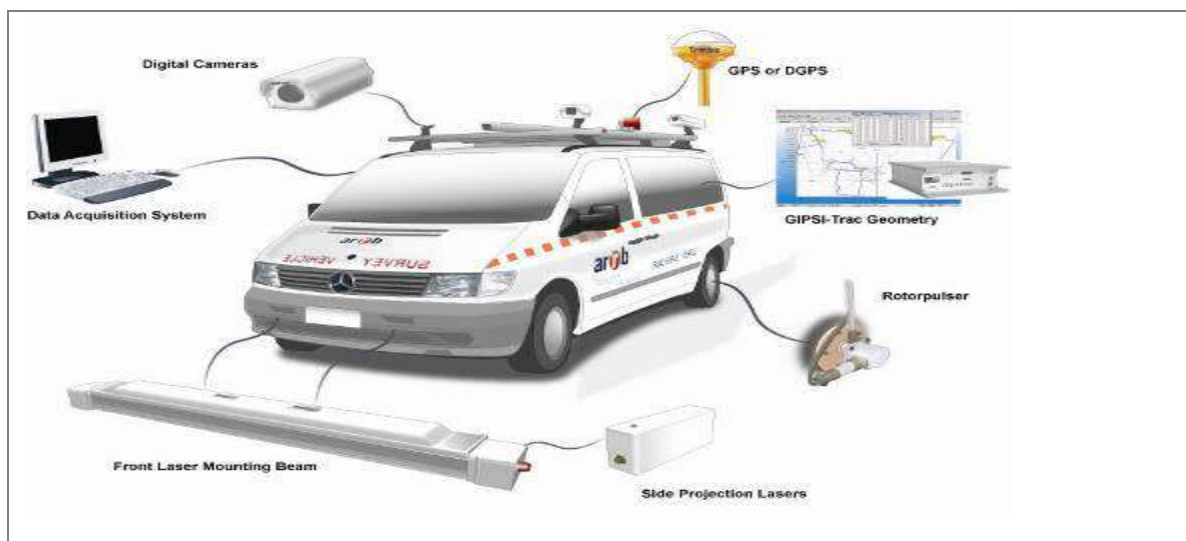


Figure 3-1: NSV Laser Profilometer

The Summary of Roughness Index as per IRC 82 Guidelines is given in Table below.

Table 3-5: Summary of Roughness Index Measurements

Sl. No.	Serviceability Indicators	Condition	Length (Km) - LHS		Length (Km) - RHS	
			L1	L2	R1	R2
1	L1 (<1800)	Good	2.00	37.00	8.00	31.00
2	L2(1800 to 2400)	Average	38.00	16.00	35.00	16.00
3	L3 (>2400)	Poor	39.00	26.00	36.00	29.00

The detailed data pertaining to IRI value and analysis for each 100m for the roads are furnished in **Annexure 3.3** and the summary of Roughness Index given in Table below.

Table 3-6: Detailed Summary of Roughness Index Survey

Chainage (km)		LHS		RHS	
From	To	L1	L2	R1	R2
397.000	398.000	2987	2664	3470	3093
398.000	399.000	2882	2209	2610	2485
399.000	400.000	1982	1825	3273	3335
400.000	401.000	2402	2145	2370	2931
401.000	402.000	1970	1463	1940	2758
402.000	403.000	1622	1333	2854	1749
403.000	404.000	2424	1808	3057	2158
404.000	405.000	1881	1432	3197	2204
405.000	406.000	2007	1662	2095	1528
406.000	407.000	2881	2122	2557	2121
407.000	408.000	2715	2069	3950	2866

Chainage (km)		LHS		RHS	
From	To	L1	L2	R1	R2
408.000	409.000	2838	2489	3963	3965
409.000	410.000	2967	2616	3022	2520
410.000	411.000	2924	2614	2949	2839
411.000	412.000	3758	3275	3438	3544
412.000	413.000	3125	2598	4015	3626
413.000	414.000	2560	2765	4092	3837
414.000	415.000	3303	2781	3429	3406
415.000	416.000	3670	3669	4227	3648
416.000	417.000	3519	2732	3857	3579
417.000	418.000	2634	2139	3273	3162
418.000	419.000	2462	1495	2874	2973
419.000	420.000	3293	2435	3202	3004
420.000	421.000	2196	1744	3291	3267
421.000	422.000	2564	2196	3732	2932
422.000	423.000	3209	2891	3280	3366
423.000	424.000	3078	2657	2831	2387
424.000	424.300	3626	3044	3290	3417
Green Field-Kathua, Pathankot and Lakhanpur Combined Bypass					
453.000	454.000	2987	2183	2300	1242
454.000	455.000	2882	2383	2587	2443
455.000	456.000	1974	1595	1665	1349
456.000	457.000	2020	1486	1830	1320
457.000	458.000	2000	1445	1654	1356
458.000	459.000	2060	1569	1847	1335
459.000	460.000	2071	1371	1869	1295
460.000	461.000	1854	1288	1835	1234
461.000	462.000	2091	1668	2430	1552
462.000	463.000	1836	1465	2251	1737
463.000	464.000	2037	1714	2112	1802
Green Field-Chak Dayala Bypass & Realignment for ROB					
468.000	469.000	2291	1904	2646	2010
469.000	470.000	2172	1457	2092	1436
470.000	471.000	1956	1342	2039	1321
471.000	472.000	2100	1398	1695	1296
472.000	473.000	1971	1438	1926	1443
473.000	474.000	2965	2653	2345	2239
474.000	475.000	2253	1399	1614	1388
475.000	476.000	2525	1696	2199	1941
476.000	477.000	2240	1520	2137	1668
477.000	478.000	1898	1341	1975	1295
478.000	479.000	2025	1312	1831	1259

Chainage (km)		LHS		RHS	
From	To	L1	L2	R1	R2
479.000	480.000	1907	1358	1968	1351
Samba Bypass					
490.000	491.000	1972	1513	1766.6	2039.3
491.000	492.000	1941	1766	1978.8	1695.1
492.000	493.000	2006	1774	2320.4	1925.5
493.000	494.000	2869	2885	2786.5	2345.4
494.000	495.000	2130	1784	2116.7	1613.7
495.000	496.000	1810	1623	1670.4	1228.2
496.000	497.000	2031	1668	2056.2	1717.6
497.000	498.000	2396	1553	2140.8	1631.8
498.000	499.000	2161	1178	1805.3	1193.1
499.000	500.000	2400	1373	2187.4	1572.5
500.000	501.000	2321	1784	2116.3	1513.4
501.000	502.000	2107	1538	2101.8	1693.7
503.000 to 514 SA Infra Data to be used					
539.500	540.000	1771	1765	1842	1688
540.000	541.000	2688	2722	2319	2195
541.000	542.000	2738	2710	3119	3098
542.000	543.000	2307	2242	2010	1923
543.000	544.000	2600	2525	2232	2304
544.000	545.000	2361	2327	2949	2846
545.000	546.000	2907	2945	2392	2258
546.000	547.000	2455	2360	1979	1910
547.000	548.000	2841	2858	3128	3203
548.000	549.000	3497	3428	3653	3656
549.000	550.000	4523	4677	4801	4537
550.000	551.000	4561	4453	4937	4785
551.000	552.000	3441	3485	1761	1816
552.000	553.000	2087	2029	2110	2041
553.000	554.000	3035	2936	2403	2269
554.000	555.000	2174	2005	1731	1619

3.4.3 Falling Weight Deflectometer Survey

The study has been initiated with the aim of assessing the strength and life of existing pavement by measuring deflections as per the Indian Codes/Standards. To accomplish this purpose, FWD Test was performed along the project road.

3.5 Methodology for FWD

1. Identifications of sections for FWD survey based on existing Pavement Condition.
2. Perform the FWD test for Identified Sections.

- 3 Assess the service life of the pavement in terms of million standard axles.
- 4 Assessment of overlay required for the design period.

The FWD tests have been carried out in accordance with the IRC: 115-2014 “Guidelines for structural evaluation and strengthening of flexible/rigid pavements using Falling Weight Deflectometer (FWD) technique”.

3.6 Equipment

Falling Weight Deflectometer (FWD) is an impulse-loading device in which a transient load is applied to the pavement and the deflected shape of the pavement surface is measured. The working principle of a typical FWD is illustrated in figure below.

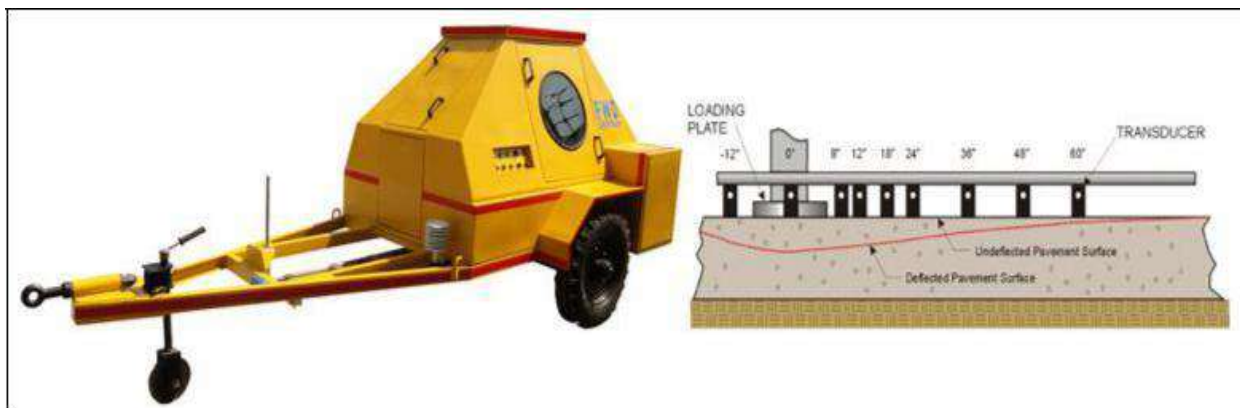


Figure 3-2: Falling Weight Deflectometer

Impulse load is applied by means of a falling mass, which is allowed to drop vertically on a system of springs placed over a circular loading plate. The deflected shape of the pavement surface is measured using displacement sensors which are placed at different radial distances starting with the center of the load plate.

3.6.1 Principle Used

A falling mass in the range of 200 kg is dropped from a height of fall in the range of 100 to 600 mm to produce load pulses of desired peak load of 40 kN (+/- 4 kN) and duration of 20-30 Ms. The target peak load of 40 kN (+/- 4 kN) applied on bituminous pavements corresponds to the load on dual wheel set of 80 kN standard axle load and duration of 20-30 ms simulates traffic moving at a speed of 60 Kmph. The corresponding peak vertical surface deflections at different radial locations are measured and recorded. The target peak load can be decreased suitably if the peak maximum (central) deflection measured with 40 kN load exceeds the measuring capacity of the deflection transducer. If the applied peak load differs from 40 kN within the above-mentioned range, the measured deflections have to be normalized linearly during the analysis to correspond to the standard target load of 40 kN. Sufficient number of deflection transducers shall be used to adequately capture the shape of deflection bowl. Six to nine velocity transducers (geophones) are generally adequate for measuring surface deflections of flexible pavements.

For the present work, the defined mass has been dropped from a height of 70mm to produce the target load and deflections have been measured from 9 deflection transducers placed at 0, 200, 300, 450, 600, 900, 1200, 1500 and 1800 mm.

3.6.2 Methodology

The FWD measurements have been carried out at spacing as mentioned in IRC: 115-2014 at slow lane and fast lane respectively for the identified sections.

Deflections measured by the FWD equipment are influenced by pavement temperature. Measurements made when the pavement temperature is different than standard temperature has be corrected. The deflection measurements, pavement temperature, sub-grade soil & deflection, and other information collected during the deflection study have been recorded. Following procedure has been followed for measurement of FWD:

- 1 The test location is marked on the field
- 2 The loading plate along with the deflection sensors have been lowered at the test location.
- 3 The target load has been applied and the deflections have been measured for 3 times
- 4 The first load is considered as a seating load and the values are not adopted for analysis

3.6.3 Temperature Measurement

The standard temperature for doing the test is 35°C. Since it is not possible to conduct the test at the standard temperature, a correction factor has to be applied for the deflection. The correction factor is determined by knowing the temperature at the time of the survey. The pavement temperature during the survey has been measured for everyone hour by drilling a hole of 40mm in the pavement and filling it with glycerol.

3.6.4 DATA, Analysis, Results, and Interpretation

- 1 KGPBACK – Genetic Algorithm based software for back calculating the layer moduli.
- 2 Three-layer system (Bituminous, Granular & Subgrade)
- 3 Data required:

The detailed FWD Calculations are given in **Annexure 3.4**.

Existing layer thickness –existing layer thicknesses is considered from the trail pits taken along the project road.

Layer moduli range – layer moduli adopted for the analysis is shown in next section.

Poisson's ratio:

- 1 BT-0.5, Granular-0.4, Subgrade-0.4 (For Back calculation and IITPAVE analysis without considering overlay).

3.6.5 Range of Moduli

Moduli ranges considered for the bituminous and granular layers are given in Table below.

Table 3-7: Moduli Ranges

Type of Layer	Lower and Upper Limit (Mpa)
Subgrade	The Lower Subgrade moduli value taken 5*Soaked CBR (%) and Upper value restricted 100.
Granular	Equation 7.3 of IRC: 37-2012, $MR_{gran}=0.2 \cdot h \cdot 0.45 \cdot MR_{sub}$ h= thickness of granular layer For Lower limit MR_{sub} Upper limit MR_{sub} (Refer lower and upper limit for subgrade given above)
Bituminous	Upper limit is fixed based on manual temperature as per Table 7.1 IRC: 37-2018 for VG-40 bitumen grade. Lower limit is curtailed at 750 and 3000, since road is in good condition as per Appendix III clause 8.4 of IRC: 115-2014.

3.6.6 Correction for Temperature

The stiffness of bituminous layer is highly susceptible to temperature and hence consequently the surface deflections of a given pavement will vary depending on the temperature of the constituent bituminous layers. If the depth of the BT surface is more than 40mm, then correction factor has to be applied. If the depth is less i.e., if it is a thin bituminous surfacing like premix carpet and surface dressing, then no correction is required. Correction for temperature variation on deflection values measured at temperature other than 35°C should be calculated by the formula provided in IRC 115.

The key points to consider are:

- 1 Pavement temperature range applicable for correction factor – 20°C to 45°C.
- 2 FWD shall not be carried for pavement temperature more than 45°C
- 3 Temperature correction not required for following cases
bituminous layers (depth < 40 mm)
“Poor” sections
Where average daily temperature is < 20°C for more than 4 months

3.6.7 Correction for Seasonal Variation

Moisture content affects the strength of sub-grade and granular sub-base/base layers. The extent to which the strength is affected will depend on the nature of sub-grade soil, gradation and nature of fines in the granular layers, etc. For the purpose of applying these guidelines, it is intended that the pavement layer moduli values should pertain to the period when the sub-grade is at its weakest condition. As per IRC: 115-2014, granular layers and sub-grade will be in its weakest condition during the post-monsoon season. Since survey was conducted during winter season seasonal correction as per Equation 6 and Equation 9 of IRC: 115-2014 were applied.

3.6.8 KGP Back Modulus and Corrected Modulus Values

The summary of KGP back modulus and corrected modulus values are given in Annexure 3.4.

3.6.9 Remaining Life of Existing Pavement

The remaining life and Overlay design are given Table below.

Table 3-8: Remaining Life of Existing Pavement

Sl. No.	Chainage (km)		Existing Thickness, mm		15 Percentile Moduli, Mpa			Strains		Remaining Life 90% reliability			Design MSA for 10 years	Check
	From	To	Existing BT	Existing Granular	BT	Granular	Sub grade	Tensile	Vertical	Fatigue	Rutting	Remainng life		
Remaining Life of LHS														
1	395.000	425.000	153	429	2049	216	77	2.12E-04	3.11E-04	35.18	111.87	35.18	35	Safe
2	453.000	464.000	192	441	2050	210	77	1.73E-04	2.54E-04	76.85	280.45	76.85	35	Safe
3	467.000	478.000	202	436	2071	186	77	1.65E-04	2.46E-04	93.51	327.83	93.51	35	Safe
4	490.000	502.000	228	448	2102	186	77	1.50E-04	2.18E-04	133.94	564.11	133.94	25	Safe
5	539.000	553.000	179	436	2025	222	77	1.83E-04	2.70E-04	63.64	212.98	63.64	25	Safe
6	554.000	568.400	146	421	2105	217	77	2.05E-04	2.95E-04	39.32	142.12	39.32	25	Safe
Remaining Life of RHS														
1	395.000	425.000	158	417	2074	205	77	2.11E-04	3.15E-04	35.46	105.28	35.46	35	Safe
2	453.000	464.000	194	437	2100	218	77	1.67E-04	2.51E-04	87.76	299.19	87.76	35	Safe
3	467.000	478.000	194	437	2076	206	77	1.72E-04	2.54E-04	78.48	280.45	78.48	35	Safe
4	490.000	502.000	192	438	2082	186	77	1.81E-04	2.61E-04	63.64	250.54	63.64	25	Safe

Sl. No.	Chainage (km)		Existing Thickness, mm		15 Percentile Moduli, Mpa			Strains		Remaining Life 90% reliability			Design MSA for 10 years	Check
	From	To	Existing BT	Existing Granular	BT	Granular	Sub grade	Tensile	Vertical	Fatigue	Rutting	Remainng life		
5	539.000	553.000	171	419	2104	190	77	2.02E-04	2.98E-04	41.75	135.96	41.75	25	Safe
6	554.400	568.400	2-Lane Section											

3.7 SUBGRADE INVESTIGATIONS

3.7.1 Introduction

Pavement sub-grade investigations comprise of making test pits and collection of material sampling and testing. Physical and mechanical properties of pavement materials and sub-grade soil forms the basis for the design of pavement layers and preparation of most appropriate subgrade proposals. For this purpose, various engineering surveys have been carried out as per the relevant MORTH/IRC Codes. This section covers the detailed pavement investigation procedures along with summary of field and laboratory test results.

The main objective of pavement investigations for existing subgrade evaluates the strength, condition of the sub-grade for the native/subgrade soil for the project road. These characteristics are intended for designing overlay for the intended MSA, and for designing new pavement on widening with enhanced durability benefits.

The Test pits were dug at 5 km interval in staggered manner at the pavement-shoulder interface extending through the pavement layers. Pits were made in such a way that one third of the pit (30 cm) was within the carriageway and the remaining two third (70 cm) in the shoulder, ensuring minimum damage to the original pavement and disruption to the traffic. The pits were backfilled and compacted after completion of work. The sequence of operations for large pits was as follows:

Manual excavation of 1.0 m x 1.0 m pit down to sub-grade level. After reaching the sub-grade level, the thickness of the different pavement layers was measured, and type of material examined. Sub-grade soil samples were collected, and field moisture content was determined at site by using moisture meter method as per IS 2720: Part 2.

The following sub-grade investigation were carried out to assess the structural condition of the existing pavement layers.

- 1 Excavate large test pits, measure pavement composition details (pavement course, material type & thickness)
- 2 Conduct field density tests using sand replacement/core cutter method to determine the in-situ density of the sub-grade soil, and field moisture content.
- 3 Perform DCP test through existing subgrade to determine its field CBR
- 4 Collection of bulk samples of existing granular crust and underlying sub-grade material for laboratory classification tests (natural moisture content, sieve analysis, liquid limit, and plastic limit), moisture - density relationship tests and CBR tests.

From each large test pit, subgrade soil samples have been collected for laboratory testing. The soil samples were collected in a bag from each test pit described above. Proper identification mark and location of the sample was recorded and sent for the laboratory for testing.

3.7.2 Existing Pavement Crust Composition

Small test pits investigations were carried out at every kilometer interval in staggered manner for determining existing pavement crust composition and sub-grade material type. Existing

pavement thickness as observed at pit locations has been recorded. Summary of existing crust composition along the project road is given in Table below.

Table 3-9 : Existing Pavement Crust Composition

Sl. No.	Location (Km)	Direction	BT (mm)-BC+DBM	GSB + WMM (mm)	Total Thickness (mm)
1	398.000	LHS	140	430	570
2	399.000	RHS	210	440	650
3	400.000	LHS	145	420	565
4	401.000	RHS	205	435	640
5	402.000	LHS	145	430	575
6	403.000	RHS	215	450	665
7	404.000	LHS	145	435	580
8	405.000	RHS	195	440	635
9	406.000	LHS	140	430	570
10	407.000	RHS	190	435	625
11	408.000	LHS	145	420	565
12	409.000	RHS	200	450	650
13	410.000	LHS	140	400	540
14	411.000	RHS	190	455	645
15	412.000	LHS	145	450	595
16	413.000	RHS	195	440	635
17	414.000	LHS	145	440	585
18	415.000	RHS	200	450	650
19	416.000	LHS	150	440	590
20	417.000	LHS	145	445	590
21	418.000	RHS	190	440	630
22	419.000	LHS	140	450	590
23	420.000	RHS	170	430	600
24	421.000	LHS	145	445	590
25	422.000	RHS	175	410	585
26	423.000	LHS	150	445	595
27	424.000	RHS	180	440	620
From Km 424.720 to Km 452.920-Green Field-Kathua, Pathankot and Lakhanpur Combined Bypass					
28	453.100	RHS	190	430	620
29	454.000	LHS	200	440	640
30	455.000	RHS	200	430	630
31	456.000	LHS	205	440	645
32	457.000	RHS	195	445	640
33	458.000	LHS	190	440	630
34	459.000	RHS	190	440	630
35	460.000	LHS	185	440	625
36	461.000	RHS	200	430	630

Sl. No.	Location (Km)	Direction	BT (mm)-BC+DBM	GSB + WMM (mm)	Total Thickness (mm)
37	462.000	LHS	190	445	635
38	463.000	RHS	190	450	640
39	464.000	LHS	195	440	635
From Km 424.120 to Km 467.6200-Green Field-Chak Dayala Bypass & Realignment for ROB					
40	467.000	RHS	200	435	635
41	468.000	LHS	195	440	635
42	469.000	RHS	195	445	640
43	470.000	LHS	200	445	645
44	471.000	RHS	205	450	655
45	472.100	LHS	210	430	640
46	473.100	LHS	205	450	655
47	474.000	RHS	200	440	640
48	475.000	LHS	200	435	635
49	476.000	RHS	210	408	618
50	477.000	LHS	195	450	645
51	478.000	RHS	220	445	665
52	479.000	LHS	200	450	650
From Km 479.520 to Km 490.320-Samba Bypass					
53	490.000	LHS	195	450	645
54	491.000	RHS	220	430	650
55	492.400	LHS	205	445	650
56	493.000	RHS	230	400	630
57	494.000	LHS	245	440	685
58	495.000	RHS	225	420	645
59	496.000	LHS	235	450	685
60	497.000	RHS	220	430	650
61	498.000	LHS	240	435	675
62	499.140	LHS	250	450	700
63	500.000	RHS	210	445	655
64	501.000	LHS	235	440	675
65	502.000	RHS	220	455	675
503.000 to 514 SA Infra Data to be used					
66	515.000	RHS	190	430	620
67	516.000	LHS	110	400	510
68	517.000	RHS	200	410	610
69	518.000	LHS	120	420	540
70	519.000	RHS	180	400	580
71	520.000	LHS	130	410	540
72	521.000	RHS	190	420	610
73	522.000	LHS	120	420	540
74	523.000	RHS	200	390	590

Sl. No.	Location (Km)	Direction	BT (mm)-BC+DBM	GSB + WMM (mm)	Total Thickness (mm)
75	524.000	LHS	130	400	530
76	525.000	RHS	190	420	610
77	526.000	LHS	220	430	650
78	527.000	RHS	185	440	625
79	528.000	LHS	260	450	710
80	529.000	RHS	155	430	585
81	530.000	LHS	230	440	670
82	531.000	RHS	160	430	590
83	532.000	LHS	240	430	670
84	533.000	RHS	160	450	610
85	534.000	LHS	200	420	620
86	535.000	RHS	150	430	580
87	536.000	LHS	160	440	600
88	537.000	LHS	170	450	620
89	538.000	RHS	155	400	555
90	539.000	LHS	160	380	540
91	540.000	RHS	200	350	550
92	541.000	LHS	175	435	610
93	542.000	RHS	195	440	635
94	543.000	LHS	180	440	620
95	544.000	RHS	175	430	605
96	545.000	LHS	170	435	605
97	546.000	RHS	170	415	585
98	547.000	LHS	165	430	595
99	548.000	RHS	160	420	580
100	549.000	LHS	170	445	615
101	550.000	RHS	145	410	555
102	551.000	LHS	165	435	600
103	552.000	RHS	140	390	530
104	553.000	LHS	160	420	580
105	554.000	RHS	150	420	570
106	555.000	LHS	150	400	550
107	556.000	RHS	155	430	585
108	557.000	LHS	140	420	560
109	558.000	RHS	145	425	570
110	559.000	LHS	145	430	575
111	560.000	RHS	140	420	560
112	561.000	LHS	140	425	565
113	562.000	RHS	140	430	570
114	563.000	LHS	145	435	580
115	564.000	RHS	150	410	560

Sl. No.	Location (Km)	Direction	BT (mm)-BC+DBM	GSB + WMM (mm)	Total Thickness (mm)
116	565.000	LHS	150	400	550
117	566.000	RHS	145	420	565
118	567.000	LHS	145	430	575
119	568.000	RHS	140	400	540

Bituminous course consists of one layer and appears to be good to fair in condition. Base course material was moderately strong and dry in general.

3.7.3 DCPT Test (TRL Method) for Field CBR

Dynamic Cone Penetration test according to TRL method was conducted to assess the in-situ CBR at and below sub-grade level. The benefits of using DCPT are sub-grade strength can be evaluated in quick succession and large amount of data can be calculated in a short time. The test was conducted at large pits along the existing pavement edge of the road. TRL's DCP apparatus consists of a hardened steel cone (60° cone angle) 20 mm in diameter, which is driven by a weight of 8 Kg with a drop height of 575 mm. A schematic diagram of DCPT instrument is shown in below figure.

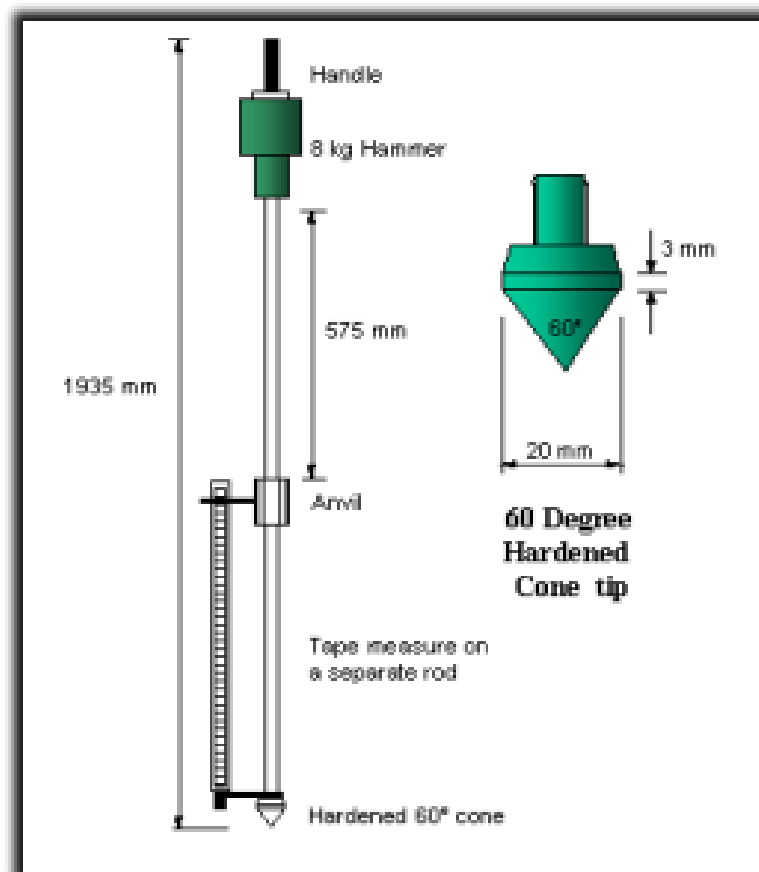


Figure 3-3: Schematic Diagram of DCPT Instrument

CBR value was calculated for different soil layers encountered from the graph of penetration versus number of blows. The depth of penetration is measured after each blow, output of the DCP test is in mm/blow. The penetration for each blow has been noted down in the field data sheet and the field CBR from DCPT test has been calculated using correlation between CBR and PI (Penetration Index). The correlations between CBR and PI are given in Table below.

Table 3-10: Correlations between CBR and PI

Author	Correlation	Field or Laboratory based Study	Material Tested
Kleyn (1975)	$\text{Log (CBR)} = 2.62 - 1.27 \log (\text{PI})$	Laboratory	Unknown
Harison (1987)	$\text{Log (CBR)} = 2.56 - 1.16 \log (\text{PI})$	Laboratory	Cohesive
Harison (1987)	$\text{Log (CBR)} = 3.03 - 1.54 \log (\text{PI})$	Laboratory	Granular
Livneh et. Al. (1994)	$\text{Log (CBR)} = 2.46 - 1.12 \log (\text{PI})$	Field and Laboratory	Granular and Cohesive
Ese et. Al. (1994)	$\text{Log (CBR)} = 2.44 - 1.07 \log (\text{PI})$	Field and Laboratory	Aggregate base course (ABC)
NCDOT (1998)	$\text{Log (CBR)} = 2.60 - 1.07 \log (\text{PI})$	Field and Laboratory	ABC and Cohesive
Coonse (1999)	$\text{Log (CBR)} = 2.53 - 1.14 \log (\text{PI})$	Laboratory	Piedmont residual soil
Gabr (2000)	$\text{Log (CBR)} = 1.40 - 0.55 \log (\text{PI})$	Field and Laboratory	Aggregate base course (ABC)

The correlation for cohesive soil has been used to convert the DCPT into CBR. Existing sub-grade soil is appraised as cohesive soil by visual means, CBR has been calculated by formulas given by Kleyn (1975) and Livneh et al (1994) and Harrison (1987) formula to compare the CBR values. the Summary of DCPT CBR (%) is given in Table below.

Observed field CBR value varies from 7% to 11% and detailed DCPT results are given in **Annexure 3.5**.

Table 3-11: DCPT CBR (%)

Sl. No.	Location (Km)	Direction	Depth (m)	No of Blows	Equivalent CBR (%)
1	399+010	LHS	576	29	10
2	404+126	LHS	549	24	8
3	409+000	RHS	567	25	9
4	414+500	LHS	540	23	8
5	419+440	RHS	545	23	8
6	424+000	RHS	548	23	8
7	457+000	RHS	568	25	9
8	462+000	LHS	544	24	7
9	468+100	LHS	566	29	10
10	474+800	RHS	530	26	10
11	491+000	RHS	566	24	8
12	496+100	LHS	568	25	9
13	502+160	RHS	554	29	11
14	539.600	LHS	551	25	9
15	544.700	RHS	569	24	8
16	551.360	RHS	552	24	7

Sl. No.	Location (Km)	Direction	Depth (m)	No of Blows	Equivalent CBR (%)
17	554.560	LHS	557	24	9
18	532+600	RHS	617	45	11
19	537+000	LHS	610	32	11

3.7.4 Existing Sub-grade Test Results

Following tests have been carried out for the existing existing sub-grade soil samples:

Field moisture content	:	As per IS: 2720
Grain size analysis	:	As per IS: 2720
Atterberg limits	:	As per IS: 2720
Free swell index	:	As per IS: 2720
Moisture-Density test	:	As per IS: 2720
(Heavy Compaction)		
CBR (4 days soaked)	:	As per IS: 2720

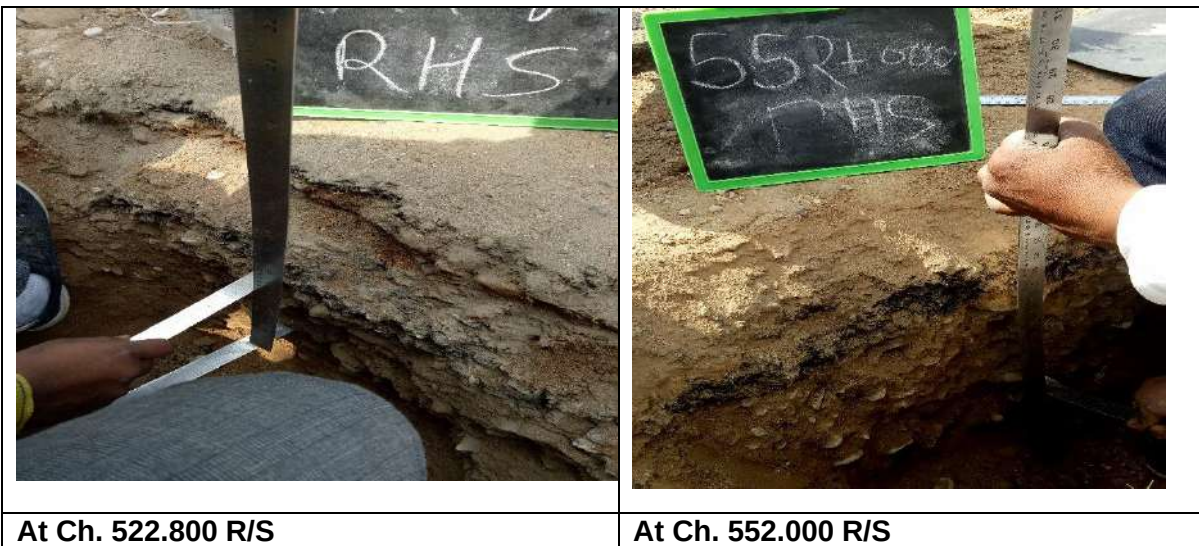
Summary of laboratory test results of the exiting subgrade is given in Table below;

Table 3-12 : Laboratory Tests Results of Existing Subgrade

Sl. No.	Location (km)	Direction	Grain Size Analysis			Soil Classification	Atterberg's Limit			OM C %	MDD gm/cc	Soaked CBR %	Un soaked (CBR %)	FSI, %
			Gravel (%)	Sand (%)	Silt & Clay (%)		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)					
1	399.000	RHS	10	68	22	SM	21.4	NP	NP	9.2	1.82	10.9	12.4	0
2	404.000	LHS	0	25	75	ML	26.8	NP	NP	12	1.9	8.4	10.6	0
3	409.000	RHS	3	29	68	ML	25.9	NP	NP	11.6	1.86	8.9	10.9	0
4	414.000	LHS	0	41	59	ML	25.3	NP	NP	10.2	1.83	7.4	9.9	0
5	419.000	LHS	0	26	74	ML	26.2	NP	NP	11.2	1.89	7.9	10.4	0
6	424.000	RHS	0	14	86	CL	29.1	15.1	14	10.8	1.96	7.4	10.4	10
7	457.000	RHS	2	34	64	ML	26.7	NP	NP	1.89	10.5	8.9	10.6	0
8	462.000	LHS	8	15	77	ML	27.6	NP	NP	1.94	11.4	7.9	9.9	0
9	468.000	LHS	4	56	40	SM	24.2	NP	NP	1.9	10.2	10.4	12.9	0
10	475.000	RHS	0	57	43	SM	24.5	NP	NP	1.97	9.6	10.4	12.4	0
11	491.000	RHS	1	23	76	ML	27.1	NP	NP	1.86	11	7.9	10.6	0
12	496.000	LHS	0	52	48	SM	25.1	NP	NP	1.94	9.8	9.9	11.9	0
13	502.000	RHS	14	56	30	SM	23.4	NP	NP	1.84	10.8	10.9	12.4	0
14	516+000	LHS	0	78	22	SM	22.0	NP	NP	13.6	1.77	10.4	13.6	0
15	522.800	RHS	0	82	18	SM	21.3	NP	NP	14.1	1.79	10.9	13.6	0
16	530.000	LHS	0	83	17	SM	20.9	NP	NP	13.8	1.73	10.9	13.9	0
17	535.000	RHS	0	75	25	SM	22.9	NP	NP	12.6	1.99	10.4	13.6	0
18	542.000	LHS	0	75	25	SM	22.9	NP	NP	12.6	1.99	10.4	13.6	0
19	545.000	RHS	0	52	48	SM	25.4	NP	NP	10.2	1.91	8.9	10.2	0
20	551.000	RHS	7	26	67	ML	26.9	NP	NP	12.2	2.01	7.9	10.2	0
21	555.000	LHS	9	36	55	SM	24.8	NP	NP	11.4	1.88	9.4	11.4	0
22	557.000	RHS	0	34	66	CL	28.6	20.3	8.3	9.6	2.03	8.4	11.9	10
23	565.000	LHS	0	36	64	CL	32.0	22.1	9.9	8.9	2.06	8.9	11.9	10

Some exhibits of the sub-grade investigations are shown below.

	
At Ch. 403.000	At Ch. 410.00 LHS
	
At Ch. 420.000	At Ch. 457.000 R/S
	
At Ch. 462.000 L/S	At Ch. 510.800 L/S



3.8 MATERIAL INVESTIGATIONS

Basic objective of material investigations is to identify the potential sources of construction materials and their suitability by testing them to establish their physical and engineering properties of the collected samples from the identified sources as per prevailing codes along the project stretches with reasonable leads, to yield adequate quantity and quality of materials which are suitable for various pavement layers viz. embankment, sub grade, sub-base, base and structures etc. The investigations have been done by studying the available information or by local enquiry of people, contractors, and material suppliers in the PIA adjacent to roads. The objectives may broadly be defined as below.

- 1 Identification of potential sources of borrow pit soil indicating places and the status of quarries whether in operation or new sources along with identification of naturally available granular material (GSB), if any
- 2 Potential sources of stone quarries
- 3 Sources of water for construction
- 4 Availability of sand

Material surveys and investigations are carried out to establish the suitability and availability of construction material as per IRC and MoRT&H guidelines and to evaluate the characteristic of soil where project highway construction is proposed and borrow materials for highway construction. Together these parameters are used in determining the pavement composition for the proposed improvement. The major activities on Material Investigations are as given below:

- 1 Investigations of existing materials within the proposed right of way.
- 2 Investigation for natural occurring construction materials including identification and inspection of potential sources of construction material, assessment of available quantities and to determine the engineering properties of such materials for road / structures construction.

The investigations of the material were mainly concentrated on the above guidelines and were initially restricted along the project road and nearby sources adjoining road sections. When suitable information was not available, the reconnaissance extended towards furthermore kilometers where potential sources were found and where access was not a major constraint.

The survey and investigations of existing ground soil and highway materials were taken-up to assess the condition of existing ground and identify suitable materials for the construction of embankment, sub-grade, sub-base, base and surface layers (bituminous mixes) of road pavement. The object of the study is to determine the engineering properties of the following materials, which are to be used in the execution.

- 1 Soil characteristic of existing ground
- 2 Borrow area materials such as Morrum, Sand, Flyash and soil / soil aggregates mixes for use in the embankment and sub-grade
- 3 Quarry Materials such as Gravel/Soil for use in the Sub-base
- 4 Quarries for locating hard stone aggregates for use in Granular, bituminous layers and Cement Concrete works
- 5 Sand for use in bituminous mixes and Cement Concrete works

Availability of other Materials such as Cement, Bitumen, Steel, Water, etc.

3.8.1 Original Ground Level Soil (OGL)

The investigations of original ground soil along the proposed alignment were carried out to know the strength properties of the existing soil. Soil samples were collected within the PROW along the project road at suitable intervals in staggered manner for laboratory testing. Testing has been carried out for collected OGL soil samples as per following testing procedure:

Test Name	Standards/Codes followed
Moisture Content Determination	IS 2720 Part 2
Particle size distribution	IS 2720 Part 4
Atterberg Limits	IS 2720 Part 5
Heavy Compaction	IS 2720 Part 8
California Bearing Ratio Test	IS 2720 Part 16
Field Density using core cutter method	IS 2720 Part 28
Free Swell Index	IS 2720 Part 40

About 40 kg of soil sample was collected from each OGL test location for testing purpose. The identification marks and location of the samples were recorded and sent to the laboratory testing.

Free Swell Index (FSI) test on the samples show that it varies are less than 10.0%. Soaked CBR varies from 6.90% to 10.90% with average value of 9.30%.

The summary of laboratory test results is given in Table below:

Table 3-13 : Laboratory Tests Results of Original Ground Level (OGL)

Sl. No.	Chainage (km)	Grain Size Analysis			Soil Classification	Atterberg's Limit			OMC	MDD	Soaked	Un soaked CBR %	FSI, %
		Gravel (%)	Sand (%)	Silt & Clay (%)		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	%	gm/cc	CBR %		
1	400.000	0	32	68	ML	24.9	NP	NP	10.2	1.85	9.9	11.4	0
2	405.000	0	29	71	ML	25.8	NP	NP	10.7	1.89	9.4	10.9	0
3	413.000	0	22	78	CL	29.8	14.7	15.1	8.9	2.05	8.4	10.4	10
4	419.000	0	20	70	ML	26.5	NP	NP	11.2	1.91	8.9	10.4	0
5	424.000	0	10	90	CL	32.5	18.3	14.2	9.2	1.94	6.9	8.4	10
6	425+700	0	23	77	CL	26.0	17.6	8.4	16.2	2.10	8.4	11.4	10
7	435+500	0	26	74	CL	26.2	17.9	8.3	15.6	1.80	8.9	11.4	10
8	436+000	0	30	70	ML	23.2	NP	NP	14.8	1.74	9.4	12.4	0
9	445+200	0	43	57	ML	22.9	NP	NP	13.9	1.79	9.6	12.9	0
10	451+000	0	44	56	CL	22.4	NP	NP	14.2	1.82	9.4	12.9	10
11	455.000	6	35	59	ML	25.6	NP	NP	10.8	1.88	10.4	12.6	0
12	460.000	0	24	76	ML	27.3	NP	NP	11.2	1.91	8.4	10.9	0
13	465.000	15	34	51	ML	25.2	NP	NP	9.6	1.84	10.4	11.9	0
14	470.000	3	38	59	ML	26.1	NP	NP	10.5	1.87	9.9	11.9	0
15	475.000	6	25	69	ML	26.9	NP	NP	11.8	1.92	9.4	11.4	0
16	480.000	0	41	59	ML	25.8	NP	NP	10.7	1.89	10.4	12.4	0
17	485.000	0	64	36	SM	24.3	NP	NP	9.7	1.84	10.9	12.4	0
18	490.000	1	30	69	ML	26.4	NP	NP	12.1	1.91	9.9	11.9	0
19	495.000	7	46	47	ML	24.6	NP	NP	9.8	1.86	10.4	11.4	0
20	501.000	2	18	80	CL	28.2	14.6	13.6	11.7	2.02	7.9	10.4	10
25	540.000	4	45	51	ML	24.6	NP	NP	10.9	1.95	8.4	9.9	0
26	544.000	0	58	42	SM	23.3	NP	NP	9.8	1.91	10.4	12.4	0

Sl. No.	Chainage (km)	Grain Size Analysis			Soil Classification	Atterberg's Limit			OMC %	MDD gm/cc	Soaked CBR %	Un soaked CBR %	FSI, %
		Gravel (%)	Sand (%)	Silt & Clay (%)		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)					
27	546.000	0	51	49	SM	25.1	NP	NP	10.2	1.86	9.9	11.9	0
28	551.000	7	19	74	ML	27.1	NP	NP	11.6	1.98	7.4	9.4	0
29	555.000	8	53	39	SM	24.9	NP	NP	9.4	1.87	10.4	11.9	0
30	557+000	0	34	66	CL	28.6	20.3	8.3	9.6	2.03	8.4	11.9	10
31	560.000	1	44	55	ML	26.2	NP	NP	12.1	1.89	9.4	10.2	0
32	565+000	0	36	64	CL	32.0	22.1	9.9	8.9	2.06	8.9	11.9	10

3.9 Construction Materials

3.9.1 Introduction

The objective is to locate suitable material for the construction of embankment, sub-grade and top layers of pavement and bridge structures. The study has been carried out to determine the engineering properties of the following materials, which are to be used in construction.

- 1 Borrow areas for soils for use in embankment and sub-grade.
- 2 Quarries for hard stone/granular materials for use in sub-bases, bases, bituminous mixes and concrete works.
- 3 Source of fine aggregate for use in DBM/BC layers and cement concrete works.

3.9.2 Fill / Embankment

The survey of soil from borrow areas for use in embankment and sub-grade layer was conducted along the proposed alignment. Soil samples of 40–50 kg in weight from each borrow area were collected and after proper identification tag for location, sent to laboratory for testing. The location of borrow areas with their distances from the proposed alignment and the quantity available is given in Table below:

Table 3-14: Summary of Identified Borrow Area Locations

Source ID	Project Road Chainage km	Direction	Lead (km)	Ownership Details	Village/town Name	Available Quantity (m3)
BA-1	399+400	RHS	2.0	Gulshan Kumar, 9682500869	Gurdaspur	32375
BA-2	404+000	LHS	3.2	Juginder Pal, 9914076602	Bariyar Sarpanch, Gurdaspur	60703
BA-3	410+300	RHS	6.3	Raju Sarpanch, 9855646644, 9463001500	Lohgarh, Dinanager, Gurdaspur	80937
BA-4	417+500	RHS	4.0	Balbir Singh, 9814759505	Marigaon, Clihari Tola, Jangal, Pathankot	32375
BA-5	422+00	RHS	5.0	Sulakhan Singh, 8968626710	Basi Behladpur, Chashma, Pathankot	32375
BA-6	425+700	RHS	2.0	Mukesh Kumar, 9815136776	Bauesh	80937
BA-7	429+500	LHS	0.5	Gurdiv Singh, Phone 9417152611	Bhagwansar	24281
BA-8	436+000	RHS	1.5	Bagel Singh, 9465830280	Gandyal	60703
BA-9	443+000	RHS	2.0	Govt. Land	Patala	809371
BA-10	447+000	LHS	2.0	Priti Singh, 9070004191	Padyari	80937
BA-11	449+000	RHS	1.5	Priti Singh, 9070004191	Varnoti	80937
BA-12	454+000	RHS	2.3	Gurmit Singh, 78895625828	Rajbagh, Kathua	101171
BA-13	458+000	RHS	1.0	Hari Gupal, 914948025229, 9796569607	Garnari, Amala, Marin, Kathua	202343
BA-14	461+000	LHS	4.0	Sethi, 9797375062	Gurhanballu, Hara Nager, Kathua	40469
BA-15	463+500	RHS	2.5	Karan Singh, 9469244266, 788980465	Saprain, Chandwan, Hiranager, Kathua	45527
BA-16	466+000	LHS	2.0	Dharmapal, 9906122279	Chajarth	101171
BA-17	466+000	LHS	2.0	Praveen Sing, 7051680061	Chajarth	101171
BA-18	468+550	LHS	4.0	Parakash Chand, 9797375062	Gurhanballu, Hara Nager, Kathua	60703
BA-19	469+900	RHS	3.0	Bharath Bhusan, 9858545549	Thuthachack	182109

Source ID	Project Road Chainage km	Direction	Lead (km)	Ownership Details	Village/town Name	Available Quantity (m3)
BA-20	470+000	RHS	3.0	Govt. Land	Yandivasi	121406
BA-21	473+000	RHS	3.0	Forest land		404686
BA-22	474+00	RHS	1.2	Ganesh Das, 9596819349	Tapyal, Ghagwal, Samba	121406
BA-23	481+000	LHS	0.9	Dhian Singh, 6005179914	Sarkal, Samba	182109
BA-24	481+000	LHS	1.0	Suresh Kumar, 7051137597	Sarkal, Deyani, Samba	32375
BA-25	484+000	RHS	0.5	Surjith Singh, 6005215396	Samba	202343
BA-26	487+500	LHS	1.5	Kuldeep Kumar (Deepo), 9858554502, 7006910493	Manhor (Chak Manglian Gugra, Pandaur, Samba	1011714
BA-27	489+000	RHS	0.3	Govt Land	Tanda	101171
BA-28	490+000	RHS	4.0	Jamyat Ram (Panch), 9682589151 Bisham Singh, 9796320253	Darul, Samba	607028
BA-29	491+200	LHS	2.0	Bulkar Babo, 7006472173	Darul, Samba	101171
BA-30	499+800	RHS	2.5	Manjoor Ahmad (Sonu), 9906040934	Sanderi (Pekhri) Rajendra Pichura, Samba	607028
BA-31	526+300	RHS	0.2	Govt. Land	Batra	202343
BA-32	529+800	RHS	0.1	Govt. Land	Sidra	222577
BA-33	535+500	LHS	0.2	Govt. Land	Nagrota	202343
BA-34	541+500	RHS	0.2	Ratan Singh, 95960323816 (Abha Sharma Sarpanch, 9622035877)	Dhammi, Nargota, Jammu	48562
BA-35	542+000	LHS	0.2	Govt. Land	Panjgrain	404686
BA-36	546+800	RHS	0.2	Khush Mohd, 60064259428	Van talab, Nargata, Jammu	607028
BA-37	549+000	LHS	0.1	Govt. Land	Ban Toll Plaza	404686
BA-38	551+000	LHS	0.1	Govt. Land	Nadhini (Ban Toll)	404686
BA-39	552+000	LHS	0.1	Govt. Land	Near Ban Toll Plaza	404686
BA-40	553+000	LHS	0.1	Govt. Land	Suketar	404686

Source ID	Project Road Chainage km	Direction	Lead (km)	Ownership Details	Village/town Name	Available Quantity (m3)
BA-41	553+900	RHS	2	Rockey, 7006623391	Suketer, Dumel, Jarjjar Kothi, Jammu	40469
BA-42	555+000	RHS	3	Ajai Sharma, 9419249796	Jhajjar Kathli, Jammu	101171
BA-43	555+700	RHS	0.1	Ajeet Singh, 9419166375	Suketer, Dumel, Jarjjar Kothi, Jammu	607028
BA-44	557+000	LHS	0.1	Govt. Land	Muri	404686
BA-45	560+300	LHS	0.4	Sager Singh, 7006471800	Mehari, Mehghal, Reasi	1214057
BA-46	562+100	RHS	1	Sager Singh, 7006471800	Mehari, Mehghal, Reasi	809371

Sufficient quantity of borrow soil is available at the identified locations. Laboratory testing of collected borrow area soil samples have been carried out for the following tests:

- 1 Grain size analysis – IS:2720 (part:4)
- 2 Atterberg's Limits (Liquid limit and plastic limit) – IS:2720 (part:5)
- 3 Modified Proctor Density– IS:2720 (part:8)
- 4 Free Swell Index Test– IS:2720 (part:16)
- 5 Four days soaked & Un Soaked CBR— IS:2720 (part:16)

From the test results, the observed soaked CBR varies from 6.90% to 10.9% with average value of 9.17%. Free Swell Index (FSI) test on the samples show that it varies from No swell to 10% swell with average value of 2.4%. The laboratory test results of borrow area soil is given in Table below:

Table 3-15: Test Results of Borrow Area Soil

Sl. No.	Location (Km)	Direction	Lead (Km)	Grain Size Analysis			Soil Classification	Atterberg's Limit			OMC %	MDD gm/cc	Soaked CBR %	Un soaked CBR %	FSI %
				Gravel (%)	Sand (%)	Silt & Clay (%)		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)					
1	404.000	LHS	3.0	0	28	72	SM	23.4	NP	NP	10.6	1.87	9.9	12.4	0
2	410.000	RHS	10.0	0	37	63	SM	22.8	NP	NP	11.2	1.91	9.4	12.9	0
3	415.000	RHS	3.0	2	46	52	SM	21.9	NP	NP	10.4	1.84	10.4	13.9	0
4	423.000	RHS	3.0	0	19	81	CL	27.6	15.5	12.1	11.6	1.89	7.9	10.9	10
5	425.700	RHS	2.0	0	17	83	CL	26.2	15.9	10.9	14.9	1.86	7.9	10.6	10
6	429.500	LHS	0.5	0	30	70	CL	28.6	18.9	9.7	15.4	1.82	8.4	11.4	0
7	443.000	RHS	2.0	0	79	21	SM	24.2	NP	NP	13.2	1.73	9.6	12.9	0
8	447.000	LHS	2.0	0	8	92	CL	29.4	20.8	8.6	16.2	1.75	7.6	10.4	10
9	454.000	RHS	2.5	0	13	87	CL	31.6	16.8	14.8	1.88	12.1	6.9	9.3	10
10	458.000	RHS	1.0	0	14	86	CL	30.2	15.7	14.5	1.86	12.4	7.4	9.9	10
11	463.500	RHS	2.0	18	38	44	SM	25.3	NP	NP	1.97	10.7	10.4	11.9	0
12	466.000	LHS	2.0	0	12	88	CL	30.6	20.3	10.3	15.3	1.84	7.6	10.9	10
13	468.550	LHS	4.0	8	54	38	SM	24.2	NP	NP	1.91	9.8	9.4	10.6	0
14	474.000	LHS	2.0	16	35	49	SM	25.8	NP	NP	1.94	10.2	10.4	12.9	0
15	481.000	LHS	1.5	0	34	66	ML	26.2	NP	NP	1.89	10.8	9.9	10.9	0
16	484.000	RHS	0.5	0	27	73	CL	29.1	19.9	9.2	14.6	1.85	8.4	11.9	0
17	489.000	RHS	0.3	0	85	15	SM	21.2	NP	NP	11.9	1.77	10.4	12.9	0
18	490.000	RHS	5.0	5	16	79	ML	27.1	NP	NP	1.97	11	8.9	10.2	0
19	499.000	RHS	4.0	0	17	83	CL	29.8	16.7	13.1	2.01	12.4	7.9	9.9	10
20	526.300	RHS	0.2	0	89	11	SM	20.6	NP	NP	10.3	1.75	10.4	13.6	0
21	529.800	LHS	0.2	0	86	14	SM	20.9	NP	NP	11.6	1.79	10.9	13.9	0
22	535.500	LHS	0.2	0	74	26	SM	21.8	NP	NP	12	1.82	9.9	13.6	0

Sl. No.	Location (Km)	Direction	Lead (Km)	Grain Size Analysis			Soil Classification	Atterberg's Limit			OMC %	MDD gm/cc	Soaked CBR %	Un soaked CBR %	FSI %
				Gravel (%)	Sand (%)	Silt & Clay (%)		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)					
23	541.500	RHS	5.0	12	51	37	SM	24.6	NP	NP	9.2	2.01	9.9	10.6	0
24	546.800	RHS	6.0	0	52	48	SM	23.9	NP	NP	9.9	1.97	9.4	10.9	0
25	551.000	LHS	0.1	0	43	57	ML	22.6	NP	NP	14.3	1.8	9.2	12.9	0
26	551.000	LHS	2.0	2	46	52	ML	25.2	NP	NP	10.5	1.85	9.4	10.2	0
27	557.000	LHS	3.0	8	53	39	SM	24.9	NP	NP	11.3	1.93	10.4	12.2	0
28	560.300	LHS	4.0	1	46	53	ML	25.8	NP	NP	10.8	1.89	8.9	10.2	0
29	562.100	RHS	4.0	0	37	63	ML	26.1	NP	NP	11.2	1.91	8.9	9.9	0

Some exhibits of the material investigations are shown below.

 Temperature : -273.15°C Accuracy : 0.9 time : 2020-07-29 19:39:13 longitude : 75.8126883 latitude : 32.0268888	
Ch. 399.000 LHS	Ch. 404.300 LHS
 Temperature : -273.15°C Accuracy : 4.9 time : 2020-07-29 18:44:06 longitude : 75.5217957 latitude : 32.0985488	
Ch. 410+300 RHS	Ch. 425+700 RHS
	
Ch. 429+500 LHS	Ch. 443+000 RHS



	
Ch. 535+500 LHS	Ch. 551+000 LHS
	
Ch. 561+000 RHS	Ch. 566+400 RHS

3.9.3 Sub-grade

The material used in sub-grade shall be soil, moorum, gravel or a mixture of these. The size of the coarse material in the mixture of earth shall ordinarily not exceed 50 mm. The materials satisfying the density requirements given in Table 300-1 of MORT&H specification will be employed for the construction of sub-grade. The material to be used in sub-grade would also satisfy design CBR at the dry unit weight applicable as per Codal provisions. Material for sub-grade layer will be considered from the identified borrow areas.

3.9.4 Sub-base

The material to be used for the work shall be gravel and / or crushed stone or a combination there of. The material shall be free from organic and other deleterious constituents and conform to grading given in Table 400-1 of MORT&H specification. Material for Sub-base will be available from stone/gravel quarries. Crushed stone samples were collected from different location to establish their suitability for use in construction as sub-base material.

3.9.5 Base

The material to be used for base shall be mixture of coarse aggregates and fine aggregates. The coarse aggregates shall consist of crushed rock and conform to physical requirements and grading as given in Table 400-12 and 400-13 respectively of MORT&H specification.

Extensive survey was conducted to locate the availability of stone metal near the project site. As a result of local enquiries and discussion with the local PWD official's stone metal was identified at various locations. The samples from the crusher were collected from quarries and tested in the laboratory for the following tests:

Los Angeles Abrasion Test	:	As per IS: 2386 (Part-4)
Aggregate Impact value	:	As per IS: 2386 (Part-6)
Combined Flakiness and Elongation Indices	:	As per IS: 2386 (Part-7)
Soundness	:	As per IS: 2386 (Part-5)
Water absorption	:	As per IS: 2386 (Part-3)

Summary of Identified Quarry/Crusher Locations is given in Table below:

Table 3-16: Details of Stone Quarry Location

Source ID	Alignmen t Chainage km	Direction	Lead (km)	Ownership Details	Village name
CA-1	413+000	RHS	1.0	Balbinder Kumar, 9914911221	Ravi River, Kiri Punjab, village, Pathankot
CA-2	436+000	RHS	7.0	JS Stone Crusher, Raju, 9875931712	Raju, 9875931712
CA-3	436+000	RHS	9.0	Kesri Stone Crusher, Abhishek Nanda, 9888801210, 9417022701	Kesri Stone Crusher, Pathankot
CA-4	436+000	RHS	7.0	Bhagwat Stone Crusher, Arvinder Singh 9915217104, Toni 8146653959	Bhagwat Stone Crusher
CA-5	436+000	LHS	5.0	Kathlor Stone Crusher	Gandyal
CA-6	436+000	LHS	5.0	Newhome Stone Crusher	Gandyal
CA-7	436+000	LHS	5.0	Balaji Stone Crusher	Gandyal
CA-8	436+000	LHS	5.0	Jayana Stone Crusher	Gandyal
CA-9	436+000	RHS	10.0	Madhopur Stone Crusher, 600509360, 9569097555	Gandyal
CA-10	465+000	LHS	1.0	Sarsing Stone Crusher, Rajiv Sasiodia, 9419208007	Sarsing Stone Crusher,
CA-11	465+000	LHS	10.0	Sain&Sone Stone Crusher, 9419140261	Sain&Sone Stone Crusher
CA-12	473+000	RHS	3.0	Narsing Stone Crusher, Vinod Sharma, 9419119070, Risho, 9858098626	Narsing Stone Crusher
CA-13	473+000	RHS	3.0	Darbar Singh, 8716844954, SP Sharma, 7051262427	Vishkarma stone Crusher

Source ID	Alignment Chainage km	Direction	Lead (km)	Ownership Details	Village name
CA-14	480+000	RHS	5.0	Kousalya Stone Crusher, 7051287116	Ghagwal
CA-15	490+000	RHS	4.0	Rameesh Kapoor, 9419190158, 9697522402	Nanak Chak, Samba
CA-16	490+000	RHS	3.0	Basanter Stone Crusher, 9419190158, 9697522402	Near chichi mandir, vill-Nanak Chack
CA-17	494+000	RHS	4.0	Choudary Stone Crusher, 9419142429	Near Chichi Mandir, vill-Nanak Chack
CA-18	530+000	RHS	2.0	Sharma Stone Crusher, Sonu, 700608108	Sidra
CA-19	543+500	LHS	5	Kashim Ali, 6005194611, Sultan Ali 9419117370	Seri, Panigarain, Jammu
CA-20	544+000	LHS	5.0	Motel Stone Crusher, Sulthan, 9419117370	Serikelan
CA-21	555+100	RHS	29	Nandkishor, 9419160751, 7006055892	Maadurga Stone Crusher, Kishanpur

Some exhibits of the material investigations are shown below.



473+000 R/S	490+000 R/S
	
490+000 R/S	494+000 R/S
	
530+000 R/S	544+000 L/S

Laboratory test results of Coarse aggregate are given in Table below:

Table 3-17: Test Results of Coarse Aggregates

Sl. No.	Location	Direction	Size (mm)	Lead (Km)	Sieve Analysis (Material Passing through IS Sieve) mm							Flakiness, %	Elongation %	Impact Value %	Water Absorption %	Specific Gravity
					63	40	20	12.5	10	4.75	2.36					
1	436+000	RHS	40	3.00	100	100	2.4	-	0.3	-	-	14.6	16.2	-	0.49	2.65
			20	3.00	-	100	99.1	-	2.3	0.6	-	13.6	14.9	13.6	0.57	2.63
			10	3.00	-	-	-	100	88.9	4.7	1.1	12.8	14.2	15.1	0.64	2.62
2	465.000	LHS	40	0.50	100	98.7	5.1	-	0.5	-	-	15.6	15.8	-	0.52	2.63
			20	0.50	-	100	98.6	-	9.3	1.1	-	14.5	14.2	12.6	0.59	2.63
			10	0.50	-	-	-	100	90.2	7.6	1.3	13.2	14.1	14.2	0.68	2.62
3	473.000	RHS	40	3.00	100	99.6	7.6	-	0.8	-	-	15.1	14.9	-	0.41	2.64
			20	3.00	-	100	97.3	-	4.6	1	-	13.9	13.5	14.3	0.55	2.63
			10	3.00	-	-	-	100	87.9	8.6	1.5	13.2	12.9	15.6	0.65	2.63
4	490.000	RHS	40	5.00	100	98.6	5.1	-	0.6	-	-	15.1	16.6	-	0.43	2.64
			20	5.00	-	100	99.6	-	6.3	0.9	-	13.9	14.5	15.1	0.55	2.62
			10	5.00	-	-	-	100	89.7	8.2	1.5	12.5	13.8	14.2	0.61	2.61
5	544.000	LHS	20	6	-	100	98.6	-	7.9	1.2	-	14.2	15.3	14.3	0.61	2.62
			10	6	-	-	-	100	91.8	9.6	1.3	13.6	14.3	15.6	0.66	2.62
6	555.100	RHS	40	32	100	97.2	7.6	-	0.8	-	-	14.9	15.3	-	0.47	2.63

			20	32	-	100	98. 3	-	8.2	1.1	-	13.5	14.2	15.1	0.59	2.62
			10	32	-	-	-	100	93. 4	9.3	1.4	12.9	13.1	14.2	0.68	2.61

3.9.6 Sand

River is the main source of course sand. The summary of identifies sand quarry locations are given in Table below:

Table 3-18: River Sand Quarry Locations

Source ID	Alignment Chainage km	Side	Lead (km)	Ownership Details	Village name	River Name
FA-1	413+000	RHS	1.00	Balbinder Kumar, 9914911221	Ravi River, Punjab, Kiri village, Pathankot	Ravi River
FA-2	436+000	RHS	7.00	JS Stone Crusher, Raju, 9875931712	Gandyal	Ravi River
FA-3	436+000	RHS	7.00	Bhagwat Stone Crusher, Arvinder Singh 9915217104, Toni 8146653959	Gandyal	Ravi River
FA-4	465+000	LHS	1.00	Sarsing Stone Crusher, Rajiv Sasiodia, 9419208007	Sarsing Stone Crusher	Seri River
FA-5	465+000	LHS	1.00	Sain & Sone Stone Crusher, 9419140261	Sain & Sone Stone Crusher	Seri River
FA-6	473+000	RHS	3.00	Narsing Stone Crusher, Vinod Sharma, 9419119070, Risho, 9858098626	Narsing Stone Crusher	Bhai River
FA-7	473+000	RHS	3.00	Darbar Singh, 8716844954, SP Sharma 7051262427	Vishkarma Stone Crusher	Bhai River
FA-8	480+000	RHS	5.00	Kousalya Stone Crusher, 7051287116	Ghagwal	Ghagwal River
FA-9	490+000	RHS	4.00	Rameesh Kapoor, 9419190158, 9697522402	Nanak Chak, Samba	Basanta River
FA-10	490+000	RHS	3.00	Basanter Stone Crusher, 9419190158, 9697522402	Near Chichi Mandir, vill- Nanak Chack	Basanta River

Source ID	Alignment Chainage km	Side	Lead (km)	Ownership Details	Village name	River Name
FA-11	494+000	RHS	4.00	Choudary Stone Crusher, 9419142429	Near Chichi Mandir, vill-Nanak Chack	Basanta River
FA-12	530+000	RHS	2.00	Sharma Stone Crusher, Sonu, 700608108	Sidra	Tawi River
FA-13	543+500	LHS	5	Kashim Ali, 6005194611, Sultan Ali 9419117370	Seri, Panigarain, Jammu	
FA-14	543+500	LHS	5	Mahinder Kumar, 7051768717	Seri River	
FA-14	544+000	LHS	5	Motel Stone Crusher, Sulthan, 9419117370	Serikelan	
FA-15	555+100	RHS	29	Nandkishor, 9419160751, 7006055892	River	

Further, sand-samples were collected from the source for testing purposes and the summary of test results are given in Table below:

Table 3-19: Test Results of Fine Aggregate

Sl. No.	Location/ Sample	Source	Direction	Lead (Km)	Sieve analysis percent passing (mm)							Zone	Fineness Modulus (%)	Specific gravity	Water Absorption	Bulk Density
					10	4.75	2.36	1.18	0.6	0.3	0.15				(%)	(Kg/Ltr.)
1	436.000	Crushed Sand	RHS	3.5	100	97.7	91.4	75.4	64.8	17.8	4.8	II	2.48	2.59	1.38	1.636
2	436.000	River Sand	RHS	3.5	100	98.1	89	67.4	54.4	18	6	III	2.68	2.56	1.52	1.618
3	490.000	Crushed Sand	RHS	3.00	100	98.8	88.4	72.6	50.2	19	5.8	II	2.65	2.58	1.31	1.631
4	490.000	River Sand	RHS	3.00	100	99.7	97	91.9	82.1	31.9	10.6	IV	1.86	2.53	1.56	1.615
5	473.000	Crushed Sand	RHS	3.00	100	98.7	89.4	75.8	53.4	16.4	6.9	II	2.6	2.56	1.38	1.643
6	473.000	River Sand	RHS	3.00	100	99.4	96.9	91.1	81.1	42.7	12.2	IV	1.76	2.51	1.52	1.621
7	465.000	Crushed Sand	RHS	0.50	100	98.4	90.1	77.5	50.4	17.9	3.4	II	2.62	2.59	1.42	1.638
8	465.000	River Sand	RHS	0.50	100	99.5	97.6	92.8	83.6	39.9	9.4	IV	1.77	2.52	1.63	1.623
9	555.100	Crushed Sand	RHS	32	100	99.7	97.1	87.6	52.4	14.7	4	II	2.65	2.59	1.42	1.629
11	543.500	Crushed Sand	LHS	6	100	99.6	96	84.8	46.5	15.1	6.6	II	2.6	2.57	1.4	1.638
12	543.500	River Sand	LHS	6	100	99.3	97.1	93	82.3	47.3	9.6	IV	1.76	2.54	1.57	1.616

3.9.7 Flyash

Fly Ash is a lightweight material, which may be used for construction of embankment, sub-grades etc. singly or by mixing with suitable admixtures. The flyash is laid in alternate layers with soil and earth blankets are also provided on the side slopes for the confinement of the material as per IRC: SP: 58 – Guidelines for use of Flyash in Road Embankment. The guidelines regarding design / construction of embankments are given in IRC SP: 58-2001.

Generally, highway will be constructed at approximately 2 to 3m from the ground level, which may be more at bridge approaches and at ROB locations. Flyash can provide technically viable, environmentally sound & cost-effective alternative to natural borrow soil. The details of the identified thermal power plants for the flyash along the project road are given in Table below.

Table 3-20: Details of Flyash Locations

Sl. No.	Chainage	Direction	Plant Name	Lead (Km)
1	397.000	RHS	Guru Hargobind Thermal Plant, Bhatinda (Punjab) -Lehramobat	264
2	397.000	RHS	Guru Gobind Singh Super Thermal Power Plant, Punjab-PSPCL	220
	436.000	RHS		225
	505.000	RHS		312
3	397.000	RHS	Thermal power plant, Goindwal Sahib (Punjab)-GVK Power Ltd.	120
	436.000	RHS		157
	505.000	RHS		260
4	397.000	RHS	Guru Nanak Dev TPS, Bathinda, Punjab	260

The following properties of flyash have been tested:

- 1 Gradation
- 2 Specific Gravity
- 3 Modified Proctor MDD & OMC
- 4 Coefficient of Consolidation
- 5 Permeability

The summary of flyash test results is given in Table below:

Table 3-21: Test Results of Flyash

Sl. No.	Chainage	Source of Sample	Gradation Test												Proctor Density		CBR (%)						
			% of Passing									Gravel Size Particles (%)	Sand Size Particles (%)	Silt Size (%)	Clay Size (%)	OMC (%)	MDD (gm/cc)	Unsoaked			Soaked		
			10 mm	4.75 mm	2.00 mm	1.18 mm	0.600 mm	0.425 mm	0.300 mm	0.150 mm	0.075 mm							10	35	65	10	35	65
2	245+000	Guru Gobind Singh Thermal power plant	100	99.2	97.7	95.5	88.7	-	71	30.6	15.8	0.8	83.4	15.8	0	21.5	1.33	16.3	28.3	45.6	5.2	7.9	9.1

Photographs showing identified Flyash locations are shown below.



(Guru Gobind Singh Super Thermal Power Plant, Punjab)

3.9.8 Bitumen

Bitumen of grade of VG-40 will be obtained from Panipath Refinery to supply the bitumen.

3.9.9 Cement

Cement of all varieties/types i.e. Ordinary Portland, Portland Slag, and Portland Pozzolona confirming to relevant IS standards are readily available in the market in sufficient quantity. Cement would be directly supplied by the manufacturer to the project site for such a huge quantum of work and may be at rebated price.

3.9.10 Reinforcement Steel

Reinforcement steel confirming to relevant IS standard is readily available in market.

3.9.11 Conclusion and Recommendations

Construction materials are available with in economical lead and fulfils MORT&H, Specifications requirement.

Construction material can be obtained/exploited without any hassles during the implementation of the project.

The lead chart of the construction materials is shown in figure below:

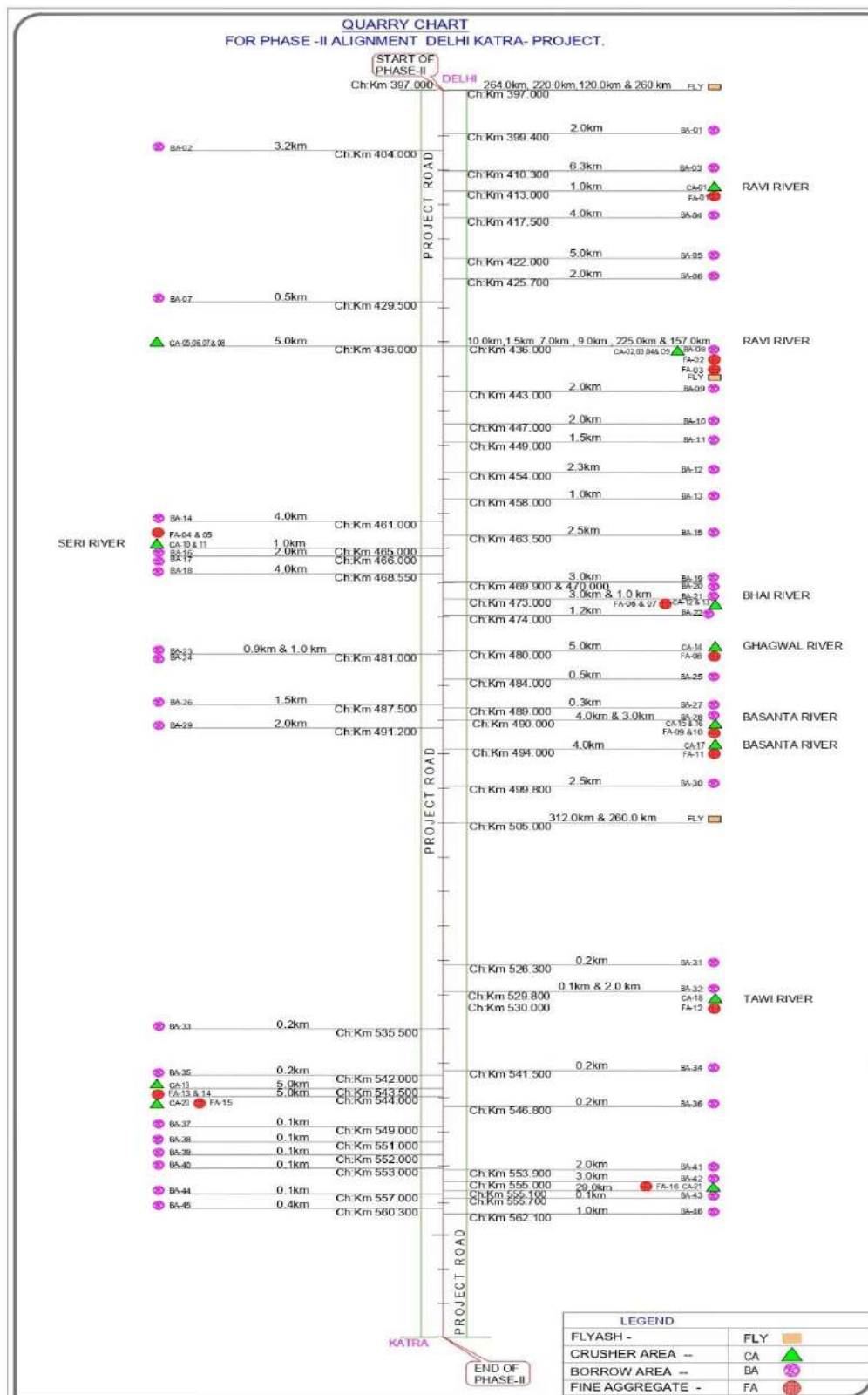


Figure 3-4: Lead Chart

3.10 TOPOGRAPHIC SURVEY

Topographical survey is important to generate the drawing and to give the overall existing features of the ground. The Topographical survey has been carried out along the project alignment to provide the information in 3D. The topo survey was carried out by following methods:

- a. Drone / Lidar
- b. DGPS / Total station.

3.10.1 Topographic Survey by Drone:

Topographic surveys have been carried out using Total station. The verification of survey using drone was also undertaken and the drone imageries were utilized in firming up the design proposal.

3.10.2 Overview

The width of survey corridor will generally be as given under:

- i) The width of the survey corridor considered is more than the layout of the proposed alignment including the extent of embankment and cut slopes and the general ground profile. While carrying out the field surveys, the widening scheme (i.e. right, left or symmetrical to the centreline of the existing carriageway) were taken into consideration so that the topographic survey covers sufficient width beyond the centreline of the proposed divided carriageway. The surveys covered a minimum of 55 m on either side of the centreline of the proposed divided carriageway or land boundary whichever was more.
- ii) Where existing roads crosses the alignments, the survey was extended to 100m on either side of the road centreline and will be of sufficient width to allow improvements, including grade separated/ at grade intersection to be designed.

Longitudinal and Cross-Sections

The topographic surveys for longitudinal and cross-sections covered the following:

- Longitudinal section levels along final centreline at every 1 m interval, at the locations of curve points, small streams, and intersections and at the locations of change in elevation.
- Cross sections at every 1 m interval in full extent of survey covering sufficient number of spot levels on existing carriageway and adjacent ground for profile correction course and earth work calculations. Cross sections were taken at closer interval at curves.
- Longitudinal section for crossroads for length adequate for design and quantity estimation purposes.
- Longitudinal and cross sections for major and minor streams which cover Cross section of the channel at the site of proposed crossing and few cross sections at suitable distance both upstream and downstream, bed level upto top of banks and ground levels to a sufficient distance beyond the edges of channel, nature of existing surface soil in bed, banks & approaches, longitudinal section of channel showing site of bridge etc.

UAV data acquisition and Data Processing

The system uses the high end sophisticated unmanned aerial vehicle technology for taking very high-resolution images from a calibrated camera and process them using the professional Photogrammetry software to produce accurate 3D maps for various analysis. System is designed to produce high precision geographical information from air. Quickly, safely & cost effectively.



Aerial Imagery Acquisition Platform



Multi Rotor – VTOL Platform



Fix Wing – Platform – Long Distance

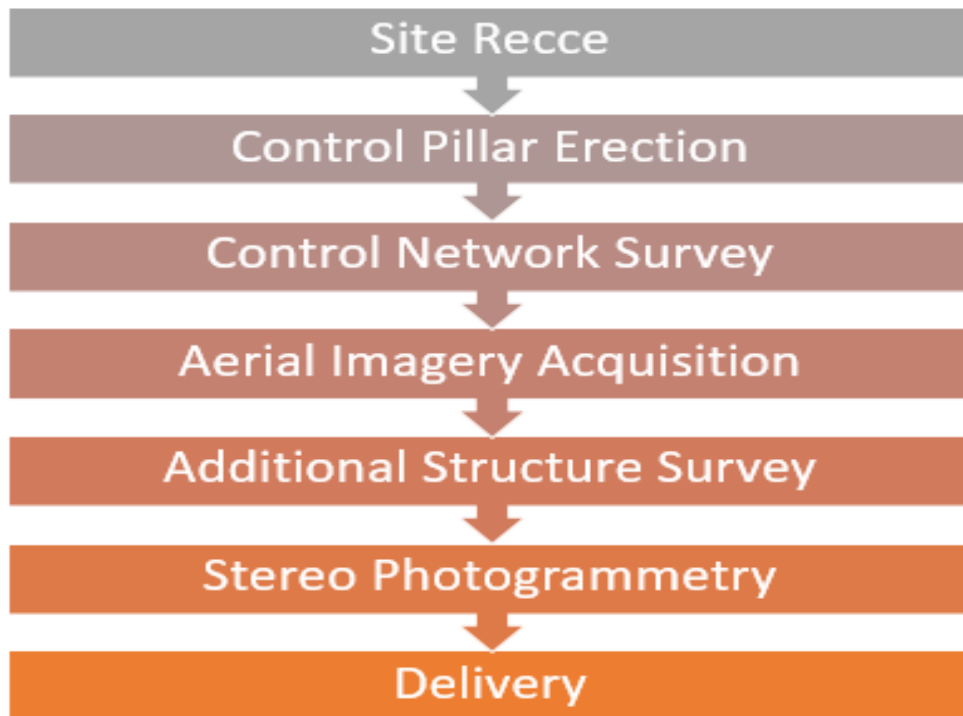
i. Features of the UAV (Drone) Aerial Data capture platform

Exact Navigation– Autopilot with GPS, Glonass & IMU for precise position & Orientation.

Exact Flight Planning – Flight planning Application to collect the desired data from the Aerial sensors over project area

Stable Aerial Photography – Vision positioning system with 4K Camera and 3-axis stabilized gimbals with Live HD Video.

ii. Work Flow



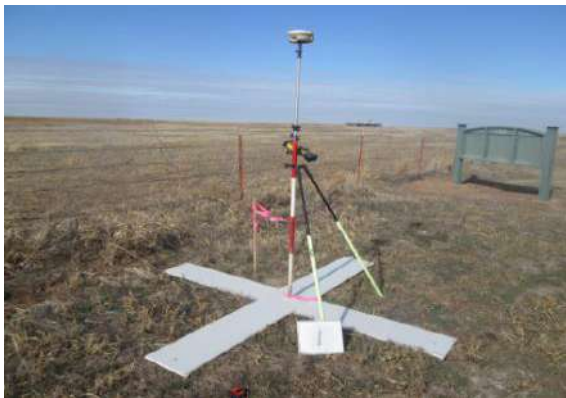
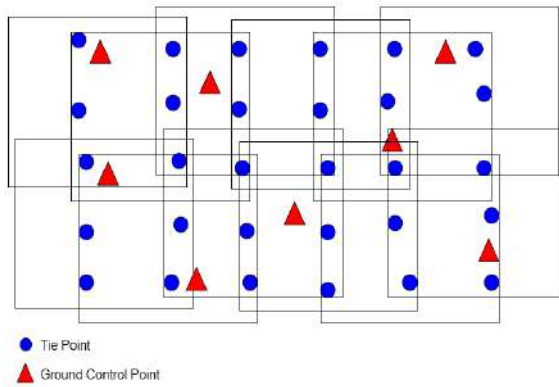
iii. Methodology

A . Control Pillar Erection

- Primary control pillars were constructed in pairs at every 5.00 km interval. The standard size of the pillar is 50cm x 50cm x 90cm casted in RCC of grade M15, with a nail fixed in the centre of the top surface for the establishment of coordinates.
- Reference Pillars were established at an interval of 250m. The standard size of Reference pillars is 15cm x 15cm x 45cm that shall be cast in RCC of grade M15 with a nail fixed in the centre of the top surface. The balance 15 cm above ground was painted yellow. DGPS/RTK/Total Station was used for observation.
- All the control pillars and reference pillars were constructed for topographic survey.

B. Control Network Survey

- Dual Global Positioning System (DGPS) was used for survey and to locate the control pillar at 5KM with minimum observation of 1hr having 5 satellites observation with the accuracy of 1cm.
- RTK /ETS was used to survey Reference pillars (TBM) or permanent structure at 250m.
- All control stations were connected with GTS.



C. Aerial Image Acquisition

- **Flight Planning**

Planning of the flight using the flight planning application involves the following process:

- Geographical Analysis of the area of Interest for elevation, forest, habitation etc.
- Tentative Flight planning over Google earth
- Flight Planning including flying height, Image Resolution, Overlaps etc.



- **Flying Operation**

Flight planning operation involves: Setting up of the UAV (Drone), validating the flight planning, transferring flight plan in Auto Pilot, Takeoff, landing and data transfer from UAV to PC and preliminary validation of captured data.

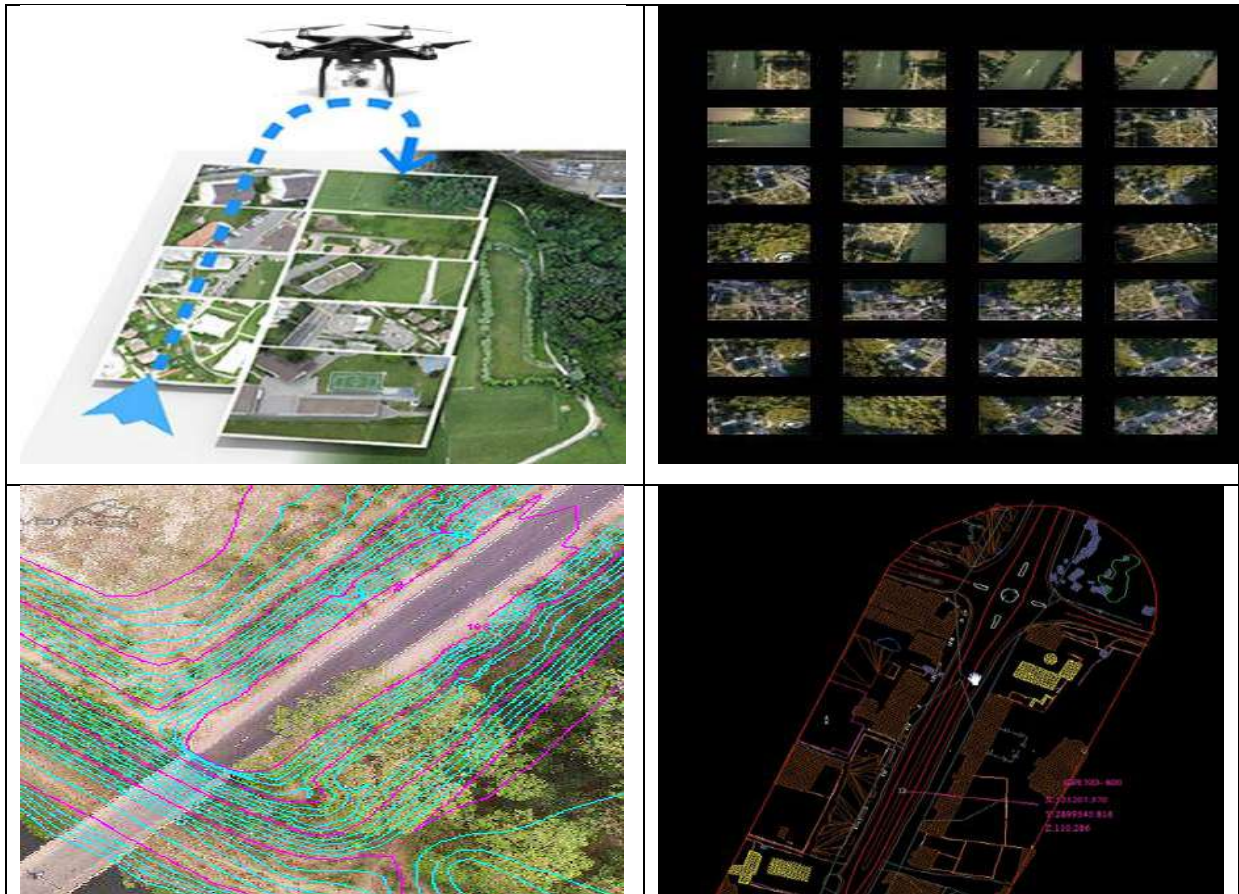


D. Photogrammetry Processing

About Technology: Photogrammetry is the science of making measurements from photographs, especially for recovering the exact positions of surface points. Stereo-Photogrammetry, involves estimating the three-dimensional coordinates of points on an object employing measurements made in two or more photographic images taken from different positions

State-of-art Infrastructure was used for creating Photogrammetry products such as Digital Elevation Models, Digital Terrain Model, 3D Topographical Maps, and Contours, Orth photo which is the feeding data for most of the engineering design and plan analysis.





1 The whole DATA PROCESSING consists of three major Steps as given below.

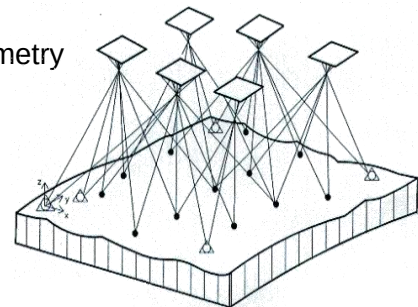
- I. Block Planning, Setup and Aerial Triangulation
- II. DTM/DEM Generation using stereo Photogrammetry
- III. Ortho Photo Generation

2 Aerial Triangulation

The collective orientation of more than two photos is called Aerial Triangulation.

Aerial triangulation is done to;

- I. Minimize the cost of surveying.
- II. Control the area with minimum no of GCP.
- III. Solve the problem of datum difference in between model and strip lap.

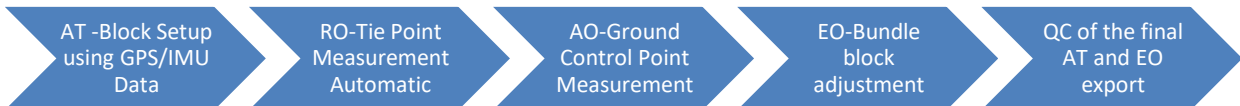


3 Software and Hardware to be use:

Photogrammetry hardware that includes high end system with 3D graphic card, 3D Monitor, 3D Glasses and 3D Mouse.



❖ Process Flow of the Aerial Triangulation



❖ Digital Elevation Model Generation

1) Specifications of DTM Generation

- i) DTM at the vertical accuracy of <5 CM
- ii) Break lines wherever required

2) Process Flow of the - DTM Generation Process workflow:

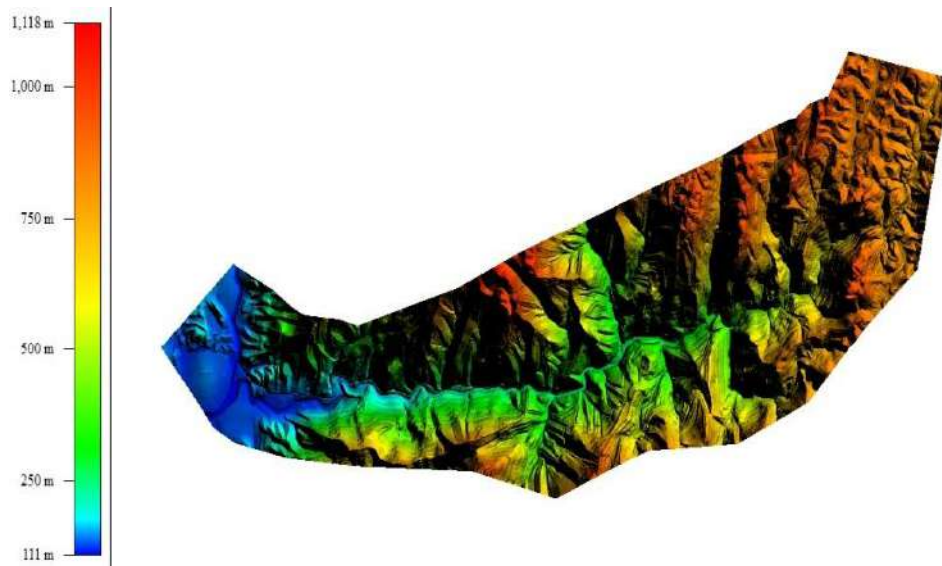


❖ Quality Control and Assurance

- Quality statistics report in comparison to check and GCP available
- Manual check for Accuracy

❖ DTM/DEM Deliverables

- 3-D Shape /DGN/DWG files containing break lines and Mass points
- Quality Control Records



❖ Topographical Features extraction

- 3D Feature Extraction was done (No of Levels and Levels of details depends on the application area) (Detailed map list may have 200 levels)
- Features such as Edge of the Roads, Railway line and assets, Buildings, Fences, Wall, Water Bodies, Tree / Vegetation, Manhole, Electricity poles, trails, paved area, unpaved areas.



❖ Digital Orthophoto Generation

- Orthophoto was developed accordingly to the resolution of the raw imagery by process of Orthophoto rectification using the corrected DTM.
- 1 Orthophoto was free from smear, wrap, hot spots, stretch area Orthophoto shall be radio metrically and geometrically corrected and Seam line editing shall be done to minimize the temporal tone effect.



❖ Analysis

Based on the specific study and project requirement various analysis were performed using the Photogrammetric map outputs and relevant information can be developed for making GEO Informed Decision such as Change Detection, Volume Analysis, Site Topographic Study, Cut & Fill Analysis, Slope Analysis, Urban Area mapping, Asset Inventory, Inspection or Monitoring and many more.

E. Additional Field Information Integration

- Field team collects other information's relevant for planning such as structure inventory, structure type, levels of various part of structures, waterbed information, Road crossings, habitation names etc.
- This information's are further integrated with the CAD drawing developed from the photogrammetric processing.
- Ground True thing was done on the sample data as quality assurance procedures to ensure the final updated topographical dataset meets the accurate, precise & complete information of the corridor for effective design process.





I. Input UAV (Drone) Survey

- The final approved **AOI/Alignment** for the drone survey (AOI/Alignment shall be followed for the survey)
- **Existing Benchmarks**, (TBM) DGPS points and approach data in XYZ, and DWG Auto Cad file of existing road or plan file.
- **Intimation to fly the UAV (Drone)** -Permission for Drone Flying was obtained from SSP (Senior Superintendent Police) of that particular district / DGCA.

II. Final Output

- Topographical Base map at 1:1000 scale covering all features including but not limited to buildings and structures, monuments, burial grounds, cremation grounds, places of worship, railway lines, stream/river/canal, water mains, sewers, gas/oil pipes, crossings, trees, plantations, utility services such as electric, and telephone lines and poles with accuracy less than 5cm. The survey also covered the entire right-of-way of the road on the adequate allowance for possible shifting of the central lines at some of the intersection location. In dwg / dgn / dxf / ESRI Shape Format.
- Contours Map at 50 cm interval with Spot Elevation Grid at Every 2 Meter in dwg / dgn / dxf Format.
- Ortho photo with the resolution of 2cm (Mosaic in ECW / JPEG2000 and Tiles in Tiff Format) (Compatible to Road CAD software)
- Digital Terrain Model (TIN Format / DGN /DWG) (Compatible to Road CAD software)
- Digital Elevation Model with Level Grid at every 1 M (ASCII Format / ARC GRID format / Tiff Format) (Compatible to Road CAD software)

III. Topo Survey by Total Station/DGPS

IV. Permanent Control Points and Benchmarks

Before starting Topographic Survey, all Control Points and Benchmarks were established. Two basic Reference Stations were permanently established on the site so that the results of

survey could be verified at any time in the future. These permanent Reference Points were placed in convenient position and well protected so that these will not be disturbed in future. Pair of Main Differential Global Positioning System (DGPS) Control Points were established at every 5km intervals by using DGPS survey (WGS-84); a pair of pillars has been placed at 5-km intervals. A pair of Secondary Control Points were established at every 500m intervals which were transferred from Main DGPS Control Points by Total Station of 1-second accuracy or by GPS itself.

The Main DGPS Control Points had been concrete pillars with 50 cm x 50 cm (as shown in below figure) and the Secondary Control Points had been concrete pillars with 15 cm x 15 cm (as shown in below figure). Both Main DGPS Control points and Secondary Control Points are of a minimum 60-cm height and have been embedded up to depth of minimum of 45 cm into ground (15 cm protruding above the ground).

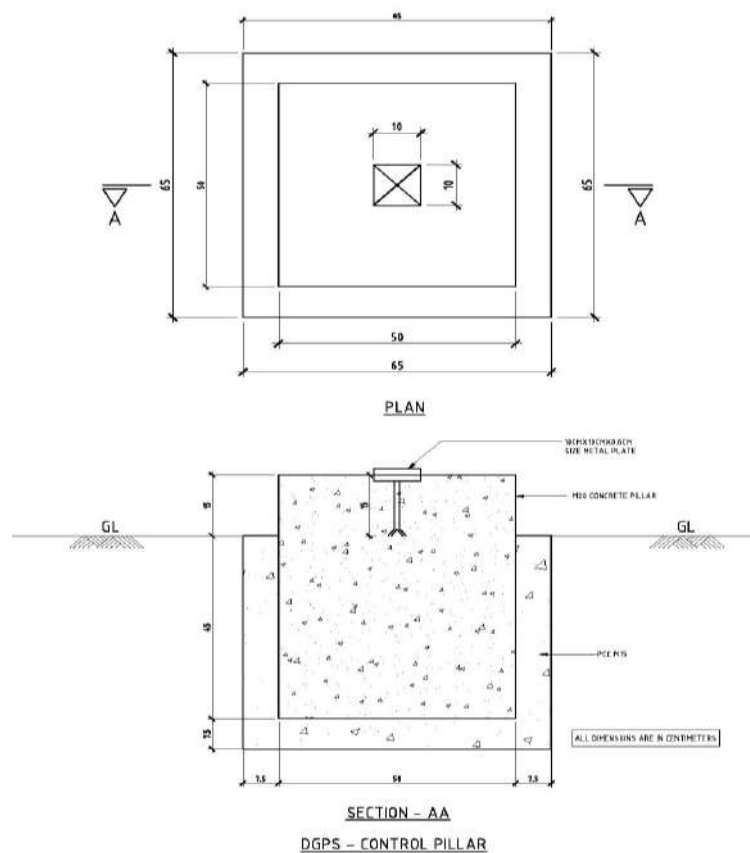


Figure 3-5 : Details of DGPS Control Pillar

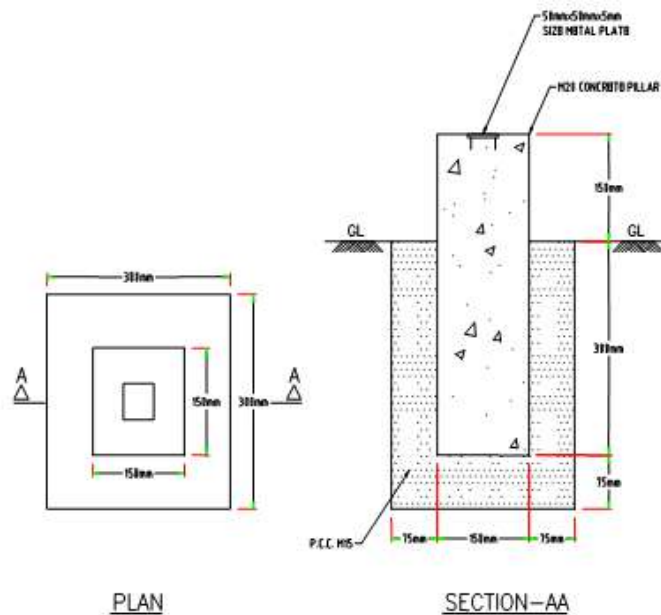


Figure 3-6 : Details of Secondary Control Pillars

I. Differential Global Positioning System (DGPS)

II. General

Once installations of DGPS control pillars were done, as per the dimensions given above, DGPS survey was commenced. Each GPS satellite transmits number of signals. The signal comprises of two waves (L1 and L2) and two codes (C/A on L1 and P or Y on L1 and L2) as well as satellite orbit message. Differential GPS with dual frequency receivers was used. Pair of DGPS stations were established all along the project with the inter visibility between pair.

III. Methodology

The survey was carried out using differential technique. Static Method was adopted for Control Survey and point positioning.

In this method, the raw GPS data from satellite was recorded and processed using Skipro/Geo office or equivalent software. Two GPS receivers have been used to form a base line which was measured from a fixed point (a reference station) to unknown station (a rover station). Base station has been established in the beginning of the project and had tracked signals continuously without break from the satellite till, Rover Stations GPS work completes. Thus, reference station tracks continuously on a known point and rover receiver spends a short period on each point.

Simultaneously, Rover Stations shall also track signals from the satellite for a minimum period of one hour, which has been established at the outer boundary of the project area. The observation time was proportional to the length of baseline. During DGPS survey the following points have been recorded in the field book for better accuracy of the survey:

- Availability of number of satellites (minimum four nos.)
- Mask angle (Elevation, cut off angle)
- Range determination by code and phase observation

- Dilution of precision was an indicator as the geometric strength of satellite being tracked at the time of measurement. The values of precision shall not be more than 4.
- Geometrical Dilution of Precision
- Positional Dilution of Precision
- Horizontal Dilution of Precision
- Vertical Dilution of Precision

The raw data in rinex format was utilised for processing data in WGS 84 Ellipsoid and Mercator projection. Following survey parameters have been collected along with the survey report:

- Semi major axis
- Semi minor axis
- Flattening 1/f values
- Central Meridian
- Scale factor at Central Meridian
- Zone code for the surveyed area to be submitted

DGPS control pillars and secondary pillars have been located, free from bushes, trees, water bodies and also avoiding any high raised structures.

IV. Traverse Survey

GPS traverse survey was conducted from Main DGPS Control Pillar to another DGPS control pillar established at every 5-km interval. Electronic total station was used to traverse between DGPS control pillar.

The traverse closure was more than 1:20,000 and was distributed. If the error is more (i.e. accuracy was less than 1:20,000), the entire traverse was repeated till accuracy of more than 1:20,000 was obtained. All computation complied with the following:

- Traverse adjustment by Bowditch Method
- Least square adjustment

Cross sections were taken at every 50 m intervals, and at each cross-section the survey extended beyond 75m on either side of the proposed road centre line with survey points at 5-10 m apart and at all variations in the natural ground or breaks in level.

Topographic survey thus carried out contains the details of all physical and topographical features within the survey corridor such as roads, rivers, streams, rail crossings, electric / telephone lines, high/ low tension lines and their offsets from the road edge, buildings, trees (girth more than 300mm), etc. The width of the survey corridor is extended appropriately to accommodate the proposed alignment.

The survey data thus collected by the topographic survey was processed and converted to graphic files using Highway Design software called "MX ROAD", for ascertaining quantities, grid levelling was utilised.



Figure 3-7 : Observation by Total Station



Figure 3-8 : Observation by Real Time Kinematic (GPS by RTK)

Details of GPS are given in the table below;

Table 3-22: Details of GPS

Sl. No.	GPS / No	Proposed Chainage	Northing (m)	Easting (m)	Elevation (m)	Side
	GPS399.5	400+050	539797.264	3544650.881	261.741	LHS
	GPS402	402+425	541177.446	3546388.636	268.628	RHS
	GPS402A	402+650	541176.480	3546614.285	268.545	LHS
	GPS404.5	404+950	542123.227	3548584.565	267.536	LHS

Sl. No.	GPS / No	Proposed Chainage	Northing (m)	Easting (m)	Elevation (m)	Side
	GPS407	407+460	543142.430	3550887.464	268.679	Centre
	GPS407A	407+650	543217.062	3551062.676	268.494	Centre
	GPS409.5	409+880	544241.985	3552914.340	266.893	LHS
	GPS412	412+420	546042.560	3554363.168	271.504	Centre
	GPS412A	412+670	546107.265	3554603.256	271.507	Centre
	GPS414.5	414+478	546342.399	3556804.249	273.875	Centre
	GPS417	417+420	547164.735	3559108.310	270.872	Centre
	GPS417A	417+650	547357.773	3559207.014	271.441	Centre
	GPS419.5	419+900	549260.709	3560389.812	272.856	RHS
	GPS422	422+670	550476.179	3562880.451	278.378	Centre
	GPS422A	422+900	550569.670	3563083.508	279.099	LHS
	GPS424.5	424+470	550842.951	3564526.411	283.318	Centre
	GPS427	426+450	550306.585	3566505.835	281.587	Centre
	GPS427A	426+620	550298.906	3566661.735	282.147	Centre
	GPS429.5	428+850	550351.056	3568902.057	285.597	RHS
	GPS432	432+100	550188.628	3572010.321	289.975	Centre
	GPS432A	432+350	550145.618	3572272.155	290.478	LHS
	GPS434.5	434+250	550222.109	3574144.408	299.244	LHS
	GPS436	435+850	549682.901	3575460.402	305.886	Centre
	GPS436A	436+070	549521.064	3575632.322	308.669	RHS
	GPS438.5	438+510	547748.455	3577419.408	302.509	Centre
	GPS440.5	440+475	546727.703	3579035.599	303.926	Centre
	GPS442.5	442+360	545412.286	3580465.840	298.970	Centre
	GPS446	446+010	543161.275	3582930.327	305.464	LHS
	GPS449	449+040	541702.123	3585284.172	325.600	LHS
	GPS453	452+875	539564.263	3588647.525	354.651	Centre
	GPS455	454+800	537755.234	3589279.581	357.797	LHS
	GPS457.5	457+300	535543.902	3590292.781	362.115	LHS
	GPS460	460+200	533120.215	3591425.133	380.223	LHS
	GPS462.5	462+150	531309.919	3592141.894	378.151	LHS
	GPS464.5	464+400	529220.806	3592713.716	382.449	LHS
	GPS469/0	469+975	526559.153	3594304.372	386.988	Centre
	GPS469/1	469+250	524058.558	3595156.627	379.313	Centre
	GPS474/0	474+020	521994.016	3595798.550	374.652	Centre
	GPS474/1	474+220	520098.343	3597162.865	389.243	LHS
	GPS479/0	479+250	517805.848	3598430.853	408.313	RHS
	GPS479/1	478+890	514725.994	3599345.860	390.445	Centre
	GPS482.5	482+510	513037.182	3599727.357	370.532	LHS
	GPS485	485+350	510882.581	3599290.998	367.592	RHS
	GPS487.5	487+500	508300.497	3600045.223	338.456	Centre
	GPS490	490+050	506094.551	3601420.021	335.435	LHS
	GPS490/1	490+300	505884.773	3601508.987	338.356	Centre

Sl. No.	GPS / No	Proposed Chainage	Northing (m)	Easting (m)	Elevation (m)	Side
	GPS496	496+050	500586.044	3603589.721	343.797	Centre
	GPS496/1	496+250	500392.577	3603641.650	342.348	Centre
	GPS501	500+925	496596.793	3606163.918	325.581	Centre
	GPS501/1	501+750	496336.830	3606386.998	326.208	Centre
	GPS514	514+200	488264.756	3614420.321	310.433	Centre
	GPS516.5	516+720	490502.084	3615531.703	362.343	Centre
	GPS519	519+475	490543.353	3617773.166	401.401	Left Side
	GPS521.5	521+550	489809.578	3619722.408	403.739	Left Side
	GPS524	524+165	490955.780	3621319.655	466.780	Right Side
	GPS526.5	526+620	491156.524	3622890.272	445.067	Left Side
	GPS529	529+245	492120.838	3624831.414	392.434	Right Side
	GPS531.5	531+850	489532.920	3625007.977	328.478	Centre
	GPS534	534+480	489272.787	3626826.436	353.898	Right Side
	GPS536.5	537+000	490607.461	3628424.006	373.511	Centre
	GPS559	539+490	490352.286	3630778.307	382.095	Left Side
	GPS-P559	559+000	490416.088	3630930.852	386.776	Centre
	GPS-P559A	559+250	490500.486	3631179.284	394.928	Centre
	GPS-P564	564+000	493436.895	3632768.542	406.308	Centre
	GPS-P564A	564+250	493515.444	3632547.209	417.008	Centre
	GPS-P570/1	570+350	496419.537	3635672.650	612.702	Centre
	GPS-P570/2	570+525	496496.692	3635817.731	620.452	Centre
	GPS-P574	574+000	495915.428	3639029.298	596.013	Left Side
	GPS-P574A	574+150	495834.364	3639135.006	591.947	Right Side
	GPS-P579	579+050	493330.587	3643091.513	600.818	Left Side
	GPS-P579A	579+200	493250.770	3643215.435	610.795	Left Side
	GPS-P587	587+150	492477.141	3649264.698	811.640	Left Side
	GPS-P587A	587+400	492646.514	3649473.826	829.435	Left Side

Table 3-23: Details of TBM

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
1.	TBM397/2	397+900-LHS	538287.044	3543067.075	263.679
2.	TBM397/3	398+150-CENTRE	538471.651	3543286.979	263.903
3.	TBM398/0	398+400-CENTRE	538626.89	3543468.995	263.804
4.	TBM398/1	398+675-CENTRE	538821.541	3543662.594	263.712
5.	TBM398/2	398+920-LHS	538970.1	3543852.413	263.028

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
6.	TBM398/3	399+170-LHS	539163.361	3544021.157	263.319
7.	TBM399/0	399+400-CENTRE	539350.612	3544168.663	264.073
8.	TBM399/1	399+660-CENTRE	539537.586	3544347.481	264.172
9.	TBM399/2	399+900-CENTRE	539710.602	3544510.47	264.036
10.	TBM399/3	400+160-CENTRE	539900.174	3544687.787	264.013
11.	TBM400/0	400+400-LHS	540049.734	3544872.967	263.367
12.	TBM-400/1	400+660-LHS	540250.235	3545052.866	264.019
13.	TBM400/2	400+900-LHS	540445.034	3545190.091	267.210
14.	TBM400/3	401+190-CENTRE	540671.203	3545361.104	267.464
15.	TBM401/0	401+400-CENTRE	540849.617	3545511.203	267.969
16.	TBM401/1	401+700-CENTRE	541064.613	3545690.666	269.220
17.	TBM401/2	401+860-CENTRE	541156.284	3545827.399	270.272
18.	TBM401/3	402+160-CENTRE	541178.752	3546124.191	269.261
19.	TBM11	402+740-LHS	541164.107	3546697.325	268.303
20.	TBM402/2	402+900-CENTRE	541176.509	3546865.513	268.307
21.	TBM402/3	403+170-CENTRE	541173.312	3547129.428	266.624
22.	TBM12OLD	403+255-CENTRE	541175.937	3547217.105	266.047
23.	TBM403/0	403+415-CENTRE	541254.403	3547353.949	266.243
24.	TBM403/1	403+660-CENTRE	541436.547	3547523.458	266.245
25.	TBM403/2	403+990-CENTRE	541656.888	3547749.339	265.463
26.	TBM403/3	404+170-CENTRE	541780.775	3547900.712	265.446
27.	TBM404/0	404+420-CENTRE	541918.322	3548102.17	266.435
28.	TBM-13	404+450-CENTRE	541920.22	3548132.115	265.782
29.	TBM404/1	404+650-CENTRE	542024.454	3548309.673	267.634
30.	TBM-404/2	404+910-CENTRE	542132.493	3548546.055	268.842
31.	TBM-404/3	405+160-CENTRE	542215.615	3548779.563	268.460
32.	TBM405/0	405+425-CENTRE	542315.499	3549020.124	267.988
33.	TBM-405/1	405+690-LHS	542419.067	3549260.359	268.560
34.	TBM405/2	405+950-LHS	542519.587	3549498.973	269.305
35.	TBM405/3	406+170-LHS	542612.337	3549715.02	267.711
36.	TBM406/0	406+420-LHS	542702.055	3549934.631	266.186
37.	TBM406/1	406+650-CENTRE	542811.434	3550143.654	267.869
38.	TBM406/2	406+925-CENTRE	542925.803	3550399.55	268.540
39.	TBM-406/3	407+150-CENTRE	543021.587	3550603.206	269.318
40.	TBM-407/2	407+900-CENTRE	543306.02	3551291.092	268.349
41.	TBM-407/3	408+190-CENTRE	543387.846	3551563.536	268.255
42.	TBM-408/0	408+375-LHS	543406.072	3551759.208	267.756
43.	TBM-408/1	408+665-CENTRE	543475.811	3552040.365	266.610
44.	TBM-408/2	408+975-CENTRE	543614.523	3552298.723	266.363
45.	TBM-408/3	409+195-CENTRE	543787.061	3552429.011	267.487
46.	TBM-409/0	409+400-CENTRE	543939.735	3552581.468	267.578
47.	TBM-409/1	409+675-CENTRE	544132.655	3552768.195	267.680

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
48.	TBM-409/2	409+895-CENTRE	544276.982	3552930.378	267.793
49.	TBM-409/3	410+145-CENTRE	544439.336	3553118.082	270.074
50.	TBM-410/0	410+400-CENTRE	544610.682	3553316.62	270.717
51.	TBM-410/1	410+670-CENTRE	544802.131	3553500.19	269.931
52.	TBM-410/3	411+175-CENTRE	545299.681	3553535.302	271.784
53.	TBM-411/0	411+420-CENTRE	545542.389	3553540.184	270.963
54.	TBM-410/2	411+400-LHS	545028.232	3553544.097	274.114
55.	TBM-13	411+400-CENTRE	545521.778	3553553.552	269.398
56.	TBM-411/1	411+680-CENTRE	545756.941	3553677.427	270.513
57.	TBM-411/2	411+915-CENTRE	545854.594	3553892.047	271.148
58.	TBM-411/3	41v2+150- CENTRE	545942.52	3554101.162	271.483
59.	TBM-15	412+370-LHS	546008.927	3554309.624	270.687
60.	TBM-412/2	412+905-CENTRE	546168.435	3554830.353	271.609
61.	TBM-412/3	413+150-CENTRE	546230.618	3555058.22	271.758
62.	TBM-413/0	413+420-CENTRE	546298.52	3555315.61	272.157
63.	TBM-413/1	413+660-CENTRE	546356.155	3555568.205	272.368
64.	TBM-413/2	413+890-CENTRE	546398.694	3555788.346	272.129
65.	TBM-413/3	414+420-CENTRE	546397.256	3556046.434	272.282
66.	TBM-414/0	414+450-CENTRE	546350.508	3556306.714	273.440
67.	TBM-20	414+660-CENTRE	546324.235	3556346.116	272.620
68.	TBM-21	414+690-CENTRE	546324.911	3556545.842	273.296
69.	TBM-414/1	414+910-CENTRE	546328.21	3556566.378	273.604
70.	TBM-414/2	414+970-LHS	546361.683	3556792.743	274.516
71.	TBM-22	415+200-CENTRE	546343.717	3556803.397	273.856
72.	TBM-414/3	415+410-CENTRE	546405.738	3557079.416	274.511
73.	TBM-415/0	415+670-CENTRE	546429.405	3557294.294	274.851
74.	TBM-415/1	415+950-CENTRE	546443.723	3557550.503	275.631
75.	TBM-415/2	416+200-CENTRE	546486.451	3557795.341	275.566
76.	TBM-415/3	416+450-CENTRE	546600.155	3558056.58	272.921
77.	TBM-416/0	416+675-CENTRE	546692.404	3558272.734	272.210
78.	TBM-416/1	416+900-CENTRE	546769.027	3558498.946	270.796
79.	TBM-416/2	417+900-CENTRE	546850.413	3558699.643	270.515
80.	TBM-417/2	418+140-CENTRE	547587.7	3559320.836	271.696
81.	TBM-417/3	418+400-CENTRE	547800.614	3559425.411	272.061
82.	TBM-418/0	418+650-CENTRE	548045.347	3559544.189	272.304
83.	TBM418/1	418+950-CENTRE	548271.416	3559654.392	272.722
84.	TBM418/2	419+150-CENTRE	548521.189	3559788.926	273.262
85.	TBM418/3	419+400-CENTRE	548698.997	3559904.844	273.599
86.	TBM419/0	419+700-LHS	548902.937	3560061.471	273.869
87.	TBM419/1	419+900-CENTRE	549104.244	3560271.269	273.326
88.	TBM419/2	420+170-CENTRE	549255.048	3560409.387	274.089
89.	TBM419/3	420+450-CENTRE	549421.637	3560622.89	274.307

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
90.	TBM420/0	420+670-CENTRE	549571.5194	3560855.331	274.541
91.	TBM420/1	420+940-CENTRE	549674.7657	3561049.279	275.196
92.	TBM420/2	421+190-CENTRE	549785.025	3561295.706	275.554
93.	TBM420/3	421+420-CENTRE	549883.883	3561520.632	275.649
94.	TBM421/0	421+655-CENTRE	549977.216	3561734.191	276.254
95.	TBM421/1	421+925-LHS	550073.67	3561952.525	276.539
96.	TBM421/2	422+190-CENTRE	550161.814	3562206.001	276.441
97.	TBM421/3	423+130-CENTRE	550243.924	3562446.607	276.299
98.	TBM422/3	423+420-CENTRE	550666.405	3563301.144	279.691
99.	TBM423/0	423+700-CENTRE	550784.593	3563565.551	280.528
100.	TBM423/1	423+940-CENTRE	550886.478	3563823.228	284.494
101.	TBM423/2	424+060-CENTRE	550865.447	3564060.479	290.002
102.	TBM424/0	424+250-RHS	550813.16	3564183.818	289.981
103.	TBM424/1	424+250-RHS	550794.47	3564358.981	285.666
104.	TBM424/2	424+470-RHS	550720.692	3564571.926	279.994
105.	TBM424/3	424+790-RHS	550617.929	3564874.958	280.113
106.	TBM425/0	425+010-RHS	550547.253	3565088.169	280.140
107.	TBM425/1	425+240-CENTRE	550466.3	3565300.905	280.332
108.	TBM425/2	425+505-CENTRE	550391.413	3565558.439	280.381
109.	TBM425/3	425+725-CENTRE	550326.736	3565767.371	280.432
110.	TBM426/0	425+960-CENTRE	550300.916	3566022.996	278.927
111.	TBM426/1	426+250-RHS	550304.993	3566288.213	281.150
112.	TBM427/0	427+000-RHS	550347.238	3567034.01	281.785
113.	TBM427/1	427+250-RHS	550356.139	3567301.361	282.117
114.	TBM427/2	427+500-RHS	550345.636	3567537.698	282.735
115.	TBM427/3	427+750-CENTRE	550342.024	3567787.136	283.321
116.	TBM428/0	428+010-CENTRE	550356.643	3568053.171	283.744
117.	TBM428/1	428+250-CENTRE	550379.193	3568291.554	283.937
118.	TBM428/2	428+500-RHS	550381.019	3568551.149	283.667
119.	TBM428/3	428+750-RHS	550360.117	3568785.03	284.204
120.	TBM429/0	429+035-RHS	550307.198	3569065.907	286.024
121.	TBM429/1	429+250-CENTRE	550225.069	3569274.707	287.567
122.	TBM429/2	429+500-CENTRE	550148.197	3569521.177	287.185
123.	TBM429/3	429+750-CENTRE	550064.826	3569737.929	287.603
124.	TBM430/0	430+000-CENTRE	549983.568	3569982.223	285.569
125.	TBM430/1	430+300-RHS	549911.62	3570263.935	287.170
126.	TBM430/2	430+510-CENTRE	549844.567	3570472.903	284.040
127.	TBM430/3	430+760-CENTRE	549832.633	3570724.304	284.408
128.	TBM431/0	430+935-CENTRE	549857.149	3570895.275	285.621
129.	TBM431/1	431+245-CENTRE	549931.853	3571191.975	287.289
130.	TBM431/2	431+50-CENTRE	550021.644	3571441.024	286.291
131.	TBM431/3	431+750-CENTRE	550094.409	3571685.67	288.298

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
132.	TBM432/3	432+750-CENTRE	550378.39	3572632.865	291.520
133.	TBM433/0	432+975-CENTRE	550426.266	3572858.165	292.535
134.	TBM433/1	433+250-RHS	550482.199	3573129.932	293.693
135.	TBM433/2	433+500-CENTRE	550467.31	3573371.778	295.224
136.	TBM433/3	433+750-CENTRE	550444.463	3573629.632	295.557
137.	TBM434/0	434+010-CENTRE	550408.389	3573887.452	296.844
138.	TBM434/1	434+250-CENTRE	550380.485	3574122.656	298.372
139.	TBM434/2	434+500-CENTRE	550347.194	3574363.846	299.379
140.	TBM434/3	434+725-RHS	550325.266	3574594.077	300.938
141.	TBM435/0	435+000-CENTRE	550242.84	3574848.483	302.026
142.	TBM435/1	435+220-RHS	550149.278	3575051.946	302.113
143.	TBM435/2	435+470-CENTRE	549960.412	3575240.35	302.977
144.	TBM435/3	435+725-CENTRE	549762.568	3575390.822	305.466
145.	TBM OLD	437+160-RHS	548708.429	3576293.131	300.184
146.	TBM437/1	437+350-RHS	548526.318	3576397.279	309.071
147.	TBM437/2	437+550-RHS	548402.78	3576552.843	306.764
148.	TBM437/3	437+700-CENTRE	548209.97	3576600.958	302.431
149.	TBM438/0	438+000-RHS	548055.701	3576833.982	301.438
150.	TBM438/1	438+320-RHS	547856.669	3577101.172	304.333
151.	TBM438/2	438+510-CENTRE	547721.904	3577273.76	302.376
152.	TBM438/3	438+700-RHS	547666.335	3577413.788	301.488
153.	TBM438/1A	438+650-LHS	547564.618	3577356.236	301.677
154.	TBM439/0	439+000-CENTRE	547483.667	3577684.578	300.719
155.	TBM439/2	439+500-CENTRE	547233.396	3578104.391	302.232
156.	TBM439/3	439+770-LHS	547070.27	3578338.096	303.817
157.	TBM440/0	439+975-RHS	547014.299	3578517.732	302.909
158.	TBM440/2	440+550-CENTRE	546658.028	3578996.875	303.863
159.	TBM440/3	440+700-RHS	546592.466	3579103.883	302.393
160.	TBM441/0	440+975-CENTRE	546393.298	3579321.609	300.998
161.	TBM441/2	441+500-CENTRE	546083.55	3579756.935	300.375
162.	TBM441/3	441+775-RHS	545917.73	3579971.806	300.051
163.	TBM442/0	442+000-CENTRE	545762.529	3580110.058	299.446
164.	TBM442/1	442+250-CENTRE	545567.876	3580276.293	298.045
165.	TBM443/0	443+975-CENTRE	544976.423	3580715.001	298.417
166.	TBM443/2	443+475-CENTRE	544586.748	3581018.353	299.835
167.	TBM443/3	443+650-RHS	544474.242	3581135.376	299.154
168.	TBM444/0	444+050-CENTRE	544202.088	3581435.487	298.637
169.	TBM444/1	444+250-RHS	544129.25	3581612.106	299.665
170.	TBM444/3	444+740-RHS	543890.362	3582045.598	299.665
171.	TBM445/0	445+050-CENTRE	543714.378	3582309.418	301.118
172.	TBM445/2	445+550-CENTRE	543462.167	3582747.76	304.477
173.	TBM445/3	445+800-LHS	543258.519	3582916.234	304.177

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
174.	TBM446/0	445+900-LHS	543181.449	3582973.725	305.015
175.	TBM446/1	446+040-RHS	543092.752	3583048.286	305.849
176.	TBM444/2	446+500-CENTRE	542707.375	3583296.174	308.138
177.	TBM447/2	447+400-CENTRE	542122.137	3583951.023	314.076
178.	TBM447/3	447+550-RHS	542121.978	3584110.229	315.389
179.	TBM448/0	448+000-CENTRE	541908.364	3584519.276	318.504
180.	TBM448/3	448+750-CENTRE	541629.244	3585211.858	323.635
181.	TBM449/0	449+050-CENTRE	541509.759	3585501.267	326.524
182.	TBM449/2	449+480-CENTRE	541349.59	3585896.134	329.637
183.	TBM450/0	450+020-RHS	541093.557	3586360.871	334.642
184.	TBM450/2	450+590-CENTRE	540730.564	3586801.815	340.796
185.	TBM451/0	450+940-RHS	540534.158	3587082.903	342.352
186.	TBM451/1	451+265-CENTRE	540357.361	3587369.513	343.038
187.	TBM451/2	451+510-CENTRE	540268.696	3587600.64	344.553
188.	TBM453/2	453+450-CENTRE	539023.881	3588809.387	356.855
189.	TBM453/3	454+225-CENTRE	538258.373	3589016.074	358.037
190.	TBM454/2	454+530-LHS	537955.619	3589092.517	357.174
191.	TBM454/3	454+825-CENTRE	537749.736	3589284.138	358.085
192.	TBM455/0	455+045-CENTRE	537589.655	3589430.435	358.122
193.	TBM455/1	455+300-RHS	537377.031	3589605.086	359.812
194.	TBM455/2	455+550-CENTRE	537206.717	3589778.088	359.748
195.	TBM455/3	455+775-CENTRE	537029.138	3589912.644	361.608
196.	TBM456/0	456+060-CENTRE	536751.657	3589992.668	365.462
197.	TBM456/1	456+255-LHS	536555.588	3590003.184	366.208
198.	TBM456/2	456+505-CENTRE	536314.622	3590081.383	366.652
199.	TBM456/3	456+750-CENTRE	536093.717	3590169.966	365.290
200.	TBM457/0	457+000-CENTRE	535853.032	3590258.631	368.243
201.	TBM457/1	457+250-CENTRE	535609.745	3590294.682	364.298
202.	TBM457/2	457+500-LHS	535361.261	3590316.253	361.275
203.	TBM457/3	457+750-CENTRE	535124.562	3590360.142	359.292
204.	TBM458/2	458+500-CENTRE	534378.048	3590459.898	359.776
205.	TBM458/3	458+750-RHS	534123.088	3590489.4	360.009
206.	TBM459/0	459+050-CENTRE	533973.212	3590703.294	367.055
207.	TBM459/1	459+275-CENTRE	533898.938	3590947.487	372.688
208.	TBM459/2	459+500-CENTRE	533724.1	3591083.047	360.013
209.	TBM459/3	459+750-CENTRE	533500.912	3591162.919	379.216
210.	TBM460/0	460+000-LHS	533282.293	3591292.555	379.063
211.	TBM460/1	460+250-CENTRE	533081.95	3591468.819	381.358
212.	TBM460/2	460+500-CENTRE	532892.821	3591622.256	381.353
213.	TBM460/3	460+750-CENTRE	532688.846	3591732.105	379.725
214.	TBM461/0	461+000-CENTRE	532426.603	3591812.471	377.631
215.	TBM461/1	461+250-CENTRE	532204.936	3591882.301	380.209

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216.	TBM461/2	461+500-CENTRE	531952.39	3591957.223	380.088
217.	TBM462/3	461+750-CENTRE	531716.09	3592028.292	380.291
218.	TBM462/0	462+000-CENTRE	531481.966	3592099.379	380.704
219.	TBM462/1	462+250-CENTRE	531229.662	3592185.889	377.471
220.	TBM462/2	462+525-CENTRE	530991.114	3592298.31	377.461
221.	TBM462/3	462+740-CENTRE	530807.431	3592388.987	377.761
222.	TBM467/1	467+250-CENTRE	526844.151	3594195.94	385.706
223.	TBM467/2	467+500-CENTRE	526624.877	3594280.143	387.193
224.	TBM467/3	467+750-CENTRE	526374.882	3594370.241	389.262
225.	TBM468/0	468+000-CENTRE	526140.318	3594458.443	390.268
226.	TBM468/1	468+260-CENTRE	525900.936	3594547.057	387.538
227.	TBM468/2	468+500-CENTRE	525675.971	3594629.51	386.268
228.	TBM468/3	468+740-CENTRE	525461.755	3594707.615	389.808
229.	TBM469/2	469+500-CENTRE	524741.948	3594968.121	387.211
230.	TBM469/3	469+750-CENTRE	524499.951	3595037.678	384.031
231.	TBM470/1	470+250-CENTRE	524025.659	3595180.864	380.061
232.	TBM470/2	470+550-CENTRE	523735.033	3595267.418	378.519
233.	TBM470/3	470+750-LHS	523516.507	3595318.379	373.331
234.	TBM471/0	471+000-LHS	523295.296	3595387.854	376.108
235.	TBM471/1	471+240-CENTRE	523083.339	3595464.042	377.458
236.	TBM471/2	471+500-CENTRE	522819.561	3595537.262	377.693
237.	TBM471/3	471+750-CENTRE	522596.419	3595597.83	377.600
238.	TBM472/0	471+975-CENTRE	522362.874	3595662.451	375.326
239.	TBM472/1	472+225-CENTRE	522121.135	3595736.352	375.069
240.	TBM18	472+275-CENTRE	522061.656	3595751.69	375.267
241.	TBM472/2	472+500-CENTRE	521880.302	3595874.955	374.770
242.	TBM473/0	473+090-CENTRE	521410.205	3596209.164	373.297
243.	TBM473/1	473+275-CENTRE	521253.541	3596316.126	371.279
244.	TBM473/2	473+525-CENTRE	521048.78	3596454.581	379.545
245.	TBM473/3	473+790-CENTRE	520827.24	3596606.37	385.913
246.	TBM474/2	474+500-CENTRE	520241.903	3597015.034	388.028
247.	TBM21	474+800-CENTRE	520033.755	3597230.025	390.283
248.	TBM475/A	474+800-CENTRE	519992.259	3597274.199	392.242
249.	TBM475/1	475+250-CENTRE	519727.306	3597548.725	398.058
250.	TBM475/2	475+500-CENTRE	519515.82	3597670.355	400.416
251.	TBM475/3	475+750-CENTRE	519295.572	3597790.437	401.567
252.	TBM476/0	476+000-CENTRE	519051.052	3597901.396	404.151
253.	TBM476/1	476+240-CENTRE	518850.383	3597992.286	405.138
254.	TBM476/2	476+440-CENTRE	518620.446	3598097.662	402.738
255.	TBM476/3	476+750-CENTRE	518389.994	3598203.975	402.738
256.	TBM477/0	477+000-CENTRE	518149.027	3598313.465	406.085
257.	TBM477/1	477+250-CENTRE	517915.153	3598402.278	408.671

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258.	TBM477/2	477+500-CENTRE	517681.782	3598490.813	407.598
259.	TBM477/3	477+750-CENTRE	517472.467	3598617.892	411.218
260.	TBM478/0	478+000-CENTRE	517268.257	3598745.765	413.336
261.	TBM478/1	478+250-CENTRE	517061.812	3598875.064	411.534
262.	TBM478/2	478+550-CENTRE	516799.828	3599035.897	409.456
263.	TBM478/3	479+740-CENTRE	516638.342	3599137.188	404.269
264.	TBM479/1	479+150-CENTRE	516222.425	3599317.119	401.689
265.	TBM480/0	479+900-CENTRE	515498.035	3599358.677	403.475
266.	TBM480/2	480+650-CENTRE	514784.045	3599462.652	394.106
267.	TBM480/3	480+950-CENTRE	514472.07	3599566.264	388.228
268.	TBM482B	482+450-RHS	513017.629	3599688.515	369.692
269.	TBM482/2	482+450-CENTRE	513009.166	3599672.341	369.026
270.	TBM483/0	482+930-RHS	512530.624	3599686.289	367.810
271.	TBM484/0	483+875-CENTRE	511621.049	3599399.99	367.788
272.	TBM484/2	484+400-CENTRE	511123.179	3599269.196	369.813
273.	TBM485/2	485+525-CENTRE	509989.801	3599305.126	366.732
274.	TBM486/0	486+000-CENTRE	509519.604	3599395.222	365.683
275.	TBM486/1	486+150-CENTRE	509392.565	3599434.331	365.682
276.	TBM487/1	487+325-CENTRE	508338.231	3599968.718	340.066
277.	TBM487/2	487+420-CENTRE	508267.301	3600024.284	337.748
278.	TBM489/3	489+650-CENTRE	506480.699	3601374.023	336.243
279.	TBM490/2	490+515-CENTRE	505728.745	3601679.571	341.883
280.	TBM490/3	490+810-CENTRE	505509.251	3601879.906	344.678
281.	TBM76/1OLD	491+650-CENTRE	504720.398	3602147.626	340.905
282.	TBM491/3	491+750-CENTRE	504617.515	3602165.445	341.598
283.	TBM492/0	492+000-CENTRE	504391.388	3602258.097	340.572
284.	TBM492/1	492+290-CENTRE	504142.452	3602375.056	341.640
285.	TBM492/2	492+500-CENTRE	503941.55	3602460.024	343.190
286.	TBM77/4OLD	493+195-RHS	503325.554	3602742.849	344.126
287.	TBM493/2	493+500-CENTRE	503018.07	3602846.274	342.943
288.	TBM493/3	493+750-CENTRE	502780.712	3602941.999	340.485
289.	TBM494/0	494+000-CENTRE	502550.586	3603038.796	340.438
290.	TBM494/1	494+255-CENTRE	502319.468	3603132.446	339.940
291.	TBM494/2	494+475-CENTRE	502107.054	3603190.406	345.500
292.	TBM495/0	495+005-CENTRE	501591.52	3603328.366	347.366
293.	TBM495/1	495+250-CENTRE	501363.228	3603389.431	345.798
294.	TBM495/2	495+540-CENTRE	501086.345	3603464.368	345.193
295.	TBM495/3	495+750-CENTRE	500882.818	3603517.02	344.259
296.	TBM496/2	496+500-CENTRE	500169.747	3603739.304	340.506
297.	TBM496/3	496+750-CENTRE	499941.46	3603845.404	338.361
298.	TBM497/0	497+000-CENTRE	499714.802	3603962.506	331.544
299.	TBM497/2	497+500-CENTRE	499365.956	3604319.717	329.541

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300.	TBM497/3	497+780-CENTRE	499182.248	3604510.272	324.461
301.	TBM498/1	498+250-CENTRE	498755.627	3604726.081	321.669
302.	TBM498/2	498+500-CENTRE	498542.646	3604870.068	320.726
303.	TBM498/3	498+750-CENTRE	498335.43	3605008.677	321.379
304.	TBM499/0	499+020-CENTRE	498097.591	3605125.526	320.008
305.	TBM499/1	499+250-CENTRE	497865.857	3605145.444	318.793
306.	TBM499/2	499+520-CENTRE	497702.501	3605346.848	326.044
307.	TBM499/3	499+760-CENTRE	497546.312	3605532.609	328.788
308.	TBM500/0	500+010-CENTRE	497333.356	3605671.982	324.454
309.	TBM500/1	500+265-CENTRE	497138.197	3605828.393	325.516
310.	TBM500/2	500+500-CENTRE	496923.927	3605886.053	329.111
311.	TBM500/3	500+750-CENTRE	496729.349	3606044.091	327.009
312.	TBM97/2OLD	514+250-CENTRE	488315.139	3614315.543	309.514
313.	TBM514/1	514+250-CENTRE	488255.581	3614423.403	310.593
314.	TBM514/2	514+500-CENTRE	488484.631	3614571.668	312.391
315.	TBM515/1	515+450-CENTRE	489329.309	3615025.259	329.754
316.	TBM515/3	515+800-LHS	489623.765	3615199.148	336.216
317.	TBM516/0	516+125-CENTRE	489939.803	3615311.608	340.099
318.	TBM516/1	516+500-LHS	490279.55	3615461.903	352.115
319.	TBM516/2	516+800-LHS	490574.846	3615576.065	364.636
320.	TBM516/3	517+125-LHS	490863.39	3615687.693	373.410
321.	TBM517/0	517+500-CENTRE	491142.312	3615924.241	382.995
322.	TBM517/1	517+870-LHS	491138.415	3616282.413	389.797
323.	TBM517/2	518+250-LHS	490990.202	3616653.053	395.444
324.	TBM517/3	518+610-LHS	490861.948	3616976.246	400.587
325.	TBM518/0	518+950-CENTRE	490743.596	3617301.507	402.523
326.	TBM518/1	519+275-CENTRE	490628.235	3617586.128	403.219
327.	TBM518/3	519+600-CENTRE	490400.635	3618187.232	399.907
328.	TBM518/2	519+900-CENTRE	490514.583	3617886.895	401.700
329.	TBM519/2	520+900-CENTRE	490049.18	3619120.05	408.409
330.	TBM519/3	521+225-CENTRE	489936.542	3619416.614	408.757
331.	TBM520/0	521+525-CENTRE	489832.728	3619699.734	404.822
332.	TBM520/1	521+850-CENTRE	489729.456	3620001.13	398.951
333.	TBM520/2	522+160-CENTRE	489663.505	3620312.843	398.741
334.	TBM520/3	522+500-CENTRE	489599.473	3620639.554	412.847
335.	TBM521/0	522+800-CENTRE	489761.524	3620844.964	427.257
336.	TBM521/1	523+100-CENTRE	490038.961	3620944.777	438.514
337.	TBM521/2	523+425-CENTRE	490309.087	3621035.797	453.648
338.	TBM521/3	523+750-CENTRE	490620.163	3621096.188	466.857
339.	TBM522/0	524+125-CENTRE	490940.297	3621273.717	466.635
340.	TBM522/1	524+480-LHS	490708.59	3621504.528	480.212

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
341.	TBM522/2	524+770-CENTRE	490877.95	3621727.223	493.376
342.	TBM525/2	525+670-CENTRE	491206.29	3622340.741	478.685
343.	TBM525/3	525+920-CENTRE	491056.982	3622533.751	467.001
344.	TBM526/0	526+305-CENTRE	491292.795	3622656.343	447.050
345.	TBM526/1	526+640-CENTRE	491161.475	3622904.984	443.604
346.	TBM526/2	527+150-CENTRE	491253.886	3623390.958	415.004
347.	TBM526/3	527+325-CENTRE	491350.958	3623538.398	407.609
348.	TBM527/0	527+650-CENTRE	491273.637	3623819.93	399.877
349.	TBM527/1	527+950-CENTRE	491486.727	3624016.63	395.726
350.	TBM527/2	528+250-CENTRE	491653.66	3624266.955	394.263
351.	TBM527/3	528+550-CENTRE	491840.638	3624476.608	394.382
352.	TBM528/0	528+850-CENTRE	492128.842	3624563.457	391.096
353.	TBM528/1	529+135-CENTRE	492220.06	3624788.624	393.406
354.	TBM529/2	529+450-CENTRE	491916.977	3624851.359	385.105
355.	TBM529/3	529+725-CENTRE	491642.717	3624892.311	374.576
356.	TBM14OLD	529+900-CENTRE	491460.358	3624923.302	367.954
357.	TBM530/0	530+000-CENTRE	491355.006	3624935.046	363.775
358.	TBM530/3	530+875-CENTRE	490487.413	3624970.827	339.128
359.	TBM531/0	531+160-CENTRE	490200.905	3624981.446	325.035
360.	TBM531/1	531+425-CENTRE	489935.828	3624992.202	323.860
361.	TBM531/2	531+740-CENTRE	489629.219	3625002.087	328.927
362.	TBM532/3	532+625-CENTRE	488758.788	3625070.398	332.739
363.	TBM533/0	532+900-CENTRE	488761.901	3625349.343	345.705
364.	TBM533/1	533+150-CENTRE	488811.511	3625590.715	351.135
365.	TBM533/2	533+425-CENTRE	488865.922	3625851.1	351.288
366.	TBM533/3	533+700-CENTRE	488964.573	3626105.378	351.233
367.	TBM534/0	534+000-CENTRE	489090.629	3626375.433	350.883
368.	TBM534/1	534+280-CENTRE	489202.809	3626641.309	355.012
369.	TBM534/2	534+605-LHS	489291.704	3626962.467	355.345
370.	TBM535/0	534+950-CENTRE	489545.538	3627157.144	358.164
371.	TBM535/3	535+800-CENTRE	489595.704	3627934.242	365.292
372.	TBM536/0	536+075-CENTRE	489767.314	3628152.213	362.232
373.	TBM536/1	536+350-CENTRE	490034.095	3628141.048	365.241
374.	TBM536/2	536+600-CENTRE	490278.87	3628199.138	371.792
375.	TBM536/3	536+875-CENTRE	490503.129	3628320.012	376.623
376.	TBM537/0	537+130-CENTRE	490657.374	3628524.94	369.397
377.	TBM537/1	537+500-CENTRE	490572.18	3628886.858	366.249
378.	TBM537/2	537+800-CENTRE	490561.988	3629170.252	374.486
379.	TBM537/3	538+100-CENTRE	490390.628	3629414.099	378.640
380.	TBM538/0	538+440-CENTRE	490311.461	3629730.254	378.606
381.	TBM538/1	538+700-CENTRE	490302.018	3629988.757	382.274
382.	TBM538/2	538+975-CENTRE	490292.042	3630270.324	386.382

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
383.	TBM538/3	539+250-CENTRE	490310.139	3630545.869	384.319
384.	TBM539/0	539+450-CENTRE	490355.909	3630748.141	382.441
385.	TBM559/2	559+500-C	490488.979	3631397.268	391.180
386.	TBM559/3	559+850-C	490486.873	3631741.039	390.246
387.	TBM560/0	560+050-C	490567.544	3631915.191	389.790
388.	TBM560/1	560+300-C	490746.966	3632077.174	389.696
389.	TBM560/3	560+750-C	491011.813	3632429.512	400.151
390.	TBM561/0	561+000-C	491032.101	3632680.544	402.955
391.	TBM561/1	561+250-C	491223.5	3632831.758	405.835
392.	TBM561/2	561+500-C	491434.117	3632874.015	408.384
393.	TBM561/3	561+750-C	491649.5	3633023.636	411.106
394.	TBM562/0	562+000-C	491864.423	3633157.388	412.971
395.	TBM562/1	562+250-C	492059.836	3633296.655	405.409
396.	TBM562/2	562+500-LHS	492241.644	3633453.142	395.690
397.	TBM562/3	562+750-LHS	492485.963	3633387.486	385.013
398.	TBM563/0	563+000-LHS	492715.081	3633332.562	385.540
399.	TBM563/1	563+250-LHS	492880.171	3633148.383	387.583
400.	TBM563/2	563+500-LHS	493118.556	3633084.219	390.976
401.	TBM563/3	563+700-LHS	493305.886	3633027.278	399.980
402.	TBM564/2	564+500-LHS	493708.906	3632447.536	429.046
403.	TBM564/3	564+750-LHS	493608.669	3632591.54	440.619
404.	TBM565/0	565+000-LHS	493569.359	3632778.464	444.744
405.	TBM565/1	565+250-LHS	493780.293	3632685.036	455.108
406.	TBM565/2	565+500-RHS	493830.518	3632443.416	465.726
407.	TBM565/3	565+750-RHS	494008.108	3632531.733	475.849
408.	TBM566/0	566+000-RHS	494188.37	3632707.855	486.569
409.	TBM566/1	566+310-LHS	494260.93	3633006.512	501.751
410.	TBM566/2	566+500-RHS	494360.38	3633167.882	508.931
411.	TBM566/3	566+725-RHS	494406.675	3633383.704	511.082
412.	TBM567/0	567+050-C	494434.434	3633692.935	520.170
413.	TBM567/1	567+250-RHS	494556.205	3633856.928	528.462
414.	TBM567/3	567+750-LHS	494845.069	3634249.962	536.876
415.	TBM568/0	568+300-LHS	495278.791	3634625.806	556.758
416.	TBM568/2	568+625-LHS	495574.075	3634644.279	554.717
417.	TBM570/3	570+750-C	496434.37	3636024.213	625.967
418.	TBM571/0	571+000-C	496347.113	3636244.869	628.614
419.	TBM571/1	571+250-LHS	496283.858	3636498.953	633.531
420.	TBM571/2	571+525-LHS	496140.659	3636730.601	632.461
421.	TBM571/3	571+780-LHS	495990.024	3636933.249	632.210
422.	TBM572/0	572+000-LHS	495913.115	3637149.298	630.802
423.	TBM572/1	572+250-C	495882.208	3637388.915	630.512

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
424.	TBM572/2	572+500-C	495821.992	3637626.167	630.420
425.	TBM572/3	572+780-C	495818.567	3637895.006	628.065
426.	TBM573/0	573+000-RHS	495915.499	3638108.468	620.719
427.	TBM-573/1	573+250-LHS	496018.729	3638325.982	610.832
428.	TBM-573/2	573+500-C	495983.844	3638566.79	608.220
429.	TBM-573/3	573+750-C	495934.74	3638815.791	605.155
430.	TBM574/2	574+500-RHS	495608.47	3639402.269	583.165
431.	TBM574/3	574+750-RHS	495371.207	3639452.819	581.309
432.	TBM575/0	575+010-RHS	495276.02	3639688.563	577.012
433.	TBM575/1	575+280-RHS	495184.471	3639923.841	572.531
434.	TBM575/2	575+500-RHS	495017.463	3640078.906	571.700
435.	TBM575/3	575+750-RHS	494898.19	3640308.326	577.845
436.	TBM576/0	576+000-LHS	494782.255	3640524.398	570.315
437.	TBM576/1	576+250-RHS	494813.139	3640762.297	582.929
438.	TBM576/2	576+480-LHS	494689.833	3640936.626	592.430
439.	TBM576/3	576+750-LHS	494501.87	3641150.99	607.738
440.	TBM577/0	577+000-LHS	494336.769	3641328.094	607.133
441.	TBM577/1	577+220-LHS	494188.033	3641505.92	602.328
442.	TBM577/2	577+500-RHS	494082.564	3641734.053	605.328
443.	TBM577/3	577+800-LHS	493934.827	3642003.742	600.611
444.	TBM578/0	578+100-LHS	493729.993	3642257.481	591.281
445.	TBM578/1	578+300-RHS	493656.657	3642402.391	583.258
446.	TBM578/2	578+500-LHS	493558.886	3642586.246	572.535
447.	TBM578/3	578+750-LHS	493466.738	3642805.942	578.917
448.	TBM579/2	579+500-LHS	493179.082	3643504.907	630.275
449.	TBM579/3	579+750-RHS	493152.121	3643756.288	643.050
450.	TBM580/0	579+975-RHS	493122.608	3643978.931	649.745
451.	TBM580/1	580+280-RHS	493070.972	3644282.096	649.825
452.	TBM580/2	580+500-RHS	493026.473	3644481.031	650.617
453.	TBM580/3	580+750-RHS	492940.435	3644718.116	651.350
454.	TBM581/0	581+050-RHS	492833.645	3644998.676	646.377
455.	TBM581/1	581+300-RHS	492729.535	3645214.117	646.901
456.	TBM581/2	581+450-LHS	492611.131	3645366.972	656.208
457.	TBM581/3	581+750-RHS	492468.314	3645600.518	672.572
458.	TBM582/0	582+000-RHS	492315.127	3645799.189	673.420
459.	TBM582/1	582+250-RHS	492246.195	3646039.237	675.894
460.	TBM582/2	582+550-RHS	492077.646	3646261.242	677.146
461.	TBM582/3	582+750-LHS	491872.605	3646348.218	678.670
462.	TBM583/0	583+000-LHS	491838.215	3646511.522	670.184
463.	TBM583/1	583+250-RHS	491860.732	3646724.135	666.280
464.	TBM583/2	583+510-RHS	491757.16	3646985.336	675.904
465.	TBM583/3	583+750-LHS	491656.481	3647195.878	669.822

Sl. No.	Point ID	Proposed Chainage - Side	Plain Coordinates		Elevation (m)
			Northing (m)	Easting (m)	
466.	TBM584/0	584+000-LHS	491546.98	3647417.012	674.632
467.	TBM584/1	584+250-LHS	491420.803	3647630.681	687.917
468.	TBM584/2	584+500-LHS	491273.512	3647842.512	689.464
469.	TBM584/3	584+750-LHS	491221.424	3648080.829	681.669
470.	TBM-585/0	585+020-LHS	491187.655	3648347.262	687.352
471.	TBM-585/1	585+260-RHS	491363.986	3648379.001	696.279
472.	TBM-585/2	585+500-RHS	491518.175	3648303.781	709.144
473.	TBM-585/3	585+770-RHS	491682.243	3648439.328	724.209
474.	TBM-586/0	586+000-LHS	491854.263	3648383.885	733.889
475.	TBM-586/1	586+250-RHS	492008.906	3648593	745.964
476.	TBM-586/2	586+500-RHS	492113.619	3648818.456	763.884
477.	TBM-586/3	586+800-LHS	492272.562	3649000.439	783.388
478.	TBM-587/2	587+575- RHS	492745.799	3649603.651	841.057
BYPASS ORGIATING FROM 583+100					
479.	TBM564/2	564+450-LHS	492029.414	3647100.226	684.794
480.	TBM564/3	564+750 - C	492321.811	3647195.029	729.144
481.	TBM565/0	564+960-LHS	492484.389	3647326.132	749.450
482.	TBM565/1	565+310 - LHS	492641.359	3647630.35	710.196
483.	TBM565/2	565+500 - C	492718.473	3647809.952	753.133
484.	TBM565/3	565+800-C	492831.892	3648089.104	764.048
485.	TBM566/2	566+650- RHS	493131.264	3648882.367	804.505
486.	TBM566/3	566+820-RHS	493157.314	3649059.346	820.257
487.	TBM567/0	567+050-LHS	493110.362	3649278.726	816.551
488.	TBM567/2	567+489-RHS	492957.857	3649677.691	828.408
BYPASS ORIGINATING FROM 566+090					
489.	TBM0/2	0+600-RHS	492814.399	3648866.975	797.996
490.	TBM0/3	0+840-C	492654.727	3649046.936	813.684
491.	TBM0/3	1+000-LHS	492549.692	3649164.116	805.051
492.	TBM1/1	1+300-RHS	492456.632	3649441.774	821.019
493.	TBM1/2	1+490-LHS	492448.089	3649637.186	823.990
494.	TBM1/3	1+790-LHS	492613.019	3649873.563	817.999
495.	TBM2/0	2+030-RHS	492781.332	3650048.163	825.728
496.	TBM2/1	2+270-LHS	492836.731	3650284.194	811.183
497.	TBM2/2	2+470-LHS	492933.817	3650463.76	800.508
498.	TBM2/3	2+740-LHS	493147.614	3650620.921	787.215
499.	TBM3/0	2+870-LHS	493233.203	3650712.957	781.878
500.	TBM3/1	3+130-LHS	493481.862	3650677.688	772.254
501.	TBM3/2	3+460-LHS	493775.7	3650805.875	795.657
502.	TBM3/3	3+700-RHS	493951.259	3650956.441	813.636
503.	TBM4/0	4+000-LHS	494026.291	3650968.117	828.485
504.	TBM4/1	4+265-RHS	494252.312	3651113.474	845.070

3.11 Geo-Technical investigation

I. Introduction

This section covers scope of services, technical requirements, workmanship and quality for a detailed Geo-Technical investigation works to be carried out. This task is required to know the subsurface features, soil profiles, relevant soil and rock properties.

The work will cover details of field explorations and Geotechnical engineering studies that are to be performed for the proposed major bridges, minor bridges, flyovers, ROBs, and other grade separators in various predetermined locations. The purpose of the explorations and studies is to identify subsurface conditions and formulate Geotechnical recommendations for design and construction.

II. Objectives of Investigation

The objective of subsoil Investigation is to ascertain Geotechnical and geological properties of substratum for design and construction of various types of foundations. It is proposed to have exploration by drilling of boreholes at proposed structure locations. Accordingly, the exploration program of boreholes shall be taken up to a maximum depth as per the termination criteria.

Undisturbed and Disturbed samples shall be collected appropriate to the ground conditions and transported to Geotechnical laboratory. Laboratory tests shall be conducted to determine the Index and Engineering properties of soil and rock. The Net Safe bearing capacity of the soil on which structures are to be constructed shall be recommended based on the test results. Engineering analysis shall be carried out for recommending the location and Net Safe Bearing Capacity of foundation for the proposed structures.

Wherever liquefaction is observed in Open foundation and Raft Structures, Ground improvement shall be done to compact the soil to increase its penetration resistance and satisfy as per clause 8.4.4 (v) of IRC114.

III. Investigation Criteria

Location of Boreholes

The boreholes for geotechnical investigations for structures are planned as per the following criteria given in TOR of the RFP document:

S. No.	Description (Location of boring for)	Location of Boring
1	Overall length = 6 – 30 m	One abutment location
2	Overall length = 30 – 60 m	One abutment location and at least one intermediate location between abutments for structures having more than one span.
3	Overall length 60 m and more	Each abutment and alternate pier locations.

I. Specifications for Boring Through Soils / Rocks

The boring shall be done as per borehole location coordinates. Specifications for boring through soils are as follows.

- The reduced levels of boreholes shall be indicated in all bore logs. The depth shown therein shall correspond to these reduced levels.
- T.C Bit and diamond drilling through soft and hard rock respectively shall be done, if encountered, using NX size double tube core barrel in normal situations and triple tube core barrels in weak rocks, fault zones, shear zones, crush zones, folded rocks etc. Use of triple core barrel helps preventing mechanical breakage of rock cores due to rough handling. Coring length shall be limited to a maximum of 1.5 m.
- The borings in strata shall extend to a depth not less than one and half times the anticipated width of the foundation in question below the proposed foundation level. In case of soft rock / soft disintegrated rock / weathered rock, drilling for at least 6 m below founding level needs to be carried out to ascertain continuity of the strata. In case of hard rock, it is limited to 3m.
- The boreholes shall be executed at the locations corresponding to the co-ordinates provided in the respective drawings.
- The boring shall be put down in such a manner, so that each change of strata is accurately determined. During the boring operation, particular attention shall be paid to the disturbed material washed from the casing or brought up by the shell and auger, and this shall be described in the bore logs.
- These disturbed washed materials should be preserved in double polythene bags with tags of appropriate description of depth, nature of soil, etc.
- The work of boring shall be carried out in such a manner that the representative disturbed as well as undisturbed samples of soils can be conveniently collected at the required depths / intervals and tests can be carried out as required.
- Water table in the borehole shall be carefully recorded and reported. Water samples shall be collected from the boreholes prior to addition of Bentonite (wherever required) to bore holes. If this is not possible then prior to the collection of water samples, the borehole should be dewatered by about half a meter depth and water should be allowed to collect and then the water samples shall be obtained.
- Disturbed soil samples shall be collected from the split spoon sampler wherever possible and packaged in plastic bags.
- Boreholes shall be backfilled after all samples are taken and after obtaining all other information from the boreholes in such a manner that no subsequent depression is formed at the ground surface due to settlement of the backfill.
- Field observations with regard to visual description of various soil strata, the variations in consistency, the sequence and the depths to changes in strata, Level of ground water table, drilling fluid consumption, presence of lime, mica, etc. shall be recorded.
- While drilling in all kinds of rocks instructions given in IS: 4078, IS: 4464, IS: 5313 and IS: 6926 shall be followed.
- During the drilling operations, particular attention shall be paid to get the core recoveries and Rock Quality Designations (RQD) of high standards.
- Rock cores collected continuously to full depth bore holes should be clearly designated by numbers, arrows and depths to which they belong for the purpose of identification at a later date, using good quality oil paint. Cores shall be kept in weathered teak wood boxes with compartments of the exact size of the rock cores. While placing the core samples in teak wood boxes, it shall be ensured that the direction and sequence of core placement is not altered. The core run shall be restricted to 50/60cm length at a time.
- The core boxes shall be of good quality teakwood and shall be made according to the sketch on page 6 of IS: 4078-1980 with locking arrangements and compartments.
- The labeling of core samples of rock shall be done in accordance with IS: 4078-1980 or as directed.

- Each and every core piece extracted from the core barrel shall be placed in core boxes in the proper sequences of occurrence from top. The starting and finishing depth of each run shall be recorded on the core box compartments in oil paint, as the cores are placed.
- The Core boxes shall be painted inside and outside with oil paints and sprayed with insecticide to prevent damage by insects. They shall be sequentially numbered on the four sides and lid and name of project, drill hole number and the depth of the core obtained shall be prominently painted on the lid with oil paint.
- The arrangement should be made for collection of wash water by installing a top socket with cross pipe at the top of the casing before start of rock drilling. The side of the casing should be well packed near top of the hole to prevent leakage. Wash water should be collected in the bucket and allowed to settle. A record of wash water shall be maintained indicating the colour, change in colour and type of wash water (i.e. thick slurry or clean water).
- The number of revolutions per minute for rock drilling shall be kept low for “NX” size bits. The rate of penetration for every 250 mm shall be observed during the rock drilling and recorded.
- During drilling operations observations of return water (change in color, depth of occurrence), rate of penetration, etc shall be made and recorded as per IS: 5313; The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fall, any blockage of drill bit causing core loss, if any, shall be recorded. Any heavy vibration or torque noticed during drilling should be recorded together with the depth of occurrence. Special conditions like grouting during drilling, presence of artesian conditions, loss of drilling fluid, observation of gas discharge with return water etc., shall also be observed and recorded.

II. Termination Criteria

- In case refusal strata with $N > 100$ and no core recovery or conglomerate/bouldery strata is there the bore hole shall be terminated after drilling 10m into refusal strata or specified depth whichever is earlier.
- In case rocky strata is encountered in between with $RQD > 30\% \text{ \& } < 75\%$ then bore hole should be terminated by drilling up to 5m in such strata.
- In case rocky strata is encountered with $RQD > 75\%$ for continuous length of 3.0m the bore hole shall be terminated after drilling 3.0m into such strata.
- 1.5 times estimated length of pile in soil but not less than 15m beyond the probable length of pile.
- 15 times diameter of pile in weak/jointed rock but minimum 15 m in such rock.
- 4 times diameter of pile in sound, hard rock but minimum 3 m in such rock.
- As per IS4464-1985: code of practice for presentation of drilling information and core description in foundation investigation (The rock type description & grade is given in page no. 7.)
- After the cores/samples are recovered and tested, the classification shall be as per IRC: 78 - 2014.
- Point nos. d), e) and f) are applicable only if pile foundation is proposed.

III. Methodology of Field Investigation

The field exploration methods, sampling requirements, types and frequency of field tests are performed based on project design requirements. Accordingly, we have developed the overall investigation plan which enables us to obtain the data needed to define subsurface conditions and perform Engineering analysis and design.

IV. Setting Out

All investigations shall be carried out at natural ground/Bed conditions as per the drawings.

V. Rig Erection

The rig shall be erected in a safe manner in accordance with the operating manual or an approved alternative method. Where there is a risk of toppling or “runaway” appropriate stabilizing precautions shall be taken. The rig shall be set up in a level and stable position. Particular attention shall be given prior to erection to the presence of overhead services or structures.

VI. Equipment

Before starting the investigations, all the equipments shall be carefully inspected to make sure that they are as per the relevant IS Specifications and in good working condition and the latest relevant certification of equipment such as proving rigs etc shall be taken from the competent authorities. The specifications for the equipments shall be as follows.

- The drilling equipments of heavy-duty shell and auger shall be used for making a bore hole of minimum 150 mm diameter in soil strata and/or Hydraulic Feed Rotary drilling machines for deeper boreholes in soils and for all rocky strata. The drilling rods should be standard 'A' selection with 41 mm outer diameter and square threaded ends.
- The drilling rods shall not have any bends; the inside should be clear without any blockage and should maintain verticality when connected together or with any test equipment.
- The cutting edge of the standard penetration spoon and disturbed sampling tube should be free from any bends/damages.
- The undisturbed sampling tube shall have minimum 100mm diameter. Shelby thin tube samplers should be used for undisturbed samples in soil or double core barrel arrangement shall be used for rocks and for soils also wherever conditions warrant.
- The outer diameter of the cutting shoe shall be slightly greater than that of the tube to aid penetration and withdrawal. In any case, the outer clearance should not be much greater than the inside clearance. Specifications for area-ratios shall be followed.
- The hose pipe and swivel shall be in good condition with proper joints to ensure that there is no leakage and effective circulation of bentonite slurry.

VII. Working Areas

Working areas shall be kept as free as practical from borehole arising and equipment not actually in use. Particular attention shall be paid to the reduction of “trip” hazards.

VIII. Boring

Drilling of boreholes shall be carried out at specified locations to obtain information about the subsoil profile, its nature and strength and also to collect soil samples for strata identification and conducting laboratory tests. The sequence of boring shall be planned after ascertaining preliminary nature of subsoil profile. Boring shall be carried out as per the provisions given in IS: 1892-1979.

IX. Sampling

All the accessories used for sampling and the method of sampling adopted shall confirm to IS: 2132. All the disturbed and undisturbed samples collected in the field shall be classified at the site as per IS: 1498.

X. General Practice for Sampling

The preparations for and methods of taking samples, together with their size, preservation and handling shall be in accordance with the provisions of relevant code of practice, specification and as directed by the engineer.

XI. Sampling Frequency

The samples shall be taken as follows: Soil samples shall be taken at every 1.5 m intervals and at each change in soil type or change in consistency, a disturbed sample shall be taken. An 'Undisturbed' sample shall be taken in cohesive soils, a representative sample in granular soils, or a field test as appropriate. Precaution shall be taken to ensure that there shall not be any change in moisture content and disturbance, i.e. they shall be suitably sealed. All samples shall be labelled with date, bore hole or, depth of sampling as per IS: 1892.

For sampling at the bottom of the hole allowance should be made for the disturbed zone by either removing it using an auger or suitable tools. In cohesive soils the bore hole may be cleaned using a bailer with flap valve.

When the collection of undisturbed soil sample at a specified depth is not possible the reason for the same shall be indicated in the bore log. In such a case, undisturbed sampling may be replaced by using remoulded samples to field density and moisture content.

XII. Disturbed Sampling (DS)

Disturbed soil samples shall be collected from bore holes at regular intervals to determine the soil type, grain size distribution, Atterberg limits and soil classification. Disturbed samples weighing approximately 1.0 kg shall be collected in bore holes at 1.5-meter intervals starting from a depth of 0.5 meter below ground level or at every change in stratum, whichever is less. Disturbed soil samples shall be collected from thin walled samplers or split spoon samplers of SPT.

XIII. Undisturbed Sampling (UDS)

For compression test samples, a core of 40mm diameter and about 150mm long may be sufficient. For other laboratory tests a core of 75 to 100mm diameter shall be preferable. Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin-walled sampler. The sampler head which connect the tube to the boring rod is provided with vents to permit water to escape sampling under water and check valve to help to retain the sample while withdrawing the sampler.

Sampling shall be done as soon as possible after the clean out operation. The sampling tube shall be pushed / driven into the soil in such a manner that the structure of the soil its moisture content do not get altered. The distance by which the sampler penetrates the soil strata shall be checked. After removal of the sampling tube the same shall be sealed with wax on both sides.

Wherever solid cores are recovered, the length beyond the ones required for undisturbed lab testing such as triaxial shear strength (under appropriate drainage conditions, i.e. UU, CU or

CD) or consolidations tests, be preserved and suitably labelled & stored in core box. Colour photographs should be taken for core samples & some typical disturbed sample material also.

The specifications for the accessories used for sampling and the sampling procedure adopted shall conform to IS: 1892 and IS: 2132. Undisturbed samples are used to determine the shear parameters, natural moisture content and unit weight.

XIV. Rock Samples

Cores of rock should be taken by means of rotary drills with coring bit with core retainer if warranted. All types of rotary drills shall be fitted with core barrels. Core samples shall be extracted with the barrel held horizontally without vibration. Care shall be taken to maintain the direction of extrusion of sample same as while coring to avoid stress reversal. The samples shall be placed in core box. The core box shall be made from seasoned timber or any other durable material and shall be indexed on top of the lid as per IS: 4078. The description of core samples shall be recorded as per IS: 4464 and continuous record of core recovery and RQD to be mentioned in the core log as per IS11315, Part-II. Colored photographs should be taken and enclosed with reports wherever encountered (to register stable depth of W.T.)

XV. Ground Water Recording

The water level in each borehole shall be recorded before commencement and after completion of drilling. The depth of the borehole and casing (if any) shall also be recorded.

XVI. Sub-Soil Water Samples

Sub-soil water samples shall be collected for carrying out chemical analysis. Representative samples of ground water shall be collected to carry out the chemical analysis and sent to laboratory in airtight bottles with proper labelling.

Chemical analysis of water shall include determination of pH value, Sulphate and chloride contents.

XVII. Transportation and Storage of Samples

Undisturbed Samples shall be hand carried holding them in vertical. Shipping and storage shall be done vertically in most of the situations. Samples shall be kept as near to ground temperature during shipping. Samples shall be stored in a dark humid room having 90 - 94% humidity to prevent loss of moisture.

XVIII. In Situ & Laboratory Tests

XIX. In Situ Tests

Standard Penetration Test (SPT)

Standard Penetration Test shall be conducted in all types of soil deposits met within a borehole to arrive at the variation in soil stratification by correlating with the number of blows required for unit penetration of a standard penetrometer. The equipment and procedure for Standard Penetration Test shall conform to IS: 2131. The bottom of bore hole shall be cleaned of mud slurry before conducting the Standard Penetration Test (SPT). The SPT shall be conducted generally at 1.5 m intervals and in addition at changes of soil strata, as per IS: 2131. The blow count shall be recorded. Following points are to be particularly observed:

Sufficient quantity of representative soil samples shall be collected from the split spoon sampler for identification and laboratory testing. The sample shall be visually classified and recorded at the site and shall be properly preserved without loss of moisture content and labelled for future identification.

The observed 'N' values shall be corrected for ground water table corrections and the corrected (N') values shall be entered into the bore log. The ground water table shall be recorded and described in the borehole log after the water level has settled.

Standard Penetration Test (SPT) shall be conducted at different depths in all boreholes. For shallow depths SPT shall be conducted at close intervals of 1.5m. SPT split spoon sampler of standard dimensions was driven into the soil from borehole bottom using 63.5kg hammer falling from 75cm height. The SPT weight was mechanically lifted to the specified height and allowed to free fall. Blow count for each of three 15cm penetrations was recorded and the N is reported as the blows count for the last 30cm penetration of the sampler leaving the first 15cm penetration as seating drive. When the number of blows exceeded 50 to penetrate the first or second 15cm length of the Sampler, the SPT 'N' is regarded as more than 100 as described in IS: 2131 - 1981. SPT refusal is recorded when there is no penetration of the sampler at any stage and also when a rebound of the sounding system is recorded. Samples from the SPT split spoon sampler shall be preserved in polythene covers and transported to the laboratory. Additional polythene cover shall be used to prevent the loss of moisture during the transit.

XX. Laboratory Testing

Depending upon the type of substrata, appropriate laboratory tests shall be conducted on soil and rock samples. All storing, preparation and testing of samples shall be in accordance with IS codes and standards. Calibration of all the instruments and accessories shall be done precisely, and apparatus shall comply with the requirements of specifications of Indian Standards.

All samples, whether disturbed or undisturbed shall be extracted, prepared and examined by competent personnel properly trained and experienced in soil sampling, examination, testing and in using the apparatus as per the specified standards. All the laboratory test data shall be recorded in the proforma recommended in the Indian Standard Codes.

a) Tests on Disturbed Samples

1. Sieve and hydrometer analysis (Grain size analysis), silt factor calculations.
2. Visual and Engineering classification,
3. Atterberg limits,
4. Moisture content, porosity and density,
5. Specific Gravity.

b) Tests on Undisturbed Samples

1. Natural moisture content,
2. Unit weight,
3. Oedometer test (consolidation & swelling parameters),
4. Unconfined Compression,
5. Triaxial Shear test (Unconsolidated Undrained test - UU Test, Consolidated drained test – CD Test),
6. Direct Shear test
7. Swell pressure and determination of free swell pressure index

c) Chemical analysis of Ground Water

1. Visual examination,
2. pH
3. Sulphate content
1. Chloride content

d) Tests on Rock Samples

1. Uniaxial compression test and
2. Point load strength index
3. Porosity & Water absorption
4. Density & specific gravity
5. Petrography- Hand and microscopic petrographic examination

XXI. Codes and References

Field and Laboratory works are conducted based on Indian Standard specifications and, as per the requirement of project. The codes and specifications that are to be followed to conduct the geotechnical investigations are as follows.

Unless specifically mentioned otherwise, all applicable codes and standards of practice in their latest editions as published by the Bureau of Indian Standards and all relevant amendments published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed hereunder.

In the event of any conflict between the requirements in this specification and the below referred codes, the former shall govern.

Code No.	Description
IS: 1498	Classification and identification of soils for general engineering purposes
IS: 1888	Method of load tests on soils
IS: 1892	Code of practice for sub-surface investigations for foundations
IS: 2131	Method of standard penetration test for soils
IS: 2132	Code of practice for thin-walled tube sampling of soils
IS: 2720	Methods of test for soils (ALL PARTS)
IS: 2809	Glossary of terms and symbols relating to soil engineering
IS: 2810	Glossary of terms and symbols relating to soil dynamics
IS: 3025	Methods of sampling and Testing (Physical and Chemical) for Water used in Industry
IS: 4078	Code of practice for Indexing and storage of drill cores.
IS: 4434	Code of practice for in-situ vane shear test for soils
IS: 4453	Code of practice for exploration by pits, trenches, drifts and shafts
IS: 4464	Code of Practice for presentation of Drilling information and Core Description of Foundation Investigation
IS: 4968	Method for sub-surface sounding for soils (ALL PARTS)
IS: 5249	Method of test for determination of dynamic properties of soils
IS: 5313	Guide for Core Drilling Observations
IS: 5529	Code of practice for in-situ permeability tests (ALL PARTS)
IS: 6065	Recommendations for the preparation of Geological and Geotechnical maps for River Valley Project

Code No.	Description
IS: 6403	Code of practice for determination of Allowable Bearing Pressure on Shallow foundation
IS: 6926	Code of practice for Diamond core Drilling for Site Investigation for River Valley Project
IS: 6935	Method of determination of water level in bore holes
IS: 6955	Code of Practice of subsurface exploration for Earth and Rockfill dams
IS: 7422	Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs. (ALL PARTS)
IS: 8763	Guide for undisturbed sampling of sands
IS: 8764	Method of determination of point load strength index of Rocks
IS: 9143	Method for the determination of unconfined compressive strength of Rock Materials
IS: 9179	Method of preparation of Rock specimen for Laboratory testing
IS: 9798	Specification for Compaction rammer for soil testing
IS: 9214	Method for determination of modulus of subgrade reaction (k-value) of soils in the field
IS: 9259	Specification for Liquid Limit apparatus
IS: 9640	Specification for split spoon sampler
IS: 9669	Specification for CBR mould and its accessories
IS: 10050	Method of determination of Slake Durability Index of Rocks
IS: 10060	Code of practice for subsurface investigation for powerhouse sites
IS: 10074	Specification for compaction mould assembly for light and heavy compaction test for soils.
IS: 10108	Code of practice for sampling by thin wall sampler with stationary piston
IS: 10589	Equipment for determination of subsurface sounding of soils
IS: 10837	Specification of moulds for determination of Relative density and its accessories
IS: 11229	Specifications for shear box testing of soils
IS: 12070	Code of practice for design & construction of shallow foundations on rocks.
IRC 112	Code of Practice for Concrete Road Bridges
IRC 78	Standard specifications and code of Practice for Road Bridges
MoRT&H	Specifications for Road & Bridge works, fifth Revision

XXII. Detailed Geo-Technical Report

Final Geo-technical Investigation report shall contain procedure adopted for investigation, field observations, summarized test data, detailed bore logs, field test results, laboratory observations, with all the necessary photographs and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculation for the conclusions drawn and recommendations etc.

The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different type of structures envisaged in the area under investigation. The report shall also include but not be limited to the following;

- 1) Detailed write up on the methods, procedures and equipment used in all phases of the work.
- 2) A plot plan showing the locations and reduced levels of top of each BH and all field tests.
- 3) A true cross section in two perpendicular and diagonal directions of all individual bore holes with reduced levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, grain size distribution, index and engineering properties of representative samples, various in-situ tests conducted, samples collected at different depths and the rock stratum if met with,
- 4) A set of longitudinal and transverse Soil/Rock profiles connecting various bore holes, Geological information of the area such as Geomorphology, Geological structure, Lithology, Stratigraphy and techniques, core recovery and rock quality designation etc.
- 5) Detailed test results of all laboratory tests both in tabular and graphical form for each sample with all the relevant charts, tables, graphs, figures supporting calculations, conclusions and photographs of representative rocks.
- 6) Necessary extracts and references from technical literature used in calculation, evaluation and recommendations, Plot of SPT (N value both observed and corrected) with depth for identified areas.
- 7) The value of Cohesion, Angle of Internal Friction, shall be furnished along with sample calculation.
- 8) Past observation and historical data, if available, for the area or for other areas with similar soil profile or for the similar structures in the nearby areas.
- 9) Type of foundation, minimum founding depth and width of foundation to be adopted for various structures considering sub-soil characteristics, water table, max scour depth, total settlements permissible for structures. Values obtained from field test and laboratory tests shall be compared and suitable interpretation shall be furnished.
- 10) Calculation for allowable bearing pressure w.r.t. shear failure and corresponding total settlements for open foundation, well foundations and pile capacities for various combinations of diameter and length (both vertical and lateral). Load test curves and consolidation curves to be included. For settlement criteria – at least 2 methods shall be used as given in IS 8009 Part-1.
- 11) If expansive soil is met with clear indication of swelling characteristics etc., recommendation on removal or retainment of the same under the structure / roads etc. shall be given.
- 12) Comments on chemical nature of soil and ground water with due regard to potential deleterious effects on concrete and steel with recommended protective measures. Remedial measures for sulphate attack or acidity shall be dealt with in detail giving clear and practical recommendation.
- 13) Estimates of magnitude and rate of settlement of the proposed foundations/structures/sub-base, critical review of the expected differential settlements and recommendations to avoid differential settlement and damage to proposed structure.
- 14) Susceptibility of subsoil strata to liquefaction in the event of earthquake, if so recommendation for remedial measures.
- 15) Additional specific and definitive recommendation regarding stability of slopes (soil or rock), & ground improvement if any under proposed structure.
- 16) Recommendation for ground improvement, if any.
- 17) Any other information related to foundation design.

The detailed Geotechnical Investigation report is given as **Annexure 3.6**.

3.12 Hydrological and Hydraulic Study

XXIII. Main Objective

- The main objective of the hydrological and hydraulic study is to determine the required size of drainage structures to allow the estimated design flow of the streams to cross the road safely.
- To check whether waterway of proposed structures is sufficient to transmit the flow without risk, so that appropriate decisions could be taken concerning their span arrangement.
- To estimate the peak discharge for 100-year return period flood

In order to achieve the objectives mentioned above, the workflow of hydrological & hydraulic analysis adopted has been given in schematic diagram:

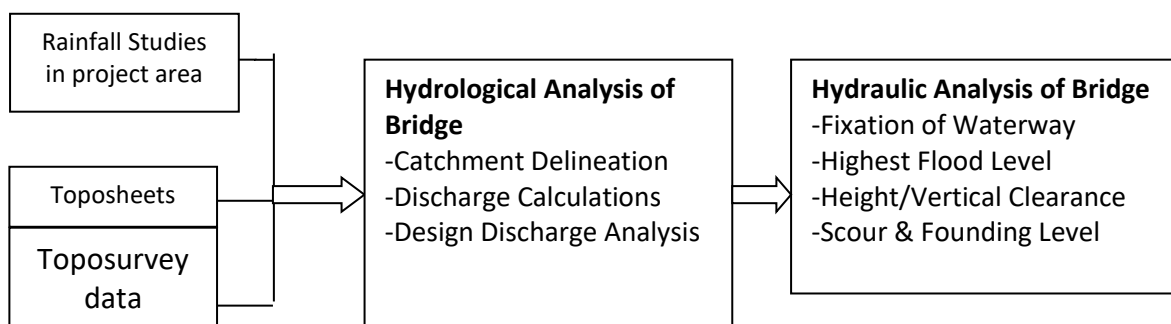


Figure 3-9 : General studies of Hydrological and Hydraulic Analysis

XXIV. General Description of the Project Site

The road alignment on which the bridges under consideration falls in the hydro meteorological sub zone of Upper Indo-Ganga plain subzone (1e). Hilly part shall be covered in Western Himalaya Subzone 7.

There are defined rivers, streams, drains and irrigation canals crossing the proposed alignment. Some of the major rivers crossing the alignment are Beas & Black bein nalla etc., which are generally flowing from right to left in the direction of increasing chainage. Beas River bridge is also designed for navigational clearance as per Inland Waterway Authority of India.

XXV. Data Collection and Data Analysis

XXVI. Requirements of Data collection for Hydrological Study

Top sheets, Rainfall Data, bhuvan imaginaries and topographical survey data are the primary basis of hydrological studies.

The data requirement and their applications are summarized in the below table:

Table 3-24: Topo sheets, Rainfall Data & Topographical Survey Data

Sl. No.	Title	Category (Primary/ Secondary)	Source	Relevant Information
1	Toposheets (1:50,000) & 1:2,50,000)	Primary	Survey of India & U.S. Army Map Service	Mark the catchment area, length of the stream and fall in elevation from originating point to the point of crossing & slope of the stream could be determined to calculate the design discharge of the proposed bridge location.
2	Rainfall	Primary	IMD Rainfall Map from CWC Subzone reports	100-yr 24-hour Rainfall is used to calculate the design discharge
3	Bhuvan Imaginaries	Secondary	Indian Geo-Platform of ISRO, Govt of India	Assessment of catchment area and stream network for calculating design discharge.
4	Topographical survey data	Primary	Survey at field/ site along the alignment	To make cross section and longitudinal slopes of the Nala / stream used in computation.

Source: Survey of India & U.S. Army Map Service, CWC subzone reports, Bhuvan website of ISRO and field data

XXVII. *Hydrological and Hydraulic Study for Bridges*

For performing the hydrological and hydraulic analysis which essentially need the design flood of a specific return period for fixing the waterway vis-à-vis the design HFL of bridges depending upon their size and importance to ensure safety as well as economy. As per IRC 5-2015-Section I General Features of Design specify that the waterway of a bridge is to be designed for a maximum flood of 100 years return period. The catchment area has been marked on the topo-sheets of Survey of India, maps available and bhuvan imaginaries for their assessment.

The following methods can be used to estimate the peak discharge for bridge sites on major and minor streams up to the catchment area of 2500 sqkm;

1. Empirical Formulae
2. Rational Method
3. Slope Area Method
4. Synthetic Unit Hydrograph Method
5. Catchment area based on existing dam data or measuring site data (wherever applicable)

In case of catchment area more than 2500 sq km, the discharge calculations shall be considered based on the slope area method at local enquiry highest flood level/ water marks on nearest bridge or the basis of dam/ barrage outflow data of central water commission/ irrigation department/ boards with reference to the catchment area at proposed bridge location.

Highest of above shall be considered at design discharge. With the design discharge, calculations for the 100-year flood level shall be obtained using manning's equation-based

flood discharge. Afflux calculation, span arrangement and scour levels for piers and abutment shall be estimated.

Apart from rivers and streams, there are number of defined canals & drains with service road/inspection & non inspection paths crossing the alignment. The hydrological calculation shall not be required as there is a controlled flow from canal regulators/ headworks. In such cases provision of vertical clearances shall be made sufficient to cater uninterrupted village transport/ light machineries movement and horizontal span covering combined canal/drain with service road.

XXVIII. Empirical Formulae

The empirical formulae used for the estimation of the flood peak are essentially regional formulae based on the statistical correlation of the observed peak and important catchment properties. Dicken's & Ryve's method (empirical formulae) are most popular methods given in IRC: SP-13-2004.

2 Dicken's Method

$$Q = CA^{3/4}$$

Where,

Q = Peak discharge in cumecs

A = Catchment area in sq km

C = Dicken's coefficient

= 11-14 where the annual rainfall is 600 mm to 1200 mm

= 14-19 where the annual rainfall is more than 1200 mm

= 22 in Western Ghats

3 Ryve's Method

$$Q = CM^{2/3}$$

Where,

Q = Peak discharge in cumecs

M = Catchment area in sq km

C = Coefficient, which varies with the region as given below

C = 6.8 for areas within 25Km of coast.

= 8.5 for area between 25 Km to 160 Km of the coast.

= 10 for limited areas near the hills

XXIX. Rational Method

Discharge Estimation for the Catchment Areas Less than 25 sq km

This is a well-known method as given in IRC: SP-13-2004 and the formula for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances viz. time of concentration and critical intensity of rainfall.

Here, 100 year Peak Discharge is calculated by following formula

$$Q_{\max} = 0.0278 P f A I_c$$

Where,

$Q_{\max}$ = design flood (m^3/s) for 100 year return period

f = Areal Distribution/spread Factor

- C = Coefficient of runoff for the catchment characteristics
A = Catchment area (Ha)
 I_c = Critical intensity of rainfall in cm/hr during the time of concentration.

Time of concentration has been taken from IRC: SP: 13-2004 Equation no. 4.9.

$$t_c = \left(0.87 \times \frac{L^3}{H}\right)^{0.385}$$

Where,

- t_c = time of concentration (hours)
L = the distance from the critical point to the structure (km)
H = the fall in level from the critical point to the structure (m)

Intensity of rainfall has been determined from formula $I_c = \frac{F}{T} \left(\frac{T1}{t_{c1}}\right)$ in cm/hr

- F = Total Precipitation (cm).
T = Duration of Storm (Hours).

The value of runoff coefficient (P) depends on the porosity of the soil, vegetation cover, surface storage, initial state of wetness of soil, area, shape & size of the catchment and may be taken from the below given Table.

Table 3-25: Maximum Value of P (Table 4.1: IRC: SP: 13-2004)

Sl. No.	Description of Catchment	Value of P
1	Steep, bare rock and also city pavements	0.90
2	Rock, steep but wooded	0.80
3	Plateaus, lightly covered	0.70
4	Clayey soils, stiff and bare	0.60
5	Clayey soils, stiff and bare and lightly covered	0.50
6	Loam, lightly cultivated or covered	0.40
7	Loam, largely cultivated	0.30
8	Sandy Soil, light growth	0.20
9	Sandy soil, light growth covered, heavy brush	0.10

The value of areal distribution factor depends on catchment area as shown in below graph given in IRC-SP-13.

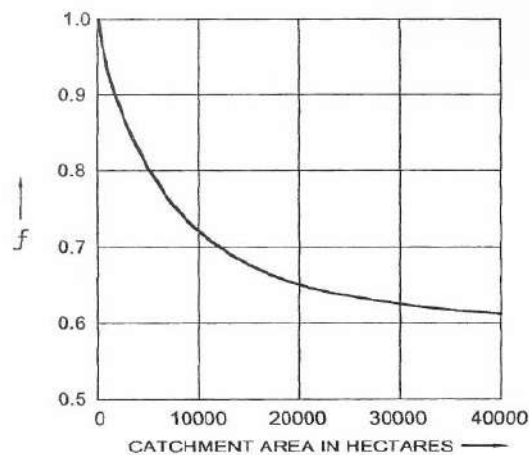


Fig. 4.2 'f' curve

Figure 3-10 : f -Curve

Thus, after calculating the above parameters, 100-year return period peak discharge has been calculated for all the bridges using the formula as given above.

XXX. Slope Area Method

This method is useful in case of known HFL value from the site as per local enquiry/ water mark on the structure or records of data available from concerned governmental agencies. On the basis of the known HFL the discharge at observed HFL can be worked out by using following equation.

$$Q = A \times V$$

$$\text{Where } V = 1/n \times R^{2/3} \times S^{1/2}$$

A = Area of cross section of natural channel

n = Manning's coefficient

R = Mean hydraulic radius = Area (A)/ Perimeter(P)

S = Slope of the natural channel

XXXI. Synthetic Unit Hydrograph Method

When catchment area is greater than 25 sq km, the flood discharge has been calculated using the synthetic unit hydrograph method specified in Flood Estimation subzone Report, Western Himalaya Subzone 7 CWC has been adopted for design discharge for the bridges.

In this zone, Synthetic Unit Hydrograph is determined using 1 hour unit duration for an ungauged catchment. Following steps have been followed as suggested in CWC report for determination of discharge by this method.

- A. Physiographic parameters of the ungauged catchment viz. A, L, Lc and S have been determined from toposheets or field observations.
- B. SUH parameters for Subzone 7 have been computed using prescribed equations.
- C. The estimated parameters of unit hydrograph from above formulas have been plotted and the plotted points were joined to draw synthetic unit hydrograph. The discharge ordinates of SUH at interval of unit hour duration were found from the equation of the plotted graph. The obtained value of the ordinates is adjusted in order to get proper unit

hydrograph shape and area under the unit hydrograph. The unit hydrograph ordinates are summed up and multiplied by the unit hour duration and compared with the volume of 1 cm direct runoff depth over catchment computed by the formula as given below:

$$Q = (A \times d) / (tr \times 0.36)$$

- D. The design storm duration has been taken equal to base period of unit graph ($TB = 1.1 \times tp$).
- E. Point rainfall is read from the plate given in CWC report for 100-year, 24 hr rainfall and has been converted to area rainfall of 100 years and design storm duration.
- F. The areal rainfall of design storm duration is split into 1-hour rainfall increments using time distribution coefficients.
- G. Estimation of effective rainfall excess unit has been done after taking design loss rate into account.
- H. Base flow has been estimated based upon the catchment area.
- I. The effective rainfall ordinates are arranged against the UG in such a way that the maximum value of rainfall is placed against the peak value of the UG, the next lower rainfall values are arranged against the next lower values of the UG in appropriate order. The order of the effective rainfall values thus obtained is reversed to get the critical sequence. The effective rainfall values are applied to 1 hour unit hydrograph ordinates. The first rainfall excess value is multiplied with each of the UG ordinate to obtain the corresponding direct runoff ordinates. The computation is repeated with the remaining rainfall excess values & the direct surface runoff derived from each successive rainfall excess is lagged by 1 hour. The total direct surface runoff for various time periods is added to get the direct surface runoff hydrograph. The base flow is then added to each of the direct surface runoff hydrograph ordinate, to get the values of design flood hydrograph ordinates.

XXXII. Catchment area basis Considering Existing Dam Data or measuring site data

Some of the major/minor bridge locations, design discharge needs to be calculated based on the existing dam/barrage design discharge. Existing barrage/dam design discharge has to be transposed to proposed bridge location on the basis of catchment area basis by using Dicken's formul.

$$Q_{DS} = Q_{GD} \times (CA_{DS}/CA_{GD})^{3/4}$$

Q_{DS}	=	Design discharge at proposed bridge location
Q_{GD}	=	Design discharge at existing barrage/dam location
CA_{DS}	=	Catchment area upto proposed bridge location
CA_{GD}	=	Catchment area of existing bridge location

The nearest measuring site data of CWC / concern board for fixing discharge shall also be used wherever measuring station available is nearest to the proposed alignment.

XXXIII. Bridges over Canals/Drains

Proposed alignment crossing over well-defined canal and drain of irrigation network at various locations in Punjab state and Union Territory of Jammu & Kashmir. The structures have been proposed duly considering the physical measurement at particular site for sufficient width and vertical clearance as per irrigation/ drainage requirement. The canal with service road/ inspection bank has been ensured for minimum vertical clearance for mobilization of vehicle

and equipment. Moreover, for further verification/compliance the canal/drain details shall be requested from concerned authorities through proper channel and in under progress.

XXXIV. Afflux Calculation

Afflux calculations were carried out as per IRC:5-2015 and Mole's worth formula have been used as given below.

$$\text{Afflux } h = [(v^2/17.88)0.015] \times [(A/A_1)^2 - 1]$$

Where,

v - Average velocity of river prior to obstruction in m/sec

A - Unobstructed sectional area of river in Sq m

A₁ - Sectional area of river at obstruction in Sq m

XXXV. Scour Depth Calculation

Scour calculation for pier & abutment or box type bridges has been carried out as per IRC SP: 13-2004 and IRC: 78-2000. Scour depth has been calculated using formula given below:

$$d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$$

Where,

d_{sm} = Mean scour depth below HFL

D_b = (Q/L)

Q = Discharge adopted for scour depth calculations (after increasing the design discharge as per clause 703.1.1 of IRC 78: 2000)

L = Clear waterway after making deductions for obstruction upto HFL

D_b = The design discharge for foundation per metre with effective linear waterway

K_{sf} = Silt factor for a representative sample of bed material obtained upto the level of anticipated deepest scour

HFL = Highest flood level

Mean scour depth at abutment = $1.27 * d_{sm}$

Maximum scour level at abutment = $HFL - 1.27 * d_{sm}$

Similarly,

Mean scour depth at pier = $2 * d_{sm}$

Maximum scour level at pier = $HFL - 2 * d_{sm}$

The founding level has been fixed on the basis of calculated scour level and bearing capacity of soil & rock.

XXXVI. Summary and Recommendations

Flood discharge estimated in four different ways was compared & highest of these was adopted as design discharge in general. However, the general condition laid down in IRC:SP-13 has been used to fix the design discharge, i.e. if the discharge obtained by one method is greater than 1.5 times the discharge obtained from the other, the design discharge should be limited to 1.5 times of the smaller one. Accordingly, the design discharge has been established for all the bridges. Based on the highest discharge, HFL was reassessed using slope area method for the hydraulic calculation, provision of spans and scour levels.

XXXVII. References

- i. IRC: SP-13:2004 - Guidelines for design of small bridges & Culverts
- ii. IRC:5:2015 - Standard specifications and code of practice for road bridges section-I
- iii. IRC:89:1997 - Guidelines for design and construction of River Training and control works for road bridges.
- iv. IRC: SP-84: 2014 - Manual of specifications and standards for four laning of highways through public private partnership
- v. IRC-78:2014 - Standard specifications and code of practice for road bridges Section – VII
- vi. CWC - Flood Estimation report for Subzone 7

The detailed Hydrology Report report is given as **Annexure 3.7.**

4 TRAFFIC STUDIES & FORECAST

4.1 Traffic Surveys and Analysis

4.1.1 Introduction

The Government of India has decided to develop access-controlled expressway from Delhi via Ludhiana & Amritsar to Katra. National Highways Authority of India has been assigned the work of preparation of Detailed Project Report of the proposed expressway.

The National Highways Authority of India (NHAI) has appointed M/s. Feedback Infra Pvt. Ltd. for providing the required Consultancy services for preparation of Detailed Project Report of Delhi-Ludhiana-Amritsar-Katra Expressway, having an approximate length of 600 km (the "Project") excluding spurs through BOT & EPC basis.

This section presents the traffic studies and analysis carried out for addressing various objectives and issues pertaining to development of Project Highway. The results of this analysis will form inputs for assessing the traffic which will be diverted to the proposed expressway from various other alternative routes. The forecast of traffic helps in planning and designing of the pavement, developing proposals of capacity augmentation, designing the toll plaza and design of intersections/ interchanges if any along the project road.

Since it is a greenfield/brownfield Expressway, a thorough knowledge of travel characteristics of traffic on various alternate routes is essential to work out the future traffic which will be diverted to project corridor. Hence, detailed traffic surveys are carried out to assess the baseline traffic characteristics on various alternative routes from Delhi to Katra.

4.1.2 Project Details

The final alignment of Delhi – Amritsar - Katra is proposed to be developed in two Phases:

➤ Phase-1: Delhi (0+000) to Gurdaspur Bypass

Alignment of the proposed Expressway starts at KMP Expressway (28.79556 °N, 76.88096 °E) near village JassaurKheri (Jhajjar, Haryana). Take-offs point of the proposed expressway alignment is about 10 km from the existing interchanges on NH-10 near Bahadurgarh and on Sonipat-Auchandi-Bawana road near Kharkhoda.

The proposed Greenfield alignment would be intersecting National and State Highways in the state of Haryana/NCR before entering Punjab. The detail of interchanges in the state of Haryana/NCR are as follows:

- KMP(Kundli-Palwal) at Village JassaurKheri.
- NH-334B (Jhajjar-Sonipat National Highway) at Village Hassangarh,
- SH-18 (Rohtak-Kharkhoda State Highway) at village Humayunpur.

- NH-709 (Rohtak-Panipa National Highway) at Village Rukhipana.
- NH-352A (Jind-Gohana National Highway) at Village Butana.
- Trans Haryana link at Dada Khera village.
- SH-12 (Jind-Naguran-Assandh-Karnal State Highway) at Villlage Alewa Village.
- NH-152 (Narwana-Kaithal-Ambala National Highway) at Village Kharak Pandwa.

And thereafter enter the state of Punjab near village Barta. In the State of Punjab, the alignment would be intersecting:

- NH-152A (Punjab-Haryana border Moonak-Kaithal) at Village GulzarपुरTharwa.
- SH-10 (Patran-Samana State Highway) at Village Lalwa.
- SH-12A (Sunam to Bhawanigarh State Highway) at Village Roshanwala.
- SH-11 (Malerkotla- Nabha State Highway) at Village Ahmdabad.
- SH-11 (Malerkotla- Ludhiana State Highway) at Village Bhogiwal.
- NH-5 (Ludhiana-Moga National Highway) at Village Dhaka.
- SH-48 (Nakodar-Nurmahal State Highway) at Village Uppal Khalsa.
- NH-703 (Jalandhar-Nakodar National Highway) at Village Kang Sahbu.
- NH-703A (Jalandhar-Kapurthala National Highway) at Village Firoz.
- NH-3 (Kartarpur-Amritsar National Highway) at Village Dialpur,
- NH-503A (Sri Hargobindpur-Amritsar National Highway) at Village KishanKot
- Spur Connecting Expressway with Dera Baba Nanak (Kartarpur Corridor)
- NH-54 (Pathankot-Amritsar National Highway) at Gurdaspur bypass

➤ Phase-2: Gurdaspur (397+700) to near Katra (End point)

Alignment of the proposed Phase 2 Expressway starts at Gurdaspur Bypass. The proposed expressway alignment would be intersecting National and State Highways in the state of Punjab / J&K before ending at Katra. The detail of interchanges in the state of Punjab / J&K are as follows:

- NH-44 (Pathankot – Jammu National Highway) at Village Rajbagh.
- Hiranagar road near Village Maila.
- NH-44 (Pathankot – Jammu National Highway) at Village Samba.
- Jammu Kunjwani bypass near Barian village.
- NH-44 (Jammu - Udhampur National Highway) at Village Rotore Dhok.
- NH-44 (Jammu - Udhampur National Highway) at Village Domel.

This report details out the traffic assessment of Phase-II. Phase II starts at Gurdaspur and ends at Katra. Detailed description of Phase I & Phase II is given in Table below.

The Project corridor has been divided into homogeneous sections based on the interchanges provided on National Highways as well as state highway crossings. The homogeneous sections are indicated in **Table 4-1** and shown in **Figure 4.1**.

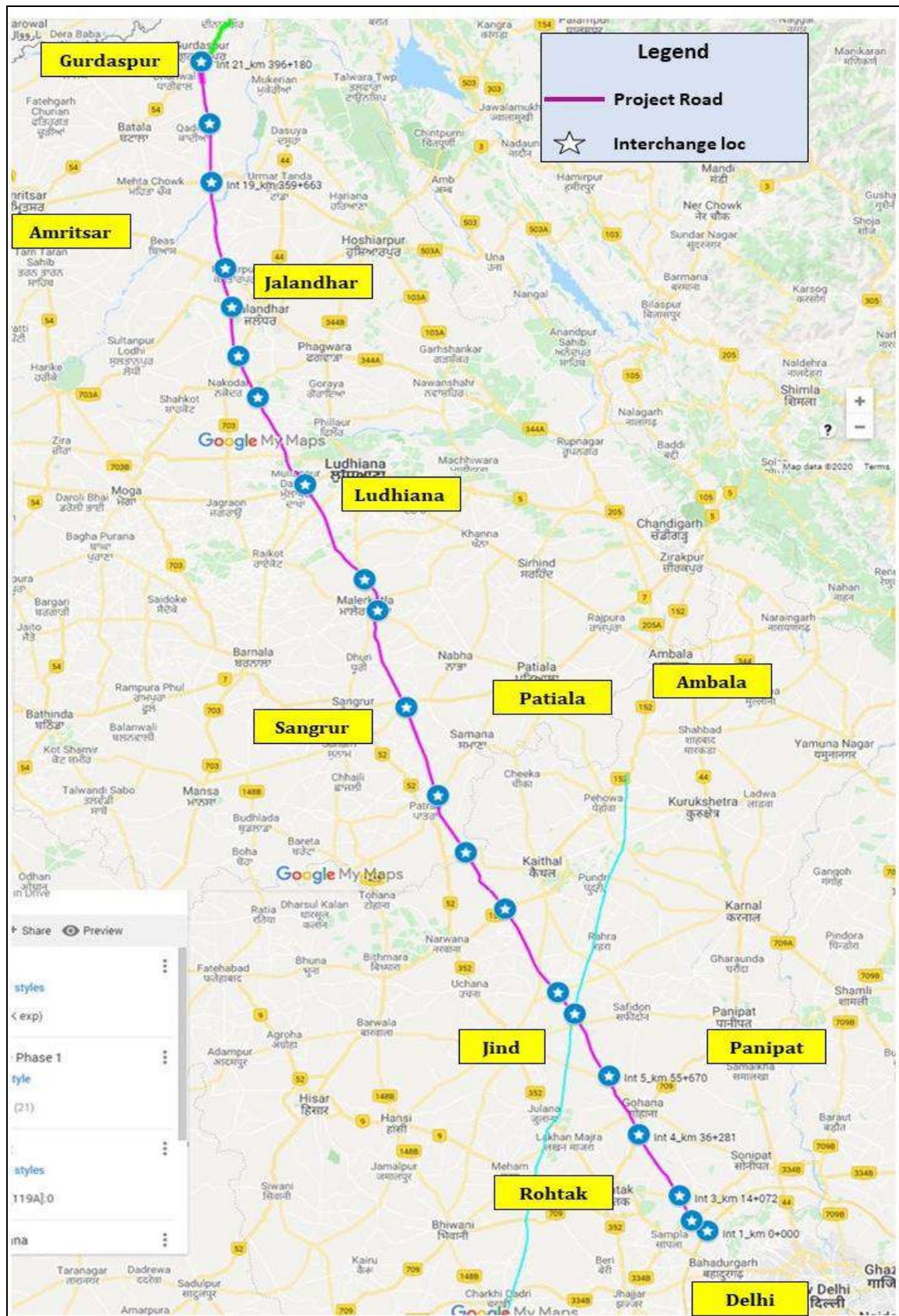
Table 4-1: Homogeneous Sections

Homogeneous Section	From (Km)	To (Km)	Length (Km)	Phase
1	0+000	5+534	5.534	Phase I
2	5+534	14+072	8.538	
3	14+072	36+281	22.209	
4	36+281	55+670	19.389	
5	55+670	79+102	23.432	
6	79+102	87+126	8.024	
7	87+126	117+211	30.085	
8	117+211	137+452	20.241	
9	137+452	157+063	19.611	
10	157+063	185+332	28.269	
11	185+332	216+755	31.423	
12	216+755	227+742	10.987	
13	227+742	261+800	34.058	
14	261+800	292+526	30.726	
15	292+526	306+054	13.528	
16	306+054	321+194	15.140	
17	321+194	333+184	11.990	
18	333+184	359+663	26.479	
19	359+663	377+353	17.690	
20	377+353	397+700	20.347	
21	397+700	424+557	26.857	Phase II
22	424+557	428+000	3.443	
23	428+000	438+780	10.780	
24	438+780	452+671	13.891	
25	452+671	465+798	13.127	
26	465+798	481+150	15.352	
27	481+150	486+993	5.843	
28	486+993	502+000*	15.007	
29	515+000	531+000	16.000	
30	531+000	552+000	21.000	
31	552+000	564+700	12.700	
Total			551.700	

*DPR study from km 502 to km 515 stretch of Delhi – Katra expressway is with another consultant.

4.1.3 Competing alternate routes

As the project corridor is greenfield / brownfield alignment and access control proposed upto km 502.000, various existing alternative routes have been identified. In order to calculate the potential divertible traffic which is currently plying on these routes and has the potential to shift on proposed expressway, detailed surveys have been conducted on these alternative routes.



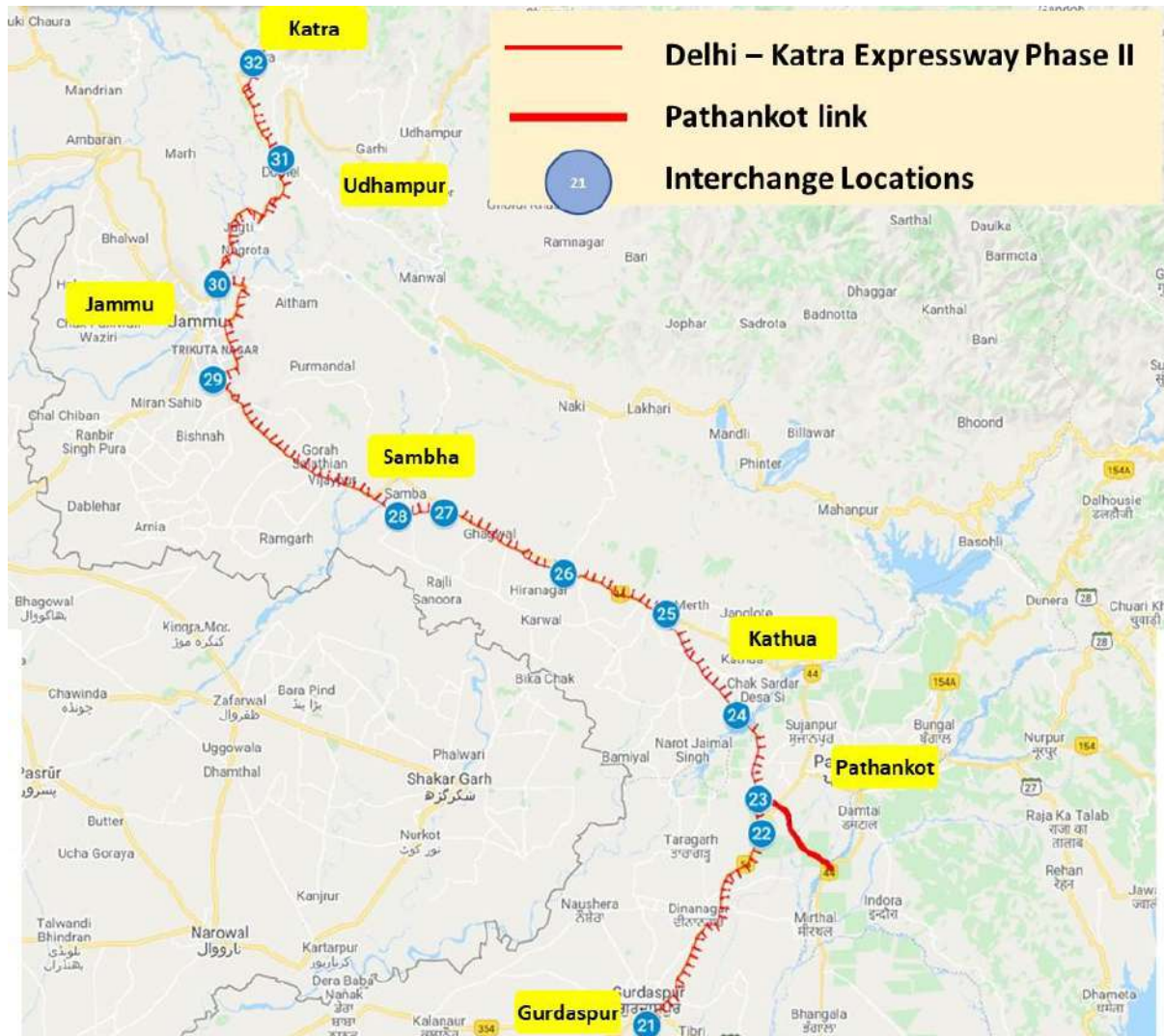


Figure 4-1: Project Road Sections and Interchange Locations

4.1.1.1 Alternate route for Traffic Movement between Delhi (Interchange 1) and Panipat (Interchange 4):

There is one existing alternative route for traffic movement between Delhi and Panipat. This route is via NH-44. It is pictorially shown in **Figure 4-8** and explained in detail in subsequent sections.

Alternate Route between Delhi (Interchange 1) and Ambala (Interchange 6):

Currently, traffic coming from Delhi, Rajasthan and other central and southern states of India and heading towards Ambala and further in North and North-East of Punjab and Haryana uses this route which is via NH-44. The alignment of this section is shown in **Figure 4-9** and explained in detail in subsequent sections.

Alternate Route between Delhi (Interchange 1) and Karnal (Interchange 7):

There is one existing alternative route for traffic movement between Delhi and Karnal. This route is via NH-44. It is pictorially shown in **Figure 4-10** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Chandigarh (Interchange 10):

This route is via combination of NH-44 and NH-152 which is pictorially shown in **Figure 4-11** & **Figure 4-12** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Ludhiana (Interchange 14):

As of today, NH-44 is the fastest route from Delhi to Ludhiana. The alignment of this section is shown in **Figure 4-13** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Jalandhar (Interchange 16):

As of today, NH-44 is the fastest route from Delhi to Jalandhar. The alignment of this section is shown in **Figure 4-14** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Amritsar (Interchange 18):

There are two exiting alternative routes for the traffic movement between Delhi and Amritsar. One is via NH-44 and NH-3 and other via combination of NH-54 and NH-9. The alignment of this section is shown in **Figure 4-15** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Gurdaspur (Interchange 21):

There are two exiting alternative routes for the traffic movement between Delhi and Gurdaspur. These routes are either via NH-44 or via combination of NH-54 and NH-9. The alignment of this section is shown in **Figure 4-16** and explained in detail in subsequent sections.

Alternate route between Ludhiana (Interchange 14) and Jalandhar (Interchange 16):

There is an existing alternative route for the traffic moving between Ludhiana and Jalandhar via NH-44. The alignment of this section is shown in **Figure 4-17** and explained in detail in subsequent sections.

Alternate route between Ludhiana (Interchange 14) and Amritsar (Interchange 18):

There is an existing alternative route for traffic moving between Ludhiana and Amritsar via combination of NH-44 and NH-03. The alignment of this section is shown in **Figure 4-18** and explained in detail in subsequent sections.

Alternate route between Amritsar (Interchange 19) and Gurdaspur (Interchange 21):

There is an existing alternative route for traffic moving between Amritsar and Gurdaspur via NH-54. The alignment of this section is shown in **Figure 4-19** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Pathankot (Interchange 22):

There are two exiting alternative routes for the traffic movement between Delhi and Pathankot. These routes are either via NH-44 or via combination of NH-54 and NH-9. The alignment of this section is shown in **Figure 4-20** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Jammu (Interchange 29):

There are two exiting alternative routes for the traffic movement between Delhi and Jammu till Pathankot then it traverses through NH-44. These routes are either via NH-44 or via combination of NH-54 and NH-9. The alignment of this section is shown in **Figure 4-20** and explained in detail in subsequent sections.

Alternate route between Delhi (Interchange 1) and Katra (Interchange 32):

There are two exiting alternative routes for the traffic movement between Delhi and Katra till Pathankot then it traverses through NH-44. These routes are either via NH-44 or via combination of NH-54 and NH-9. The alignment of this section is shown in **Figure 4-20** and explained in detail in subsequent sections.

Alternate route between Gurdaspur (Interchange 21) and Katra (Interchange 32):

There are one exiting alternative routes for the traffic movement between Gurdaspur and Katra. This route is via NH-54. It is pictorially shown in **Figure 4-21** and explained in detail in subsequent sections.

Alternate route between Talwara Jattan (NH-44) and Kathua (Interchange 25) (Pathankot link vs NH-44):

There are one exiting alternative routes for the traffic movement between Talwara Jattan and Kathua. This route is via NH-44. It is pictorially shown in **Figure 4-21** and explained in detail in subsequent sections.

4.1.4 Survey Methodology

4.1.5 Primary surveys and considerations

In order to capture traffic and travel characteristics, speed characteristics, users' preference regarding toll imposition of traffic passing through the existing alternative routes from Delhi to Gurdaspur, following primary traffic surveys were conducted.

- Classified traffic volume count (CTVC) using ATCC method
- Origin – destination survey (OD)
- Speed and Delay studies

Traffic survey stations for carrying out CTVC, OD and axle load surveys were selected after a site reconnaissance considering the following parameters.

- The station should be located at the alternate route alignment
- The station should be free from urban and local traffic influence
- The station should be located in a reasonably level terrain with good visibility

The summary of primary surveys conducted on the project corridor is illustrated in **Figure 4.2**.



4.1.6 Classified traffic volume count

The classified volume count surveys were carried out at six locations, considering the possibility of diversion of traffic from existing alternative routes to proposed expressway. These locations are characterized by centres of heavy economic activities, population and are away from the influence of city areas in order to avoid the influence of local traffic. The surveys were conducted continuously for seven consecutive days for 24 hours through Automatic Traffic Counter and Classifier (ATCC) method. For carrying out the counts, vehicles were grouped under different categories as indicated in **Table 4-2**.

Automatic Traffic Counter and Classifier (ATCC) is capable of counting vehicles according to their class with help of different non-intrusive technologies such as infrared sensors, Pneumatic tubes etc. Pneumatic Tube Technology was used for the present traffic study.

Table 4-2: Vehicle classification system

Motorized traffic	
2 wheelers: Scooters, bikes, motorcycles and mopeds etc.	
3 wheelers including auto rickshaw	
Passenger Car	Car, jeep, taxi & van
Bus	Minibus
	Govt. bus
	Private bus
Truck	Light commercial vehicles (LCV)
	2 Axle truck
	3 Axle truck
	4 to 6 Axle Truck
	Truck with more than 6 Axle
Other Vehicles	Agriculture Tractor, Tractor & Trailer
Slow moving vehicles/ Non- Motorized Traffic	
Bicycle, Cycle rickshaw, Animal drawn, Hand cart	

This traffic data is used to work out traffic analysis, forecast, capacity augmentation and toll analysis. The schedule of survey is given in **Table 4-3**.

Table 4-3: Schedule of traffic volume count survey

Location	Start Date	End Date	Duration (days)
Mukarba Chowk-Panipat Section of NH-44(Near Bhagan Toll Plaza)	21/05/2018	01/05/2018	7
Kurukshetra- Ambala Section of NH-44(Near Sharifgarh)	21/05/2018	01/05/2018	7
Ludhiana-Jalandhar Section of NH-44*			-
Jalandhar-Pathankot Section of NH-44*			-
Pathankot-Jammu Section of NH-44*			-
Amritsar - Gurdaspur Section of NH-54*			-
Gurdaspur - Pathankot Section of NH-54*			-
Hissar-Sirsa Section of NH-9*			-
Churu -Hissar Section of NH-52	10/01/2019	16/01/2019	7

Location	Start Date	End Date	Duration (days)
Jalandhar-Amritsar Section of NH-3	11/01/2019	17/01/2019	7
Patiala-Rajpura Section of NH-44(Near Daun Kalan)	21/05/2018	01/05/2018	7
Jammu – Domel Section of NH-44*			-
Domel – Katra	06/02/2020	12/02/2020	7

***CVC surveys at rest of locations along NH-44, NH-09 and NH-54 were not carried out as IHMCL data was available. For the purpose of OD analysis, the CVC data from the surveys carried out earlier has been used to determine the volume count according to the vehicular classification used for the present study.**

4.1.7 Origin-Destination survey

Origin-destination surveys were carried out with the primary objective of studying the travel pattern of goods and passenger traffic along the existing routes in the network. The results have also been useful for identifying the influence area of the proposed corridor, estimating the growth rates of traffic and planning tolling strategies. The tonnage analysis will form valuable inputs for pavement design.

The survey was conducted at twelve locations for a day (24 hours) as stated in **Table 4-4**. Roadside interview method was adopted for the survey in accordance with guidelines given by IRC: SP 19 – 2001. The road users were interviewed by trained enumerators to obtain the required data under the guidance of traffic engineers and supervisors.

For this purpose, cars and buses were considered as passenger vehicles. Similarly, LMVs, LCVs, 2-axle trucks, 3-axle trucks and Multi Axle Trucks (MAVs) were considered as goods vehicles. Data collected with the help of primary survey includes trip origin, trip destination and total trip length. In addition, type of commodity and tonnage for goods vehicles and purpose and occupancy for passenger vehicles were also collected. Further, trip frequency is also elicited during O-D survey.

Table 4-4: Schedule of origin – destination survey

Location	Start Date	End Date	Duration (days)
Delhi – Panipat section (NH-44 near Baghan)	01-06-2018	02-06-2018	1
Ambala -Kurukshetra section (NH-44 near Sarifgarh)	21-05-2018	22-05-2018	1
Rajpura – Patiala (NH-07 near Daun Kalan)	24-05-2018	25-05-2018	1
Jalandhar - Ludhiana section (NH-44 near Ladhawal)	01-06-2018	02-06-2018	1
Amritsar - Jalandhar section (NH-3 near Nirajpur)	29-05-2018	30-05-2018	1
Pathankot – Jalandhar section (NH-44 near HarsaMansar)	30-05-2018	31-05-2018	1
Amritsar - Gurdaspur section (NH-54 near WaryamNagal)	28-05-2018	29-05-2018	1
Pathankot – Jammu section (NH-44 near Lakhanpur)	31-05-2018	01-06-2018	1
Hisar – Sirsa section (NH-9 near Landhari)	31-05-2018	01-06-2018	1
Hisar – Churu section (NH-52 near Lasedij)	05-06-2018	06-06-2018	1
Gurdaspur - Pathankot section (NH-54 near Ladpalwan)	16-01-2019	17-01-2019	1
Jammu – Domel Section of NH-44*	10-02-2020	11-02-2020	1

4.1.8 Data Analysis

4.1.9 Traffic volume count

The classified traffic volume count survey data for six locations was analyzed in order to obtain the following traffic characteristics:

- Average hourly variation of traffic volume
- Daily variation of traffic volume
- Average Composition of traffic
- Directional distribution of traffic
- Average Daily Traffic (ADT) volume

Daily and hourly variation of classified traffic flow is recorded by conducting traffic count at strategically selected traffic count stations. Recorded traffic data is converted into Passenger Car Unit using PCU factors as shown in **Table 4-5**. These equivalency factors are extracted from IRC: 64 – 1990, Guidelines for Capacity of Roads in Rural Areas.

Table 4-5: Passenger car equivalency factors

Sl. No	Vehicle Type	PCU Factors
1	Two-Wheeler	0.5
2	Auto-rickshaw	1
3	Car / Jeep / Van	1
4	Minibus	1.5
5	Standard Bus	3
6	Light Commercial Vehicle (LCV), Agricultural Tractor	1.5
7	Two Axle Truck	3
8	Three Axle Truck	3
9	Truck Trailer/Multi Axle Vehicle	4.5
10	Agriculture Tractor-trailer	4.5
11	Animal Drawn	8
12	Cycle	0.5
13	Hand Cart	3
14	Cycle Rickshaw	2

4.1.10 Average daily traffic (ADT)

Traffic volume count data for seven days at each of the eleven count locations were averaged to determine Average Daily Traffic (ADT). Traffic volume count summary sheets for survey locations along with ADT tables are presented in **Annexure 4.1a to 4.1f** to this report. The survey location ADT by vehicle type is presented in **Table 4-6**.

Table 4-6: Average Daily Traffic at survey locations

Vehicle Type	Mukarba Chowk- Panipat Section of NH-44	Kurukshetra- Ambala Section of NH-44	Ludhiana-Jalandhar Section of NH-44	Jalandhar-Pathankot Section of NH-44	Pathankot-Jammu Section Of NH-44	Amritsar - Gurdaspur Section of NH-54	Gurdaspur– Pathankot section of NH-54	Patiala-Rajpura Section Of NH-7	Hissar-Sirsa Section of NH-9	Churu -Hissar Section of NH-52	Jalndhar-Amritsir Section of NH-3	Jammu - Domel Section of NH-44	Domel - Katra
Tollable Traffic No													
Car / Jeep / Van	46268	33453	27511	5801	7862	10593	6935	17826	7225	1658	19740	10180	3129
Car / Jeep (Taxi)										0	447		500
Shared Jeep										22	65		0
Minibus	681	608	0	0	0	0	0	94	0	8	181	0	158
School. Bus	0	0	0	0	0	0	0	0	0	8	89	0	11
Govt. Bus	2437	2406	0	0	0	0	0	891	0	49	474	0	59
Pvt. Bus	0	0	0	0	0	0	0	0	0	58	532	0	259
Maxx/Pick-Up	2395	1515	3150	565	283	961	677	1246	702	554	1279	916	0
LCV (4 tyre)	5952	4121	2923	759	848	403	592	644	601	156	136	940	0
LCV (6 tyre)	0	0	0	0	0	0	0	0	0	264	730	0	117
2 Axle	1111	2081	2992	1933	1947	1016	1315	444	813	190	366	2459	182
3 Axle	1886	2180	1266	1172	1155	718	1597	462	477	578	250	407	24
MAV (4 to 6 Axles)	1299	2249	637	294	662	501	1061	349	476	1463	342	249	9
MAV (> 6 Axles)	0	5	0	0	0	0	0	7	0	0	0	0	0
Others	35	0	11	4	4	2	5	0	2	0	3	8	0
Total vehicles	62064	48618	38490	10528	12761	14193	12182	21963	10295	5008	24635	15160	4448
Total PCUs	80918	72206	50734	18163	21719	19622	22032	27172	14846	12109	29790	22265	5687

Vehicle Type	Mukarba Chowk- Panipat Section of NH-44	Kurukshetra- Ambala Section of NH-44	Ludhiana-Jalandhar Section of NH-44	Jalandhar-Pathankot Section of NH-44	Pathankot-Jammu Section Of NH-44	Amritsar - Gurdaspur Section of NH-54	Gurdaspur– Pathankot section of NH-54	Patiala-Rajpura Section Of NH-7	Hissar-Sirsa Section of NH-9	Churu -Hissar Section of NH-52	Jalndhar-Amritsar Section of NH-3	Jammu - Domel Section of NH-44	Domel - Katra
Non Tollable Traffic													
3-Wheeler	1535	293	1607	92	184	193	557	726	298	17	2277	130	280
2-Wheeler	9030	4001	10591	4225	8063	6708	8978	5621	2119	503	10435	1634	764
Agriculture Tractor	60	37	47	32	13	14	23	32	24	5	18	9	2
Agriculture Tractor/ Trailer	293	131	313	221	97	99	275	206	228	176	142	61	14
Cycle	182	11	83	133	186	295	157	29	25	2	351	1	3
Cycle Rickshaw	18	1	9	12	30	69	15	8	6	0	38	0	0
Animal Drawn Cart	10	0	0	0	0	0	0	0	0	1	5	0	0
Toll Exempted Car	23	74	0	0	0	0	0	50	0	2	49	0	11
Toll Exempted Bus	0	0	0	0	0	0	0	0	0	0	20	0	1
Toll Exempted LCV	8	30	0	0	0	0	0	37	0	0	26	0	1
Toll Exempted Truck	18	32	0	0	0	0	0	30	0	1	2	0	18
Total Non-Tollable (Nos.)	11177	4610	12651	4714	8573	7379	10006	6739	2700	707	13363	1835	1094
Total Non-Tollable (PCUs)	7735	3161	8443	3335	4825	4301	6426	4738	2443	1080	8596	1237	799
Grand Total (Nos.)	73241	53228	51141	15243	21333	21572	22188	28702	12995	5715	37998	16995	5542
Grand Total (PCUs)	88652	75367	59177	21498	26544	23923	28458	31910	17289	13189	38386	23501	6486

Maximum traffic has been observed at Mukarba Chowk- Panipat Section of NH-44 near Bhagan Toll Plaza, followed by Kurukshetra –Ambala section of NH-44.

4.1.11 Annual average daily traffic (AADT)

Seasonal variation factors by vehicle types are required to account for variations in the pattern of traffic volume on the project road sections over different seasons of the year. These factors are worked out based on the month wise fuel sales data collected along the roads where the survey was carried out. The seasonal correction factors adopted for petrol and diesel driven vehicles are presented in **Table 4-7**.

Table 4-7: Seasonal Correctional Factors

Month	SCF	
	Petrol	Diesel
April	1.03	0.99
May	1.01	0.94
June	0.96	0.96
July	1.00	1.10
August	0.90	1.11
September	1.05	1.06
October	0.97	0.98
November	0.94	0.90
December	1.02	0.90
January	1.09	1.07
February	1.06	1.01
March	1.01	1.06
Average	1.00	1.01

The traffic volume survey along the project road is carried out in the month of May 2018 and seasonal factor for this month is considered for converting ADT to AADT. Vehicle class wise AADT at survey locations along the project road is shown in **Table 4-8**.

The AADT value of base year (FY-2019) is used for the traffic volume projection up to horizon year and projected traffic volume is used in design of pavement and for projecting the tollable traffic. Summary of ADT & AADT are shown in **Figure 4.3**.

Table 4-8: Annual Average Daily Traffic at survey locations

Vehicle Type	Mukarba Chowk-Panipat Section of NH-44	Kurukshetra- Ambala Section of NH-44	Ludhiana-Jalandhar Section of NH-44	Jalandhar-Pathankot Section of NH-44	Pathankot-Jammu Section Of NH-44	Amritsar - Gurdaspur Section of NH-54	Gurdaspur- Pathankot section of NH-54	Patiala-Rajpura Section of NH-7	Hissar-Sirsa Section of NH-9	Churu -Hissar Section of NH-52	Jalandhar-Amritsar Section of NH-3	Jammu - Domel Section of NH-44	Domel - Katra
Car / Jeep / Van	45343	32784	27731	6335	8916	11567	7004	17469	8193	1791	21319	8934	3066
Taxi										0	478		470
Shared Jeep										24	70		0
Minibus	681	608	0	0	0	0	0	94	0	8	181	0	158
School. Bus	2437	2406	0	0	0	0	0	891	0	8	89	0	11
Govt. Bus										49	475	0	59
Pvt. Bus										58	532	0	259
Maxx/Pick-Up	2251	1424	3175	604	317	1019	671	1171	789	593	1369	866	0
LCV (4 tyre)	5595	3874	2946	811	953	427	586	605	675	167	146	888	0
LCV (6 tyre)	0	0	0	0	0	0		0	0	282	781		110
2 Axle	1044	1956	3016	2064	2187	1078	1302	417	912	203	392	2324	171
3 Axle	1773	2049	1277	1252	1298	761	1581	434	536	618	268	384	23
MAV (4 to 6 Axles)	1221	2114	643	314	743	531	1050	328	534	1565	366	235	8
MAV (> 6 Axles)	0	5	0	0	0	0	0	7	0	0	0	0	0
Others	35	0	11	4	4	2	5	0	2	0	3	8	0
Total vehicles	60380	47220	38799	11384	14418	15385	12199	21416	11641	5366	26469	14539	4335
Total PCUs	78423	69700	51147	19535	24479	21142	21951	26422	16751	12944	31827	21250	5543
Non Tollable Traffic													

Vehicle Type	Mukarba Chowk-Panipat Section of NH-44	Kurukshetra- Ambala Section of NH-44	Ludhiana-Jalandhar Section of NH-44	Jalandhar-Pathankot Section of NH-44	Pathankot-Jammu Section Of NH-44	Amritsar - Gurdaspur Section of NH-54	Gurdaspur- Pathankot section of NH-54	Patiala-Rajpura Section of NH-7	Hissar-Sirsa Section of NH-9	Churu -Hissar Section of NH-52	Jalandhar-Amritsar Section of NH-3	Jammu - Domel Section of NH-44	Domel - Katra
3-Wheeler	1535	293	1687	97	193	203	557	726	313	17	2277	130	280
2-Wheeler	9030	4001	11121	4436	8466	7043	8978	5621	2225	503	10435	1634	764
Agriculture Tractor	60	37	49	34	14	15	23	32	25	5	18	9	2
Agriculture Tractor/ Trailer	293	131	329	232	102	104	275	206	239	176	142	61	14
Cycle	182	11	87	140	195	310	157	29	26	2	351	1	3
Cycle Rickshaw	18	1	9	13	32	72	15	8	6	0	38	0	0
Animal Drawn Cart	10	0	0	0	0	0	0	0	0	1	5	0	0
Toll Exempted Car	23	73	0	0	0	0	0	49	0	2	53	0	11
Toll Exempted Bus	0	0	0	0	0	0	0	0	0	0	20	0	1
Toll Exempted LCV	8	28	0	0	0	0	0	35	0	0	28	0	1
Toll Exempted Truck	17	30	0	0	0	0	0	28	0	1	2	0	17
Total Non-Tollable (Nos.)	11176	4605	13282	4952	9002	7747	10005	6734	2834	707	13369	1835	1093
Total Non-Tollable (PCUs)	7732	3151	8863	3506	5066	4514	6427	4728	2564	1080	8603	1236	796
Grand Total (Nos.)	71556	51825	52081	16336	23420	23132	22204	28150	14475	6073	39838	16374	5428
Grand Total (PCUs)	86154	72851	60010	23041	29545	25656	28377	31150	19314	14024	40430	22485	6339

Table 4-9: Summary of ADT and AADT at survey locations

Sl. No.	Location	ADT		AADT	
		Nos.	PCUs	Nos.	PCUs
1	Mukarba Chowk-Panipat Section of NH-44	73241	88652	71556	86154
2	Kurukshetra- Ambala Section of NH-44	53228	75367	51825	72851
3	Ludhiana-Jalandhar Section of NH-44	51141	59177	52081	60010
4	Jalandhar-Pathankot Section of NH-44	15243	21498	16336	23041
5	Pathankot-Jammu Section Of NH-44	21333	26544	23420	29545
6	Amritsar - Gurdaspur Section of NH-54	21572	23923	23132	25656
7	Gurdaspur - Pathankot Section of NH-54	22188	28458	22204	28377
8	Patiala-Rajpura Section Of NH-7	28702	31910	28150	31150
9	Hissar-Sirsa Section of NH-9	12995	17289	14475	19314
10	Churu -Hisar Section of NH-52	5715	13189	6073	14024
11	Jalandhar-Amritsar Section Of NH-44	37998	38386	39838	40430
12	Jammu - Domel Section of NH-44	16995	23501	16374	22485
13	Domel – Katra Section	5542	6486	5428	6339

4.1.12 Composition of traffic

The composition of tollable and total traffic at count locations is presented in **Table 4-10, Table 4-11** and

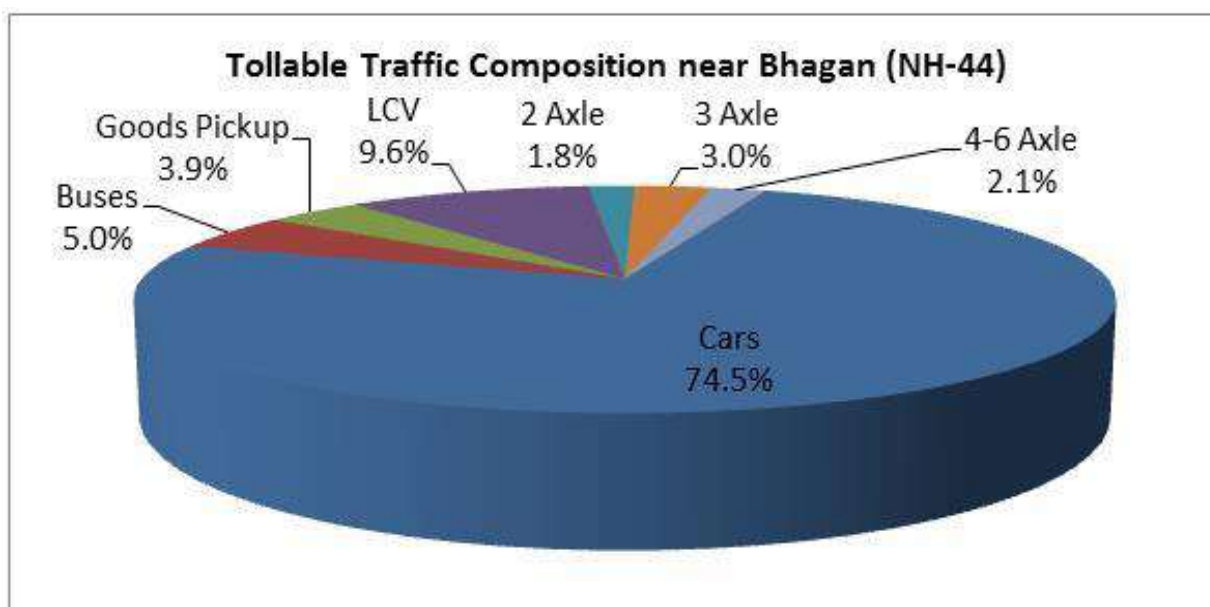
Figure 4-2. The share of car/jeep varies between 62.1% and 63.2% while 3-wheelers vary from 0.6% to 2.5%, whereas trucks composition varies from 11.5% to 22.8 % of traffic. The buses constitute 4.4% to 5.7% of total traffic.

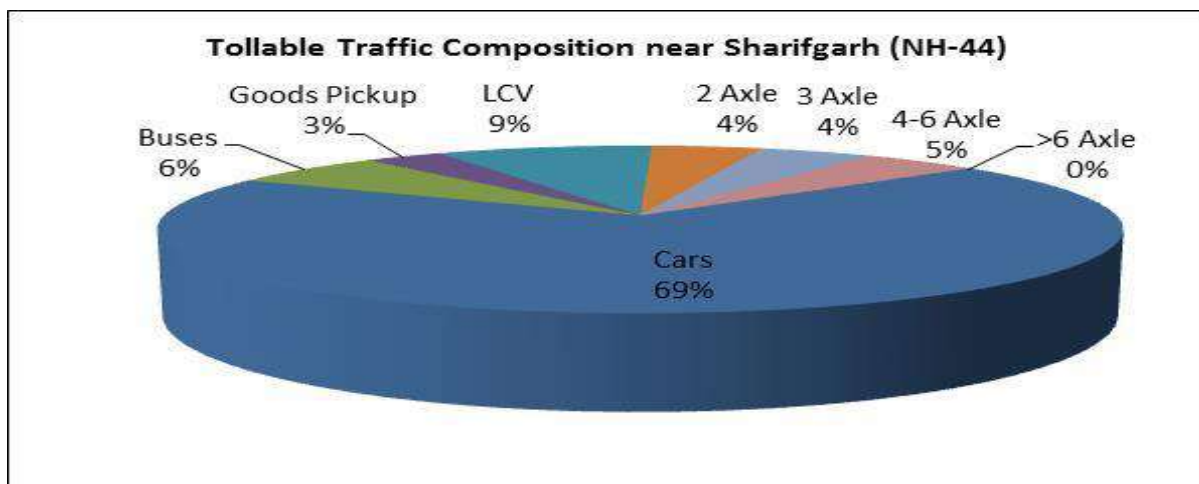
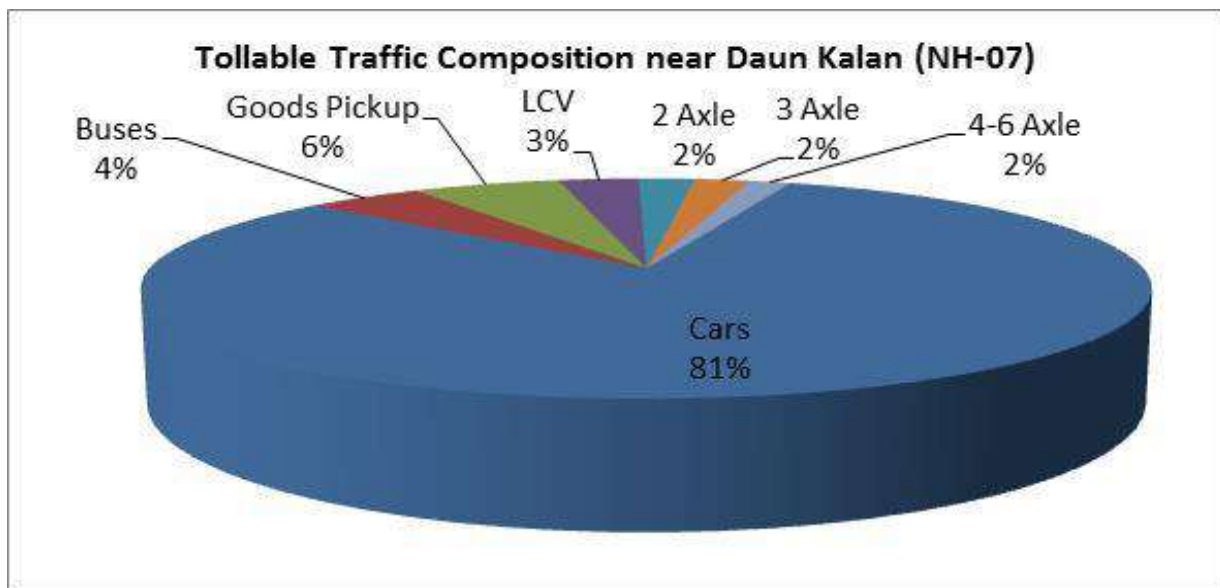
Table 4-10: Total Traffic Composition at Survey Locations

Location	Passenger Vehicles (%)				Goods Vehicles (%)		Slow Moving Vehicle (%)
	Car	2 W	3 W	Buses	Truck	Tractor	
Mubarak Chowk – Panipat section (NH-44 near Baghan)	63.2	12.3	2.1	4.26	17.35	0.5	0.3
Rajpura – Patiala (NH-07 near Daun Kalan)	62.1	19.6	2.5	3.4	11.5	0.8	0.1
Ambala -Kurukshetra section (NH-44 near Sarifgarh)	62.8	7.5	0.6	5.8	22.8	0.5	0
Churu – Hisar (Lasari Toll Plaza NH-52)	29.43	8.8	0.3	2.15	56.1	3.17	0.05
Jalandhar – Amritsar NH-3	53.43	27.46	5.99	3.41	8.25	0.42	1.04
Domel - Katra	65.68	13.79	5.05	8.81	6.33	0.29	0.05

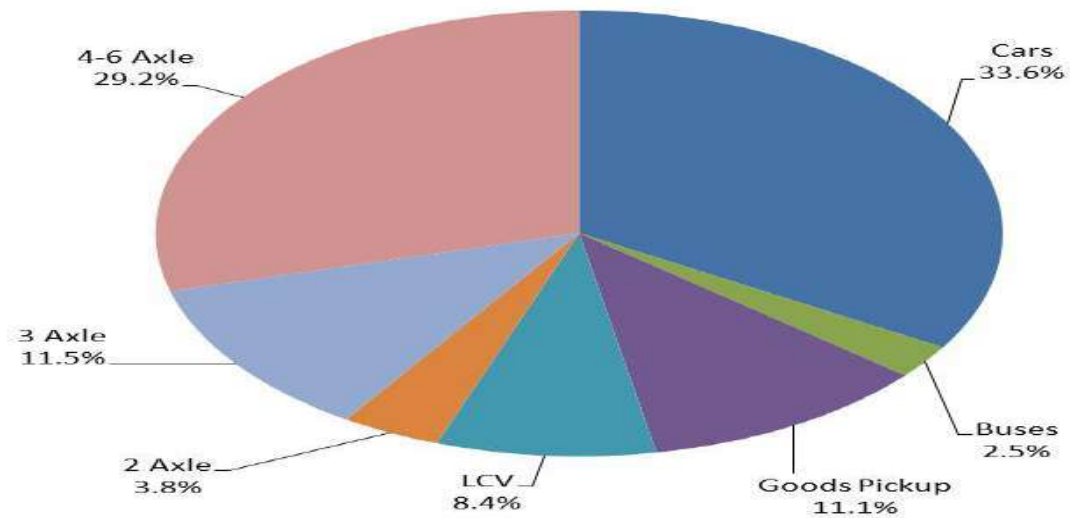
Table 4-11: Tollable Traffic Composition at Survey Locations

Location	Passenger Vehicles (%)			Goods Vehicles (%)				
	Cars	Taxi	Buses	Goods Vehicles	LCV	2 Axle	3 Axle	4-6 Axle
Mubarak Chowk – Panipat section (NH-44 near Baghan)	74.5	0.0	5.0	3.9	9.6	1.8	3.0	2.2
Rajpura – Patiala (NH-07 near Daun Kalan)	81.2	0.0	4.5	5.7	2.9	2.0	2.1	1.6
Ambala -Kurukshetra section (NH-44 near Sarifgarh)	68.8	0.0	6.2	3.1	8.5	4.3	4.5	4.6
Churu – Hisar (Lasari Toll Plaza NH-52)	33.57	0.00	2.45	11.06	8.38	3.81	11.53	29.20
Jalandhar Amritsar NH-3	80.28	1.81	5.24	5.17	3.61	1.49	1.01	1.38
Domel - Katra	70.10	11.16	10.90	0.00	2.63	4.47	0.54	0.20

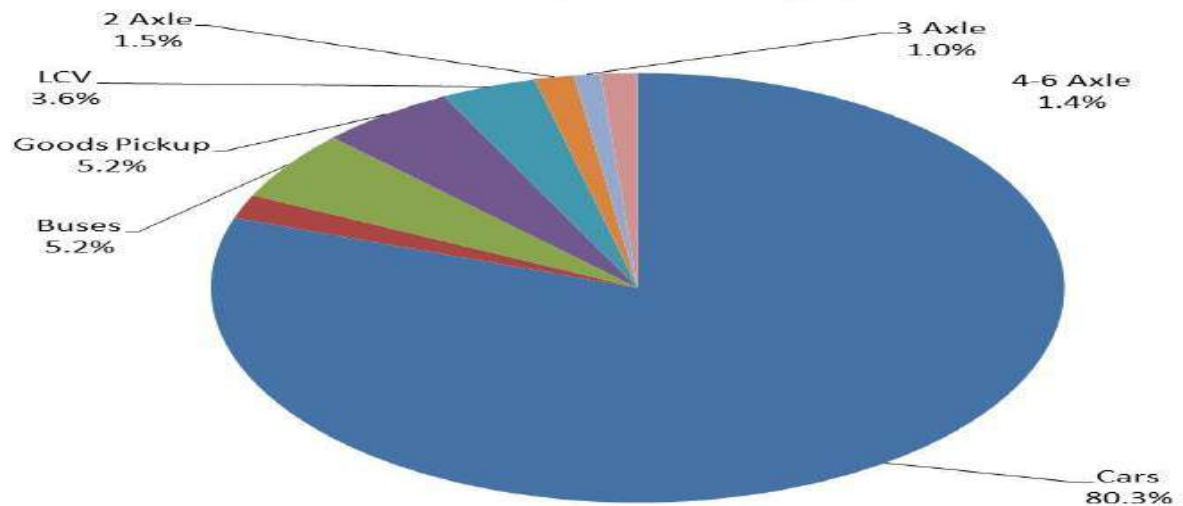




Tollable Traffic Composition near Laseri Toll



Tollable Traffic Composition near Nijjarpur Toll



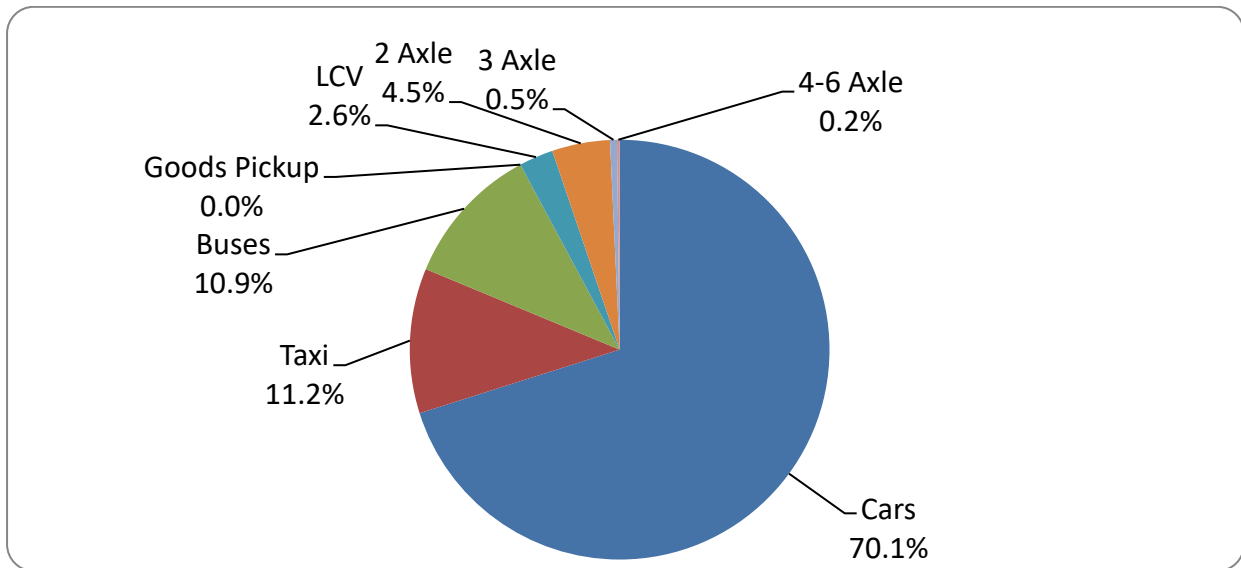


Figure 4-3: Tollable Traffic Composition

4.1.13 Hourly variation of traffic

Average hourly variation of traffic at survey locations is shown in **Figure 4-4**. At all the three locations, peak hour is observed between 17.00PM to 18.00PM

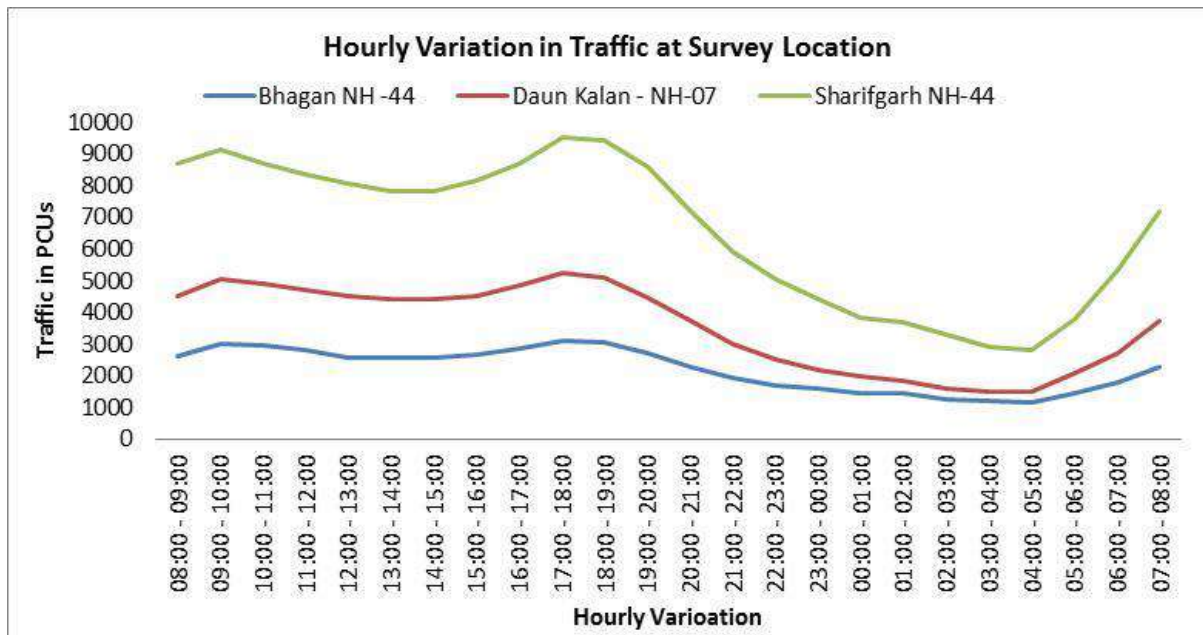


Figure 4-4: Hourly traffic variation at survey locations

4.1.14 Daily variation of traffic volume

Daily variation of tollable traffic for survey locations is shown in **Figure 4-5**. The variation of daily tollable traffic PCU is presented in **Table 4-12** along with maximum and minimum variations from average volume.

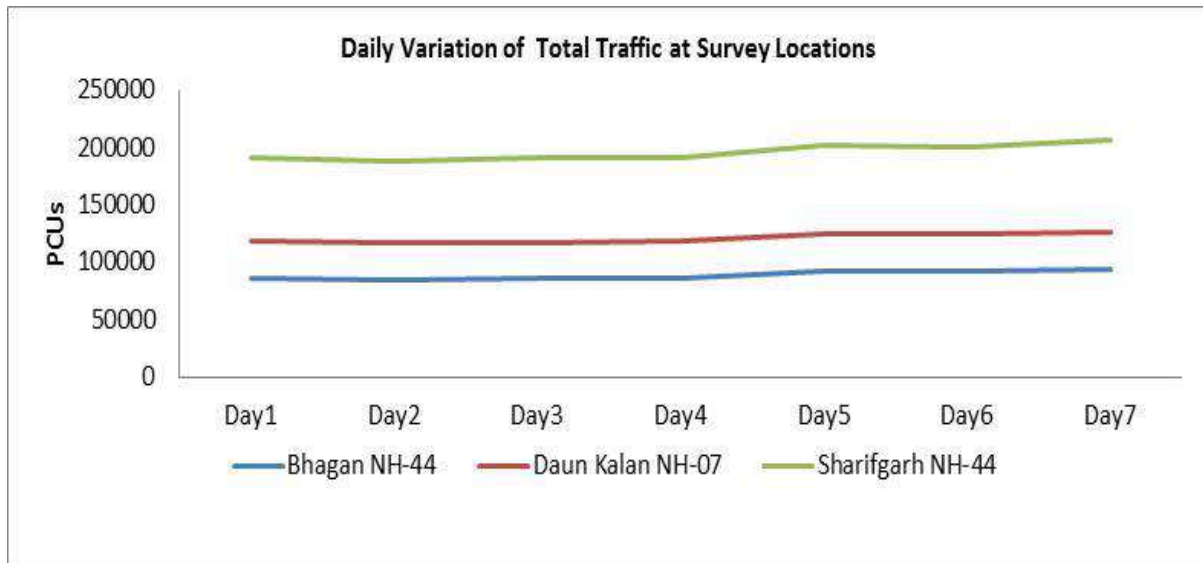


Figure 4-5: Daily variation of tollable traffic at survey locations

Table 4-12: Daily Variation of Tollable Traffic Volume (PCUs)

Location	Mon	Tue	Wed	Thu	Fri	Sat	Sun	ADT	Maximum variation	
									+Ve (%)	- Ve (%)
Mubarak Chowk – Panipat section (NH-44 near Baghan)	85223	85057	85737	86296	91683	92419	94174	88652	6.0	-4.0
Rajpura – Patiala (NH-07 near Daun Kalan)	32442	31366	31450	31599	32419	32735	31352	31910	3.0	-2.0
Ambala -Kurukshetra section (NH-44 near Sarifgarh)	73185	71742	74248	73792	78389	75491	80692	75367	7.0	-5.0
Churu – Hisar (Lasari Toll Plaza_NH-52)	12799	12999	11517	13594	13839	13920	13636	13189	6.0	-13.0
Jalandhar – Amritsar_NH-3	35770	40674	40055	40397	41952	39318	30542	38386	9.0	-20.0
Domel - Katra	6908	7399	6460	6468	5857	6004	6292	6484	14.07	-9.71

Day wise variation is given at each survey location. It is observed that variations in traffic across the week is varying on each day and is attributed to local factors along with other reasons like market days, weekly holidays etc.

4.1.15 Directional distribution of traffic

Directional split at survey locations is shown in **Table 4-13**. This is a useful input for capacity analysis and pavement design. As seen, the directional split for up and down traffic is almost equal along the survey locations.

Table 4-13: Directional split

Location	UP Direction (%)	Down Direction (%)
Mubarak Chowk– Panipat section (NH-44 near Baghan)		
Rajpura – Patiala (NH-07 near Daun Kalan)		
Ambala -Kurukshetra section (NH-44 near Sarifgarh)		
Churu – Hisar (Lasari Toll Plaza NH-52)		
Jalandhar – Amritsar NH-3		
Domel – Katra		

4.1.16 Origin – Destination Survey

The origin–destination survey was carried out at locations provided in previous section. The analysis of daily flow of classified traffic volume count has been the basis for fixing sample size of vehicles by type and direction. The expansion factors are calculated based on ADT and sample size at each location separately. Percentage of OD sample size at each location is presented in **Table 4-14**.

Table 4-14: Sample Size for O – D Survey (%)

Vehicle type	Delhi – Panipat section (NH-44 near Baghan)	Ambala -Kurukshetra section (NH-44 near Sarifgarh)	Rajpura – Patiala (NH-07 near Daun Kalan)	Jalandhar - Ludhiana section (NH-1 near Ladhawal)	Amritsar - Jalandhar section (NH-1 near Nirajpur)	Pathankot – Jalandhar section (NH-44 near HarsaMansar)	Amritsar - Gurdaspur section (NH-54 near WaryamNagal)	Gurdaspur - Pathankot section (NH-54 near Ladpalwan Toll)	Pathankot – Jammu section (NH-44 near Lakhampur)	Hisar – Sirsa section (NH-9 near Landhari)	Hisar – Churu section (NH-52 near Lasedij)	Jammu - Domel section (NH-44 near Bann Toll Plaza)
Car	15.0	15.0	42.0	17.0	17.0	24.0	23.0	29.4	20.0	25.4	38.0	18.0
Minibus	39.0	11.0	39.0	55.0	12.0	19.0	49.0	34.1	34.0	56.9	88.0	82.0
Std Bus	48.0	11.0	44.0	61.0	12	76.0	74.0	51.6	35.0	53.0	62.0	41.9
Mini LCV	24.0	12.0	29.0	40.0	8.0	21.0	14.0	24.4	68.0	24.6	56.0	21.0
LCV	32.0	35.0	55.0	30.0	49.0	48.0	23.0	39.3	67.0	31.3	59.0	21.9

Vehicle type	Delhi – Panipat section (NH-44 near Baghan)	Ambala -Kurukshetra section (NH-44 near Sarifgarh)	Rajpura – Patiala (NH-07 near Daun Kalan)	Jalandhar - Ludhiana section (NH-1 near Ladhowal)	Amritsar - Jalandhar section (NH-1 near Nirajpur)	Pathankot – Jalandhar section (NH-44 near HarsaMansar)	Amritsar - Gurdaspur section (NH-54 near WaryamNagal)	Gurdaspur - Pathankot section (NH-54 near Ladpalwan Toll)	Pathankot – Jammu section (NH-44 near Lakhapur)	Hisar – Sirsa section (NH-9 near Landhari)	Hisar – Churu section (NH-52 near Lasedij)	Jammu - Domel section (NH-44 near Bann Toll Plaza)
2A	47.0	33.0	54.0	49.0	64.0	40.0	14.0	39.8	68.0	42.0	77.0	50.2
3A	41.0	40.0	58.0	51.0	71.0	64.0	26.0	38.2	67.0	47.0	65.0	14.3
4-6 A	43.0	16.0	59.0	56.0	55.0	70.0	44.0	75.0	87.0	39.1	63.0	19.3

Data collected was checked manually and analyzed in excel. Incorrect entries were removed by cross-checking it with original field data sheets. Inconsistencies were also monitored. The checked and corrected data was used for final analysis. The checking includes:

- Trips from zones to zones which cannot possibly ply through the survey location
Vehicle type with their corresponding lead / load / occupancy for any inconsistencies

4.1.17 Zoning system

For analysis of O-D data collected from the field, it is required to code the origin and destination of trip. The zoning was done at four levels. In first level, all-important towns located along the proposed project stretch were assigned a zone code. Secondly, immediate influence areas of project road were considered, and nearby areas/towns were defined as zones. In the next level, all nearby districts were grouped in zones. Finally, states beyond the influence area were aggregated broadly in terms of direction of project road. In all, total 99 traffic analysis zones (TAZs) were created for the project road. The list of traffic zones is presented in **Table 4-15**.

Table 4-15: Adopted zoning system for the study

Zone No.	Zone Name	District	State
1	New Delhi	Delhi	Along the Project Road
2	Bahadurgarh	Haryana	
3	Kharkhoda, Sampla		
4	Rohtak		
5	Gohana, Mundlana		
6	Jind, Barwala		
7	Kaithal, Narwana, Kalayat		
8	Patran	Punjab	
9	Sangrur, Sunam		

Zone No.	Zone Name	District	State
10	Bhawanigarh		
11	Dhuri, Maler Kotla		
12	Barnala		
13	Bhatinda, Mansa		
14	Patiala		
15	Raikot, Jagraon		
16	Ludhiana		
17	Moga		
18	Jalandhar		
19	Amritsar		
20	Gurdaspur		
21	Pathankot		
22	Kathua	J & K	
23	Jammu		
24	Katra, KatraVaishno Devi	Delhi	Delhi
25	Dwarka , Janakpuri, UttamNatar (South West)		
26	Rajouri Garden (West Delhi), Khanjhwala (North West), Narela (North Delhi)		
27	Seelampur (North East), Daryaganj (Central Delhi), Shahdara, Preet Vihar, Anand Vihar (East Delhi)		
28	Defence Colony (South East), Saket (South Delhi)	Haryana	Sonepat
29	Sonepat		
30	Gannur		Panipat
31	Panipat		
32	Samlakha		Districts of Haryana
33	Karnal		
34	Kurukshetra		
35	Yamunanagar,		
36	Ambala		
37	Gurgaon		
38	IMT Manesar		
39	Faridabad, Palwal, Nuh		
40	Riwari		
41	Jhajjar		
42	Charkhi Dadri, Mahendergarh		
43	Bhiwani		
44	Hisar		
45	Fatehabad, Sirsa		
46	Rajpura	Patiala	Punjab
47	Nabha, Samana		
48	Fatehgarh Sahib	Fatehgarh Sahib	
49	Chandigarh	Chandigarh	

Zone No.	Zone Name	District	State
50	Ladhowal	Ludhiana	
51	Khanna, Payal		
52	Samrala		
53	Phillaur	Jalandhar	
54	Nakodar	Kapurthala	
55	Kapurthala		
56	Phagwara		
57	Rupnagar	Rupnagar	
58	Nawanshahr	Nawanshahr	
59	Hoshiarpur	Hoshiarpur	
60	Dasuya		
61	Mukherian		
62	Taran	Taran	
63	Firozpur	Firozpur	
64	Faridkot	Faridkot	
65	Muktsar, Fazilka	Muktsar, Fazilka	
66	Rayya	Amritsar	
67	Ajnala		
68	Batala	Gurdaspur	
69	Dinanagar		
70	Sambha	Jammu Division	J&K
71	Udhampur		
72	Doda, Kishtwar,Rajouri, Reasi, Ramban, Poonch		
73	Srinagar, Anantnag, Kulgam, Pulwama, Shopian, Budgam, Ganderbal, Bandipora, Baramulla, Kupwara	Kashmir Division	
74	Leh	Ladakh Division	
75	Sirmaur, Solan, Shimla, Kinnaur	Himachal Pradesh	Himachal Pradesh
76	Bilaspur, Una, Hamirpur, Mandi, Kullu		
77	Kangra, Chamba, Kyelang		
78	Saharanpur, Shamli, Muzaffarnagar, Bagpat, Meerut	Uttar Pradesh	Uttar Pradesh
79	Meerut, Bijnor, Hapur, Amroha, Moradabad, Lucknow, Allahabad		
80	Bulandshahr, Aligarh, Mathura, Agra		
81	Ghaziabad, Dadri, Noida		
82	Rest of Uttar Pradesh		
83	Haridwar, Dehradun	Uttarakhand	Uttarakhand
84	Garhwal, Tehri Garhwal, Uttarakashi		
85	Rest of Uttarakhand		
86	Sri Ganganagar, Hanumangarh	Rajasthan	Rajasthan
87	Churu, Bikaner, Nagaur, Sikar, Jhunjhun		

Zone No.	Zone Name	District	State
88	Alwar, Dausa, Bharatpur, Jaipur, Ajmer, Bhilwara, Chittaurgarh, Udaipur		
89	Dholpur, Karauli, Tonk, Sawaimadhopur, Bundi, Kota, Baran, Jhalawar, Pratapgarh, Banswara, Dungarpur		
90	Jaisalmer, Jodhpur, Barmer, Jalor, Sirohi, Pali, Rajsamand		
91	Maharashtra	other States of India	other States of India
92	Kerala		
93	Tamil Nadu		
94	Karnataka, Goa		
95	Andhra Pradesh, Telengana		
96	Gujarat		
97	Madhya Pradesh		
98	Bihar, Jharkhand, Orissa, Chhattisgarh, West Bengal		
99	Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Assam, Meghalaya		

4.1.18 Expansion factors and development of O–D matrices

The origin–destination details were collected during the survey on sample basis. Sampling varied with the changes in traffic flow across the day. Care has been taken to eliminate any element of bias in sampling. Since data was collected on sample basis, expansion factors are required to replicate the pattern as reflected in the sample to the total number of vehicular trips made during the day. These expansion factors are calculated separately for each class of vehicle. For example, if x_c is number of cars interviewed and X_c is the total number of cars counted during the day, then X_c/x_c would be the expansion factor for the matrix of cars.

O–D matrices are developed to assess the traffic movement pattern. These matrices actually speak about distribution of trips for each zone as intra zonal and inter zonal movements. The vehicle wise O–D matrices are developed by multiplying the sample O–D matrix obtained from survey data with expansion factors. Accordingly, 8 matrices, for different modes were developed for each survey location. O–D matrices for different vehicle types for all seven survey locations are presented in **Annexure 4.2A to 4.2L**.

4.1.19 Travel Pattern

The share of trips from major areas within the project road is presented in **Table 4-16**.

Table 4-16: Distribution of Trip in the Project Influence Area

State/ Vehicle Type	Passenger Vehicles (%)			Freight Vehicles (%)				
	Car	Minibus	Bus	Mini LCV	LCV	2-Axle Trucks	3- Axle Trucks	MAV (4 to 6 Axle)
Punjab	46	44	43	49	31	42	41	33
Haryana	29	23	21	31	36	20	24	29
Delhi	14	16	18	9	15	12	10	11
J & K	5	7	8	5	6	16	13	10
Rest of India	7	10	10	6	12	10	12	16
Total	100	100	100	100	100	100	100	100

From the above tables, it is observed that most of the trips originating or destined are from Punjab followed by Haryana and Delhi.

4.1.20 Lead Distribution

The O-D survey data has been analysed to obtain lead ranges for various categories of vehicles. Different categories of freight vehicles viz. LCV, 2/3 axle trucks and multi axle trucks are distributed on the basis of spectrum developed using various load and lead ranges. The lead distribution in terms of percentage is also presented in **Table 4-17** and **Table 4-18**.

Table 4-17: Lead Distribution of Passenger Vehicle

Vehicle type	Trip Length Range (km)							Total
	0-20	20-50	50-100	100-200	200-500	500-1000	>1000	
Delhi – Panipat section (NH-44 near Baghan)								
Car	0.3	2.6	13.0	33.8	47.1	2.6	0.8	100.00
Mini Bus	0.0	2.8	8.0	28.4	54.5	5.2	1.2	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Rajpura – Patiala (NH-07 near Daun Kalan)								
Car	9.4	26.8	30.7	18.4	14.5	0.1	0.1	100.00
Mini Bus	5.3	71.6	18.9	4.2	0.0	0.0	0.0	100.00
Std. Bus	19.9	11.7	35.7	19.3	13.0	0.2	0.2	100.00
Ambala -Kurukshetra section (NH-44 near Sarifgarh)								
Car	0.0	0.0	18.9	16.6	60.3	3.5	0.7	100.00
Mini Bus	0.0	0.0	16.3	12.4	60.9	7.4	3.0	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Jalandhar - Ludhiana section (NH-1 near Ladhowal)								
Car	11.1	9.9	34.2	21.5	18.5	3.4	1.5	100.00
Mini Bus	5.9	7.5	47.2	21.5	15.2	2.0	0.7	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Amritsar - Jalandhar section (NH-1 near Nirajpur)								

Vehicle type	Trip Length Range (km)							Total
	0-20	20-50	50-100	100-200	200-500	500-1000	>1000	
Car	0.0	5.1	33.3	14.3	43.0	2.7	1.5	100.00
Mini Bus	0.0	20.0	20.0	0.0	60.0	0.0	0.0	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Pathankot – Jalandhar section (NH-44 near HarsaMansar)								
Car	0.0	15.5	2.8	28.3	38.7	12.7	2.0	100.00
Mini Bus	0.0	4.1	0.0	22.1	31.1	33.6	9.0	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Amritsar - Gurdaspur section (NH-54 near WaryamNagal)								
Car	0.0	51.4	16.3	18.8	13.2	0.1	0.1	100.00
Mini Bus	0.0	23.7	0.0	44.7	31.6	0.0	0.0	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Gurdaspur - Pathankot section (NH-54 near Ladpalwan)								
Car	0.3	49.1	3.8	27.7	17.5	1.5	0.1	0.3
Mini Bus	0.0	13.2	0.0	56.6	30.2	0.0	0.0	0.0
Std. Bus	0.0	5.5	0.0	64.7	27.6	2.2	0.0	0.0
Pathankot – Jammu section (NH-44 near Lakhanpur)								
Car	5.3	0.4	0.6	21.1	31.1	33.9	7.5	100.00
Mini Bus	16.7	4.9	0.0	27.8	31.9	12.5	6.3	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Hisar – Sirsa section (NH-9 near Landhari)								
Car	0.0	0.0	52.5	11.1	33.7	2.2	0.6	100.00
Mini Bus	0.0	0.0	61.1	0.0	38.9	0.0	0.0	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Hisar – Churu section (NH-52 near Lasedi)								
Car	0.6	10.2	2.9	69.7	13.7	1.3	1.5	100.00
Mini Bus	0.0	12.5	0.0	48.2	39.3	0.0	0.0	100.00
Std. Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00
Jammu – Domel Section (Bann Toll Plaza)								
Car	0.0	60.0	0.4	0.9	36.3	1.8	0.7	100.00
Mini Bus	0.0	64.2	0.0	4.5	28.4	3.0	0.0	100.00
Std. Bus	0.4	74.7	0.0	0.5	23.4	0.6	0.5	100.00

Table 4-18: Lead Distribution of Goods Vehicle

Vehicle type	Trip Length Range (km)						
	0-20	20-100	100-200	200-500	500-1000	>1000	Total
Delhi – Panipat section (NH-44 near Baghan)							
Mini LCV	7.1	31.3	42.1	19.0	0.3	0.2	100.0
LCV	1.9	17.4	40.4	36.8	2.3	1.2	100.0
2A	1.3	8.7	25.6	51.2	9.3	3.9	100.0
3A	1.4	11.9	37.1	42.7	4.7	2.1	100.0
MAV	3.5	10.6	38.2	41.9	3.9	1.9	100.0
Rajpura – Patiala (NH-07 near Daun Kalan)							
Mini LCV	55.7	21.0	16.7	6.3	0.0	0.3	100.0
LCV	49.4	20.9	18.1	9.6	1.3	0.7	100.0

Vehicle type	Trip Length Range (km)						Total
	0-20	20-100	100-200	200-500	500-1000	>1000	
2A	44.8	19.7	22.3	10.6	1.0	1.7	100.0
3A	36.8	24.4	20.9	14.0	1.6	2.3	100.0
MAV	25.4	22.7	21.5	18.2	0.9	11.3	100.0
Ambala -Kurukshetra section (NH-44 near Sarifgarh)							
Mini LCV	0.0	29.9	12.5	46.1	7.5	3.9	100.0
LCV	0.1	11.9	14.1	56.1	12.0	5.8	100.0
2A	0.0	9.1	13.4	56.7	13.8	7.1	100.0
3A	0.0	9.0	13.4	55.7	14.1	7.9	100.0
MAV	0.0	11.7	14.2	53.5	11.2	9.4	100.0
Jalandhar - Ludhiana section (NH-1 near Ladhowal)							
Mini LCV	13.2	33.4	22.2	21.3	7.3	2.6	100.0
LCV	15.8	31.8	22.4	20.6	5.7	3.7	100.0
2A	7.6	30.2	23.6	26.6	7.5	4.6	100.0
3A	7.2	27.0	24.8	25.6	8.5	6.9	100.0
MAV	9.5	19.9	20.1	31.9	10.0	8.7	100.0
Amritsar - Jalandhar section (NH-1 near Nirajpur)							
Mini LCV	1.7	53.3	15.0	30.0	0.0	0.0	100.0
LCV	1.9	28.2	20.4	42.7	6.8	0.0	100.0
2A	1.2	37.0	19.8	39.5	2.5	0.0	100.0
3A	0.0	0.0	0.0	0.0	0.0	0.0	100.0
MAV	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Pathankot – Jalandhar section (NH-44 near HarsaMansar)							
Mini LCV	11.4	3.1	46.9	30.1	8.4	0.0	100.0
LCV	13.2	2.3	32.9	30.6	17.4	3.6	100.0
2A	5.6	2.3	31.8	38.4	17.9	4.0	100.0
3A	10.9	1.7	43.1	27.5	13.1	3.8	100.0
MAV	4.1	1.3	36.0	39.2	14.3	5.1	100.0
Amritsar - Gurdaspur section (NH-54 near WaryamNagal)							
Mini LCV	27.1	2.1	32.7	29.1	3.4	5.6	100.0
LCV	25.1	20.0	26.9	19.4	4.9	3.7	100.0
2A	18.7	4.9	35.9	32.5	2.0	6.0	100.0
3A	10.1	6.6	48.1	24.0	4.1	7.1	100.0
MAV	7.3	3.9	35.2	29.3	3.2	21.1	100.0
Gurdaspur - Pathankot section (NH-54 near Ladpalwan)							
Mini LCV	49.3	11.2	22.1	14.8	2.2	0.4	100.0
LCV	15.4	5.4	49.2	24.8	3.8	1.5	100.0
2A	15.3	8.0	32.6	36.8	5.7	1.5	100.0
3A	17.7	7.6	35.2	28.9	6.9	3.7	100.0
MAV	10.1	3.6	31.2	35.3	9.7	10.0	100.0
Pathankot – Jammu section (NH-44 near Lakhanpur)							
Mini LCV	6.3	0.3	50.5	31.5	9.8	1.6	100.0
LCV	1.5	0.4	18.5	36.5	36.4	6.7	100.0
2A	0.8	0.0	6.7	27.2	54.7	10.6	100.0
3A	0.4	0.2	9.6	40.9	34.3	14.6	100.0
MAV	0.3	0.0	11.0	17.0	48.2	23.6	100.0

Vehicle type	Trip Length Range (km)						Total
	0-20	20-100	100-200	200-500	500-1000	>1000	
Hisar – Sirsa section (NH-9 near Landhari)							
Mini LCV	0.0	66.2	25.6	8.2	0.0	0.0	100.0
LCV	0.0	48.8	10.3	34.7	4.0	2.3	100.0
2A	0.0	37.0	14.1	42.6	2.1	4.3	100.0
3A	0.0	27.6	31.5	37.7	1.1	2.1	100.0
MAV	0.0	19.5	24.0	45.2	3.2	8.1	100.0
Hisar – Churu section (NH-52 near Lasedi)							
Mini LCV	1.0	1.0	72.0	17.9	5.3	2.9	100.0
LCV	1.8	1.8	60.7	26.8	3.6	5.4	100.0
2A	9.8	2.0	33.3	25.5	7.8	21.6	100.0
3A	5.8	1.9	34.6	21.2	11.5	25.0	100.0
MAV	4.2	0.0	29.2	29.2	12.5	25.0	100.0
Jammu – Domel Section (Bann Toll Plaza)							
Mini LCV	32.3	2.3	11.0	52.7	1.7	0.0	100.0
LCV	25.5	0.9	2.0	69.6	1.2	0.8	100.0
2A	18.4	0.4	0.0	79.3	1.3	0.6	100.0
3A	11.7	0.0	1.6	82.3	3.9	0.5	100.0
MAV	15.3	2.6	1.3	73.2	0.0	7.7	100.0

Zones with highest trip attraction and generation centers are Delhi, Chandigarh, Amritsar, Jalandhar, Ludhiana, Pathankot and Jammu.

4.1.21 Commodity Group and Analysis

The different commodities recorded during O–D survey have been classified in 17 categories and are presented in **Table 4-19**. Due consideration has been given to include all possible commodities and to categorize them into homogeneous groups.

Table 4-19: Classification of commodities

Code	Commodity type
1	Food grains and other agricultural products (Rice, wheat, pulses, maize, chilly, coconut, sugarcane, sugar, cotton, coffee, tea, eggs etc.)
2	Fruits, vegetables – perishables
3	Wood and Forest Products
4	Petroleum, oil, Gas and lubricants product
5	Minerals, chemicals, fertilizer
6	Iron, Metal and steel
7	Finished and manufactured products (Vehicles, Products of machinery, rubber, electric & electronics, textile, automobile, glass, plastic etc.)
8	Parcel Service & Containers
9	Medicines
10	Building materials (Brick, Tiles, Mud and Blocks)
11	Mining (Sand, Bajri and Coarse Aggregate)
12	Cement
13	Marble stone
14	Textiles & Fiber

Code	Commodity type
15	Coal
16	Miscellaneous goods (Livestock, Waste, paper etc.)
17	Empty vehicles

The commodity movement pattern along the project corridor under study is analyzed and presented in **Table 4-20**

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Table 4-20: Distribution of Goods Carried by Commercial Vehicles

Vehicle type	Vehicle Wise Commodities Distribution (%) at each survey location																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Delhi – Panipat section (NH-44 near Baghan)																	
LMV	9.2	12.0	0.6	1.0	1.2	11.7	10.9	0.8	0.0	1.9	0.2	0.0	1.0	8.1	0.5	8.8	31.9
LCV	12.4	9.2	2.1	1.0	0.6	13.6	8.6	0.9	0.5	2.2	0.3	0.6	1.0	7.1	0.9	8.3	30.7
2A Truck	11.0	6.9	2.4	1.1	1.6	17.6	14.6	1.5	0.0	1.5	0.3	0.2	1.7	8.4	0.8	9.7	20.7
3A Truck	9.2	9.5	0.8	2.8	1.2	13.7	24.6	0.5	0.3	3.8	0.0	0.7	2.0	9.8	1.6	4.5	15.0
MAV	12.1	9.3	1.4	4.7	5.5	11.3	17.0	1.3	0.0	3.1	0.0	1.4	0.9	8.2	0.6	5.3	17.9
Rajpura – Patiala (NH-07 near Daun Kalan)																	
LMV	6.2	3.3	1.1	1.5	0.0	0.4	2.1	1.0	1.6	0.3	0.6	0.7	0.0	0.8	0.4	2.2	77.9
LCV	9.6	2.1	1.5	2.3	2.3	1.8	5.3	2.3	1.5	1.8	0.5	1.5	0.0	0.7	0.8	2.3	63.7
2A Truck	12.0	1.7	0.5	8.9	5.3	1.0	6.7	0.5	2.6	1.0	3.1	0.5	0.5	1.0	0.5	4.8	49.8
3A Truck	7.1	3.7	2.8	9.2	2.1	0.5	1.6	1.6	1.6	1.2	4.6	0.5	1.2	1.2	0.0	2.8	58.5
MAV	8.7	5.1	0.0	7.2	6.0	1.5	6.9	0.0	4.2	3.3	2.4	1.5	1.5	0.6	0.9	1.5	48.9
Ambala -Kurukshetra section (NH-44 near Sarifgarh)																	
LMV	6.7	5.0	4.1	3.1	1.3	5.6	6.0	1.3	1.3	1.7	7.2	0.5	1.7	2.4	0.0	10.0	42.3
LCV	12.6	8.8	3.7	5.5	2.0	8.2	10.3	1.9	6.7	0.9	1.9	1.3	0.5	3.2	0.7	7.2	24.6
2A Truck	11.5	7.8	5.2	6.9	1.9	7.6	12.8	3.1	5.4	0.8	2.4	0.8	0.1	5.9	0.8	8.8	18.3
3A Truck	12.8	6.4	3.3	12.2	2.8	7.6	12.3	1.3	5.4	1.9	1.3	0.8	1.2	3.1	1.2	9.8	16.6
MAV	10.7	5.6	6.5	4.5	3.2	10.5	16.4	1.9	3.3	0.8	2.4	0.2	0.0	3.5	1.1	7.8	21.5
Jalandhar - Ludhiana section (NH-1 near Ladhawal)																	
LMV	17.2	4.8	2.0	2.0	1.0	8.5	9.3	1.0	0.8	1.0	4.0	0.7	0.1	2.4	0.2	10.4	34.7
LCV	16.4	7.2	1.8	3.9	1.3	6.5	11.3	1.3	1.8	1.6	1.8	0.4	0.4	2.2	0.3	11.7	30.2
2A Truck	18.9	8.0	0.6	2.5	0.4	9.6	7.0	1.5	0.8	1.5	4.3	0.7	0.7	2.3	0.8	11.0	29.3
3A Truck	15.3	5.2	1.6	2.7	1.3	7.2	8.9	2.0	0.3	1.6	8.5	0.2	1.5	1.7	0.4	8.3	33.2
MAV	12.6	3.1	2.0	3.9	0.8	7.2	14.0	1.9	0.6	0.8	5.9	0.2	1.1	1.2	0.0	7.2	37.9
Amritsar - Jalandhar section (NH-1 near Nirajpur)																	
LMV	18.0	1.6	1.6	0.0	0.0	1.6	1.6	6.6	0.0	0.0	1.6	1.6	0.0	0.0	0.0	9.8	55.7

Vehicle type	Vehicle Wise Commodities Distribution (%) at each survey location																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LCV	17.6	2.0	2.0	3.9	0.0	9.8	1.0	2.0	1.0	0.0	8.8	1.0	1.0	2.0	0.0	2.9	45.1
2A Truck	23.8	1.3	1.3	6.3	1.3	6.3	2.5	3.8	0.0	0.0	5.0	1.3	0.0	1.3	0.0	7.5	38.8
3A Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pathankot – Jalandhar section (NH-44 near HarsaMansar)																	
LMV	9.1	10.1	1.5	0.0	0.7	0.7	12.3	0.7	0.7	0.0	3.6	0.0	0.0	0.0	1.5	5.1	54.1
LCV	9.9	7.4	1.7	3.2	0.9	2.6	10.6	1.7	0.7	0.0	2.0	0.0	0.3	0.6	0.0	4.3	54.1
2A Truck	10.6	2.2	0.1	9.3	0.5	1.3	5.1	2.0	1.1	1.4	6.4	0.0	0.0	0.5	0.0	3.4	55.9
3A Truck	8.5	1.0	0.1	4.2	0.9	1.1	1.9	2.2	1.5	1.1	25.2	0.0	0.0	0.6	0.0	3.0	48.6
MAV	5.1	0.3	0.0	9.6	1.9	1.9	8.9	3.2	0.3	1.3	14.4	0.0	0.0	1.3	0.0	4.2	47.9
Amritsar - Gurdaspur section (NH-54 near WaryamNagal)																	
LMV	6.3	8.3	0.7	2.8	0.7	2.8	10.4	2.1	1.4	1.4	16.7	0.7	0.7	0.7	0.7	0.7	43.1
LCV	12.3	22.9	1.7	0.0	0.9	4.9	13.7	5.7	2.9	0.0	5.4	0.0	0.0	0.0	0.9	0.0	28.9
2A Truck	3.9	16.6	0.0	1.0	2.9	0.0	2.0	4.9	1.0	0.0	21.3	1.9	1.0	1.0	0.0	2.9	39.9
3A Truck	3.0	7.6	1.0	3.5	0.5	2.5	1.6	2.0	0.5	3.0	27.8	1.6	4.6	1.6	1.6	2.5	35.0
MAV	1.3	5.3	1.5	7.0	1.5	2.3	2.5	6.2	0.0	1.5	33.2	2.1	5.7	2.1	3.6	1.5	22.7
Gurdaspur - Pathankot section (NH-54 near Ladpalwan)																	
LMV	6.8	5.4	1.8	1.3	1.3	3.6	3.6	1.5	1.0	1.5	2.1	0.7	0.0	1.3	0.7	4.3	62.9
LCV	8.1	4.2	1.5	1.3	1.7	4.8	2.7	2.3	0.4	1.3	6.7	1.0	0.0	1.0	0.4	3.3	59.3
2A Truck	11.3	7.0	0.9	0.6	1.2	6.4	3.3	2.1	0.8	1.8	16.3	0.9	0.0	0.6	0.4	3.9	42.6
3A Truck	6.8	6.8	0.8	2.1	0.9	7.1	1.5	0.6	0.0	1.6	25.9	3.1	0.3	0.4	0.4	1.5	40.4
MAV	5.3	4.6	2.6	2.4	1.0	6.6	2.8	0.8	0.2	2.6	29.9	5.2	1.0	0.0	1.4	1.4	32.4
Pathankot – Jammu section (NH-44 near Lakhampur)																	
LMV	17.0	15.8	0.0	1.6	4.7	3.2	2.5	3.5	0.0	3.8	3.8	0.0	0.0	0.0	0.0	1.6	42.6
LCV	17.0	12.6	1.6	2.1	2.7	2.3	4.9	3.1	0.4	1.7	4.6	0.0	0.0	0.1	0.1	6.0	40.6
2A Truck	13.8	18.4	0.7	2.3	3.9	6.2	9.4	6.3	0.4	1.5	5.6	0.0	0.0	0.5	0.7	6.4	24.1
3A Truck	15.8	14.5	1.2	2.5	5.1	7.5	5.6	4.1	0.4	4.1	5.6	0.2	0.2	0.3	1.0	6.8	25.1
MAV	10.2	7.0	0.8	1.7	8.3	6.9	8.7	3.8	0.7	6.7	5.6	0.1	0.3	0.0	2.0	5.8	31.3

Vehicle type	Vehicle Wise Commodities Distribution (%) at each survey location																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hisar – Sirsa section (NH-9 near Landhari)																	
LMV	17.0	15.8	0.0	1.6	4.7	3.2	2.5	3.5	0.0	3.8	3.8	0.0	0.0	0.0	0.0	1.6	42.6
LCV	17.0	12.6	1.6	2.1	2.7	2.3	4.9	3.1	0.4	1.7	4.6	0.0	0.0	0.1	0.1	6.0	40.6
2A Truck	13.8	18.4	0.7	2.3	3.9	6.2	9.4	6.3	0.4	1.5	5.6	0.0	0.0	0.5	0.7	6.4	24.1
3A Truck	15.8	14.5	1.2	2.5	5.1	7.5	5.6	4.1	0.4	4.1	5.6	0.2	0.2	0.3	1.0	6.8	25.1
MAV	10.2	7.0	0.8	1.7	8.3	6.9	8.7	3.8	0.7	6.7	5.6	0.1	0.3	0.0	2.0	5.8	31.3
Hisar – Churu section (NH-52 near Lasedi)																	
LMV	12.1	26.2	5.3	1.9	0.0	1.5	2.4	1.9	0.0	1.9	0.5	0.5	1.5	0.5	0.0	4.9	38.8
LCV	19.6	16.1	5.4	1.8	1.8	5.4	5.4	3.6	0.0	1.8	1.8	1.8	1.8	1.8	0.0	5.4	26.8
2A Truck	20.8	11.3	1.9	5.7	1.9	3.8	5.7	5.7	1.9	0.0	1.9	7.5	0.0	1.9	1.9	3.8	24.5
3A Truck	25.0	9.6	1.9	3.8	1.9	3.8	5.8	5.8	1.9	3.8	1.9	5.8	0.0	1.9	0.0	5.8	21.2
MAV	29.2	4.2	0.0	8.3	4.2	4.2	4.2	4.2	4.2	4.2	0.0	8.3	4.2	0.0	4.2	4.2	12.5
Jammu – Domel Section (Bann Toll Plaza)																	
LCV	14.9	15.5	0.7	15.1	0.0	6.8	11.8	0.0	0.0	2.4	3.5	0.0	0.0	0.0	0.0	0.0	29.3
2A Truck	19.9	18.1	1.5	4.2	0.5	3.4	13.2	0.0	0.0	1.5	0.5	0.5	0.5	0.0	0.0	0.0	36.1
3A Truck	12.2	8.4	1.1	24.2	0.0	3.6	10.0	0.0	0.0	1.1	1.7	0.8	0.3	0.0	0.0	0.1	36.6
MAV	20.4	13.6	0.8	5.2	0.0	6.8	21.1	0.0	0.0	0.0	0.0	3.9	0.5	0.0	0.0	0.0	27.7

From the above data, it can be analyzed that food grains and other agricultural products have the maximum share of around 12.3%, followed by perishable commodities like Fruits and Vegetable the share of which is 8.3%, finished and manufactured products (7.3%), Mining(Sand, Bajri, and Corse Aggregate) 5.5% , Miscellaneous goods (5.3%) , Iron, Metal and Steel (5.2%) ,Petroleum, oil, gas and Lubricants Product(3.5%), parcel services and containers (2.2 %) and. Empty vehicles have a higher share, close to 34.8 % as many trips have trip-ends as either pickup or drop.

4.1.22 Location of Ramp Plaza

4.1.23 Toll Plaza

Since the project road is an access-controlled Greenfield expressway in phase I and partially access controlled greenfield / brownfield in phase II from Delhi (Bahadurgarh) to Katra in the state of Haryana, Punjab & jammu & Kashmir, there are 21 ramp plazas on phase I & 8 ramp plaza on phase II at the interchange locations proposed on the corridor upto sambha and toll plaza on remaining section will be on main carriageway.

Interchange points are proposed at intersection of all National Highways and some important state highways along the project corridor. These Interchange points are proposed keeping in view the important towns in vicinity of the corridor. These interchanges will act as the entry and exit points for traffic which will use this corridor in future. The details of the interchange are given in **Table 4-21**.

Table 4-21: Location of Interchange

Sl. No	Interchange	Interchange serving major city/ town	Location of Toll Plaza (Ch.)	Phase I or Phase II
1	IC-1	Start of Expressway	0.000	
2	IC-2	Kharkhoda / Sampla	5.534	
3	IC-3	Rohtak / Kharkhoda	14.072	
4	IC-4	Panipat / Rohtak	36.281	
5	IC-5	Jind / Gohana / Sonipat	55.670	
6	IC-6	Rajasthan / Panipat	79.102	
7	IC-7	Karnal / Jind	87.126	
8	IC-8	Kaithal / Narwana	117.211	
9	IC-9	Patran, Kaithal, Karnal	137.452	
10	IC-10	Patiala / Patran / Chandigarh	157.063	
11	IC-11	Sangrur	185.332	
12	IC-12	MalerKotla / Patiala	216.755	
13	IC-13	Malerkotla / Ludhiana	227.742	
14	IC-14	Ludhiana / Ambala	261.800	
15	IC-15	Nakodar	292.526	
16	IC-16	Jalandhar / Nakodar	306.054	
17	IC-17	Kapurtala / Jalandhar	321.194	
18	IC-18	Amritsar / Jalandhar	333.184	
19	IC-19	Dasuya / Hoshiarpur / Amritsar	359.663	
20	IC-20	Batala	377.353	
21	IC-21	Gurdaspur / Pathankot and J&K	397.000	
22	IC-22	Patankot	424.557	
23	IC-23	Pathankot link	428.000	
24	IC-24	Kathua	438.780	
25	IC-25	Kathua	452.671	
26	IC-26	Chak Dayala	465.798	
27	IC-27	Sambha	481.150	
28	IC-28	Sambha	486.993	
29	IC-29	Jammu	515.000	
30	IC-30	Jammu	531.000	
31	IC-31	Domel	552.000	
32	IC-32	Katra	564.700	

4.1.24 Methodology Adopted for Study

As the project road has closed tolling system, the vehicles which enter the project corridor from entry ramp of any interchange will get a slip at entry ramp, and the charges will be deducted at the exit ramp of interchange from where he will leave the corridor. Thus, in order to access the revenue which will be generated from a particular toll plaza/booth, the traffic entering and leaving any toll plaza / toll booth has to be worked out from OD surveys.

4.1.25 Potential Diverted Traffic

Potentially divertible traffic at entry/exit of interchanges for each category of vehicle for phase 2 has been assessed and is given in **Error! Not a valid bookmark self-reference..**

Table 4-22: Potential Diverted Traffic at Exit of Corridor in Year 2018-19

Vehicle Type	Interchange location/No. Phase II											
	IC- 21	IC- 22	IC- 23	IC- 24	IC- 25	IC- 26	IC- 27	IC- 28	IC- 29	IC- 30	IC- 31	IC- 32
Cars	2914	4277	479	357	997	0	37	60	3201	5429	2895	3438
Minibus	14	67	2	21	13	0	0	0	79	80	31	59
Std. Bus	50	331	47	22	59	0	4	4	264	454	189	401
Mini LCV	242	579	14	81	66	0	4	20	274	399	323	217
LCV	158	321	38	69	76	0	5	20	324	390	415	151
2 axle Truck	175	538	48	33	66	0	6	20	530	835	929	177
3 axle Truck	330	773	43	41	98	0	8	20	528	279	419	81
MAV	168	395	18	34	40	0	2	12	345	165	272	31
Total Vehicles	4051	7281	689	658	1415	0	67	156	5545	8030	5471	4556
Total PCUs	5835	12143	1048	1013	2044	0	117	298	9598	11977	9719	6089

*IC – Interchange

4.2 Traffic forecast and demand estimates

4.2.1 Traffic Forecasting

Investment priorities are governed by traffic demand, assessed benefits and cost of the project. Demand plays important role, which governs which type of facility / infrastructure is to be created. This in turn determines likely benefits and costs to develop the same.

A highway project of this nature calls for significant investment. Prediction of traffic demand becomes an important task and has to be carried out as accurately as possible. Accurate estimation of traffic has direct bearing on the viability of the project. Recognizing this, efforts need to be made to carefully assess all the parameters that help in predicting the traffic demand in future, which necessitates realistic estimation of traffic growth rates. Traffic growth on a road facility is generally estimated on the basis of historical trends. In the present case, traffic growth rates are estimated using elasticity method in accordance with **IRC: 108 – 2015**. Demand changes are usually because of shift in pattern of economic activities in the surrounding regions. Hence, future traffic estimation necessitates a preview, however imprecise, of the probable pattern of future growth of the economy.

In the absence of historical traffic census data on the project road, the future traffic has been forecasted using transport demand elasticity approach by regression of registered vehicles of the influencing states of Delhi (UT), Haryana, Punjab and Jammu with respect to socio-economic parameters viz., population, Per Capita Income (PCI), NSDP and GDP as explained below.

The exercise of traffic growth rate estimation has been carried out using the elasticity approach. The elasticity method relates traffic growth to changes in the related economic parameters. According to IRC: 108 – 2015, elasticity based econometric model for highway projects could be derived in the following form:

$$\text{Log } e(P) = A_0 + A_1 \text{Log } e(EI)$$

Where,

- P = Traffic volume (of any vehicle type)
- EI = Economic Indicator (GDP/NSDP/Population/PCI)
- A₀ = Regression constant;
- A₁ = Regression co-efficient (Elasticity Index)

The main steps followed are:

- Defining the Project Influence Area from OD analysis of travel pattern
- Estimating the past elasticity of traffic growth from time series of registered vehicles of influencing states
- Assessment of future elasticity values for major vehicle groups, namely, cars, buses and trucks
- Study of past performance and assessment of prospective growth rates of state economies of influence area

The elasticity values are obtained by fitting log-log regression between the registered vehicle types (car, bus and goods vehicles) and NSDP, population and per-capita income of influencing states and GDP of India. The regression analysis is carried out using various combinations of economic indicators and population of registered vehicles and the elasticity values resulted from the best fit equations are used in estimating growth rates.

4.2.2 Past Vehicle registered details

In order to analyze the vehicle growth in Project Influence Area (PIA), the vehicle registration data of Delhi, Haryana, Punjab, Jammu and Kashmir and India have been collected. The Compounded Average Growth Rate (CAGR) for different vehicle types is shown in **Table 4-23**, **Table 4-24**, **Table 4-25**, **Table 4-26** and **Table 4-27**.

Table 4-23: Growth of Vehicle Registration of Punjab

Year	TW	Car	Bus	Trucks
2004-05	2777147	349560	19855	100571
2005-06	2975198	389494	21136	107534
2006-07	3181759	427608	21982	111415
2007-08	3385088	470059	24457	129797
2008-09	3581837	510972	25682	139065
2009-10	3956279	554699	27146	149367
2010-11	4332540	598882	28463	159179
2011-12	4729594	698615	30160	180706
2012-13	5131051	773970	31927	197976
2013-14	5670670	899726	35310	219447
2014-15	6258303	1020891	38154	239070
CAGR	8.46%	11.31%	6.75%	9.04%

Source: MORT&H

Table 4-24: Growth of Vehicle Registration of Haryana

Year	TW	Car	Bus	Trucks
2004-05	1729236	419879	11297	166437
2005-06	1881174	485453	19986	176046
2006-07	2172669	568758	22101	200977
2007-08	2463672	664134	26906	220470
2008-09	2768197	745335	29516	230858
2009-10	2975418	851374	33520	249991
2010-11	3370426	988958	35646	275162
2011-12	3755349	1134514	39153	292735
2012-13	4146906	1293065	43456	307509
2013-14	4541932	1454182	46558	327882
2014-15	4988518	1609544	52640	348732
CAGR	11.18%	14.38%	16.64%	7.68%

Source: MORT&H

Table 4-25: Growth of Vehicle Registration of Jammu & Kashmir

Year	TW	Car	Bus	Trucks	LMV
2004-05	273265	108934	20735	31515	29003
2005-06	297656	123023	21435	33174	32762
2006-07	320754	138072	22161	35697	36566
2007-08	341834	156508	23149	38977	41114
2008-09	363029	175433	24051	41696	44441
2009-10	407928	199611	23480	35109	54196
2010-11	446791	237846	25858	35414	59212
2011-12	480815	280825	25765	38482	65171
2012-13	530594	321310	26888	40751	72637
2013-14	588207	361578	27947	43132	79639
2014-15	644458	401855	29695	45802	86854
CAGR	8.96%	13.94%	3.66%	3.81%	11.59%

Source: MORT&H

Table 4-26: Growth of Vehicle Registration of Delhi

Year	TW	Car	Bus	Truck
2004-05	2839838	1182801	24797	122006
2005-06	3078660	1303303	25511	128193
2006-07	3335763	1649785	26491	137983
2007-08	3578199	1791478	26933	155871
2008-09	3808503	1931486	28453	208294
2009-10	4065789	2091522	30560	226256
2010-11	4352963	2258434	33067	242331
2011-12	4654706	2303052	34251	129339
2012-13	4980227	2547877		131715
2013-14	5296163	2691282		142203
2014-15	5681265	2859620		153406
CAGR	7.18%	9.23%	4.72%	2.32%

Source: www.delhi.gov.in

Table 4-27: Growth of Vehicle Registration of Trucks (All India)

Year	Trucks (All India)
2004-05	3877622
2005-06	4274984
2006-07	5118880
2007-08	5600938
2008-09	6040924
2009-10	6431926
2010-11	7064495
2011-12	7658391
2012-13	8306834
2013-14	8697541
2014-15	9344464
CAGR	9.19%

4.2.3 Past Growth of Economy

The past performance of the economic indicators for the project influence area (PIA) was also collected for the same period (2004-05 to 2014-15), with the objective of establishing elasticity of travel demand to the different economic indicators. The economic indicators considered for the analysis include:

- Net State Domestic Product and Net National Domestic Product
- Per Capita Income (PCI)
- Population

Table 4-28, Table 4-29, Table 4-30, Table 4-31 and Table 4-32 give the growth of Economic indicators for Punjab, Haryana, Delhi, J&K and India.

Table 4-28: Growth in Economic Indices of Punjab State (at 2004-05 Prices)

Year	NSDP (Million)	PCI	Population
2004-05	8610813	33103	25925000
2005-06	9032981	34096	26257000
2006-07	10007179	37087	26587000
2007-08	10873818	39567	26916000
2008-09	11476627	41003	27240000
2009-10	12209725	42831	27556000
2010-11	12998333	44769	27861000
2011-12	13698738	46325	28160000
2012-13	14258538	47854	28454000
2013-14	15030456	49529	28738000
2014-15	15887725	51403	29010000
CAGR	6.32%	4.50%	1.13%

Table 4-29: Growth in Economic Indices of Haryana State (at 2004-05 Prices)

Year	NSDP (Million)	PCI	Population
2004-05	8622228	37972	22707000
2005-06	9401146	40627	23140000
2006-07	10470049	44423	23569000
2007-08	11289592	47046	23997000
2008-09	12158839	49780	24425000
2009-10	13677999	55044	24849000
2010-11	14605347	57797	25270000
2011-12	15852299	61716	25686000
2012-13	16716882	64052	26099000
2013-14	17830719	67260	26510000
2014-15	19243700	71493	26917000
CAGR	8.36%	6.53%	1.72%

Table 4-30: Growth in Economic Indices of J & K State (at 2004-05 Prices)

Year	NSDP (Million)	PCI	Population
2004-05	2730462	21734	10877000
2005-06	2888283	22406	11035000
2006-07	3060158	23375	11192000
2007-08	3256098	24470	11350000
2008-09	3466422	25641	11506000
2009-10	3622489	26518	11659000
2010-11	3826996	27666	11806000
2011-12	4120305	28790	11952000
2012-13	4340196	30035	12096000
2013-14	4584716	31448	12235000
2014-15	4512631	28882	12369000
CAGR	5.15%	2.88%	1.29%

Table 4-31: Growth in Economic Indices of Delhi State (at 2004-05 Prices)

Year	NSDP (Rs lacs)	PCI
2004-05	947169	63877
2005-06	1044734	69128
2006-07	1174441	76243
2007-08	1306830	83243
2008-09	1469612	91845
2009-10	1590435	97525
2010-11	1722352	103619
2011-12	1807222	106677
2012-13	1941403	112441
2013-14	2083682	118411
2014-15	2256296	125809
CAGR	8.83%	6.78%

Table 4-32: Growth in Economic Indices of All India (at 2004-05 Prices)

Year	GDP (Billion Rs.)
2004-05	2971464
2005-06	3253073
2006-07	3564364
2007-08	3896636
2008-09	4158676
2009-10	4516071
2010-11	4918533
2011-12	5247530
2012-13	5482111
2013-14	5741791
2014-15	6070669
CAGR	7.41%

The trend in economy in the influence region had fluctuations in last decade. The same for various time periods along with national trend is depicted in **Table 4-33**. The growth of PIA factored with regional influence mentioned earlier also is given.

Table 4-33: Past Growth Trend of Economy (CAGR %)

Year	Punjab	Haryana	Delhi	J & K	AI (New)	AI (Old)	PIA growth
2005-2016	7.75	8.36	9.07	8.54	-	7.59	8.15
2009-2016	8.07	7.96	7.41	7.58	-	6.66	7.77
2012-2016	5.42	6.06	7.68	6.97	6.01	4.6	5.98

4.2.4 Transport demand elasticity

The regression analysis tool performs linear regression analysis by using the "least squares" method to fit a line through a set of observations. We can analyze how a single dependent variable is affected by the values of one or more independent variables. In the present case, registered vehicles by type are dependent variables whereas the economic parameters are independent variables.

T-statistic

The t-statistic is a measure of how strongly a particular independent variable explains variations in the dependent variable. The larger the t-statistic, the better the independent variable's explanatory power. Next to each t-stat is a P-value. The P-value is used to interpret the t-stat. In short, the P-value is the probability that the independent variable in question has nothing to do with the dependent variable. Generally, we look for a P-value of less than .05, which means there is a 5% chance that the dependent variable is unrelated to the dependent variable. If the P-value is higher than .10, a strong argument can be made for eliminating this particular independent variable from a model because it "isn't statistically significant."

R Square

R Square is another measure of the explanatory power of the model. In theory, R square compares the amount of the error explained by the model as compared to the amount of error explained by averages. The higher the R-Square, the better it is.

Regression analysis has been carried out by creating econometric models as suggested in IRC: 108 – 1996, using past vehicle registration data, and economic indicators such as population and PCI for passenger vehicles and NSDP for freight vehicles. All India registered trucks are also regressed with GDP to estimate national level elasticity value for trucks and its growth rate. The elasticity values obtained for each class of vehicle are given in **Table 4-34**, **Table 4-35**, **Table 4-36**, **Table 4-37**.

Table 4-34: Elasticity Values Derived based on Regression Analysis for Punjab

Vehicle Type	Indicator	Elasticity	GR (%)	R-square	t-stat	p-value
Two-Wheeler	PCI	1.913	8.406	0.968	18.211	0.000
	NSDP	1.386	8.497	0.974	20.387	0.000
	Population	7.667	8.222	0.983	25.230	0.000
Car	Population	9.05	9.706	0.99	27.39	0.00
	PCI	2.254	9.903	0.966	17.741	0.000
	NSDP	1.633	10.011	0.973	19.797	0.000
Bus	Population	6.137	6.581	0.979	22.665	0.000
	PCI	1.538	6.755	0.972	19.390	0.000
	NSDP	1.112	6.821	0.976	21.101	0.000
Trucks	NSDP	1.394	8.546	0.981	23.719	0.000
LCV/LMV	NSDP	0.000	0.000	0.000	0.000	0.000

Table 4-35: Elasticity Values Derived based on Regression Analysis for Haryana

Vehicle Type	Indicator	Elasticity	GR (%)	R-square	t-stat	p-value
Two-Wheeler	PCI	-0.117	10.807	0.999	-0.348	0.737
	Population	6.748			5.371	0.001
	Population	6.312	10.824	0.999	81.305	0.000
	NSDP	1.330	11.130	0.996	44.848	0.000
	PCI	1.684	11.013	0.994	38.077	0.000
Car	PCI	0.026	13.690	0.999	0.097	0.925
	Population	7.883			7.794	0.000
	NSDP	1.682	14.078	0.997	53.819	0.000
	PCI	2.130	13.931	0.995	43.800	0.000
	Population	7.982	13.686	0.999	128.580	0.000
Bus	NSDP	2.920	13.709	0.926	0.938	0.376
	Population	-6.256			-0.424	0.683
	Population	7.563	12.968	0.918	10.050	0.000
	PCI	2.030	13.280	0.926	10.575	0.000
	NSDP	1.602	13.403	0.925	10.507	0.000
	PCI	2.918	13.381	0.926	0.937	0.376
	Population	-3.329			-0.286	0.782
Trucks	NSDP	0.928	7.769	0.996	48.528	0.000
LCV/LMV	NSDP	1.084	9.071	0.985	24.693	0.000

Table 4-36: Elasticity Values Derived based on Regression Analysis for J & K

Vehicle Type	Indicator	Elasticity	GR (%)	R-square	t-stat	p-value
Two Wheeler	PCI	1.959	6.734	0.968	17.270	0.000
	NSDP	1.577	8.792	0.981	22.487	0.000
	Population	6.81	8.68	0.989	17.270	0.000
Car	Population	10.49	13.3687	0.994	41.936	0.000
	PCI	2.254	7.747	0.966	17.741	0.000
	NSDP	3.025	16.869	0.977	20.498	0.000
Bus	PCI	0.785	2.699	0.955	14.638	0.000
	Population	2.719	3.465766	0.970	17.864	0.000
	NSDP	0.628	3.504	0.957	14.930	0.000
Trucks	NSDP	0.563	3.139	0.725	5.139	0.000
LCV/LMV	NSDP	2.008	11.199	0.990	31.707	0.000

Table 4-37: Elasticity Values Derived based on Regression Analysis for Delhi

Vehicle Type	Indicator	Elasticity	GR (%)	R-square	t-stat	p-value
Two-Wheeler	PCI	1.003	6.908	0.982	22.398	0.000
	NSDP	0.787	7.035	0.990	29.874	0.000
Car	PCI	1.273	8.766	0.987	26.044	0.000
	NSDP	0.993	8.877	0.984	23.218	0.000
Bus	PCI	-0.277	-1.905	0.043	-0.638	0.539
	NSDP	0.489	4.371	0.925	8.619	0.000
Trucks	NSDP	0.213	1.902	0.062	0.768	0.462
LCV/LMV	NSDP	0.000	0.000	0.000	0.000	0.000

The elasticity of commercial vehicles in PIA for various time periods was computed and are presented in **Table 4-38**. The commercial vehicle registration and NSDP of the states are used to arrive at the elasticity.

Table 4-38: Elasticity of commercial vehicles in PIA

Period	Punjab	Haryana	Delhi	J & K	All India
LCV					
2005-2015	1.39	1.08	0.21	2.01	1.78
2009-2015	1.70	1.13	0.21	2.56	1.56
2012-2015	2.08	1.48	0.21	2.38	1.56
Trucks					
2005-2015	1.39	0.93	0.21	0.56	0.69
2009-2015	1.70	1.04	0.21	0.46	0.74
2012-2015	2.08	1.36	0.21	1.50	0.74

4.2.5 Projected transport demand elasticity

In order to arrive at realistic future elasticity for the project road, various factors relating to vehicle technology changes besides character of traffic and travel pattern on the project road have been considered. The basic projection for elasticity of each mode with respect to the relevant parameter is presented in **Table 4-39**.

Table 4-39: Projected Basic Elasticity

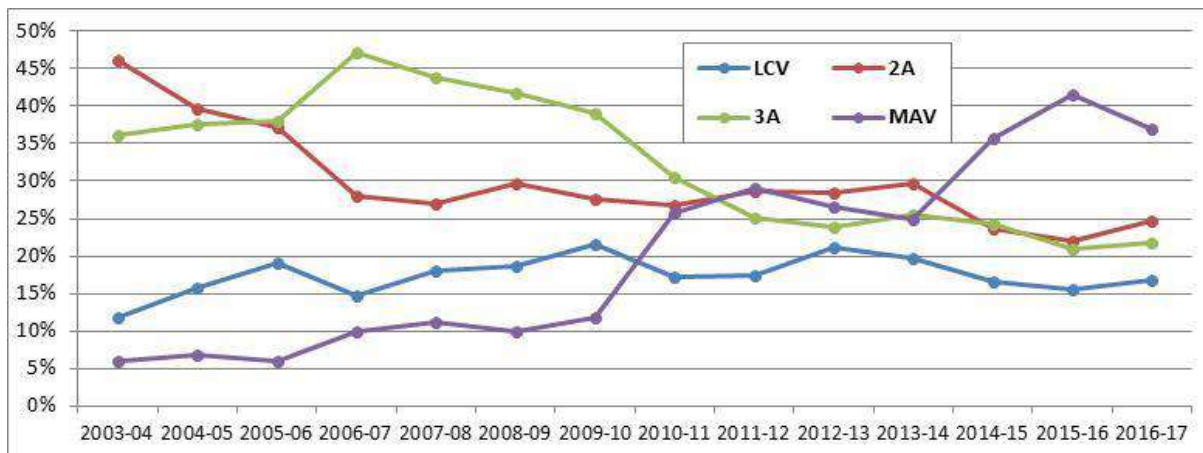
Period	Car	Bus	LCV	2-Axle Trucks	3-Axle Trucks	MAV
2020-24	1.01	0.81	0.85	0.45	0.49	0.84
2025-29	0.82	0.65	0.81	0.41	0.44	0.80
2030-34	0.66	0.53	0.77	0.37	0.41	0.76
2035-39	0.54	0.44	0.74	0.32	0.35	0.74
2040-44	0.46	0.37	0.70	0.24	0.27	0.72
> 2044	0.40	0.32	0.67	0.25	0.29	0.70

The high elasticity of cars witnessed at present is due to the large demand facilitated by financing schemes and loans. Factors like growth of household incomes (particularly in urban areas), reduction in the prices of entry-level cars, growth of the used car market, changes in life style, growing personal incomes, desire to own a vehicle facilitated by availability of loans/financing schemes on easy terms, etc. have all contributed to the rapid growth in ownership of cars. However, such trend could slow down and elasticity could decline in future, which the assumption is made in this report. However, given India's current low level of motorization it could also be a possible scenario where the levels of elasticity could be maintained at current levels into the future.

Over the years there is a change in passenger movement with more and more people shifting towards personalized modes. Moreover, the buses are usually plying on fixed pre-decided routes and thus elasticity values for buses have been considered accordingly.

With the changing freight vehicle mix in favour of LCV for short distance traffic and MAVs for long-distance traffic, higher elasticity values for these have been considered as compared to 2-axle and 3 axle trucks. Considering the on-going technical advancements in automobile industry, some of the standard two axle trucks were getting replaced by three axle truck and MAVs over last few years, further the three axle trucks also started replaced by MAVs in last few years leading to reduction in number of trucks. But presently, production of new technology 2 and 3 axle trucks has been observed and the same is expected to grow over a period of next few years. This shift has already been observed in various areas of the country. The production trends of commercial vehicles in the country also depict the increase in share of 2A and 3A trucks in last 2 years.

The **Figure 4-6** shows the percentage changes in commercial vehicles, category-wise, in India from FY04 to FY17. The introduction of rigid body MAVs and 6-wheel LCVs have resulted in increased use of these modes. These days the LCVs are used for even long-haul trips, contrary to their conventional usage. The changes in vehicle technology, improved safety standards etc. have contributed to these shifts, but it is clear from the chart below that the shift may have achieved equilibrium and plateaued over the recent few years. However, for the purposes of our report, we have assumed that the shift continues.



Source: from various volumes published by SIAM

Figure 4-6: Trend of production of commercial vehicles in India

It would be easier to relate the PIA growth and vehicular growth projections. Thus, the final elasticities are calculated with respect to PIA growth and are presented in **Table 4-40**, which depict the direct relation of projection of vehicular growth to PIA growth.

Table 4-40: Projected transport demand elasticity values

Period	LCV	2-Axle Trucks	3-Axle Trucks	MAV
2020-24	0.84	0.68	0.69	0.65
2025-29	0.80	0.65	0.66	0.62
2030-34	0.76	0.62	0.63	0.58
2035-39	0.72	0.59	0.59	0.56
2040-44	0.68	0.56	0.56	0.53
> 2044	0.65	0.53	0.54	0.50

4.2.6 Perspective growth: state and national economies

Against this background, any agenda for future growth of the state economies has to take into account past trends, future prospects, and the emerging challenges. The growth prospects for the subject state has been developed taking into consideration the past performance of the state economy and the economic growth envisaged for

the future. The pace with which the regional economies grow with the envisaged growth of the state is a major contributing factor in growth of traffic.

Various studies by economic houses, researchers and other observers like World Bank, CID¹ of Harvard University, EIU², OECD³ etc. have published the forecast for GDP, from time to time. Observing the trend and relation of NSDP to GDP in the past the forecast for future is framed carefully. The past 10 years witnessed a lot of changes in economic front of the country. Considering that entire block as a guiding factor may skew the values, and thus a short period of recent past (2012-15) has been taken as guiding block duly considering the trend in various periods.

This helps in framing the future GDP values for smaller periods initially, like blocks of two and three years and subsequently for five years till 2059-60. depicts the projection of GDP for horizon years.

Among the various GDP projections, OECD projection covers long term and is in line with recent trends in growth. Thus, that series is adopted in the present study. The GDP suggested is considered for factoring NSDP and the projections. The regions which out-performed the GDP in the past will continue to do so, while others will follow the trends which are marked by their present trend as well as likely changes in longer term.

As mentioned earlier, the government of India introduced a new series for GDP growth recently which has changed the datum from FY05 to FY15 and the methodology of calculating the GDP also has been changed. This made the historic values in the new series and projection of the old series difficult to calculate, and moreover there is no data available for linking both. Thus, the elasticities of different modes are moderated considering the growth of both series in the overlapping period.

Table 4-41: Projected growth rates of indicators in percentage

Period	Punjab	Haryana	Delhi	J & K	All India
2020-24	6.50	7.80	9.80	3.90	5.90
2025-29	6.50	7.80	9.80	3.90	5.90
2030-34	6.50	7.80	9.80	3.90	5.90
2035-39	6.40	7.60	9.70	3.90	5.80
2040-44	6.10	7.20	9.20	3.70	5.50
> 2044	5.70	6.80	8.70	3.50	5.20

4.2.7 Projected traffic growth rates

In view of the above, it is felt that the future growth rates should neither be under nor over targeted. The complexities involved and sensitive dimensions of economy are many. It is therefore, important that its larger issues are addressed.

¹ CID: Centre for International Development, Harvard University

² EIU: Economic Intelligent Unit

³ OECD: Organisation for Economic Co-operation and Development

Based on the present composition of goods vehicles, overall growth of goods vehicles and average load carried by each vehicle type, tonnage is calculated for present and future composition of traffic. On this basis growth rates of goods vehicles are appropriated keeping the overall growth of trucks constant. The final recommended growth rates are given in **Table 4-42**

Table 4-42: Estimated and recommended traffic growth rates

Mode	2020-24	2025-29	2030-34	2035-39	2040-44	> 2044
Car	6.9	5.6	4.5	3.6	3.0	2.4
Bus	5.5	4.5	3.6	2.9	2.4	1.9
LCV	5.8	5.5	5.3	4.9	4.5	4.0
2 Axle Truck	3.0	2.8	2.5	2.2	1.5	1.5
3 Axle Truck	3.3	3.0	2.8	2.3	1.7	1.7
MAVs	5.7	5.5	5.2	4.9	4.6	4.2

4.2.8 Traffic forecast for non-motorised traffic

As the project corridor is an expressway, there is no provision of non-motorized traffic on this corridor. so traffic forecast for non-motorized traffic has not been done.

4.3 Travel Demand Estimates

4.3.1 Traffic demand estimation for proposed project road

This section presents the assessment of traffic on proposed Delhi – Katra Greenfield alignment. The result of this analysis will form input for forecasting toll traffic and revenue, deciding tolling strategy, planning and designing the pavement, developing capacity augmentation proposals and designing the toll plaza.

The corridor traffic would consist of three components:

- **Diverted Traffic:** This is traffic based on trips that are already being made between various origin and destination pairs and likely to be diverted to the proposed project corridor.
- **Development Traffic:** This is the traffic based on new trips that would be generated due to the development of new nodes along the project highway.
- **Generated / Induced Traffic:** This is traffic that is based on trips that were not taken earlier due to lack of desired infrastructure.

Thus, the total traffic on project corridor is sum of regular traffic, diverted traffic, developmental traffic and generated traffic. Once the expressway is completed, additional traffic will be generated from developments around the project road and

diverted traffic from nearby roads to the project road. However, it is nearly impossible to quantify these volumes in the absence of clear-cut plans and roadmap. Hence, 5% of base traffic are assumed as additional traffic based on existing traffic volume along the project corridor. This additional traffic will be considered from the year 2024-25 which is supposed to be the opening year of the expressway facility. There after the traffic may considered to grow normally. The traffic projection for the homogenous section is presented in tables below.

4.3.2 Traffic Diversion Methodology

Cost ratio diversion curves is used to estimate diverted traffic to the project corridor. In this approach, traffic likely to be diverted from existing alternate routes to project road is estimated using diversion curves, which computes the ratio of perceived costs on the competitive/alternative facilities.

According to the model, the vehicle will shift if the perceived cost on the project road is lower in comparison to alternate road. The rate of diversion is calculated using the diversion curve/equations, which is similar to the Logit curve. These equations are presented in **Table 4-43**.

Table 4-43: Diversion Curve Equation

Vehicle	Cost Ratio Interval	Relationship
Car	<0.634	% Div = 98.75 – ((CR/0.634)* 8.125)
	0.64 = CR <1.465	% Div= 90.625-((CR-0.634)/0.831)*84.375
	1.465 <=CR <= 2.00	%Div = 6.25-((CR-1.465)/0.535))*5.25
Truck & Buses	<= 0.75	% Div=100-(CR/0.75)*5
	0.75 <= CR <=1.25	% Div= 95-((CR-0.75)/.5)*90
	1.25<=CR <=2.00	% Div= ((2-CR)/0.75)*5

Where,

CR = (Total Cost of Project Route) / (Total Cost of Alternate Route)

Total Cost (INR) = Vehicle Operating Cost (INR) Toll Charges (INR) Value of time (INR)

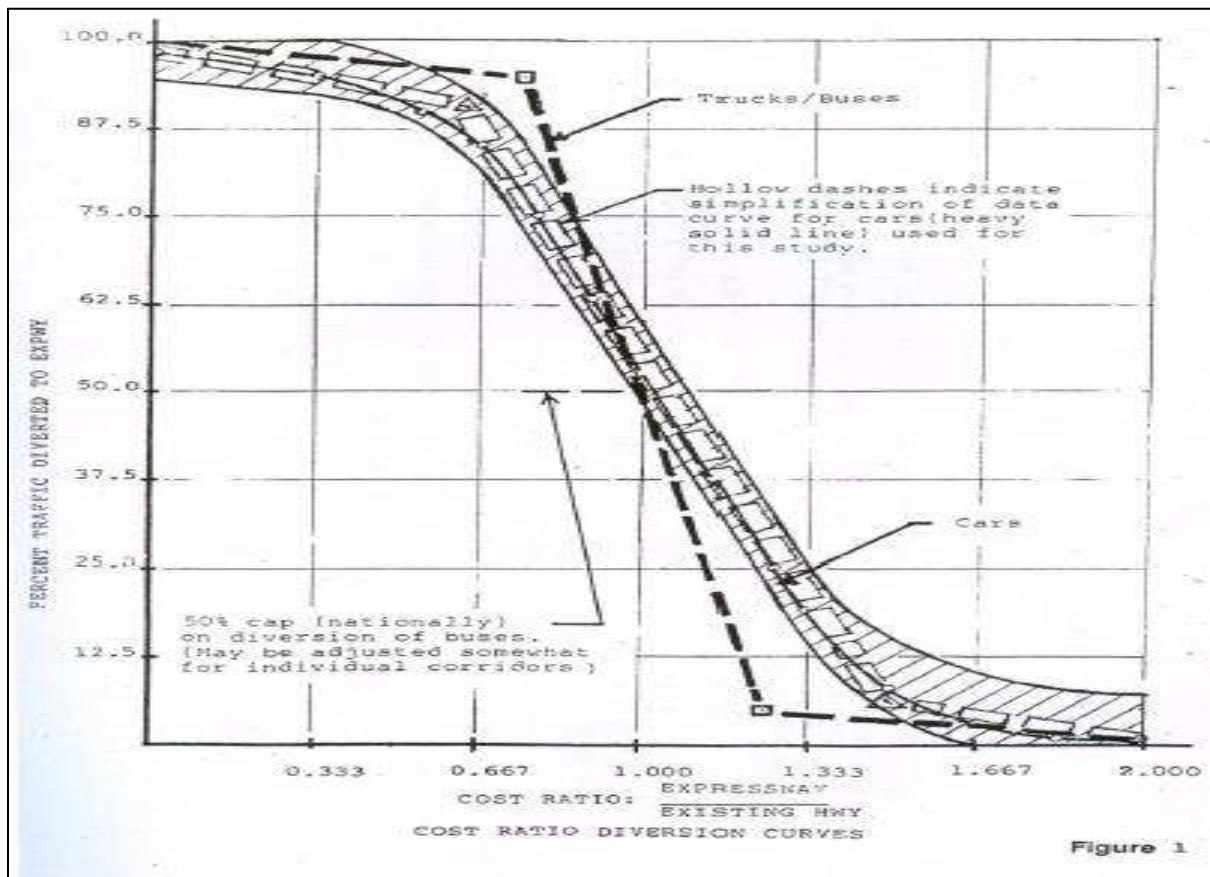


Figure 4-7: Diversion Curves

For calculating the cost ratio, the generalized cost is considered on the project corridor and alternative road. The generalized cost consists of three components. These are:

- Vehicle operating cost (VOC),
- Value of time (VOT) and
- Toll Fee

Percentage diversion is estimated based on the Cost ratio as given in above table and is applied on the potential divertible traffic obtained from OD Matrix to get the total traffic that will be diverted from the alternate route to the project to corridor.

4.3.3 Vehicle Operating Cost (VOC)

The VOC for various vehicle types are suggested in IRC: SP:30–2009. It comprises of fixed and variable costs. Variable cost varies with the distance travelled like fuel cost, tyres cost, maintenance cost, lubricants cost etc. whereas insurance, taxes and depreciation are the component of fixed cost. The IRC SP:30–2009 suggests VOC based on rise and fall, lane configuration and roughness. The revised VOC for present year is calculated for alternate routes mentioned above based on the lane configuration and pavement conditions.

4.3.4 Value of Time (VOT)

VOT for different modes is adopted from IRC: SP:30–2009. It is revised for present year and the adopted values given below.

Table 4-44: Value of time for present year

Nature of Journey by Passenger	Value of Time (INR per hour) (2009)		Value of Time (INR per hour) (2018)	
	Primary Route	Secondary Route	Primary Route	Secondary Route
Cars	63	53	89	75
Ordinary Bus Passenger	40	15	57	21
Deluxe Bus Passenger	44	-	62	-

Table 4-45: Type of route and commodity holding cost

Types of Routes	Commodity Holding Cost (INR/day)	Commodity Holding Cost (INR/hr) (2009)	Commodity Holding Cost (INR/hr) (2018)
Primary Route	58	2	4
	178	7	11
	333	14	20
Secondary Route	54	2	3
	148	6	9

Travel Time: Travel time is calculated both for the existing alternate routes and proposed project corridor. The calculation is based on the total length of the road and average speed of road.

Toll: Toll estimation for each route is done using data from prevailing toll policies and actual toll on various alternative routes, wherever necessary. The toll on project highway is considered as suggested by NHAI toll notification.

Generalized cost: The Generalized Cost for cost ratio calculation for vehicles has the following form:

$$GC = VOC \cdot TL + VOT + TR$$

Where,

VOC = Vehicle Operating Cost

VOT = Value of Travel Time

TR = Toll Rates

TL = Trip Length

4.3.5 Diversion Analysis

A) Alternative route for Traffic between Point 1(First Toll Plaza) and Point 4 (Sonipat):

There is one existing alternative route for the traffic moving between Points 1-4. This route is via NH-44 & KMP Expressway. The alignment of existing alternative road along with project corridor is presented in **Figure 4-8** and explained in detail below:

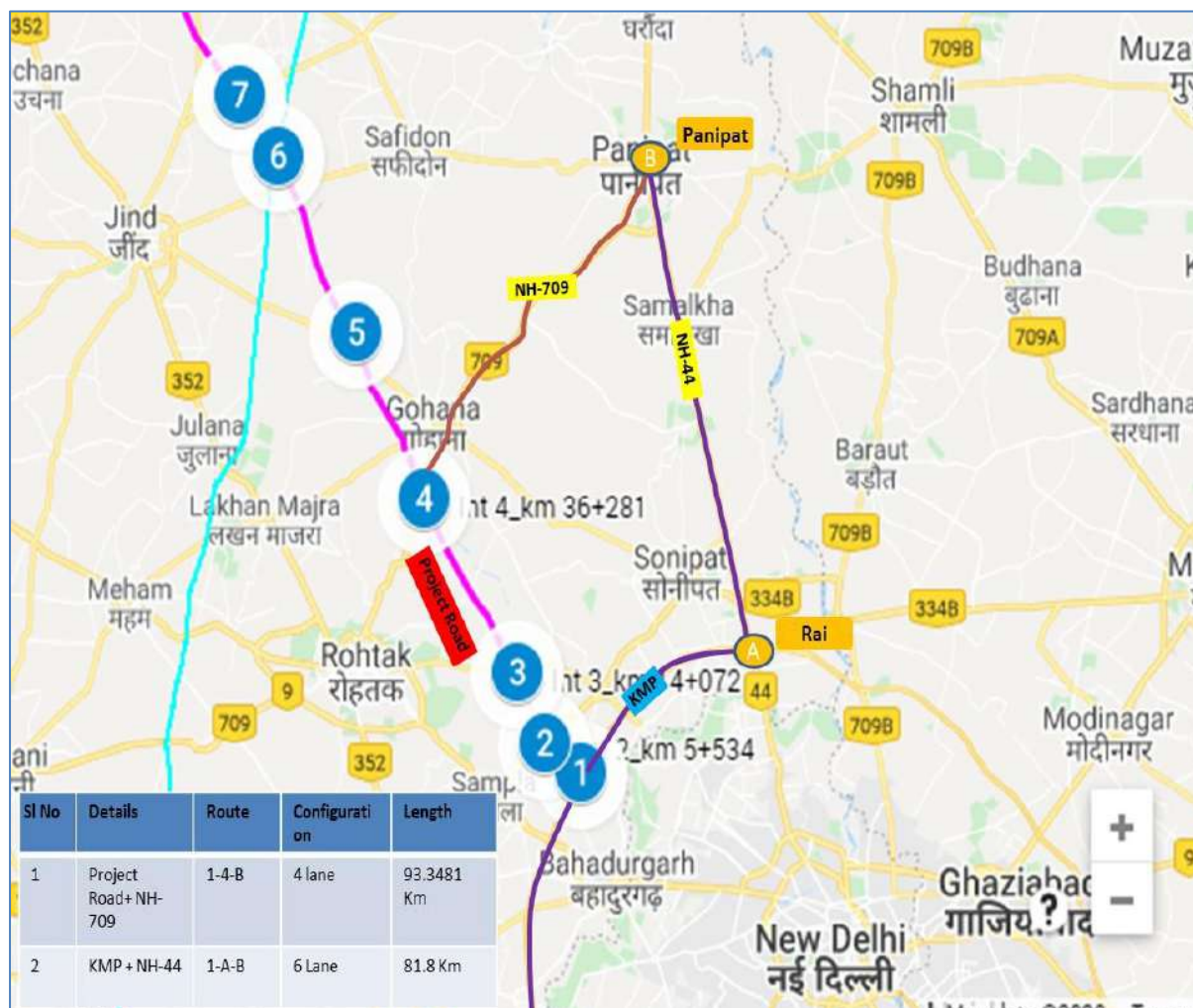


Figure 4-8: Alternate Route from Point 1(Delhi) to Point 4 (Panipat)

Alternative Route-1: Via NH-44: This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western states of India and destined at Panipat, North and North-East of Haryana, Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-46: Details of Alternate Road via NH-44 and Project Road (Delhi-Katra Expressway)_Int 1-4

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Start Point to Rai	27	6 lane	Good	NH-44	1
Rai to Panipat	54.8	6 lane	Good	NH-44	1
Total	81.8	-	-	-	2
Project Road					
Km 0.000 to Km 36.281 (Gohana)	36.281	4 lane	Very Good	Expressway	1
Km 35.855 to Panipat	57.2	4 lane	Good	NH-709	1
Total	93.481	-	-	-	2

Table 4-47 gives the generalized cost of alternate route and project corridor.

Table 4-47: Generalized cost of Alternate Road and Project corridor from Int 1 to Panipat

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	1086	1232
Pvt Bus	4868	5474
LCV	1611	1831
2Axle	2199	2484
3Axle	2276	2681
MAV	3845	4456

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-48**. Highest diversion can be seen in cars which is 40.0% and lowest is in freight vehicles which varies from 19% to 28% depending upon the axle configuration vehicles.

Table 4-48: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor Int 1 to Panipat

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	40.0
Taxi/Shared Jeep	40.0
Mini Bus	25.0
Govt Bus	28.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Pvt Bus	28.0
Mini LCV	40.0
LCV	25.0
2-Axle Trucks	27.0
3-Axle Trucks	18.0
MAV	21.0

B) Alternative Route for Traffic Between Point 1 (Main Toll Plaza-Bahadurgarh) and Point 6 (Ambala):

There is an existing alternative route for movement of traffic between Points 1-6. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-9** and explained in detail below:

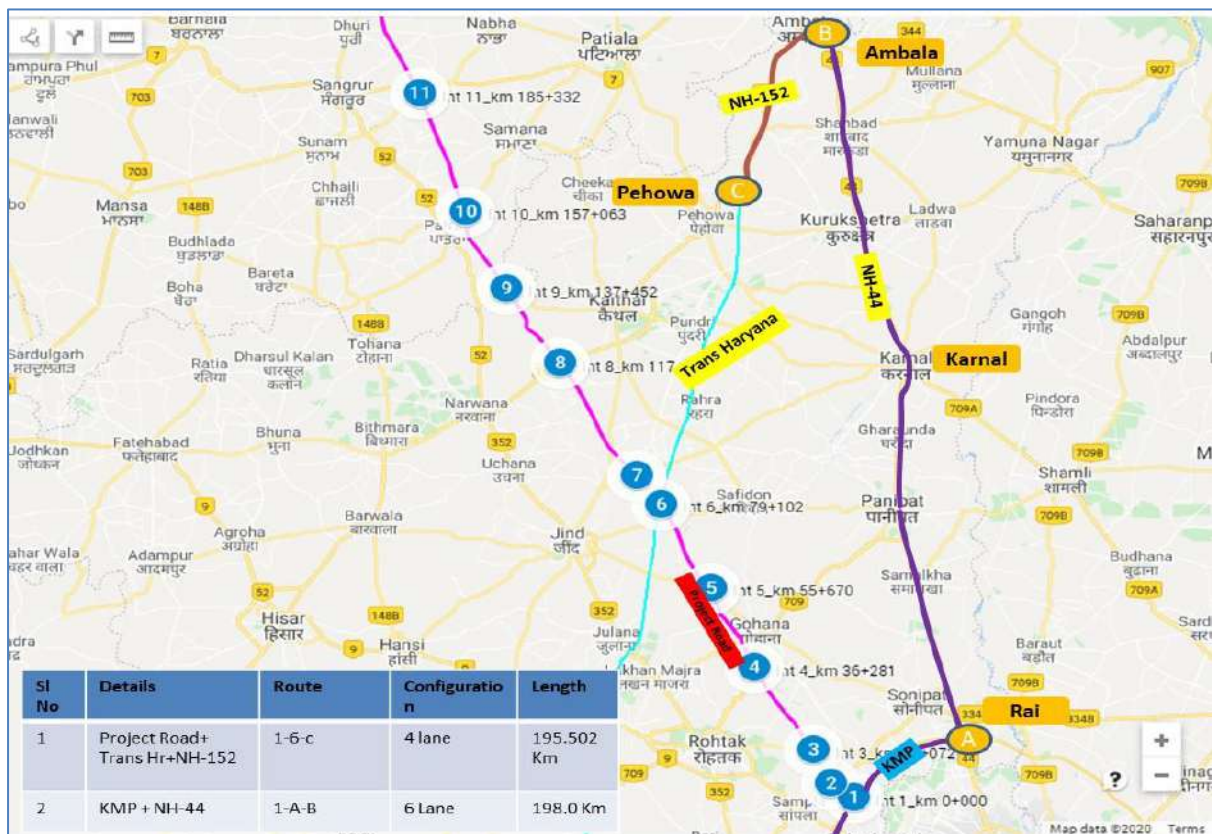


Figure 4-9: Alternate Route from Point 1(Delhi) to Point 6 (Ambala)

Alternative Route via NH-44: This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western states of India and destining at Ambala, North and North-East of Haryana, Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-49: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route					
Start Point to Rai	27	6 lane	Good	KMP	1
Rai to Ambala	171	6 lane	Good	NH-44	3
Total	198	-	-	-	4
Project Route					
Km 0.000 to Km 79.102	79.102	4 lane	Very Good	Expressway	1
km 70.102 to Pehowa (Through Trans Haryana)	75			Trans Haryana	1
Pehowa (Through Trans Haryana) to Ambala	41.4	4 lane	Good	NH-152	
Total	195.502	-	-	-	2

Table 4-50 gives the generalized cost of alternate route and project corridor.

Table 4-50: Generalized cost of Alternate Road and Project Road from Int 1 to Ambala

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	2708	2516
Pvt Bus	12200	11449
LCV	3880	3725
2-Axle Trucks	5276	5027
3-Axle Trucks	5706	5150
MAV	9224	8773

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-51**. Highest diversion can be seen in cars which is 61% and lowest is in freight vehicles which varies from 57% to 68% depending upon the axle configuration vehicles.

Table 4-51: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Int 1 to Ambala

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	61.0
Taxi/Shared Jeep	61.0
Minibus	57.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Govt Bus	61.0
Pvt Bus	61.0
Mini LCV	61.0
LCV	57.0
2-Axle Trucks	58.0
3-Axle Trucks	68.0
MAV	59.0

C) Alternative Route for Traffic Between Point 1 (Main Toll Plaza-Bahadurgarh) and Point 7 (Karnal):

There is an existing alternative route for movement of traffic between Points 1-7. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-10** and explained in detail below:

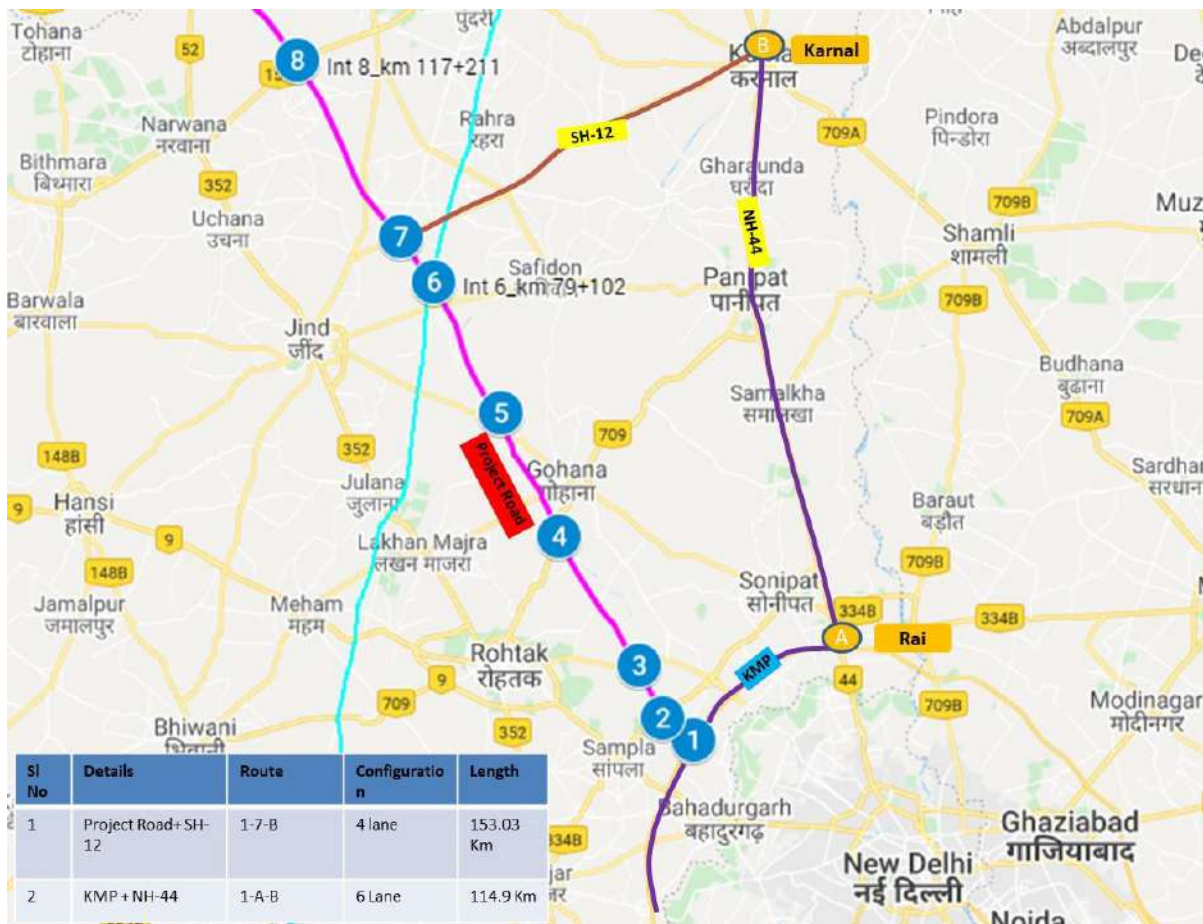


Figure 4-10: Alternate Route from Point 1(Delhi) to Point 7(Karnal)

Alternative Route via NH-44: This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-

West and South-West of Rajasthan and all the western states of India and destined at Karnal, North and North-East of Haryana, Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-52: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route					
Start Point to Rai	27	6 lane	Good	KMP	1
Rai to Panipat	54.8	6 lane	Good	NH-44	1
Panipat to Karnal	33.1	6 lane	Good	NH-44	2
Total	114.9	-	-	-	4
Project Route					
Km 0.000 to Km 87.126	87.126	4 lane	Very Good	Expressway	1
Km 87.126 to Karnal	65.9	4 lane	Good	NH-709	0
Total	153.026	-	-	-	1

Table 4-53 gives the generalized cost of alternate route and project corridor.

Table 4-53: Generalized cost of Alternate Road and Project Road from Int 1 to Karnal

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	1655	1863
Pvt Bus	7317	8373
LCV	2436	2848
2-Axle Trucks	3440	3766
3-Axle Trucks	3795	3856
MAV	5921	6632

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-54**. Highest diversion can be seen in cars which is 41% and lowest is in freight vehicles which varies from 20% to 47% depending upon the axle configuration vehicles.

Table 4-54: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Int 1 to Karnal

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	41.0
Taxi/Shared Jeep	41.0
Mini Bus	20.0
Govt Bus	24.0
Pvt Bus	24.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Mini LCV	41.0
LCV	20.0
2-Axle Trucks	33.0
3-Axle Trucks	47.0
MAV	28.0

D) Alternative route for Traffic Between Point 1 (First Toll Plaza) and Point 10 (Partan/ Chandigarh)

There is an existing alternative route for movement of traffic between Points 1-10. This route is via combination of NH-44 and NH-152. The alignment of existing alternative road along with project corridor is presented in **Figure 4-11** and explained in detail below:

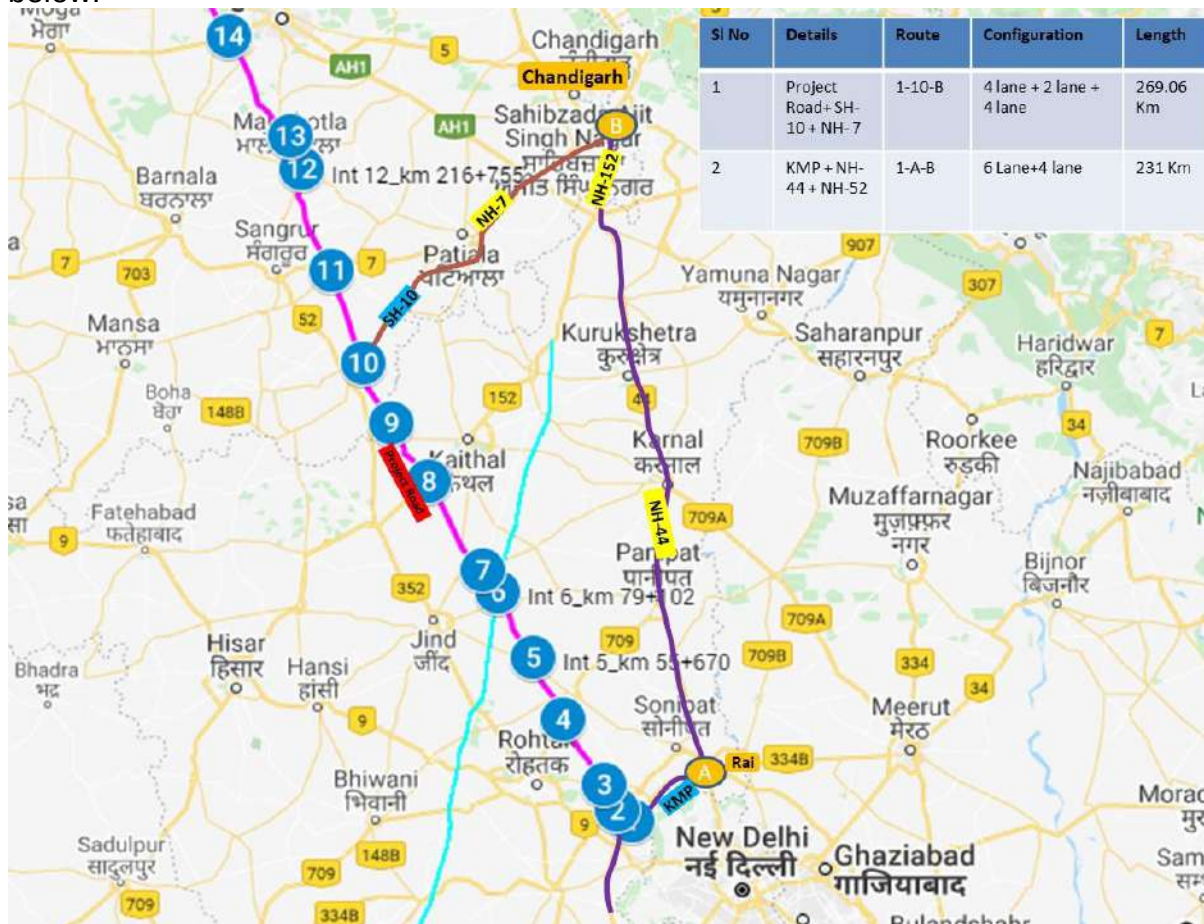


Figure 4-11: Alternate Route from Point 1(Delhi) to Point 10 (Chandigarh) keeping KMP as start point.

Alternative Route-1: Via NH-44 and NH-152 (Keeping KMP as Start Point): This route is currently used by traffic which is originating from Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western

states of India and destining at Chandigarh, North-East of Haryana, East of Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-55: Details of Alternate Road via NH-44 & NH-152 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type Road	No of Toll Plaza
Alternative Route-1					
Start Point to Rai	27	6 lane	Good	KMP	1
Rai to Chandigarh	204	6 lane	Good	NH-44/ NH-152	4
Total	231	-	-	-	5
Project Route					
Km 0.000 to Km 157.063 (Patran)	157.063	4 lane	Very Good	Expressway	1
Km 157.063 to Patiala Bypass	53.80	2 lane	Good	SH-10	1
Patiala Bypass to Chandigarh	58.20	4 lane	Good	NH-7	2
Total	269.063	-	-	-	4

Table 4-56 gives the generalized cost of alternate route and project road.

Table 4-56: Generalized cost of Alternate Road and Project road from point 1 to Chandigarh

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	3241	3381
Pvt Bus	14662	15234
LCV	4528	5155
2-Axle Trucks	6160	6955
3-Axle Trucks	6731	7243
MAV	10801	12119

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-57**. Highest diversion can be seen in Cars which is 49% and lowest is in freight vehicles which varies from 25% to 36% depending upon the axle configuration vehicles.

Table 4-57: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from point 1 to Chandigarh

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	48.0
Taxi/Shared Jeep	48.0
Minibus	24.0
Govt Bus	42.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Pvt Bus	42.0
Mini LCV	48.0
LCV	24.0
2-Axle Trucks	24.0
3-Axle Trucks	34.0
MAV	26.0

Alternate Route-2 (Keeping Connaught Place as a starting Point): This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western states of India and destining at Chandigarh, North-East of Haryana, East of Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

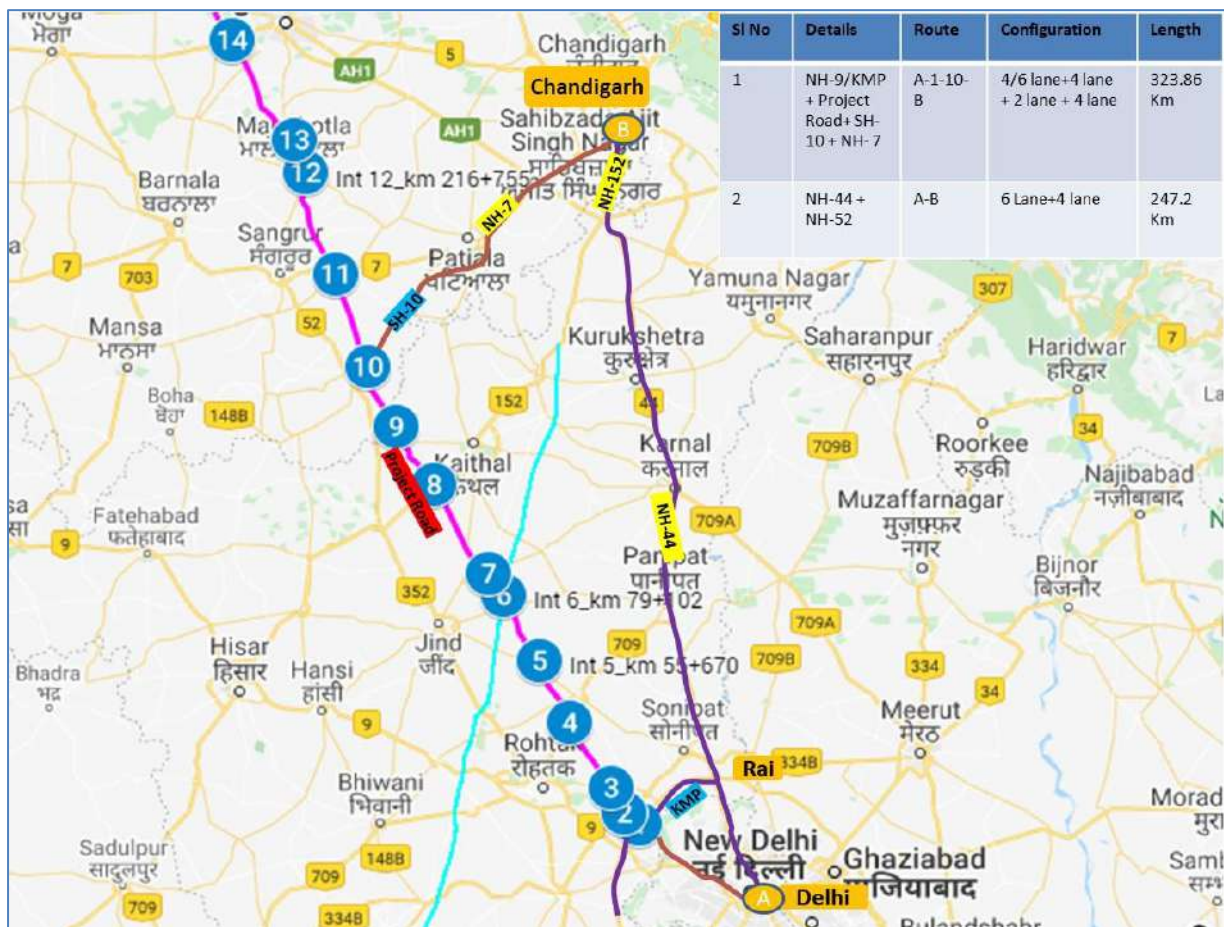


Figure 4-12: Alternate Route from Delhi (CP) to Point 10 (Chandigarh) keeping Connaught Place as start point

Table 4-58: Details of Alternative Route via NH-44&NH-152 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi (CP) to Rai	43.2	6 lane	Good	Delhi City Road/ NH-44	0
Rai to Chandigarh	204	6 lane	Good	NH-44/ NH-152	4
Total	247.2	-	-	-	4
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 157.063 (Patran)	157.063	4 lane	Very Good	Expressway	1
Km 157.063 to Patiala Bypass	53.80	2 lane	Good	SH-10	1
Patiala Bypass to Chandigarh	58.20	4 lane	Good	NH-7	2
Total	323.863	-	-	-	4

Table 4-59 gives the generalized cost of alternate route and project corridor.

Table 4-59: Generalized cost of Alternate Road and Project Road from Delhi (CP) to Chandigarh

Vehicle Type	Generalised Cost	
	Alternate Road	Project Road
Car	3391	4190
Pvt Bus	15421	19061
LCV	4715	6156
2Axle	6323	8290
3Axle	6893	8656
MAV	11140	14500

Percentage of Traffic Diversion from Alternate Road is as shown in **Table 4-60**.

Table 4-60: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Delhi (CP) to Chandigarh

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	30.0
Taxi/Shared Jeep	30.0
Minibus	5.0
Govt Bus	8.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Pvt Bus	8.0
Mini LCV	30.0
LCV	5.0
2-Axle Trucks	5.0
3-Axle Trucks	5.0
MAV	5.0

E) Alternative route for Traffic Between Point 1 (first Toll Plaza) and Point 14 (Ludhiana):

There is an existing alternative route for the traffic moving between Points 1-14. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-13** and explained in detail below:

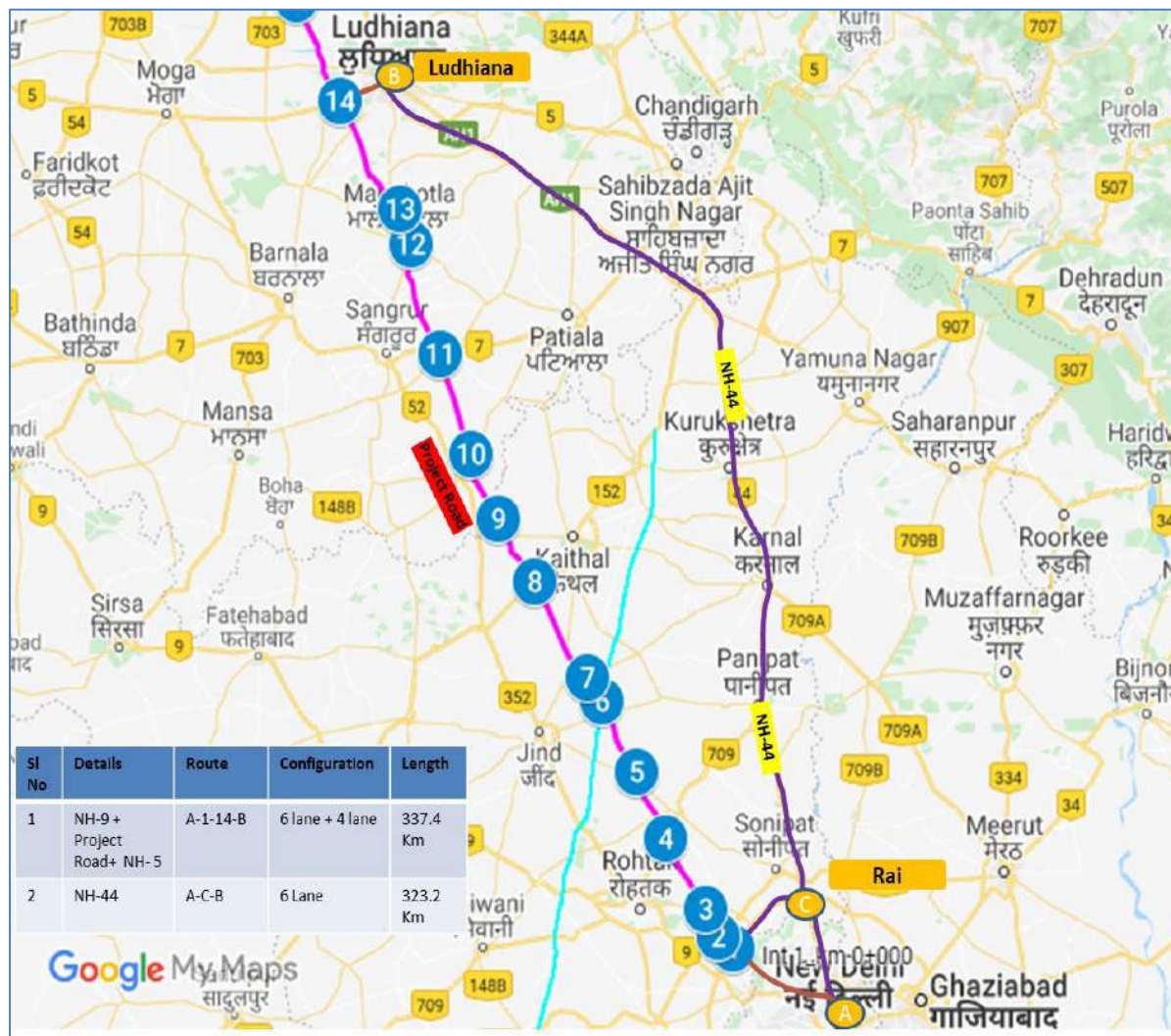


Figure 4-13: Alternate Route from Point 1 (Delhi) to Point 14 (Ludhiana)

Alternative Route-1: Via NH-44: This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western states of India and destined at Ludhiana, North, North-East and North-West of Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-61: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi (CP) to Rai	43.2	6 lane	Good	Delhi City Road/ NH-44	0
Rai to Ludhiana	280	6 lane	Good	NH-44	4
Total	323.2	-	-	-	4
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 261.800	261.800	4 lane	Very Good	Expressway	1
Km 261.800 to Ludhiana	20.8	4 lane	Good	NH 5	
Total	337.40	-	-	-	1

Table 4-62 gives the generalized cost of alternate route and project corridor.

Table 4-62: Generalized cost of Alternate road and Project road from Delhi to Ludhiana

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	4392	4082
Pvt Bus	20018	18124
LCV	6095	6427
2-Axle Trucks	8122	8616
3-Axle Trucks	8837	8787
MAV	14358	15059

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-63**. Highest diversion can be seen in Buses which is 67% and lowest is in freight vehicles which varies from 39% to 51% depending upon the axle configuration vehicles.

Table 4-63: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor Delhi to Ludhiana

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	61.0
Taxi/Shared Jeep	61.0
Minibus	40.0
Govt Bus	67.0
Pvt Bus	67.0
Mini LCV	61.0
LCV	40.0
2-Axle Trucks	39.0
3-Axle Trucks	51.0
MAV	41.0

F) Alternative route for Traffic Between Point 1 (first Toll Plaza) and Point 16 (Jalandhar):

There is an existing alternative route for the traffic moving between Points 1-16. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-14** and explained in detail below:

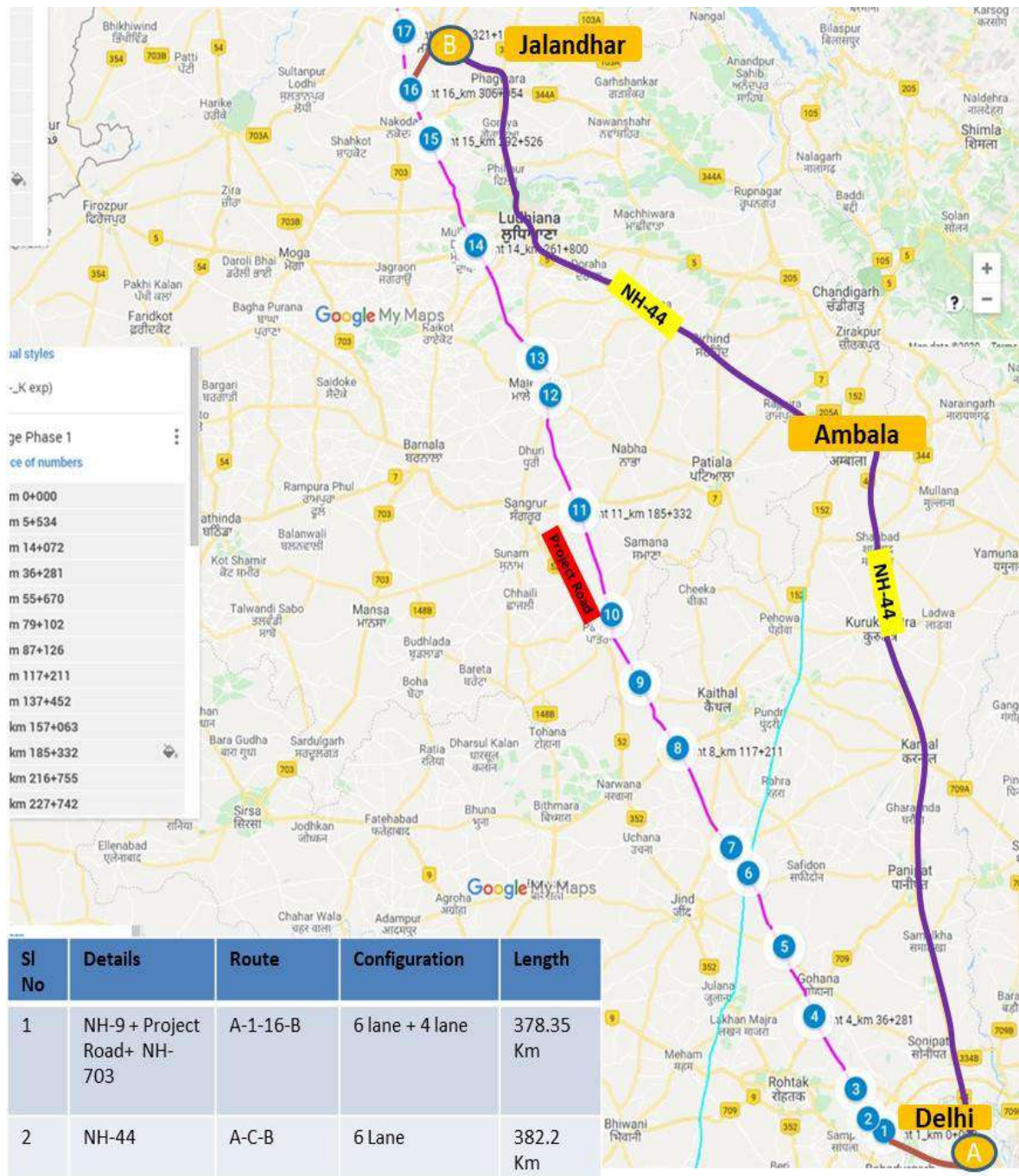


Figure 4-14: Alternate Route from Point 1 (Delhi) to Point 16 (Jalandhar)

Alternative Route-1: Via NH-44: This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western states of India and destined at Jalandhar, North, North-East and North-West of Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-64: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi (CP) to Rai	43.2	6 lane	Good	Delhi City Road/ NH-44	0
Rai to Jalandhar	339	6 lane	Good	NH-44	5
Total	382.2	-	-	-	5
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 306.054	306.054	4 lane	Very Good	Expressway	1
Km 306.054 to Jalandhar	17.5	4 lane	Good	NH 703	
Total	378.354	-	-	-	1

Table 4-65 gives the generalized cost of alternate route and project corridor.

Table 4-65: Generalized cost of Alternate Road and Project Road from Delhi to Jalandhar

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	5267	4586
Pvt Bus	23928	20299
LCV	7335	7249
2-Axle Trucks	9861	9744
3-Axle Trucks	10890	9938
MAV	17399	17014

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-66**. Highest diversion can be seen in Buses which is 77% and lowest is in freight vehicles which varies from 52% to 66% depending upon the axle configuration vehicles.

Table 4-66: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor Delhi to Jalandhar

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	67.0
Taxi/Shared Jeep	67.0
Mini Bus	52.0
Govt Bus	77.0
Pvt Bus	77.0
Mini LCV	67.0
LCV	52.0
2-Axle Trucks	52.0
3-Axle Trucks	66.0
MAV	54.0

G) Alternative route for Traffic Between Point 1 (First Toll Plaza) and Point 18 (Amritsar):

There are two existing alternative routes for the traffic moving between Point 1 and 18. These are via NH-44 and Combination of NH-09 and NH-54. The alignment of existing alternative road along with project corridor is presented in **Figure 4-15** and explained in detail below:

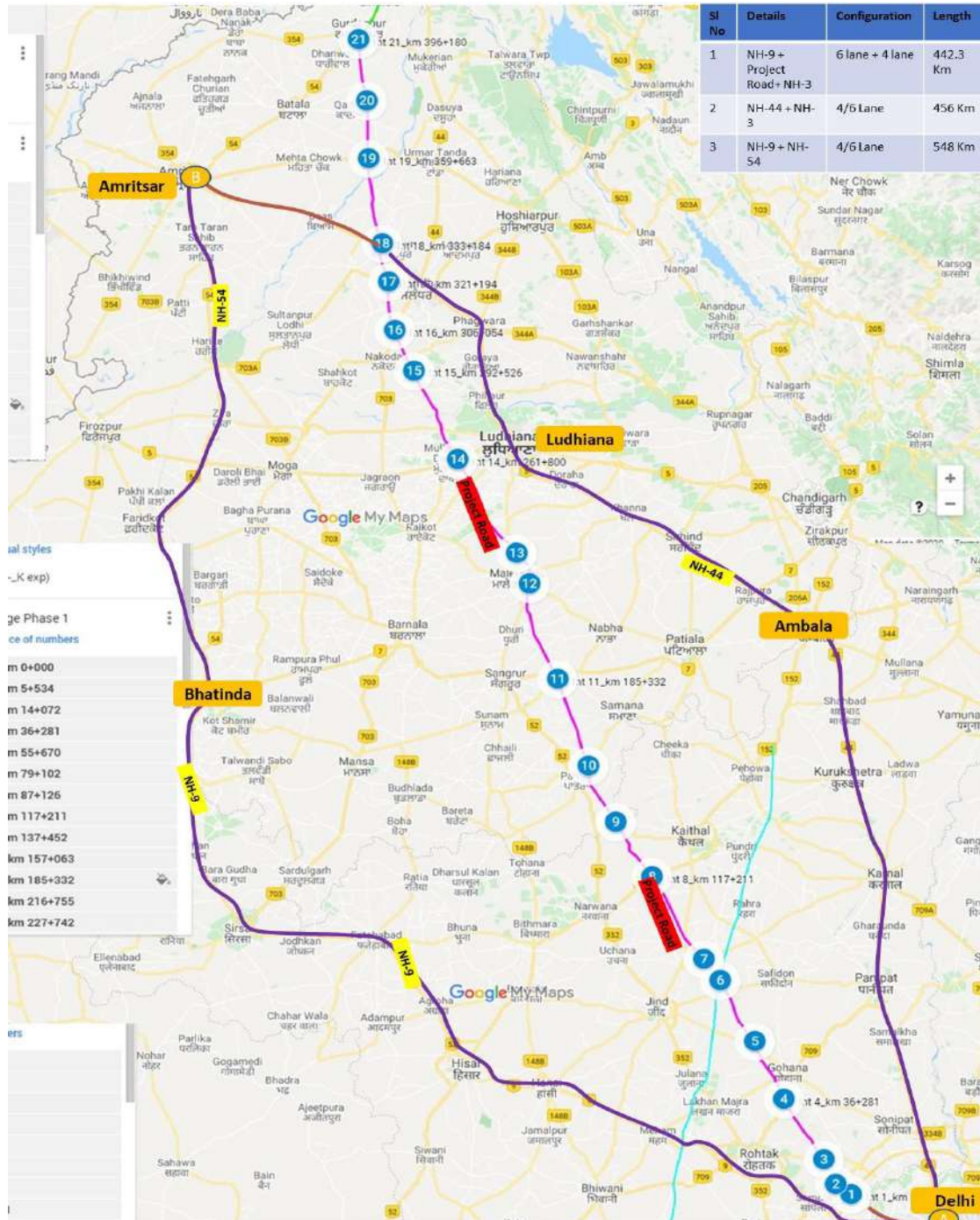


Figure 4-15: Alternate Routes for Point 1 (Delhi) to Point18 (Amritsar)

Alternative Route 1: Via NH-44: This route is currently used by traffic which is originating from Delhi, Gurugram, South and South-East of Haryana; West, North-West and South-West of Rajasthan and all the western states of India and destining at Panipat, North and North-East of Haryana, Punjab, Himachal Pradesh and J&K. This is the most preferred highway for traffic which is bound to Amritsar and further to the Northern States of India from Delhi. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-67: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type Road	No of Toll Plaza
Alternative Route					
Delhi to Amritsar via Ambala	456	4/6 lane	Good	Delhi City Road/ NH-44	7
Total	456	-	-	-	7
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 333.184	332.184	4 lane	Very Good	Expressway	1
Km 333.184 to Amritsar	54.3	4 lane	Good	NH-3	1
Total	442.284	-	-	-	2

Table 4-68 gives the generalized cost of alternate route and project corridor.

Table 4-68: Generalized cost of Alternate Road and Project road from Delhi to Amritsar via Ambala

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	6780	6269
Pvt Bus	32532	28821
LCV	8760	8612
2-Axle Trucks	12088	11764
3-Axle Trucks	12876	12355
MAV	20622	20604

Traffic Diversion from Alternate Road to project corridor is given in

Table 4-69. Highest diversion can be seen in Buses which is 71% and lowest is in freight vehicles which varies from 50% to 57% depending upon the axle configuration vehicles.

Table 4-69: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	61.0
Taxi/Shared Jeep	61.0
Mini Bus	53.0
Govt Bus	71.0
Pvt Bus	71.0
Mini LCV	61.0
LCV	53.0
2-Axle Trucks	55.0
3-Axle Trucks	57.0
MAV	50.0

Alternative Route 2: Via NH-09 and NH-54: This is the least preferred route for traffic which is bound to Amritsar and further North of India. This route is currently used by traffic which is originating from Delhi, Haryana, Rajasthan and all the Central, Southern and western states of India and destining at Amritsar, North of Punjab, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-70: Details of Alternate Road via NH-09 and NH-54 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route					
Delhi to Amritsar via Bathinda	548	4/6 lane	Good	NH-9,NH-54	5
Total	548	-	-	-	5
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 333.184	332.184	4 lane	Very Good	Expressway	1
Km 333.184 to Amritsar	54.3	4 lane	Good	NH-3	1
Total	442.284	-	-	-	2

Table 4-71 gives the generalized cost of alternate route and project corridor.

Table 4-71: Generalized cost of Alternate Road and Project corridor from Delhi to Amritsar via Bhatinda

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	7245	5414
Pvt Bus	33230	24005
LCV	9980	8510
2-Axle Trucks	13060	11453
3-Axle Trucks	13799	11794
MAV	23296	20010

Traffic Diversion from Alternate Road to project corridor is given **Table 4-72**. Highest diversion can be seen in Buses which is 95.17% and lowest is in freight vehicles which varies from 72% to 76% depending upon the axle configuration vehicles. As it can be seen which the help of table that diversion from the existing alternative route is highest in this case as compared to other alternative roads. This is just because this route is quite longer as compared to the proposed expressway.

Table 4-72: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Delhi to Amritsar via Bhatinda

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	79.0
Taxi/Shared Jeep	79.0
Mini Bus	77.0
Govt Bus	95.0
Pvt Bus	95.0
Mini LCV	79.0
LCV	77.0
2-Axle Trucks	72.0
3-Axle Trucks	76.0
MAV	75.0

H) Alternative route for Traffic Between Point 1 (Delhi) and 21 (Gurdaspur):

There is an existing alternative route for the traffic moving between Points 1 to 21. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-16** and explained in detail below:

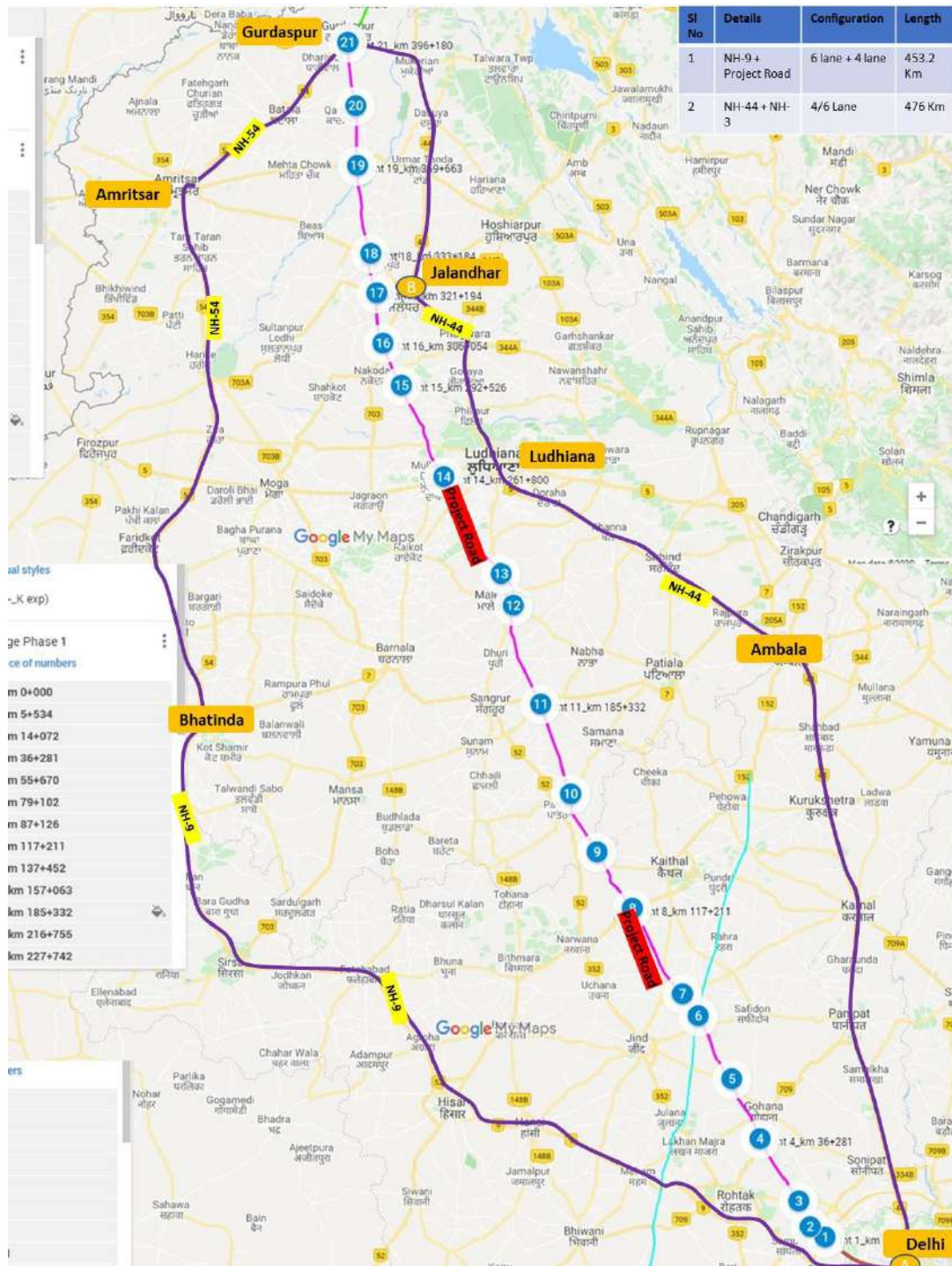


Figure 4-16: Alternate Routes from Point 1(Delhi) to Point 21 (Gurdaspur)

Alternative Route: Via NH-44: This route is currently used by traffic which is originating from Delhi, Haryana, Rajasthan and all the Central, Southern and western states of India and destining at Gurdaspur, Pathankot, Himachal Pradesh and J&K. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-73: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi to Gurdaspur	476	4/6 lane	Good	Delhi City Road/ NH-44	6
Total	476	-	-	-	6
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 396.180 (Gurdaspur)	396.180	4 lane	Very Good	Expressway	1
Km 396.180 to Gurdaspur	2.2	4lane	Good	NH-44	1
Total	453.18	-	-	-	2

Table 4-74 gives the generalized cost of alternate route and project corridor.

Table 4-74: Generalized cost of Alternate road and Project road from Delhi to Gurdaspur

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	6539	5469
Pvt Bus	29724	24169
LCV	9095	8720
2-Axle Trucks	12204	11727
3-Axle Trucks	13473	11942
MAV	21554	20453

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-75**. Highest diversion can be seen in Buses which is 83% and lowest is in freight vehicles which varies from 56% to 69% depending upon the axle configuration vehicles.

Table 4-75: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Delhi to Gurdaspur

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	70.0
Taxi/Shared Jeep	70.0
Mini Bus	57.0
Govt Bus	83.0
Pvt Bus	83.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Mini LCV	70.0
LCV	57.0
2-Axle Trucks	56.0
3-Axle Trucks	69.0
MAV	58.0

I) Alternative route for Traffic Between Point 14 (Ludhiana) to Point 16 (Jalandhar):

There is existing alternative route for traffic between Ludhiana and Jalandhar. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-17** and explained in detail below:

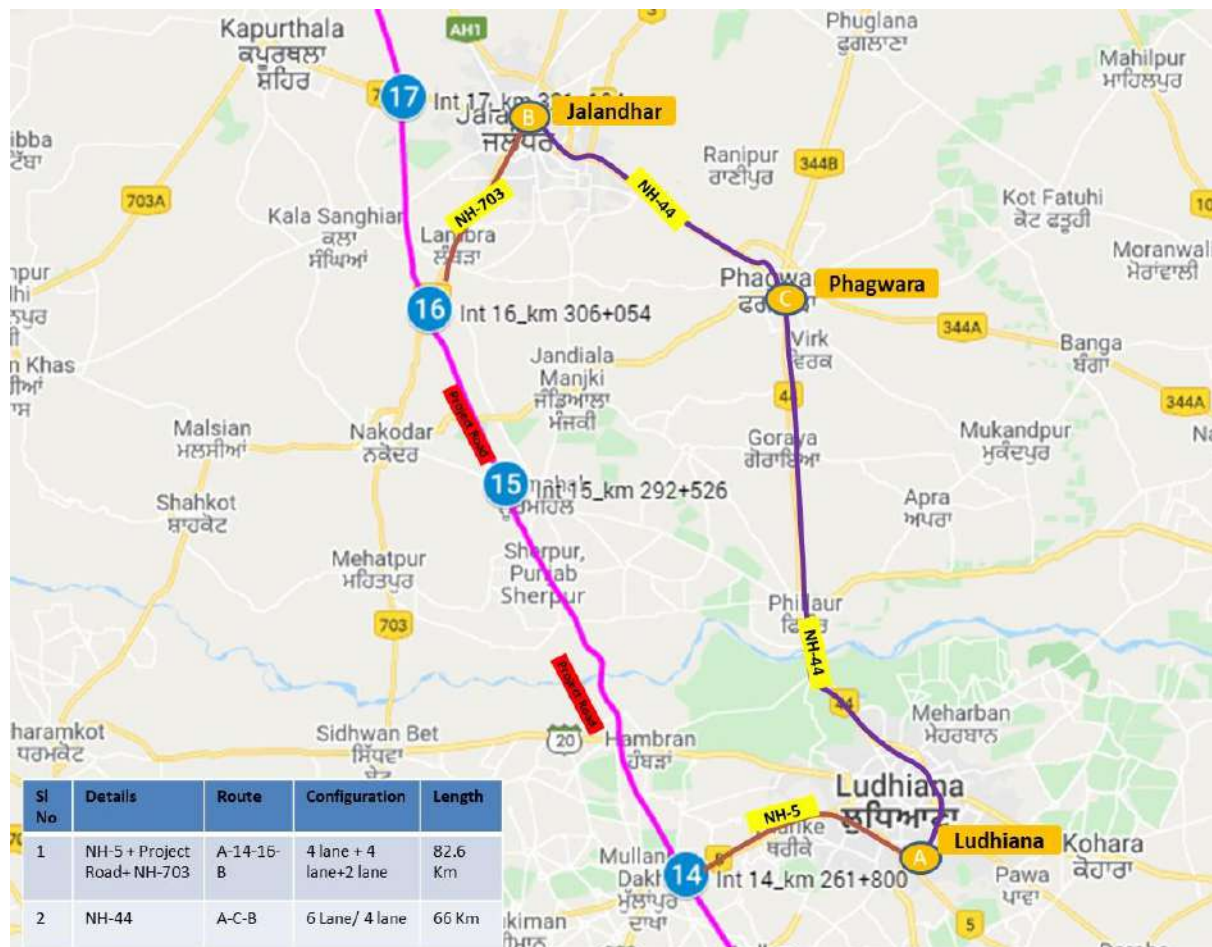


Figure 4-17: Alternative Routes for Through Traffic between Ludhiana and Jalandhar

Alternative Route 1: Via NH-44 (Ludhiana- Jalandhar Road):

Existing NH-44 is an existing alternative route for traffic which is originating from Ludhiana and destining at Jalandhar (Vice-Versa). Though there will be very less diversion from the alternative route to the project corridor due to factors like route length, but some of the vehicles will definitely be diverted to the project corridor from existing alternative route.

Table 4-76: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route					
Ludhiana to Jalandhar	66	4/6 lane	Good	NH-44	1
Total	66	-	-	-	1
Project Route					
Ludhiana to Km 261.800 (Interchange 14)	20.8	4 Lane	Good	NH-5	
Km 261.800 to Km 306.054	44.254	4 lane	Very Good	Expressway	1
Km 306.054 to Jalandhar	17.5	4 lane	Good	NH-703	
Total	82.554	-	-	-	1

Table 4-77 gives the generalized cost of alternate route and project corridor.

Table 4-77: Generalized cost of Alternate Road and Project Road from Ludhiana to Jalandhar

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	1039	1169
Pvt Bus	4913	5441
LCV	1369	1572
2-Axle Trucks	1954	2137
3-Axle Trucks	2214	2207
MAV	3320	3749

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-78**. Highest diversion can be seen in Cars which is 41% and lowest is in buses which is in the range 23% to 51%.

Table 4-78: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Ludhiana to Amritsar

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	41.0
Taxi/Shared Jeep	41.0
Mini Bus	23.0
Govt Bus	31.0
Pvt Bus	31.0
Mini LCV	41.0
LCV	23.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
2-Axle Trucks	33.0
3-Axle Trucks	51.0
MAV	27.0

J) Alternative route for Traffic Between Point 14(Ludhiana) and Point 18 (Amritsar):

There is an existing alternative route for the traffic moving between Point 14 and 18. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-18** and explained in detail below:

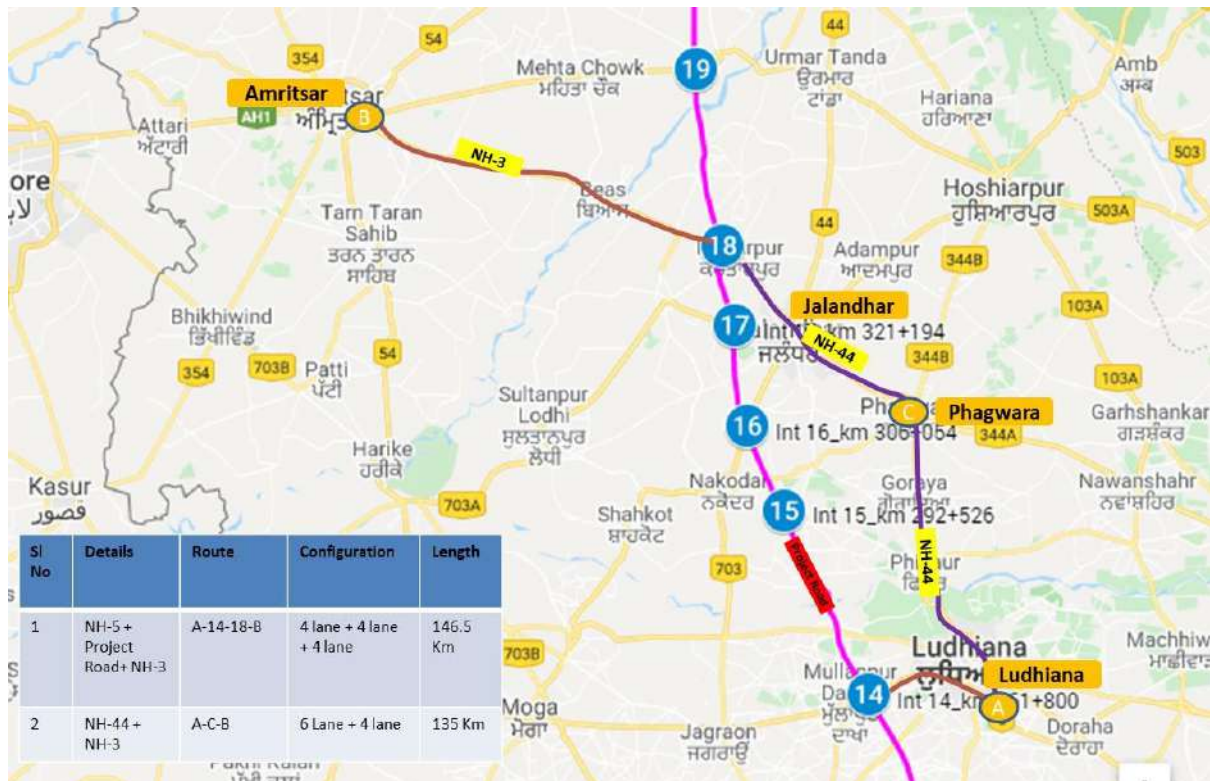


Figure 4-18: Alternative Routes for Through Traffic between Ludhiana and Amritsar

Alternative Route: Via NH-44:

Existing NH-44 is an existing alternative route for traffic which is originating from Ludhiana and destining at Amritsar (Vice-Versa). As there is not much difference in route lengths in both the roads some of the vehicles will be diverted to the project corridor from existing alternative route, so it is important to study this route also.

Table 4-79: Details of Alternate Road via NH-48 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Ludhiana to Amritsar via Jalandhar	135	4/6 lane	Good	Delhi City Road/ NH-44	3
Total	135	-	-	-	3
Project Route					
Ludhiana to Km 261.800 (Interchange 14)	21.9	4 Lane	Good	NH-5	
Km 261.800 to Km 333.184	71.384	4 lane	Very Good	Expressway	1
Km 333.184 to Amritsar	54.3	4 lane	Good	NH-3	2
Total	146.484	-	-	-	3

Table 4-80 gives the generalized cost of alternate route and project corridor.

Table 4-80: Generalized cost of Alternate Road and Project road from Ludhiana to Amritsar

Vehicle Type	Generalized Cost	
	Alternate Road	Project Road
Car	2047	2105
Pvt Bus	9774	9812
LCV	2666	2828
2-Axle Trucks	3722	3868
3-Axle Trucks	4090	4087
MAV	6351	6729

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-81**. Highest diversion can be seen in Cars which is 51% and lowest is in buses and LCVs which is 39%.

Table 4-81: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Ludhiana to Amritsar

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	51.0
Taxi/Shared Jeep	51.0
Mini Bus	39.0
Govt Bus	49.0
Pvt Bus	49.0
Mini LCV	51.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
LCV	39.0
2-Axle Trucks	43.0
3-Axle Trucks	50.0
MAV	39.0

K) Alternative route for Traffic Between Point 19 (Amritsar) and Point 21 (Gurdaspur):

There is an existing alternative route for the traffic moving between Point 19 and 21. This route is via NH-54. The alignment of existing alternative road along with project corridor is presented in **Figure 4-19** and explained in detail below:

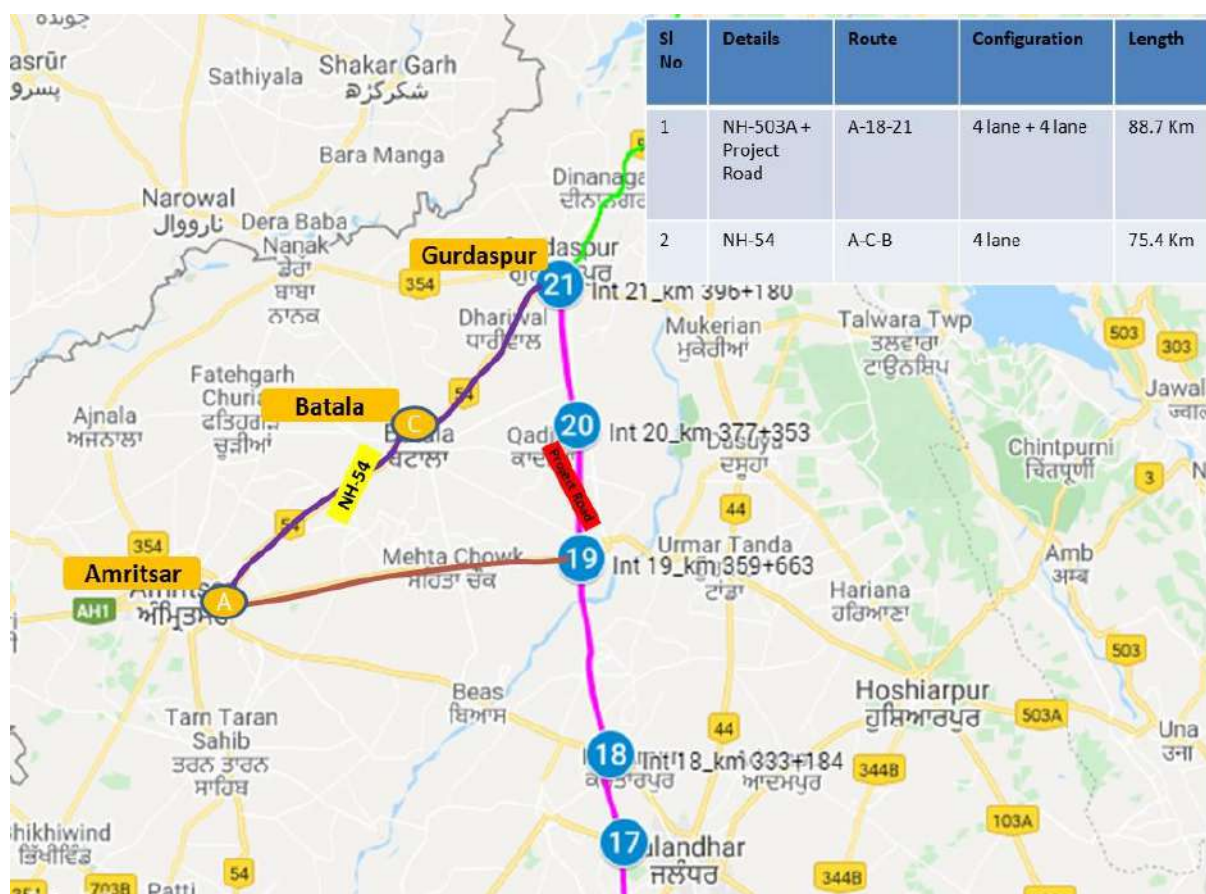


Figure 4-19: Alternative Routes for Through Traffic between from Amritsar to Gurdaspur

Alternative Route: Via NH-54:

Existing NH-54 is an existing alternative route for traffic which is originating from Amritsar and destined at Gurdaspur, Pathankot and J&K state (Vice-Versa). As there is not much difference in route lengths in both the roads some of the vehicles will be

diverted to the project corridor from existing alternative route, so it is important to study this route also.

Table 4-82: Details of Alternate Road via NH-48 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Amritsar to Gurdaspur	75.4	4/6 lane	Good	NH-54	1
Total	75.4	-	-	-	1
Project Route					
Amritsar to km 359.663	50	4 Lane	Good	NH-503A	0
Km 359.663 to Km 396.180 (Gurdaspur)	36.517	4 lane	Very Good	Expressway	1
Km 396.180 to Gurdaspur	2.2	4lane	Good	NH-44	0
Total	88.72	-	-	-	1

Table 4-83 gives the generalized cost of alternate route and project corridor.

Table 4-83: Generalized cost of Alternate Road and Project road from Amritsar to Jalandhar

Vehicle Type	Generalized Cost	
	Alternate Road	Project Road
Car	1043	1091
Pvt Bus	4716	4943
LCV	1445	1623
2-Axle Trucks	1941	2128
3-Axle Trucks	2160	2182
MAV	3423	3761

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-84**. Highest diversion can be seen in Cars which is 49% and lowest is in buses and LCVs which is 28%.

Table 4-84: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Amritsar to Jalandhar

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	49.0
Taxi/Shared Jeep	49.0
Mini Bus	28.0
Govt Bus	41.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Pvt Bus	41.0
Mini LCV	49.0
LCV	28.0
2-Axle Trucks	33.0
3-Axle Trucks	48.0
MAV	32.0

L) Alternative route for Traffic Between Point 1 (Delhi) and 22 (Pathankot):

There is an existing alternative route for the traffic moving between Points 1 to 22. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-20** and explained in detail below:

Alternative Route: Via NH-44: This route is currently used by traffic which is originating from Delhi, Haryana, Rajasthan and all the Central, Southern and western states of India and destining at Pathankot. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.



**Figure 4-20: Alternative Routes for Through Traffic between from Delhi to Pathankot
and onwards**

Table 4-85: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi to Pathankot	494	4/6 lane	Good	Delhi City Road/ NH-44	7
Total	494	-	-	-	7
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 424.557 (Pathankot)	424.557	4 lane	Very Good	Expressway	1
Km 424.557 to Pathankot	15.2	4lane	Good	NH-54	0
Total	494.557	-	-	-	1

Table 4-86 gives the generalized cost of alternate route and project corridor.

Table 4-86: Generalized cost of Alternate Road and Project Road from Delhi to Pathankot

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	6863	5998
Pvt Bus	31109	26478
LCV	9562	9549
2-Axle Trucks	12926	12890
3-Axle Trucks	14243	13142
MAV	22780	22463

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-87**. Highest diversion can be seen in Buses which is 77% and lowest is in freight vehicles which varies from 50% to 64% depending upon the axle configuration vehicles.

Table 4-87: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Delhi to Pathankot

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	66.0
Taxi/Shared Jeep	66.0
Mini Bus	50.0
Govt Bus	77.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Pvt Bus	77.0
Mini LCV	66.0
LCV	50.0
2-Axle Trucks	51.0
3-Axle Trucks	64.0
MAV	53.0

M) Alternative route for Traffic Between Point 1 (Delhi) and 29 (Jammu):

There is an existing alternative route for the traffic moving between Points 1 to 29. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-20** and explained in detail below:

Alternative Route: Via NH-44: This route is currently used by traffic which is originating from Delhi, Haryana, Rajasthan and all the Central, Southern and western states of India and destining at Jammu. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-88: Details of Alternate Road via NH-44 and Project Corridor from Delhi to Jammu

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi to km 502.800	581	4/6 lane	Good	Delhi City Road/ NH-44	8
Km 502.800 to Jammu	11.3	4lane	Good	NH-44	1
Total	592.3	-	-	-	9
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 502.800 (Jammu Ring Road)	502.8	4 lane	Very Good	Expressway	1
Km 502.800 to km 514.500	11.7	4 lane	Good	Expressway	1
Total	569.3	-	-	-	2
Alternative Route-2 (Via Pathankot Link)					
Delhi to St. of Pathankot link	486	4/6 lane	Good	Delhi City Road/ NH-44	7
Pathankot link	13.5	4 lane	Very Good	Expressway	1
km 428.500 to km 453.000	24.5	4 lane	Very Good	Expressway	1
Km 453.000 to Jammu	62.1	4lane	Good	NH-44	1
Total	569.3	-	-	-	10

Table 4-89 gives the generalized cost of alternate route and project corridor.

Table 4-89: Generalized cost of Alternate Road and Project road from Delhi to Jammu

Vehicle Type	Generalized Cost		
	Alternate Road-1	Alternate Road-2	Project Corridor
Car	9267	9046	7039
Pvt Bus	43983	42891	30847
LCV	11700	11583	11273
2-Axle Trucks	16240	16094	15419
3-Axle Trucks	17821	17597	15746
MAV	28938	28627	26756

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-90**. Highest diversion can be seen in Buses which is 95% and lowest is in freight vehicles which varies from 55% to 69% depending upon the axle configuration vehicles.

Table 4-90: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Delhi to Jammu

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	76.0
Taxi/Shared Jeep	76.0
Mini Bus	55.0
Govt Bus	95.0
Pvt Bus	95.0
Mini LCV	76.0
LCV	55.0
2-Axle Trucks	58.0
3-Axle Trucks	69.0
MAV	62.0

N) Alternative route for Traffic Between Point 1 (Delhi) and 32 (Katra):

There is an existing alternative route for the traffic moving between Points 1 to 32. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-20** and explained in detail below:

Alternative Route: Via NH-44: This route is currently used by traffic which is originating from Delhi, Haryana, Rajasthan and all the Central, Southern and western states of India and destining at Katra and beyond. This is the potential divertible traffic which can be shifted to the proposed Greenfield Expressway.

Table 4-91: Details of Alternate Road via NH-44 and Project Corridor from Delhi to Katra

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Delhi to Katra	643	4/6 lane	Good	Delhi City Road/ NH-44	10
Total	643	-	-	-	10
Project Route					
Delhi (CP) to Start Point	54.8	4/6 Lane	Good	NH-9, KMP	0
Km 0.000 to Km 564.700	564.7	4 lane	Very Good	Expressway	1
Total	619.5	-	-	-	1
Alternative Route-2 (via Pathankot link)					
Delhi to St. of Pathankot link	486	4/6 lane	Good	Delhi City Road/ NH-44	8
Pathankot link	13.5	4 lane	Very Good	Expressway	1
km 428.500 to km 453.000	24.5	4 lane	Very Good	Expressway	1
Km 453.000 to Jammu	113	4lane	Good	NH-44	1
Total	637	-	-	-	11

Table 4-92 gives the generalized cost of alternate route and project corridor.

Table 4-92: Generalized cost of Alternate Road and Project Road from Delhi to Katra

Vehicle Type	Generalized Cost		
	Alternate Road – 1	Alternate Road - 2	Project Corridor
Car	10482	10252	8088
Pvt Bus	50316	49169	36201
LCV	12858	12742	12497
2-Axle Trucks	18048	17902	17365
3-Axle Trucks	19771	19542	17750
MAV	32239	31924	30204

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-93**. Highest diversion can be seen in Buses which is 95% and lowest is in freight vehicles which varies from 53% to 67% depending upon the axle configuration vehicles.

Table 4-93: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Delhi to Katra

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	75.0
Taxi/Shared Jeep	75.0
Mini Bus	53.0
Govt Bus	95.0
Pvt Bus	95.0
Mini LCV	75.0
LCV	53.0
2-Axle Trucks	55.0
3-Axle Trucks	67.0
MAV	60.0

O) Alternative route for Traffic from Point 21 (Gurdasur) to Point 22 (Pathankot):

There is an existing alternative route for the traffic moving between Points 21 to 22. This route is via NH-54. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** and explained in detail below:



Figure 4-21: Project Route and Alternative Routes for Through Traffic between from Gurdasur to Katra

Alternative Route: Via NH-54: This route is currently used by traffic which is originating from Gurdaspur and south of Gurdaspur and destining at Pathankot. This is the potential divertible traffic which can be shifted to the proposed Expressway.

Table 4-94: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Gurdaspur to Pathankot	39.9	4 lane	Good	NH-54	1
Total	39.9	-	-	-	1
Project Route					
Km 396.180 to Km 424.557 (Pathankot)	28.377	4 lane	Very Good	Expressway	1
Km 424.557 to Pathankot	15.2	4lane	Good	NH-54	1
Total	43.557	-	-	-	2

Table 4-95 gives the generalized cost of alternate route and project corridor.

Table 4-95: Generalized cost of Alternate road and Project road from Gurdaspur to Pathankot

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	607	530
Pvt Bus	2665	2371
LCV	848	822
2-Axle Trucks	1197	1094
3-Axle Trucks	1398	1119
MAV	2067	1921

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-96**. Highest diversion can be seen in 3-axle truck which is 85% and lowest is in LCV vehicles which is 56%.

Table 4-96: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Gurdaspur to Pathankot

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	66.0
Taxi/Shared Jeep	66.0
Mini Bus	56.0
Govt Bus	70.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Pvt Bus	70.0
Mini LCV	66.0
LCV	56.0
2-Axle Trucks	65.0
3-Axle Trucks	85.0
MAV	62.0

P) Alternative route for Traffic from Point 21 (Gurdasur) to Point 25 (Kathua):

There is an existing alternative route for the traffic moving between Points 21 to 25. This route is via NH-54/NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** above and explained in detail below:

Table 4-97: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Gurdaspur to Kathua	65	4 lane	Good	NH-54/ NH-44	2
Total	65	-	-	-	2
Project Route					
Km 397.000 to Km 452.671 (Kathua)	56.671	4 lane	Very Good	Expressway	1
Total	56.671	-	-	-	1

Table 4-98 gives the generalized cost of alternate route and project corridor.

Table 4-98: Generalized cost of Alternate Road and Project Road from Gurdaspur to Kathua

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	1141	696
Pvt Bus	5191	3031
LCV	1572	1129
2-Axle Trucks	2162	1565
3-Axle Trucks	2426	1595
MAV	4013	2697

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-99**. Highest diversion can be seen in Bus / 3-axle truck / MAV which is 96% and lowest is in Car vehicles which is 91%.

Table 4-99: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Gurdaspur to Kathua

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	91.0
Taxi/Shared Jeep	91.0
Mini Bus	95.0
Govt Bus	96.0
Pvt Bus	96.0
Mini LCV	91.0
LCV	95.0
2-Axle Trucks	95.0
3-Axle Trucks	96.0
MAV	96.0

Q) Alternative route for Traffic from Point 21 (Gurdasur) to Point 29 (Jammu):

There is an existing alternative route for the traffic moving between Points 21 to 29. This route is via NH-54/NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** above and explained in detail below:

Table 4-100: Details of Alternate Road via NH-44 and Project Corridor from Gurdaspur to Jammu

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No. of Toll Plaza
Alternative Route-1					
Gurdaspur to Jammu	127.3	4 lane	Good	NH-55 / NH-44	3
Total	127.3	-	-	-	3
Project Route					
Km 397.000 to Km 514.000 (Jammu Ring Road)	117.00	4 lane	Very Good	Expressway	1
Total	117.00	-	-	-	2

Table 4-101 gives the generalized cost of alternate route and project corridor.

Table 4-101: Generalized cost of Alternate Road and Project Road from Gurdaspur to Jammu

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	2194	1616
Pvt Bus	10283	6891
LCV	2918	2624
2-Axle Trucks	3938	3810
3-Axle Trucks	4298	3925
MAV	7430	6494

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-102**. Highest diversion can be seen in buses which is 96% and lowest is in 2 axle truck vehicles which is 56%.

Table 4-102: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Gurdaspur to Jammu

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	80.0
Taxi/Shared Jeep	80.0
Mini Bus	68.0
Govt Bus	96.0
Pvt Bus	96.0
Mini LCV	80.0
LCV	68.0
2-Axle Trucks	56.0
3-Axle Trucks	66.0
MAV	73.0

R) Alternative route for Traffic from Point 21 (Gurdasur) to Point 32 (Katra):

There is an existing alternative route for the traffic moving between Points 21 to 32. This route is via NH-54/NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** above and explained in detail below:

Table 4-103: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Gurdaspur to Katra	178	4 lane	Good	NH-54 / NH-44	4
Total	178	-	-	-	4
Project Route					
Km 397.000 to Km 564.700	167.700	4/6 lane	Very Good	Expressway	1
Total	167.700	-	-	-	1

Table 4-104 gives the generalized cost of alternate route and project corridor.

Table 4-104: Generalized cost of Alternate Road and Project Road from Gurdaspur to Katra

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	3096	2359
Pvt Bus	14484	10324
LCV	4123	3699
2-Axle Trucks	5592	5356
3-Axle Trucks	6048	5516
MAV	10533	9198

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-105**. Highest diversion can be seen in Buses which is 95% and lowest is in freight vehicles which varies from 58% to 73% depending upon the axle configuration vehicles.

Table 4-105: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Gurdaspur to Katra

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	78.0
Taxi/Shared Jeep	78.0
Mini Bus	68.0
Govt Bus	95.0
Pvt Bus	95.0
Mini LCV	78.0
LCV	68.0
2-Axle Trucks	58.0
3-Axle Trucks	66.0
MAV	73.0

S) Alternative route for Traffic from Point 25 (Kathua) to Point 29 (Jammu):

There is an existing alternative route for the traffic moving between Points 25 to 29. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** above and explained in detail below:

Table 4-106: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Kathua to Jammu	62.5	4 lane	Good	NH-44	1
Total	62.5	-	-	-	1
Project Route					
Km 452.671 to Km 514.000 (Jammu Ring Road)	61.329	4 lane	Very Good	Expressway	1
Total	61.329	-	-	-	1

Table 4-107 gives the generalized cost of alternate route and project corridor.

Table 4-107: Generalized cost of Alternate Road and Project Road from Kathua to Jammu

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	1024	860
Pvt Bus	4886	3655
LCV	1349	1395
2-Axle Trucks	1764	2040
3-Axle Trucks	1855	2105
MAV	3386	3472

Traffic Diversion from Alternate Road to project corridor is given in Table 4-108. Highest diversion can be seen in Buses which is 95% and lowest is in freight vehicles which varies from 22% to 45% depending upon the axle configuration vehicles.

Table 4-108: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from kathua to Jammu

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	70.0
Taxi/Shared Jeep	70.0
Mini Bus	44.0
Govt Bus	95.0
Pvt Bus	95.0

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Mini LCV	70.0
LCV	44.0
2-Axle Trucks	22.0
3-Axle Trucks	26.0
MAV	45.0

T) Alternative route for Traffic from Point 25 (Kathua) to Point 32 (Katra):

There is an existing alternative route for the traffic moving between Points 24 to 29. This route is via NH-54/NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** above and explained in detail below:

Table 4-109: Details of Alternate Road via NH-44 and Project Corridor

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
Kathua to Katra	113	4 lane	Good	NH-44	2
Total	113	-	-	-	2
Project Route					
Km 452.671 to Km 564.700	112.029	4/6 lane	Very Good	Expressway	1
Total	112.029	-	-	-	1

Table 4-110 gives the generalized cost of alternate route and project corridor.

Table 4-110: Generalized cost of Alternate road and Project road from Kathua to Katra

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	1918	1634
Pvt Bus	9050	7091
LCV	2543	2563
2-Axle Trucks	3405	3773
3-Axle Trucks	3593	3893
MAV	6464	6447

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-111** Table 4-90. Highest diversion can be seen in Buses which is 89% and lowest is in freight vehicles which varies from 31% to 50% depending upon the axle configuration vehicles.

Table 4-111: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor from Kathua to Katra

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	69.0
Taxi/Shared Jeep	69.0
Mini Bus	49.0
Govt Bus	89.0
Pvt Bus	89.0
Mini LCV	69.0
LCV	49.0
2-Axle Trucks	31.0
3-Axle Trucks	35.0
MAV	50.0

U) Alternative route for Traffic moving from NH-44 vs Pathankot link

There is an existing alternative route for the traffic moving between Mukerian and below to Kathua, Jammu and north of Jammu. This route is via NH-44. The alignment of existing alternative road along with project corridor is presented in **Figure 4-21** above and explained in detail below:

Table 4-112: Details of Alternate Road via NH-44 and Project Corridor via Pathankot link

Existing Route	Length (km)	Lane Configuration	Condition	Type of Road	No of Toll Plaza
Alternative Route-1					
St. of Pathakot Link to km 452 of Phase 2	51	4/6 lane	Good	NH-44	1
Total	51.0	-	-	-	1
Project Route					
Pathankot link	13.5	4 lane	Very Good	Pathankot link	1
km 428.500 to km 453.000	24.5	4 lane	Very Good	Expressway	1
Total	38	-	-	-	2

Table 4-113 gives the generalized cost of alternate route and project corridor.

Table 4-113: Generalized cost of Alternate Road and Project Road via Pathankot link

Vehicle Type	Generalized Cost	
	Alternate Road	Project Corridor
Car	833	485
Pvt Bus	3881	2104
LCV	1138	783
2-Axle Trucks	1504	1104
3-Axle Trucks	1587	1124
MAV	2859	1898

Traffic Diversion from Alternate Road to project corridor is given in **Table 4-114**. Highest diversion can be seen in Buses which is 96% and lowest is in freight vehicles which varies from 95% to 96% depending upon the axle configuration vehicles.

Table 4-114: Percentage of Traffic Diversion from Alternate Road to Proposed Project Corridor via Pathankot link

Vehicle Type	% Diversion to Project Road in the Base Year (2018-19)
Cars	91.0
Taxi/Shared Jeep	91.0
Mini Bus	95.0
Govt Bus	96.0
Pvt Bus	96.0
Mini LCV	91.0
LCV	95.0
2-Axle Trucks	95.0
3-Axle Trucks	95.0
MAV	96.0

4.1.1.2 Interchange / Toll booth wise final traffic

There are 12 Interchange / toll booths under phase 2. All the booths will be at the entry and exits of interchanges. The final traffic diverted traffic at exit of interchange which will be diverted to the project corridor is given in

Table 4-115

Table 4-115: Diverted traffic summary at exit of Interchange in base year (2018-19)

Vehicle Type	Interchange location/No. Phase II											
	IC-21	IC-22	IC-23	IC-24	IC-25	IC-26	IC-27	IC-28	IC-29	IC-30	IC-31	IC-32
Cars	1806	2020	436	202	783	0	20	39	1861	3741	2003	2356
Minibus	9	22	2	8	9	0	0	0	34	45	18	32
Std. Bus	33	104	46	14	40	0	3	3	141	269	113	252
Mini LCV	146	231	13	58	44	0	2	13	132	234	187	137
LCV	74	107	36	41	53	0	2	13	144	224	235	85
2 axle Truck	101	188	46	19	46	0	3	13	233	483	518	101
3 axle Truck	249	339	41	22	69	0	5	13	261	158	245	45
MAV	106	149	17	20	27	0	1	8	182	95	157	19
Total Vehicles	2523	3159	637	385	1069	0	36	101	2987	5248	3477	3027
Total PCUs	3702	5006	982	590	1503	0	62	191	4982	7533	5907	3947

4.1.1.3 Section-wise Traffic

Project road under phase 2 is divided into 11 homogeneous sections based on interchange points provided. The section wise final traffic which will be diverted to the project corridor from various existing alternative routes is given in below **Table 4-116**.

Table 4-116: Final Diverted Traffic at Each section in base year (2018-19)

Vehicle Type	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average
Cars	6859	5646	6517	6308	6295	6295	6256	6253	9834	9834	4713	5539
Mini Bus	123	109	113	100	104	104	104	104	160	160	64	89
Std Bus	680	569	660	639	584	584	578	572	813	813	505	538
Mini LCV	503	394	419	510	514	514	510	528	866	866	273	422
LCV	563	490	562	590	570	570	566	583	728	728	169	446
2 axle Truck	957	882	973	978	934	934	928	940	1511	1511	202	735
3 axle Truck	1012	920	1002	1011	1009	1009	1000	1007	384	384	90	732
MAV	568	643	677	687	675	675	673	684	243	243	37	474
Total Vehicles	11265	9653	10923	10823	10685	10685	10615	10671	14539	14539	6053	10950
Total PCUs	18894	16945	18900	18829	18439	18439	18318	18447	21250	21250	7893	17964

Traffic number on the expressway of Phase II alignment is estimated based on present proposal. If any change is happen on proposal then traffic number would be impacted.

4.3.6 Projected Traffic

The total projected traffic at the exit of Interchange / toll booth is presented in **Table 4-117** and the mode wise projected traffic is presented in **Annexure 4.3**.

Table 4-117: Projected Total Traffic for IC-22 to IC-28

FY	IC 21 at km 397.700		IC 22 at km 424.557		IC 23 at Km 428.800		IC 24 at Km 438.780		IC 25 at Km 452.671		IC 26 at Km 465.798	
	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs
2018-19	2523	3702	3159	5006	637	982	385	590	1069	1503	0	0
2019-20	2679	3907	3350	5275	676	1036	408	623	1137	1589	0	0
2020-21	2846	4126	3552	5560	718	1093	433	658	1208	1680	0	0
2021-22	3023	4357	3768	5862	762	1154	459	695	1284	1777	0	0
2022-23	3211	4603	3997	6181	809	1218	487	733	1365	1879	0	0
2023-24	3412	4863	4240	6519	859	1287	517	774	1452	1989	0	0
2024-25	3769	5354	4680	7168	949	1415	571	853	1605	2190	0	0
2025-26	3967	5615	4920	7507	998	1483	601	895	1689	2299	0	0
2026-27	4174	5888	5173	7863	1050	1554	632	940	1778	2412	0	0
2027-28	4393	6176	5440	8237	1104	1629	666	987	1872	2531	0	0
2028-29	4623	6478	5720	8630	1161	1707	701	1036	1971	2657	0	0
2029-30	4826	6750	5969	8986	1211	1776	732	1081	2058	2769	0	0
2030-31	5038	7034	6228	9357	1263	1849	766	1129	2148	2885	0	0
2031-32	5260	7332	6500	9745	1318	1924	800	1178	2243	3007	0	0
2032-33	5491	7642	6783	10150	1375	2004	837	1230	2341	3134	0	0
2033-34	5733	7965	7079	10572	1435	2087	875	1284	2445	3267	0	0
2034-35	5943	8253	7337	10949	1486	2159	909	1334	2534	3383	0	0
2035-36	6161	8551	7606	11340	1540	2234	945	1386	2627	3504	0	0

FY	IC 21 at km 397.700		IC 22 at km 424.557		IC 23 at Km 428.800		IC 24 at Km 438.780		IC 25 at Km 452.671		IC 26 at Km 465.798	
	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs
2036-37	6387	8861	7885	11746	1595	2312	982	1439	2723	3630	0	0
2037-38	6622	9182	8174	12167	1653	2393	1020	1495	2823	3760	0	0
2038-39	6866	9516	8474	12605	1712	2476	1060	1553	2927	3895	0	0
2039-40	7075	9805	8732	12984	1763	2548	1096	1605	3015	4011	0	0
2040-41	7290	10103	8999	13375	1815	2621	1132	1659	3107	4131	0	0
2041-42	7512	10412	9274	13781	1869	2697	1170	1714	3201	4255	0	0
2042-43	7742	10730	9558	14199	1925	2776	1210	1772	3298	4383	0	0
2043-44	7979	11060	9851	14632	1983	2857	1250	1832	3398	4515	0	0
2044-45	8184	11355	10108	15022	2032	2928	1287	1886	3485	4631	0	0
2045-46	8395	11659	10371	15424	2083	3002	1324	1942	3573	4750	0	0
2046-47	8612	11972	10642	15838	2135	3078	1363	2000	3664	4874	0	0
2047-48	8835	12294	10920	16265	2189	3156	1402	2060	3758	5000	0	0
2048-49	9063	12626	11207	16704	2244	3236	1443	2122	3854	5131	0	0
2049-50	9299	12967	11501	17156	2301	3319	1486	2186	3953	5265	0	0
2050-51	9541	13320	11804	17623	2359	3403	1530	2253	4055	5403	0	0
2051-52	9789	13682	12115	18104	2418	3490	1575	2321	4159	5545	0	0
2052-53	10045	14056	12436	18599	2480	3580	1621	2392	4266	5691	0	0
2053-54	10307	14440	12765	19110	2542	3671	1670	2465	4376	5841	0	0
2054-55	10577	14837	13104	19636	2607	3766	1719	2540	4489	5996	0	0
2055-56	10854	15245	13453	20179	2673	3864	1770	2618	4605	6155	0	0
2056-57	11140	15667	13812	20739	2741	3964	1823	2699	4725	6319	0	0
2057-58	11433	16101	14181	21316	2811	4067	1878	2783	4848	6487	0	0
2058-59	11735	16548	14561	21911	2883	4173	1934	2869	4974	6661	0	0
2059-60	12045	17009	14952	22525	2957	4282	1993	2959	5103	6840	0	0

FY	IC 27 at km 397.700		IC 28 at km 424.557		IC 29 at Km 428.800		IC 30 at Km 438.780		IC 31 at Km 452.671		IC 32 at Km 465.798	
	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs
2018-19	36	62	101	191	2987	4982	5248	7533	3477	5907	3027	3947
2019-20	38	65	106	201	3167	5250	5574	7955	3679	6208	3222	4187
2020-21	40	69	112	211	3357	5533	5920	8402	3893	6525	3431	4441
2021-22	43	73	118	221	3560	5833	6289	8876	4121	6861	3653	4712
2022-23	45	77	125	232	3775	6150	6682	9378	4363	7215	3890	5000
2023-24	48	81	132	244	4004	6486	7101	9912	4619	7590	4143	5306
2024-25	53	89	145	268	4419	7132	7844	10908	5093	8330	4583	5854
2025-26	56	93	152	280	4645	7470	8253	11435	5347	8708	4828	6151
2026-27	59	98	160	293	4883	7825	8684	11988	5615	9105	5086	6464
2027-28	61	102	168	306	5134	8198	9138	12569	5897	9521	5358	6794
2028-29	64	106	176	320	5397	8590	9616	13180	6194	9958	5646	7141
2029-30	67	111	184	334	5631	8945	10035	13721	6458	10355	5895	7443
2030-31	70	115	192	348	5875	9317	10471	14286	6734	10770	6155	7759
2031-32	73	119	201	362	6129	9704	10928	14875	7022	11202	6427	8088
2032-33	76	124	209	377	6395	10109	11404	15490	7323	11653	6711	8431
2033-34	79	128	219	393	6673	10531	11902	16130	7638	12124	7008	8789
2034-35	82	132	227	407	6916	10909	12333	16690	7914	12545	7263	9097
2035-36	85	137	236	422	7169	11302	12779	17271	8200	12982	7527	9417
2036-37	88	141	245	438	7430	11710	13242	17873	8498	13435	7801	9749
2037-38	91	146	254	454	7702	12134	13723	18497	8807	13907	8085	10093
2038-39	94	151	264	472	7984	12574	14221	19144	9127	14395	8380	10448
2039-40	97	156	273	487	8227	12958	14646	19696	9402	14816	8631	10751
2040-41	100	161	282	502	8477	13355	15084	20265	9686	15252	8889	11062

FY	IC 27 at km 397.700		IC 28 at km 424.557		IC 29 at Km 428.800		IC 30 at Km 438.780		IC 31 at Km 452.671		IC 32 at Km 465.798	
	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs	Nos	PCUs
2041-42	103	166	291	519	8735	13765	15535	20851	9980	15702	9155	11384
2042-43	106	171	301	535	9002	14189	16001	21456	10283	16167	9430	11715
2043-44	110	176	311	553	9277	14628	16482	22080	10596	16647	9713	12055
2044-45	112	181	320	570	9518	15025	16895	22629	10871	17084	9954	12348
2045-46	115	185	329	587	9766	15434	17320	23192	11155	17534	10201	12648
2046-47	118	190	339	604	10020	15855	17755	23771	11446	17998	10454	12957
2047-48	121	195	349	622	10282	16290	18203	24367	11746	18476	10714	13272
2048-49	125	200	359	641	10551	16739	18663	24978	12054	18968	10981	13597
2049-50	128	205	370	661	10828	17201	19134	25607	12371	19474	11255	13930
2050-51	131	211	381	681	11112	17677	19619	26252	12697	19996	11536	14271
2051-52	135	216	393	702	11405	18168	20116	26916	13032	20535	11824	14621
2052-53	138	221	405	723	11706	18675	20627	27598	13378	21089	12120	14981
2053-54	142	227	417	745	12016	19198	21152	28299	13733	21661	12423	15350
2054-55	145	233	429	768	12335	19737	21691	29020	14098	22250	12735	15729
2055-56	149	239	442	791	12663	20293	22244	29761	14474	22858	13054	16118
2056-57	153	245	456	816	13000	20867	22813	30523	14861	23484	13383	16517
2057-58	157	252	469	840	13347	21459	23397	31306	15260	24130	13719	16926
2058-59	161	258	484	866	13704	22070	23997	32112	15670	24796	14065	17346
2059-60	165	264	498	893	14072	22701	24614	32941	16092	25483	14420	17777

4.3.7 Toll Plaza

4.3.8 Location of toll plaza

Since this is an access-controlled expressway upto km 502, Ramp Plazas will be installed at all entry and exit ramps of each interchange point and for remaining section on main carriageway along the expressway.

4.3.9 Capacity Analysis

4.3.10 Capacity augmentation proposals (lane requirement) as per IRC: SP:099-2013

For the purpose of design and future augmentation of the Project Expressway, the design service volume for level of service- B for plain/rolling terrain shall be 1300 PCU/hr/lane. The design service volume can be determined as per MORTH Guidelines for Expressways. The design service volume per day will depend on the peak hour flow and will be as specified in **Table 4-118**.

Table 4-118: Design Service Volume for Expressways in Plain and Rolling Terrain (in PCUs/per day) for LOS B

Design Service Volume in PCUs per day for LOS B		
4- Lane	6-Lane	8-Lane
86,000 for Peak hour flow (6%)	1,30,000 for Peak hour flow (6%)	1,73,000 for Peak hour flow (6%)
65,000 for Peak hour flow (8%)	98,000 for Peak hour flow (8%)	1 30,000 for Peak hour flow (8%)

The projected traffic in all homogeneous sections in PCUs is presented in Error! Reference source not found.. The mode wise projected traffic is presented in **Annexure 4.4**.

Table 4-119: Section wise Total Traffic Projection (PCUs)

FY	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average PCUs
2018-19	18894	16945	18900	18829	18439	18439	18318	18447	21250	21250	7893	17964
2019-20	19898	17837	19901	19821	19413	19413	19286	19421	22422	22422	8372	18928
2020-21	20961	18780	20959	20871	20443	20443	20309	20451	23666	23666	8881	19948
2021-22	22084	19777	22077	21981	21533	21533	21392	21540	24983	24983	9423	21028
2022-23	23272	20832	23260	23154	22685	22685	22536	22691	26379	26379	9999	22170
2023-24	24530	21946	24511	24395	23904	23904	23748	23910	27859	27859	10611	23380
2024-25	26958	24116	26937	26808	26270	26270	26099	26278	30647	30647	11707	25703
2025-26	28219	25241	28197	28060	27500	27500	27321	27508	32112	32112	12302	26916
2026-27	29543	26422	29519	29375	28791	28791	28604	28799	33650	33650	12928	28188
2027-28	30932	27662	30907	30755	30146	30146	29950	30155	35267	35267	13588	29525
2028-29	32391	28963	32365	32204	31569	31569	31364	31578	36966	36966	14281	30929
2029-30	33711	30149	33689	33524	32866	32866	32652	32876	38476	38476	14886	32197
2030-31	35088	31385	35071	34901	34218	34218	33997	34230	40051	40051	15516	33521
2031-32	36524	32675	36512	36337	35629	35629	35399	35644	41693	41693	16174	34901
2032-33	38021	34022	38016	37836	37102	37102	36863	37119	43406	43406	16861	36341
2033-34	39584	35427	39585	39401	38639	38639	38390	38658	45192	45192	17577	37844
2034-35	40977	36689	40991	40806	40020	40020	39763	40042	46759	46759	18194	39184
2035-36	42423	38000	42451	42266	41454	41454	41188	41479	48383	48383	18833	40574
2036-37	43924	39362	43967	43781	42943	42943	42668	42971	50067	50067	19496	42017
2037-38	45482	40775	45542	45356	44490	44490	44206	44522	51812	51812	20182	43515
2038-39	47099	42243	47176	46991	46096	46096	45802	46133	53623	53623	20894	45071
2039-40	48498	43522	48598	48416	47496	47496	47194	47537	55167	55167	21499	46417
2040-41	49944	44846	50068	49889	48944	48944	48633	48990	56761	56761	22121	47809
2041-42	51439	46214	51589	51413	50442	50442	50122	50493	58404	58404	22763	49248
2042-43	52983	47629	53161	52989	51990	51990	51662	52048	60100	60100	23424	50734
2043-44	54580	49093	54786	54619	53593	53593	53255	53656	61850	61850	24106	52271
2044-45	56019	50423	56258	56099	55047	55047	54702	55118	63394	63394	24691	53654

FY	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average PCUs
2045-46	57501	51794	57776	57624	56547	56547	56193	56624	64980	64980	25290	55078
2046-47	59028	53207	59339	59197	58092	58092	57729	58177	66611	66611	25906	56544
2047-48	60600	54663	60951	60819	59685	59685	59314	59777	68286	68286	26538	58055
2048-49	62220	56166	62613	62490	61328	61328	60948	61429	70009	70009	27186	59611
2049-50	63888	57714	64326	64213	63022	63022	62632	63132	71779	71779	27851	61214
2050-51	65607	59311	66092	65990	64769	64769	64369	64887	73599	73599	28533	62866
2051-52	67378	60958	67913	67823	66571	66571	66161	66699	75470	75470	29233	64568
2052-53	69204	62657	69790	69714	68429	68429	68009	68567	77394	77394	29951	66322
2053-54	71085	64410	71726	71664	70346	70346	69914	70494	79372	79372	30689	68129
2054-55	73023	66218	73723	73676	72324	72324	71881	72483	81406	81406	31445	69992
2055-56	75021	68084	75783	75751	74365	74365	73910	74535	83498	83498	32222	71912
2056-57	77081	70008	77907	77893	76471	76471	76004	76653	85650	85650	33019	73892
2057-58	79205	71995	80099	80104	78644	78644	78165	78838	87863	87863	33837	75932
2058-59	81395	74045	82361	82385	80886	80886	80396	81094	90139	90139	34677	78037
2059-60	83653	76161	84694	84740	83201	83201	82698	83422	92480	92480	35539	80206

Table 4-120: Capacity Augmentation as per IRC: SP: 99-2013

FY	Section 21	Section 22	Section 23	Section 24	Section 25	Section 26	Section 27	Section 28	Section 29	Section 30	Section 31	Average PCUs
Year when Expressway will be functional 2024-25	26958	24116	26937	26808	26270	26270	26099	26278	30647	30647	11707	25703
Threshold for Upgradation of Expressway From 4 To 6 Lanes (2052-53)	69204	62657	69790	69714	68429	68429	68009	68567	77394	77394	29951	66322

As per IRC: SP: 99-2013, the capacity of 4-lane is 65000 PCUs for peak hour flow (8%) which gets exhausted in 2052 -53. Hence, considering the IRC: SP: 099-2013, the entire expressway is to be made 4-lane except Jammu Ring Road which is proposed to develop 6 laning.

5 COST ESTIMATE

5.1 Introduction and Assumption

Cost estimation is important for the DPR as it provides vital input to the economic and financial evaluation of the project. The cost estimates have been prepared for the Project Highway for the recommended Greenfield/Brownfield alignment. The estimate has been prepared for constructing a 6/4 lane carriageway with paved shoulder configurations including construction of:

- Structures (minor/ major bridge, elevated structure, VUP, LVUP, SVUP, ROB,);
- Cross drainage structures.
- Unlined longitudinal drains.
- Interchanges (Cloverleaf, Diamond);
- Road signs and markings.
- Toll plaza and administrative buildings; and
- Wayside amenities.

5.1.1 Typical Cross section

The typical cross sections which have been proposed to be used for the Project Corridor have been provided in previous section.

5.1.2 Quantification

The main items that have been covered in cost estimation are as following:

S. No	Description of work	Items of work
1	Site clearance	Clearing & grubbing
2	Earth work	Earth work excavation for ordinary soil/ soft rock/ hard rock
		Constructions of embankment with borrow material from approved source.
		Construction of embankment with useful material obtained from roadway excavation.
		Construction of subgrade and shoulder with selected soil.
		Excavation and disposal of unsuitable materials
3	Non-Bituminous base & subbase courses	Granular subbase
		Wet mix macadam
4	Bituminous course	Prime coat
		Tack coat
		Dense Bituminous macadam
		Bituminous concrete
5	CD – Structures	New construction of Culverts

S. No	Description of work	Items of work
6	Bridges, Grade Separators, Underpasses and ROB's	New construction of Bridges, Grade Separators, Underpasses and ROB's
7	Drainage & protection works	PCC Toe wall Unlined drain, Saucer drain Boundary wall Geo Green for High Embankment Semi-circular chute drain
8	Junctions	PCC Kerb, Painting on Kerb
9	Traffic signs marking and other appurtenance	Pavement markings Road signage 5th km, Ordinary km and Hectometer Stones Metal beam crash barrier and Guard post Solar blinkers Gantry/Overhead Cantilever sign Board
10	Miscellaneous	Landscaping and Tree plantation Electrical Works Rainwater Harvesting
11	Project Facilities	Operational and Maintenance Base Camp Advanced traffic management system (ATMS) Highway Nest Mini and Toilet Blocks Rest Area (Wayside Amenities)
12	Toll plaza & Wayside Amenities	Administrative building in toll plaza Toll plaza road works ETC Lane Toll Plaza Equipment Crane, Highway Patrol, Ambulance Medical Aid Post, Traffic Aid Post, Vehicle Rescue Post

The quantities for various items of work have been computed as detailed below:

- The quantities for sub grade, subbase, base and bituminous/rigid courses have been computed as per TCS.
- The quantities for earthwork (earthwork excavation and embankment construction) have been computed as per corresponding TCS with certain assumptions
- The quantities for structures like bridges, ROB, culverts, VUP, LVUP, SVUP, etc., have been calculated based on the preliminary GAD's and design calculations.
- The quantities for drainage & protection works and other items have been computed based on the proposed details and drawings.

5.2 Adoption of unit rates

5.2.1 Construction Items

The unit rates for each construction items have been arrived by using the latest available “**Schedule of Rates (SOR): (Highways Department & PWD Department) for Punjab and UT of Jammu & Kashmir**”. The detailed analysis has been carried out as per **Standard Data Book of Ministry of Road Transport & Highways (MORTH)** for deriving unit rates of items of Road and Bridge works.

The input rates of Bitumen, Emulsion, Cement and Steel have been taken from market. The rates of plant, machinery, labour and other materials like metal, sand etc. have been taken from latest available Schedule of rates of PWD, Highway Department Punjab and UT of Jammu & Kashmir. The basic rates for each construction items have been analysed based on material study, the prices of construction materials collected from various sources and on the anticipated distance between source and the site of work. For items where rates are not available in SOR, the rates have been adopted as per previous experience of the consultant or on the present market rates.

The basis and sources of various components being considered in Rate Analysis and Quantification are provided in the following table:

Table 5-1: Rate Analysis: Basis and Source

Sl. No.	Particular	Source	Reference/ Rate Basis
1.	Rate Analysis	MORT&H	MORT&H Standard Data Book
Material			
1.	Aggregate Quarry	Nearby project corridor	Punjab/Jammu
2.	Sand	Nearby project corridor	Punjab/Jammu
3.	Earth	Nearby borrow area	Punjab/Jammu
4.	Bitumen	Panipath Refinery	IOCL
5.	Cement	INAMPRO	INAMPRO
6.	Steel	SAIL	SAIL
7.	Emulsion	Haldia Refinery	IOCL
8.	Labour	Gazzatte of India	Gazzatte of India

5.2.2 Materials Source and Lead

The location of material quarry like gravel, sand, crushed aggregate has been obtained from the material investigations. The leads of different materials have been derived by drawing the lead chart and the basic material rates has been adopted as per latest available Punjab and UT of J&K Schedule of Rates (SOR)

Package wise lead distance for some of the major material source is shown in the following table:

Table 5-2: Material Source and Lead

Package-13: Km 397.700 to Km 423.500

Material	Source Distance	Lead	Remarks

Aggregate	7.00 Km	Average Lead of various Quarries From, Punjab and Jammu.
Sand	5.00 Km	Average Lead of various Quarries From, Punjab and Jammu.
Bitumen	420.00 Km	Panipath Refinery
Emulsion	2141.00 Km	Panipath Refinery
Cement	18.00 Km	INAM-PRO
Steel	0.000 Km	SAIL (No Lead is required for 100.00 Km As per SAIL Rates)

Package-14: Km 423.500 to km 468.100

Material	Source Distance	Lead	Remarks
Aggregate	9.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Sand	16.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Bitumen	430.00 Km		Panipath Refinery
Emulsion	2151.00 Km		Panipath Refinery
Cement	80.00 Km		INAM-PRO
Steel	0.000 Km		SAIL (No Lead is required for 100.00 Km As per SAIL Rates)

Package-15: Km 468.100 to Km 503.250

Material	Source Distance	Lead	Remarks
Aggregate	14.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Sand	14.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Bitumen	460.00 Km		Panipath Refinery
Emulsion	2181.00 Km		Panipath Refinery
Cement	80.00 Km		INAM-PRO
Steel	0.000 Km		SAIL (No Lead is required for 100.00 Km As per SAIL Rates)

Package-17: Km 515.000 to Km 528.300 (Kunjwani to Sidhra Section)

Material	Source Distance	Lead	Remarks
Aggregate	13.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Sand	13.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Bitumen	505.00 Km		Panipath Refinery
Emulsion	2226.00 Km		Panipath Refinery
Cement	129.00 Km		INAM-PRO
Steel	0.000 Km		SAIL (No Lead is required for 100.00 Km As per SAIL Rates)

Package-17: Km 550.900 to Km 566.520 (Domel to Katra Section)

Material	Source Distance	Lead	Remarks
Aggregate	15.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Sand	15.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Bitumen	542.00 Km		Panipath Refinery
Emulsion	2263.00 Km		Panipath Refinery
Cement	166.00 Km		INAM-PRO
Steel	0.000 Km		SAIL (No Lead is required for 100.00 Km As per SAIL Rates)

Package- Pathankot Link Road: Km 0.000 to Km 12.345

Material	Source Distance	Lead	Remarks
Aggregate	19.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Sand	21.00 Km		Average Lead of various Quarries From, Punjab and Jammu.
Bitumen	378.00 Km		Panipath Refinery
Emulsion	2102.00 Km		Panipath Refinery

Cement	35.00 Km	INAM-PRO
Steel	0.000 Km	SAIL (No Lead is required for 100.00 Km As per SAIL Rates)

The details of plant and camp locations are given in following table:

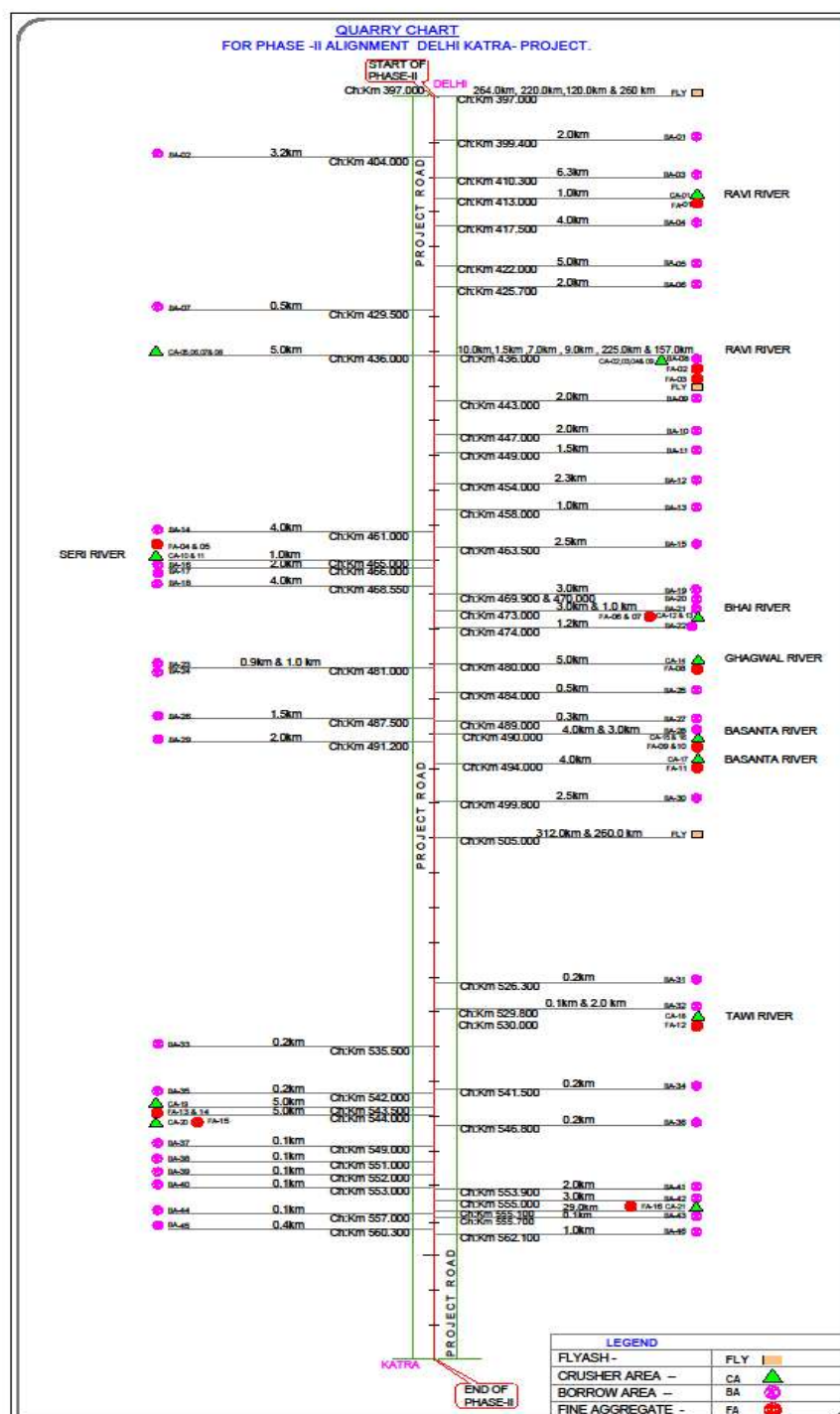


Figure 5-1 : Lead Chart

Table 5-3: Plant & Camp Locations along the Corridor

Sl. No.	Design Chainage (Ch.)					
	PKG-13	PKG-14	PKG-15	PKG-17 Kunjwani-Sidhra	PKG-17 Domel-Katra	Pathankot
1	410+600	445+850	485+675	521+950	558+720	10+000

The assumptions for bitumen rates have been made as given in the following table:

Table 5-4: Bitumen Basic Rate

Bitumen: Source and Rate		
Package No	Panipat Refinery Grade VG 40	Lead: Varies (From Panipath to plant at site)
13	Basic Rate (INR) per MT	43402.00
14 & 15	Basic Rate (INR) per MT	39820.00
17	Basic Rate (INR) per MT	52132.00
Pathankot-Link	Basic Rate (INR) per MT	39430.00

Table 5-5: Cement Basic Rates

Rate of Cement as per INAM-PRO	
INAMPRO Website	Lead: Varies
Cement Grade: OPC 43	
Basic Rate (INR/MT)	5600.00

Table 5-6: Steel Basic Rates

Rate of STEEL as per SAIL		
Package No	SAIL	Lead: Varies
13	Rate inclusive of GST (INR/MT)	60618.00
14 & 15	Rate inclusive of GST (INR/MT)	53475.00
17	Rate inclusive of GST (INR/MT)	64521.00
Pathankot-Link	Rate inclusive of GST (INR/MT)	55585.00

5.3 Bill of Quantity (BOQ)

Bill of Quantity (BOQ) has been prepared and is being submitted in a separate volume.

5.4 Costing of Safety Devices

Adequate numbers of road signs and pavement markings (as per IRC Guidelines: IRC 35/ IRC 67/ IRC SP 99) have been considered as safety measures while estimating cost for road safety to give information to the road users to avoid accident and aid in convenience on the project road. Details of major road safety devices adopted for the project are as under:

- Pavement markings

- Road signage
- 5th km, Ordinary km and Hectometer Stones
- Metal beam crash barrier and Guard post
- Solar blinkers
- Gantry/Overhead Cantilever sign Board
- Bus shelter

5.5 Project Cost Abstract

The detailed cost estimate is given in a separate volume. Package wise summary of project cost has been worked and shown in the following table:

Table 5-7 : Abstract of Cost Estimate

Abstract of Cost of Package – 13: Km 397.700 to Km 423.500

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	49,40,321
2	Earth Work	67,64,28,478
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	62,19,46,085
4	Bituminous and Rigid Pavement Courses	1,51,00,47,964
5	Culverts	18,18,43,936
6	Bridges	
	a) Minor Bridges	18,66,10,466
	b) Major Bridges	9,65,63,455
	c) FO, ROB	56,22,40,389
	d) VUP/PUP	29,06,60,879
	e) RE Wall	1,10,94,77,338
	f) FOB	1,26,09,420
7	Drainage & Protective Works	19,03,41,311
8	Junctions	3,84,08,068
9	Traffic signs, Road markings and other road appurtenances	51,39,48,846
10	Miscellaneous Works	16,30,55,280
11	Maintenance of roads	1,46,21,256
12	Toll Plaza	7,98,78,366
13	Environmental Plan	2,25,69,894
	Civil Cost	6,27,61,91,751
	12% GST on Civil Cost	75,31,43,010
	Utility Shifting	62,57,78,191
	Total Civil Cost	7,65,51,12,95
	Cost Per Km in Crores (On Civil Cost)	24
	Cost Per Km in Crores (On Total Civil Cost)	30
	Supervision Charges of Utility Shifting	1,56,44,455
	GST @ 18% on Supervision Charges	28,16,002
	Land Acquisition, Resettlement and Rehabilitation Cost	41,94,00,000

Sr. No.	Particulars	Amount (INR)
	Other Preconstruction Expenses (EMP Cost)	22,16,00,000

Abstract of Cost of Package – 14: Km 423.500 to km 468.100

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	1,33,45,051
2	Earth Work	1,65,07,28,620
3	Granular Subbase Courses and Base Courses (Non-Bituminous)	85,36,68,511
4	Bituminous and Rigid Pavement Courses	1,70,86,83,008
5	Culverts	1,11,47,26,228
6	Bridges	
	a) Minor Bridges	1,21,01,82,881
	b) Major Bridges	3,27,89,07,771
	c) FO, ROB	1,86,20,98,618
	d) VUP/PUP	39,11,90,398
	e) RE Wall	2,02,38,00,501
7	Drainage & Protective Works	26,35,07,553
8	Junctions	0
9	Traffic signs, Road markings and other road appurtenances	80,42,39,028
10	Miscellaneous Works	41,79,93,670
11	Maintenance of roads	0
12	Toll Plaza	37,24,68,204
13	Environmental Plan	3,91,60,592
	Civil Cost	16,00,47,00,634
	12% GST on Civil Cost	1,92,05,64,076
	Utility Shifting	18,02,30,000
	Total Civil Cost	18,10,54,94,711
	Cost Per Km in Crores (On Civil Cost)	35.88
	Cost Per Km in Crores (On Total Civil Cost)	40.60
	Supervision Charges of Utility Shifting	45,05,750
	<u>GST @ 18% on Supervision Charges</u>	8,11,035
	Land Acquisition, Resettlement and Rehabilitation Cost	11,41,72,00,000
	Other Preconstruction Expenses (EMP Cost)	19,66,00,000

Abstract of Cost of Package – 15: Km 468.100 to Km 503.250

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	1,94,58,706
2	Earth Work	1,15,87,42,721
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	87,64,74,238
4	Bituminous and Rigid Pavement Courses	1,36,73,11,403
5	Culverts	47,58,97,863

Sr. No.	Particulars	Amount (INR)
6	Bridges	
	a) Minor Bridges	90,54,98,146
	b) Major Bridges	1,38,78,92,776
	c) FO, ROB	5,05,98,81,367
	d) VUP/PUP	31,09,89,109
	e) RE Wall	1,35,61,43,008
7	Drainage & Protective Works	60,00,69,083
8	Junctions	3,60,55,974
9	Traffic signs, Road markings and other road appurtenances	59,08,20,554
10	Miscellaneous Works	47,67,60,000
11	Maintenance of roads	0
12	Toll Plaza	88,10,98,419
13	Environmental Plan	3,08,19,210
	Civil Cost	15,53,39,12,578
	12% GST on Civil Cost	1,86,40,69,509
	Utility Shifting	34,75,99,000
	Total Civil Cost	17,74,55,81,087
	Cost Per Km in Crores (On Civil Cost)	44.26
	Cost Per Km in Crores (On Total Civil Cost)	50.56
	Supervision Charges of Utility Shifting	86,89,975
	GST @ 18% on Supervision Charges	15,64,196
	Land Acquisition, Resettlement and Rehabilitation Cost	8,53,20,00,000
	Other Preconstruction Expenses (EMP Cost)	16,01,00,000

Abstract of Cost of Package – 17: Km 515.000 to Km 528.300 (Kunjwani to Sidhra Section) and Km 550.900 to Km 566.520 (Domel to Katra Section)

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	3,06,73,026
2	Earth Work	56,18,08,156
3	Granular Subbase Courses and Base Courses (Non-Bituminous)	63,32,21,780
4	Bituminous and Rigid Pavement Courses	1,32,19,67,808
5	Culverts	63,20,48,140
6	Bridges	
	a) Minor Bridges	88,69,47,060
	b) Major Bridges	52,56,48,335
	c) FO, ROB	5,96,88,10,906
	d) VUP/PUP	28,79,36,394
	e) RE Wall	1,06,32,55,041
	f) FOB	0
7	Drainage & Protective Works	1,06,31,86,228
8	Junctions	8,49,46,425
9	Traffic signs, Road markings and other road appurtenances	51,26,87,766
10	Miscellaneous Works	47,97,69,811
11	Maintenance of roads	2,11,84,071
12	Toll Plaza	0
13	Environmental Plan	56,89,966
	Civil Cost	14,07,97,80,914
	12% GST on Civil Cost	1,68,95,73,710

Sr. No.	Particulars	Amount (INR)
	Utility Shifting	85,35,34,750
	Total Civil Cost	16,62,28,89,373
	Cost Per Km in Crores (On Civil Cost)	48.69
	Cost Per Km in Crores (On Total Civil Cost)	57.48
	Supervision Charges of Utility Shifting	21338369
	<u>GST @ 18% on Supervision Charges</u>	3840906
	Land Acquisition, Resettlement and Rehabilitation Cost	7996400000
	Other Preconstruction Expenses (EMP Cost)	34815600

Abstract of Cost of Pathankot Link Road: Km 0.000 to Km 12.345

Sr. No.	Particulars	Amount (INR)
1	Site clearance and Dismantling	15,83,653
2	Earth Work	69,36,55,707
3	Granular Subbase Courses and Base Courses (Non- Bituminous)	24,15,52,955
4	Bituminous and Rigid Pavement Courses	26,78,30,809
5	Culverts	24,95,89,963
6	Bridges	
	a) Minor Bridges	2,43,43,723
	b) Major Bridges	77,02,26,963
	c) FO, ROB	35,81,40,538
	d) VUP/PUP	13,35,43,019
	e) RE Wall	25,61,65,526
	f) FOB	
7	Drainage & Protective Works	17,68,40,927
8	Junctions	1,78,27,714
9	Traffic signs, Road markings and other road appurtenances	20,49,49,750
10	Miscellaneous Works	5,90,10,240
11	Maintenance of roads	0
12	Toll Plaza	6,67,57,344
13	Environmental Plan	87,66,126
	Civil Cost	3,53,07,84,957
	12% GST on Civil Cost	42,36,94,195
	Utility Shifting	11,54,10,151
	Total Civil Cost	4,06,98,89,303
	Cost Per Km in Crores (On Civil Cost)	28.60
	Cost Per Km in Crores (On Total Civil Cost)	32.97
	Supervision Charges of Utility Shifting	28,85,254
	<u>GST @ 18% on Supervision Charges</u>	5,19,346
	Land Acquisition, Resettlement and Rehabilitation Cost	2,49,04,00,00
	Other Preconstruction Expenses (EMP Cost)	6,55,00,000

6 ENVIRONMENTAL ASSESSMENT

6.1 Introduction

Road projects are meant for improving the quality of life and overall development of the region as well as economy. Development projects also impact its surrounding environment. However, these impacts can be minimized by suitable means of mitigation measures based on environmental impact assessment. Environmental impact assessment is an integral part of any road development project.

6.2 Project Location

The proposed alignment starts at Gurdaspur Bypass in Gurdaspur district of Punjab State and ends at Karta in Reasi district of Union Territory of Jammu and Kashmir. Project also involves construction of Pathankot Link (Bypass), starting from Talwar Jattan on NH-1A and connecting with the Delhi-Katra Expressway at Chainage 428+100 in Pathankot district of Punjab State.

6.3 Study Area

As per the EIA Guidance Manual for Highways (MoEF&CC, 2010), a study area of 15 Km radius from the project road was considered for secondary data collection. Primary data has been collected within 500 meters on either side of the proposed alignment. Secondary data were collected from published reports, research papers, working plans, consultations and discussions with govt. officials. Primary baseline environment monitoring was carried out for the period from October 2020 to December 2020.

6.4 Scope of Environmental Assessment

The environmental assessment is carried out to identify critical issues to be addressed in detail during subsequent stages of the project. The assessment is based on existing policy, legal and administrative framework considering the applicable environmental legislations, regulations, and guidelines. The scope of present study is as follows:

- Project screening based on legal and statutory requirements
- Baseline environment profiling based on secondary data
- Assessment of potential impacts and recommendation of mitigation measures
- Stakeholder Consultations
- Formulation of Environmental Management Plan
- Outline of Environmental Budget

Present chapter is based on field investigations and secondary data.

6.5 Regulatory Framework

The Government of India has formulated various policy guidelines, acts and regulations to protect and enhance environmental resources. The summary of environment laws and analysis of their applicability pertaining to present project are discussed in Table 11-1.

Table 6-1: Regulatory Framework for Environmental Clearances

S. No.	Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
1	The Environmental (Protection) Act, 1986 and the Environmental (Protection) Rules, 1987-2002 (various amendments)	This Act called Umbrella Act for protection and improvement of the environment.	Yes	All environmental notifications, rules and schedules are issued under this act	MoEF&CC, State Department of Environment & Forest, Central Pollution Control Board and State Pollution Control Board
2	The EIA Notification, 14 th September 2006 & subsequent amendments	Identifies all new national highways, expansion of national highways projects greater than 100 km involving additional ROW or land acquisition greater than 40m on existing alignments and 60m on re-alignments or by-passes (item 7 (f) of schedule) as one of the projects requiring prior clearance.	No	Project is widening and improvement of existing National Highway, with additional right of way or land acquisition less than 40m on existing alignment and 60 m on re-alignments or by-passes.	MoEF&CC and SEIAA
		Opening of new Quarry Area (including Riverbed mining)	Yes	Prior Environmental Clearance to be taken by Contractor if there is any need of new mining activity	
3	Notification for use of Fly ash, 3 rd November 2009 and its	"No agency, person or organization shall, within a	Yes	Guru Gobind Singh Super TPS, Rajpura TPS, Guru	MoEF&CC, SPCB

S. No.	Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
	amendment on 25 th January 2016	radius of 300 km of a thermal power plant undertake construction or approve design for construction of roads or flyover embankments with top soils; the guidelines or specifications issued by the Indian Road Congress (IRC) as contained in IRC specification No. SP: 58 of 2001 as amended from time to time regarding use of fly ash shall be followed and any deviation from this direction can only be agreed to on technical reasons if the same is approved by Chief Engineer (Design) or Engineer-in-Chief of the concerned agency or organization or on production of a certificate of "fly ash not available" from the Thermal Power Plant(s)		Nanak Dev TPS, Talwandi Sabo Power Project, etc. are located within 300 km from the project highway	

S. No.	Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
4	The Water (Prevention and Control of Pollution) Act, 1974	Central and State Pollution Control Board to establish / enforce water quality and effluent standards, monitor water quality, prosecute offenders, and issue licenses for construction / operation of certain facilities.	Yes	Consent required for not polluting ground and surface water during construction	State Pollution Control Board
5	The Air (Prevention and Control of Pollution) Act. 1981	Empowers SPCB to set and monitor air quality standards and to prosecute offenders, excluding vehicular air and noise emission.	Yes	Consent required for establishment and operation of crushers, hot mix and batching plants etc.	State Pollution Control Board
6	Noise Pollution (Regulation and Control) Act, 1990, 2010 and its subsequent amendments.	Standards for noise emission for various land uses	Yes	Construction machineries and vehicles to conform to the standards for construction	State Pollution Control Board
7	Forest (Conservation) Act, 1980 its subsequent amendments.	Conservation and definition of forest areas. Diversion of forest land follows the process as laid by the Forest conservation Act.	Yes	Project alignment passes through forest area at different locations.	State Forest Department, MoEF&CC
8	Wildlife (Protection) Act, 1972 and amended thereof,	Protection of Wildlife Sanctuaries and National Park	Yes	Project highway is passing through the Nandini Wildlife Sanctuary,	Chief Wildlife Warden, SBWL & NBWL

S. No.	Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
				Bahu Conservation Reserve and Ramnagar Rakha Wildlife Sanctuary	
9	The Motor Vehicle Act, 1988 its subsequent amendments.	Empowers State Transport Authority to enforce standards for vehicular pollution. From August 1997 the "Pollution Under Control Certificate" is issued to reduce vehicular emissions	Yes	All vehicles used for construction will need to comply with the provisions of this act.	State Motor Vehicles Department
10	The Explosives Act (& Rules) 1884 (1983) its subsequent amendments.	Sets out the regulations as to regards the use of explosives and precautionary measures while blasting & quarrying	Yes	Use of blasting materials if required for new quarrying operation and storing of Diesel / Petrol in the camp site, to be obtained by the Contractor / Concessionaire	Chief Controller of Explosives
11	Public Liability and Insurance Act, 1991	Protection to the general public from accidents due to hazardous materials	Yes	Hazardous materials like Bitumen shall be used for road construction	Labour Commissioner / District Magistrate
12	Hazardous and Other Wastes (Management, & Trans-boundary Movement) Rules, 2016 and amended thereof	Protection to the general public against improper handling and disposal of hazardous wastes	Yes	Hazardous wastes shall be generated due to activities like maintenance and repair work of vehicles	State Pollution Control Board
13	Construction and Demolition Waste	Safe disposal of construction waste and	Yes	Construction waste shall be generated due	State Pollution Control Board

S. No.	Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
	Management Rules, 2016 and Solid Waste Management Rules 2016	municipal solid waste		to the demolition of existing structures & construction activities and municipal waste shall be generated from the construction worker camp	
14	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Protection against chemical accident while handling any hazardous chemicals resulting	Yes	Handling of hazardous (flammable, toxic and explosive) chemicals during road construction	District & Local Crisis Group headed by the DM and SDM
15	Mines & Minerals (Regulation & Development) Act, 1957 & amended thereof,	Permission of Mining of aggregates and sand from riverbed & aggregates	Yes	Mining of sand, soil or aggregates shall require permission from mining dept.	State Department of Mining
16	The Building & Other Construction Workers (Regulation of Employment & Conditions of Service) BOCW Act, 1996	Employing Labour workers /	Yes	Employment of labours	District labour Commissioner

6.6 Environmental Profile of Project Influence Area

The environmental profile along the project alignment is assessed based on parameters like physical environment, seismology, geology, soil, land use, water resources & ecology and described as follows:

6.6.1 Terrain

The main alignment follows 'plain', 'rolling' and 'hilly' terrain. The elevation varies from ~259m above MSL to ~837m above MSL at different locations. Average elevation of the project stretch is ~374m above MSL.

The alignment of Pathankot link follows 'plain' and 'rolling' terrain. The elevation varies from ~279m above MSL to ~304m above MSL at different locations. Average elevation of the project stretch is ~287m above MSL.



Figure 6-1: Elevation Profile of Main Alignment under Delhi-Katra Expressway Phase II



Figure 6-2: Elevation Profile of Project Alignment under Pathankot Link

6.6.2 Climatology

The climate of the region is sub-humid to sub-tropical. The climate of project region can be divided into three major conventional seasons as follows:

- Hot- Weather Season (mid-March to end of June)
- Monsoon Season (End of June to September)
- Cold- Weather Season (October to February)

The climate conditions prevalent in project influence districts are summarized based on District Ground Water Brochures, Central Ground Water Boards and presented in table below.

Table 6-2: Climatic Conditions of Project Districts

Project District	Climatic Condition
Punjab	
Gurdaspur	The climate of district is semi-arid and hot which is mainly dry with very hot summers and cold winters.

Project District	Climatic Condition
Pathankot	The district has a semi-arid to tropical type of climate. The temperature in summer may rise to a maximum of 48 °C (rarely) and Winters are mild, but it can sometimes get quite chilly.
Jammu & Kashmir	
Kathua	Various parts of the district experiences wide range of climate from sub-tropical to temperate and even Alpine in higher regions of Bani and Lohai-Malhar blocks. Due to altitudinal variations the temperature differs in the different tehsils of the district.
Samba	The climate of the area is sub-tropical. The area experiences hot and dry summers and severely cold winters.
Jammu	The district has a sub-tropical extreme climate while it is hot and dry in summer and cold in winter. Nights are generally cooler being in the foothills of the mountains.
Reasi	The climatic conditions vary with ranging from sub-tropical to semi-temperate. Summers are generally warm and winters are cold with snowfall on the high Ridges.

Source: District Ground Water Brochures, Central Ground Water Board

The Indian Meteorological Department's (IMD) observatories in vicinity of proposed alignment is located at Kathua, Jammu and Reasi districts. Long-Term climatological data (Year 1981 – 2010) has been analysed for assessment of prevailing climatological scenario in the project region and is shown in the table below:

Table 6-3: Long-Term Climatological Conditions at IMD Observatories near Project Road (1981-2010)

Month	Temp Monthly (°C)		Humidity (%)		Avg. Wind Speed (kmph)	Dominant Direction (from)	Avg. Rainfall (mm)
	Max	Min	Mor.	Eve.			
Jammu							
January	23.7	3.6	83	62	3.9	NE	62.2
February	26.6	6.1	77	54	4.7	NE	71.2
March	31.6	9.8	68	49	5.2	NE	68
April	38.8	13.5	55	39	5.8	NE	42.7
May	42.6	17.7	46	32	6.2	NE/C	27
June	43.6	20.0	52	37	5.5	NE	96.5
July	39.6	21.1	78	64	4.6	C/NE/E	416.9
August	36.0	21.2	84	72	3.8	C/NE/E	353
September	35.5	18.8	79	65	4.1	NE	137.4
October	34.3	14.2	69	57	4.5	NE	22.6
November	30.4	8.8	74	63	4.4	NE	8.5
December	25.4	5.1	80	68	3.9	NE	32.7
Total / Avg.	34.01	13.32	70	56	4.7	NE	1338.6
Kathua							
January	23.7	3.3	85		65	-	NE

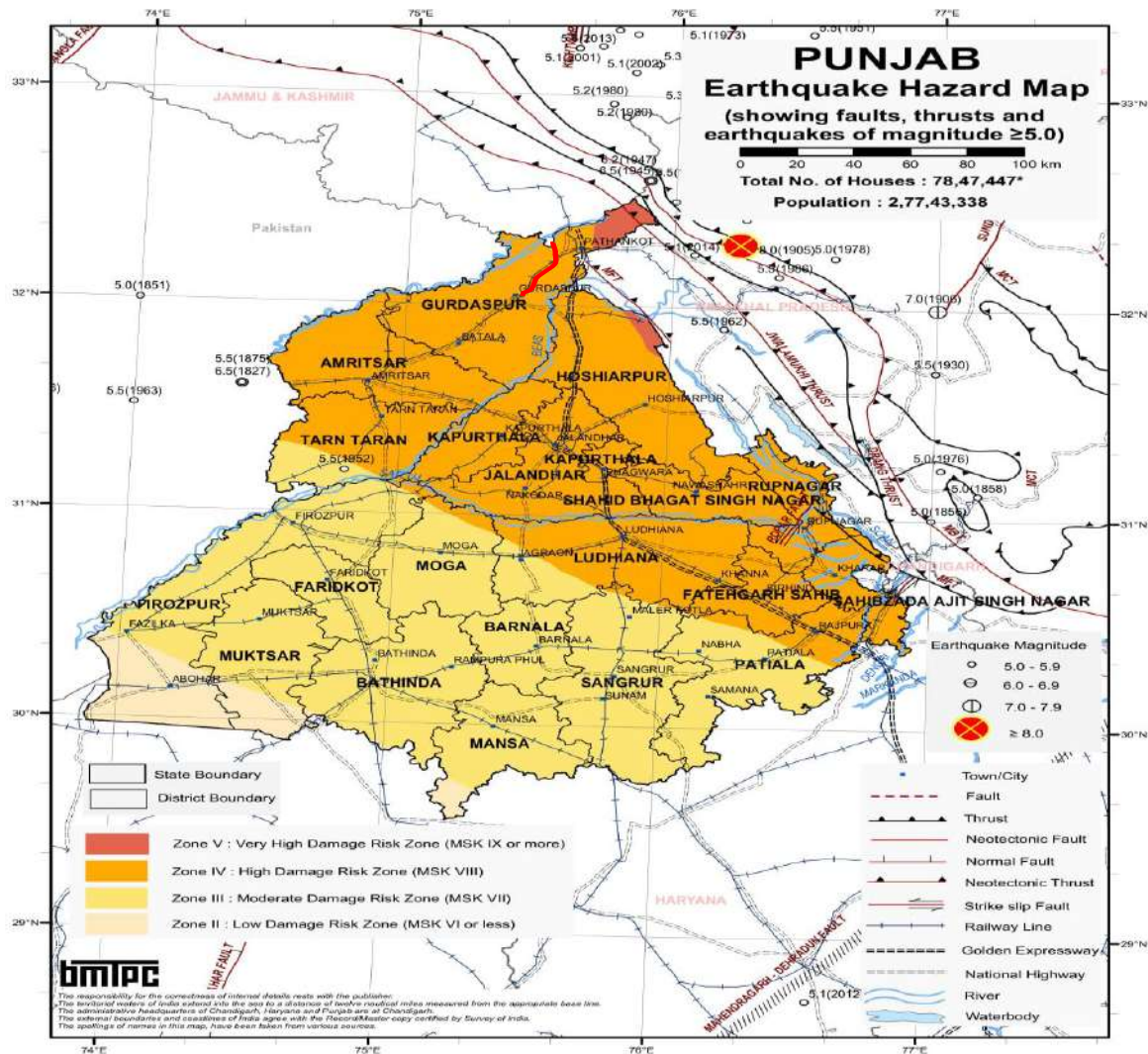
Month	Temp Monthly (°C)		Humidity (%)		Avg. Wind Speed (kmph)	Dominant Direction (from)	Avg. Rainfall (mm)
	Max	Min	Mor.	Eve.			
February	26.0	4.7	77		55	-	NE/E
March	31.6	8.5	67		50	-	E/NE
April	39.1	12.1	53		37	-	E/NE
May	41.7	17.5	45		31	-	E/SE
June	42.6	20.4	55		39	-	E/SE
July	38.0	20.6	78		64	-	E/SE
August	35.9	20.6	84		72	-	E/SE
September	35.2	18.1	79		66	-	E/SE
October	34.1	12.5	70		57	-	E/NE
November	30.0	7.5	73		63	-	NE/E
December	25.3	4.1	80		69	-	NE/E
Total / Avg.	33.6	12.5	71		56	-	E
Katra (Reasi)							
January	21.8	2.7	73	70	1.5	C/E	110.3
February	24.3	4.0	68	63	2.0	C/E	131.2
March	29.1	7.5	61	55	1.9	C/E	141.7
April	35.2	11.1	50	42	2.1	C/E/SE	75
May	39.2	14.6	44	36	2.1	C/E/W/SE	61.3
June	40.2	16.9	52	42	1.7	C/E/SE	137.2
July	35.8	18.2	82	75	1.4	C/E/SE	589.6
August	33.1	18.2	87	83	1.2	C/E/SE	635.1
September	32.1	15.4	79	75	1.1	C/E/SE	199.6
October	30.9	11.9	65	62	1.0	C/E	35.2
November	27.3	7.7	66	64	0.9	C/E	23.4
December	23.2	4.7	67	68	1.1	C/E	58.7
Total / Avg.	31.01	11.07	66	64	1.5	C/E	2198.3

Source: Climatological Normals 1981-2010, India Meteorological Department

Winds are generally variable as the union territory has mostly hilly terrain with lofty mountains and valleys. With the progress of the monsoon, south-westerly and westerly components of the wind become increasingly predominant. October onwards, the changeover of the pressure to winter pattern commences but wind pattern slightly changes as sometimes northerly and easterly components are seen. The average annual rainfall found varying from ~1294.7 mm at Kathua Observatory, 1338.6 mm at Jammu observatory and 2198.3 mm at Reasi (Katra) Observatory. Project region generally experiences hot climatic conditions during summer and chilled weather during winter with mercury reducing to 2.7°C at Katra.

6.6.3 Seismicity

Bureau of Indian Standards [IS-1893 Part 1:2002] categorises the country into four seismic zones viz. Zone-II, Zone-III, Zone-IV and Zone-V. Seismicity increases from Zone-II (Least active) to Zone-V (Highest Active). Alignment of proposed project is found in Seismic Zone IV (High Damage Risk Zone). The project districts are the part of High damage earthquake Risk Zone.



BMTPC : Vulnerability Atlas - 3rd Edition; Peer Group, MoHUA, GOI; Map is Based on digitised data of SOI; Seismic Zones of India Map IS:1893 (Part I); 2002; BIS; Earthquake Epicentre from IMD; Seismotectonic Atlas of India and its Environs, GSI; Houses/Population as per Census 2011; * Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

Figure 6-3: Earthquake Hazard Map of Punjab

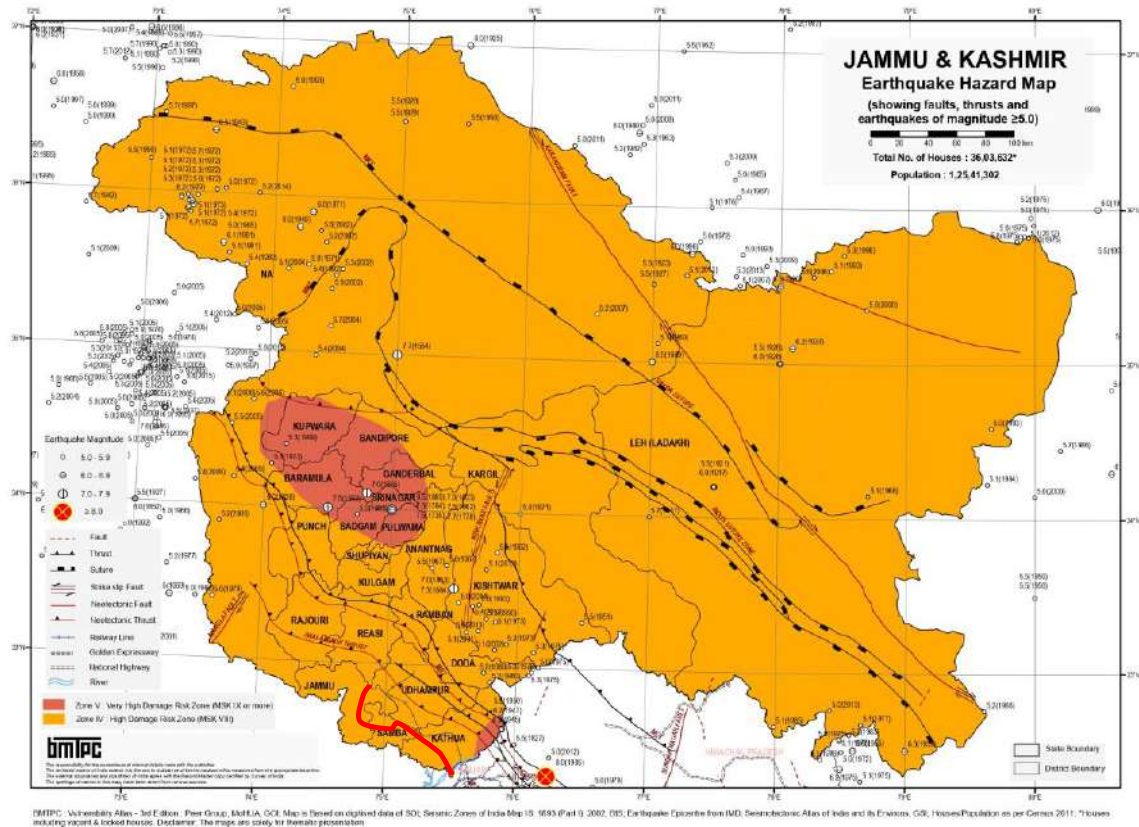


Figure 6-4: Earthquake Hazard Map of Jammu and Kashmir

6.6.4 Geology & Soil

Geology and Soil status as observed in project districts are defined in table below.

Table 6-4: Geology and Soil of project area

Project District	Geology and Soil Condition
Punjab	
Gurdaspur	The district can be divided into three geomorphological types-Hilly area, Piedmont zone and alluvial plain. Reddish chestnut soil and tropical arid soil are the major soil types of the district.
Pathankot	The district rocks, ranging in age from Tertiary to Quaternary. The soil of the district is alluvial type.
Jammu and Kashmir	
Kathua	The rock formations underlying the district ranges in age from Cambrian to Quaternary. Soft rocks forms Alluvium and Siwaliks and the Hard rock forms Panjal traps. The soils of the district consist of mainly Ochrepts, Ochrepts-Orthents and Ochrepts- Orthents-Ustalfs. The origin of the soil is Colluvio alluvium, having light brown colour. Its texture is fine loamy.
Samba	The rock formations underlying the district ranges in age from Cambrian to Quaternary. The soil type found in the district are Clayey Loam and Sandy Loam.
Jammu	The geological formation of district is of two types: 1. Porous formation made of Alluvium deposits which are Soft and unconsolidated. 2.

Project District	Geology and Soil Condition
	Fissured formation at Siwaliks made of Crystalline & Hard rocks. The two types of soils are mainly Litho soil and Alluvial soil.
Reasi	The rocks formation underlying the district ranges in age from Pre-Cambrian to Siwaliks of Miocene to Lower Pleistocene age. The four rock zones found are Pir Panjal Zone, Murree Zone, The Reasi Limestone Inlier and The Siwalik belt. The soil of the district is made up of the Ochrepts, Ochrepts-Orthents and Ochrepts-Orthents-Ustals sub-order associations. The soil is of brown colour having coarse loamy texture.

6.6.5 Indicative Land Use

Agricultural area and built-up section are the predominant land use. Project alignment is also passing through the ecologically protected area at few locations.

6.6.6 Ecology & Biodiversity

Protected Areas

The project alignment shall pass through the Nandini Wildlife Sanctuary, Bahu Conservation Reserve and Ramnagar Rakha Wildlife Sanctuary. So, NBWL (clearance under Wildlife (Protection) Act, 1972) recommendation is required.

Forest

Punjab

As per the India State of Forest Report, 2019, the State has reported extent of recorded forest area (RFA) of 3,084 km² which is 6.12% of its geographical area. The reserved, protected, and unclassified forests are 1.43%, 36.87% and 61.70% respectively. However, based on the satellite data the Forest Cover respectively of the recorded forest area in the State is 1848.63 km², which is 3.67% of its geographical area. In terms of forest canopy density classes, the State has 8.00 km² under Very Dense Forest (VDF), 800.97 km² under Moderately Dense Forest (MDF) and 1,039.66 km² under Open Forest (OF).

Jammu and Kashmir

As per the India State of Forest Report, 2019, the State has reported extent of recorded forest area (RFA) of 20,230 km² of which 17,643 km² is Reserved Forests, 2,551 km² is Protected Forest, and 36 km² is Unclassified Forests. Based on the interpretation of IRS Resourcesat-2 LISS III satellite data of the period Sept 2017 to Nov 2017, the Forest Cover is 23,611.89 km² which is 10.63% of the geographical area. In terms of forest canopy density classes, the UT have 4,280.48 km² under Very Dense Forest (VDF), 8,612.36 km² under Moderately Dense Forest (MDF) and 10,719.05 km² under Open Forest (OF).

Project Region

Project alignment is crossing the Protected Forest as well as Reserve Forest at many locations. Protected forests are the linear plantation developed along the existing road & canals and notified by forest dept. as protected forest in Punjab State. The exact

length of affected forest area along the project alignment will be measured during joint inspection with forest department at later stage.

Flora and Fauna

As per the primary survey and secondary resources, a total of 77 plant species were recorded with 24 tree species, 12 Shrubs, 24 herbs, 8 climbers and 9 species of grasses. All these floral species fall in 39 families in which Fabaceae stands with highest number of species i.e., 10 (including Caesalpinaceae) followed by Poaceae, Asteraceae and Moraceae with 9, 6 and 4 species respectively.

The review of secondary data indicates that, a total of 43 faunal species in which 14 mammals, 22 avifauna and 7 herpeto-fauna were recorded in the project study area.

One Avifauna species i.e., *Pavo cristatus* (Indian Peafowl) was found in the project affected area which is listed in Schedule-I of Indian WPA, 1972 and is having absolute protection and offences under this schedule are prescribed the highest penalties. It is though not listed in IUCN Red List. One Mammal species i.e., *Axis porcinus* (Hog Deer) was reported in forest area as per Working plan of Jammu Forest Division and the species is listed as “Endangered” as per IUCN Red List, 2020.

The detailed study of the flora and fauna is presented in the Environmental Impact Assessment (EIA) report prepared for the project.

6.7 Environmental Monitoring

Baseline Environment Monitoring was carried out for one season along the project alignment. The components of environmental study are as follows:

6.7.1 Ambient Air Quality Monitoring

The air quality monitoring is done as per the NAAQS, 2009. The parameters monitored are PM₁₀, PM_{2.5}, SO₂, NO_x and CO.

6.7.2 Noise Level Monitoring

Noise level monitoring in terms of Leq daytime and Leq night-time with hourly noise level from representative locations for a minimum of 24 hours is done. Monitoring stations are selected based on maximum coverage of land use present along the corridor.

6.7.3 Water Quality Sampling

Ground and surface water samples are collected for testing physical, chemical, and biological parameters as per applicable standards of CPCB / IS:10500 /IS:2296/ MoEF&CC. Samples for ground water quality assessment were collected from fourteen locations and for surface water at nine locations along proposed alignment and analysed for assessment of water quality. Detailed water availability and quality of surface and sub-surface sources along the project highway will be discussed in EIA report.

6.7.4 Soil Quality Sampling

In order to assess soil type, soil samples have been collected and tested based on physical and chemical characteristics (as per ICAR specification / guidelines).

6.8 Environmental Impact and Mitigation

The anticipated environmental impacts with suggested mitigation measures across different categories are listed in the table below.

Table 6-5: Impacts and Mitigation Measures

Particulars	Stages	Potential Impacts	Mitigation Measures
Physiographic Environment			
Topography	Preconstruction & Construction	Changes in topography as a result of the proposed development	Proper planning to assure minimal land reformation
Climate			
Temperature / Rainfall / Humidity	Preconstruction & Construction	Tree felling will have an impact of micro-climate of the area Heat island effect due to increase in paved roads Low spatially restricted short-term impact	Compensatory plantation in 1:10 ration of the trees to be cut With the proposed avenue plantation scheme, the micro climate of the project corridor will be smoothened
Land			
Loss of Other Land	Design, Preconstruction & Construction	Loss of Property & Livelihood	Compensation as per LARR, 2013
Induced Development	Pre-construction & Construction	Change in the land use pattern	Civil authorities to plan and guide induced development
Soil			
Soil Erosion	Preconstruction, Construction & Operation	Soil erosion in excavated areas, embankments, and spoils	Embankment protection through pitching & turfing Regular water sprinkling in excavated areas
Contamination of Soil	Preconstruction, Construction & Operation	Scarified bitumen wastes Oil and diesel spills Emulsion sprayer and laying of hot mix Production of hot mix and rejected materials Domestic waste from residential facilities for the labour and officers	Management of hazardous waste as per 'Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules, 2016' Provision of oil interceptors in storage areas to avoid accidental spill of oil and diesel Rejected material to be laid as directed by monitoring consultant.

Particulars	Stages	Potential Impacts	Mitigation Measures
			Septic tank to be constructed for waste disposal.
Water			
Impact on Water Resource	Design, Preconstruction, Construction and Operation	Depletion of ground water Contamination from fuel, lubricants, and waste disposal Contamination of surface water system due to run-off from road construction area	Provision of Storage/harvesting structure of water, wherever feasible Oil Interceptor and Septic tank in construction camp Enforcement of Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016 Both side drain facility to suitably divert the run-off from roads
Air			
Dust generation	Preconstruction & Construction	Generation of dust from site clearing, utility shifting, construction activities, crusher operation and material transportation	Regular sprinkling of water Dust generating materials to be completely covered during transport and stocking Provision of air mask for personnel working near to dust prone areas Hot mix plant, crusher or any other dust generating machineries shall be installed at least 1000m away from nearby settlement or sensitive receptor. Regular monitoring of particulate matter in ambient air
Gaseous pollutants	Preconstruction, Construction & Operation	Generation of gaseous pollutants as a result of operation of hot mix plant, construction machineries and transportation and material transportation	Hot mix plant or any other pollution generating machineries to be installed at a minimum distance of 1000m away from nearby settlement Enforcement of air pollution norms to control air pollution Use of PUC certified vehicles to transport materials Regular gaseous pollution monitoring in ambient air
Ambient air quality	Operation	Air pollution from vehicles and construction machinery.	Compliance with statutory regulatory requirements Plantation on both side of the project highway for attenuation of air pollution
Noise			
Pre-Construction Activity	Pre-Construction	Establishment of labour camps, onsite offices, stock yards and construction plants	Construction camps to be located at a minimum distance of 1000m away from settlements

Particulars	Stages	Potential Impacts	Mitigation Measures
		Noise generation as a result of man, material, and machinery movements	Control mechanisms like no horn zone signage, speed barriers etc. near sensitive receptors
Construction Activity	Construction	Operation of high noise equipment like hot mix plant, diesel generators etc.	Construction camps to be located at a minimum distance of 1000m away from settlements Noise pollution regulation to be enforced
Operation Stage	Operation	Blowing of horn near sensitive area	Restriction on use of horns No Horn Zone sign.
Ecology			
Flora	Preconstruction, Construction	Loss of vegetation cover Felling of trees Diversion of forest area for proposed development	Felling of unavoidable trees only Compensatory plantation in the ratio of 1:10 Avenue and Median Plantation along highway
Fauna	Preconstruction, Construction & Operation	Loss of insect, avian and small mammalian species due to felling of trees Accidental run over and increase in nos. of man-animal conflict	Construction camp shall be established at least 1000m away from nearby forest area Access controlled provisions to reduce the possibility of man-animal conflict Animal underpass at regular interval of nearby eco-sensitive areas Compensatory Plantation Speed breaker, Signage and limit in sensitive areas
Social			
Socio Environment	Design, Preconstruction & Construction	Impacts on project affected people Loss of Property & Livelihood Loss of CPRs, Religious Structures	Compensation as per LARR, 2013 Relocation of CPRs, Religious Structures to suitable place Continued consultation with PAPs and the competent authority for speedier settlements of appropriate compensation package and resettlement
Public Health and Road Safety			
Health and safety	Preconstruction, Construction & Operation	Migration of workers may lead to sanitation problem creating congenial condition for disease vectors Discomfort due to air and noise pollution	Ensuring sanitary measures at construction camp to prevent water borne disease and vector borne disease Provision for appropriate personal protective equipment's viz. earplugs, gloves gumboot, and mask to the work force

Particulars	Stages	Potential Impacts	Mitigation Measures
		Potential road accidents	Safe traffic management at construction area. Road safety signages and speed barriers near community facilities like school, hospital, etc.

6.9 Stakeholder Consultation

As a part of the project preparation and to ensure that the community support is obtained, and the project supports the felt needs of the people; stakeholder consultations shall be carried out as an integral component. Individual interviews, field level observations, community consultations & meetings shall be used to collect stakeholders input on the project. Meetings with community shall be conducted in both ways i.e., formal as well as informal.

Environment issues that are of concern to the Stakeholders to be discussed during consultation include:

- Employment to local people during construction work
- Pollution due to vehicular emission and generation of dust & noise
- Provision of crossing near settlement area
- Drainage system & drinking water facilities issues
- Provision of public toilet facility
- Felling of trees

6.10 Environmental Management Plan (EMP)

The EMP for the project has been developed based on the findings of detailed Environmental Impact Assessment study.

6.10.1 Environmental Budget

The environmental budget for the various environmental management measures has been detailed out in the EIA report. The following table provides a list of components included in framing of environmental budget:

Table 6-6: Components in Environmental Budget

Item No.	Component	Description	Unit
1	Mitigation / Enhancement Cost		
1.1	Pre-construction Stage		
1.1.1	Water	Relocation of affected water utilities like storage tanks, open wells, OHT, Hand-pump, etc. and aesthetic improvement of Ponds, Lakes, etc.	Nos.
1.2	Construction Stage		
1.2.1	Horticulture	Compensatory plantation to offset the loss of trees felling due to proposed development in accordance with the relevant forest laws	Nos.
1.2.2		Plantation on both side of the project highway as per IRC SP-21	Nos.
1.2.3	Slope Embankment protection /	Turfing on embankment with grass and herbs and stone pitching	meter

Item No.	Component	Description	Unit
1.2.4	Soil & Ground Water	Oil Interceptors at vehicle workshop areas and fuel storage areas	Nos.
1.2.5	Surface Water	Silt Fencing for Water Bodies adjacent to the road	meter
1.2.6	Air	Dust Management with sprinkling of water, covers for vehicles transporting construction material	km
1.2.7	Noise	Provision of noise barrier near sensitive receptors complying Technical Specifications	meter
1.2.8	Solid Waste Disposal	Disposal / treatment facility for Sewage and other wastes in the construction yard and labour camps	Months
1.2.9	Cultural properties	Relocation of cultural properties	Nos.
1.2.10		Mandatory / Regulatory Sign Boards	Nos.
1.2.11	Wildlife	Wildlife Mitigation Measures as per Wildlife Dept. recommendations	-
1.3	Operation Stage		
1.3.1	Horticulture	Maintenance of flowering, shade, medicinal, ornamental & fruit bearing trees in suitable area for 3 Years	Nos.
2	Monitoring Cost		
2.1.1	Air	Monitoring and analysis as per CPCB and MoEF&CC guidelines	Nos.
2.1.2	Water Quality	Sampling and analysis as per CPCB and MoEF&CC guidelines	Nos.
2.1.3	Noise	Monitoring and Mathematical analysis as per CPCB and MoEF&CC guidelines	Nos.
2.1.4	Soil	Sampling and Analysis as per CPCB and MoEF&CC guidelines	Nos.
3	Enhancement Measures		
3.1	Environmental	Environmental enhancements measures	L.S.
3.2	Enhancement	Facility for Roadside Drinking Water	Nos.
4	Miscellaneous Cost		
4.1	Training	Training	Nos.
4.2	Advocacy and Policy Making	Holding meetings for policy planning and subsequent review meetings with statutory bodies	L.S.
4.3	Administrative Charges	Maintenance of vehicle with the Environment Cell, Data processing, administrative support, stationery etc	L.S.
4.4	Miscellaneous	Digital Camera for the Environment Cell	Nos.
4.5	Items	Portable sound level meter	Nos.

6.11 Conclusion

- Forest and Wildlife Clearances will be ensured before undertaking construction activities in forest and wildlife area and condition of these clearance will be integrated with EMP and design of the project.
- Comprehensive contractual, design, and budgetary provisions will be made for avoidance, minimization, management, or enhancement of various environmental components likely to be impacted due to the construction of project.
- Monitoring mechanism will be developed as a part of environmental management to ensure compliance of the environmental protection plans and adoption of corrective measures to make the measures environmentally sustainable.

7 ECONOMIC AND FINANCIAL ANALYSIS

Economic and financial analysis has been carried out for complete length of the project highway. The viability of the project highway has been verified during the feasibility stage. Hence, package wise analysis is not carried out for this stage of report and considered the feasibility stage report of economic and financial analysis. Therefore, for ready reference reproduced the economic and financial analysis chapter from feasibility report. The total civil cost mentioned in this chapter is as provided in feasibility report.

7.1 ECONOMIC ANALYSIS

7.1.1 Investment Appraisal

The objective of the cost benefit economic analysis is to identify and quantify the benefits and costs associated with the project (Delhi Katra Expressway Phase II), in order to select the optimum solution along with the economic viability in terms of its likely investment return potential.

This cost benefit economic feasibility study is carried out using the overall guidelines stipulated by the Indian Roads Congress (IRC) and the World Bank in their manuals like Economic Evaluation of Highway Projects in India (SP – 30, 2009) and, Manual for Road Investment Decision Model' (SP – 38,1992) and Manual for HDM - 4 Version 2, as these are accepted by the World Bank, Ministry of Road Transport & Highways (MORT&H), National Highways Authority of India (NHAI).

The cost – benefit analysis is carried out by using the Discounted Cash Flow (DCF) technique to obtain the Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV) for the proposed investments linked with the project. This is followed by a 'sensitivity analysis' carried out by increasing or decreasing the critical factors affecting the cost and benefit streams of the proposed project, in order to ascertain their effect on the economic feasibility indicators i.e. ENPV, EIRR.

7.2 “Without Project” Alternative

Strategy 1: In the HDM model analysis, this “Do Minimum Scenario” alternative will form the base strategy against which all other strategies will be compared. The proposed road from the phase II of the project originate from Gurudaspur to Katra is brownfield alignment, except few stretches of realignment is adopted. The existing route (2/4/6-Lane+PS) from Gurudaspur through Pathankot, Jammu, Domel and Katra using NH-IA catering the present traffic has been considered as base case.

7.3 “With Project” Alternative

Strategy 2: This is the scenario of construction of Brownfield / Greenfield Expressway of 6 Lane plus 4 lane service road.

This strategy forms a 'With Project' alternative and is compared to 'Without Project' alternative. By comparing the above alternatives, the net agency costs and net user costs and finally net project benefits, associated with the project during its analysis period are calculated, for the improvement option in order to arrive at Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV).

7.4 HDM Model Input Data

7.4.1 General

The following general input values have been considered for the HDM Model as presented in tables given below.

Table 7-1: General Inputs for HDM Model

Description:	
Run Date	01-02-2022
Discount Rate (%)	12%
Analysis Period (years)	33
Calendar Year of Initial Year	2021
Length of Project	146.82 Km
Output Currency	Indian Rupees
Input Currency	Indian Rupees

Table 7-2: HDM Input - Road Sections – Basic data

ID	Name	Speed Flow Type	Road Class	Climate Zone	Surface Class	Length (km)	Carriageway Width (m)	Shoulder Width (m)	MT
Pkg-13	397.700 – 423.500	Four Lane	Primary	Semi - arid	Bituminous	27.575	14.0	1.5	16179
Pkg-14	423.500 – 438.780	Four Lane	Primary	Semi - arid	Bituminous	20.5	14.0	1.5	22027
Pkg-15	468.100 – 503.200	Four Lane	Primary	Semi - arid	Bituminous	35.8	14.0	1.5	23189
Pkg-17	514.430 – 529.000	Two / Four Lane	Primary	Semi - arid	Bituminous	17.1	14.0	1.5	15530
Pkg-17 Link	0.000 – 38.000	Two / Four Lane	Primary	Semi - arid	Bituminous	38.0	14.0	1.5	16179
Pkg-17	552.200 – 564.724	Two / Four Lane	Primary	Semi - arid	Bituminous	18.2	7.0	1.5	6076

Table 7-3: Road Sections – Condition of Project Road

ID	Condition Year	Roughness IRI (m/Km)	Total Cracking Area (%) ACRA	Ravelled Area (%)	Potholes (no./km)	Edge Break (m/km)	Rut Depth (mm)
Pkg-13	2020	2814	32.7	2.6	3	4	0.74
Pkg-14	2020	2800	20.0	2.0	3	4	0.74
Pkg-15	2020	1912	3.9	0.3	0	4.5	0.65
Pkg-17	2020	2650	18.5	1.2	0	4	0.5
Pkg-17 Link	2020	2765	21.6	1.4	0	7	0.52
Pkg-17	2020	2765	16.8	20.89	2	7	0.52

Table 7-4: HDM Input: Road Sections- Geometry of Project Road

ID	Speed Flow Type	Rise + Fall (m/km)	Curvature Deg/km	Horizontal Super elevation (%)	Speed Limit (kmph)
Pkg-13	4 Lane	8.3	20	5.5	45
Pkg-14	4 Lane	7.7	14.8	5.5	45
Pkg-15	4 Lane	9.8	24	5.5	35
Pkg-17	4 Lane	9.0	15	5.5	35
Pkg-17 Link	2/4 Lane	9.0	15	5.5	30
Pkg-17	2/4 Lane	9.0	15	5.5	30

Table 7-5: HDM Input: Road Sections – Pavement Condition of Project Road

Material Type	Current Surface Thickness (mm)	Previous Surface Thickness (mm)	Last Construction / Re-Construction New Year	Last Rehabilitation Year	Base Thickness (mm)
Asphalt Concrete (AC)	50	30	2010	2010	250

7.4.2 Traffic

The assignable traffic likely to use the proposed project road has already been discussed in Traffic Chapter of this report. For the economic analysis, fast moving motorised traffic excluding two wheelers and non-motorised vehicles has been considered. The AADT of the three sections of the alternate route has been taken in the analysis.

7.4.3 Growth Rate

Traffic growth rates necessary to estimate traffic levels in future on project road are products of economic factors of the influence area and elasticity of traffic demand. Normal – most likely growth scenario has been considered for economic analysis presented in the table below.

Table 7-6: Most likely Growth Scenario (in %)

Mode	2019-22	2023-27	2028-32	2033-37	2038-42	2043-47
Car	6.9	5.6	4.5	3.6	3.0	2.4
Bus	5.5	4.5	3.6	2.9	2.4	1.9
LCV	5.8	4.9	5.3	4.9	4.5	4.0
2 Axle Truck	3.0	2.8	2.5	2.2	1.5	1.5
3 Axle Truck	3.3	3.0	2.8	2.3	1.7	1.7
MAVs	5.7	5.5	5.2	4.9	4.6	4.2

7.5 Project Cost

7.5.1 Capital Cost

The capital costs of the new construction of the project road including the phasing of investment during the construction period have been calculated. The total capital costs (including road works, bridges, culverts and utilities, land acquisition, resettlement and rehabilitation, environment cost, utility shifting, quality and project development charges) at current prices with contingency costs for road works and structures have been considered.

The capital costs (financial) of the project road have been converted into economic costs by using a standard conversion factor of 0.90, to construction costs (road works and structures). The economic cost of land acquisition, R & R, environment cost and utility shifting has been taken as the same as financial cost, without resorting to shadow pricing or assessing opportunity cost in any other alternative. The project costs, over the construction period, are shown in tables given below.

Table 7-7: Project Cost Taken in Analysis (In Crores)

Civil Cost with Centages	LA and R&R Cost	Envn. Cost	Utility Cost	Financial Cost	Economic Cost	Economic Cost Per Km
5542.54	3085.54	67.86	217.56	8913.50	8359.24	56.93

Table 7-8: Cost Phasing (%)

Cost Phasing	FY 2020	FY 2021	FY 2022
Phase I	30	40	30

7.5.2 Routine and Period Maintenance

The various maintenance costs have been divided into two parts: routine and periodic maintenance. The salient features and construction policy for the both types of are mentioned below. Routine and Periodic maintenance has been taken as given in table below.

Table 7-9: Operation and Maintenance Cost

Maintenance Type	Lane	Financial Cost (per m2)	Economic Cost (per m2)
Routine Maintenance	4 Lane	33.0	30.0
	6 Lane	36.0	32.0
	8 Lane	42.0	38.0
Periodic Maintenance	4 Lane	333.0	300.0
	4 Lane	360.0	324.0
	8 Lane	415.0	374.0

Other maintenance: additional operational expenses associated with project such as traffic signposts, lighting etc., are considered as annual charges and included in routine maintenance costs. For annual supervision & administration charges, it has been assumed that the arrangement under 'without project' will continue for the 'with project' situation.

7.5.3 Road Users Cost

The economic cost inputs that are required for estimating road user costs are:

- Price of selected (popular) models, by vehicle type
- Tyre prices
- Fuel cost including oil
- Crew cost (wages of drivers / assistants)
- Time costs for :
 - Passengers
 - Freight (holding cost)\

The cost of vehicles and tyres were collected from the manufacturers, and dealers. All the transfer payments such as sales tax, excise duty and octroi are deducted from the financial cost to arrive at the resource cost.

A pilot survey has been conducted to estimate the wages of drivers and their assistants. The crew cost is estimated with 2400 hours of work time per annum. With respect to maintenance and labour costs, local workshops have been contacted to assess the annual wage bill and assuming 2400 hrs of work per annum, the labour costs have been calculated per hour.

The value of passenger time has been calculated based on the average annual income of passenger collected with the assumption of 2400 hours of work time per annum. About 30 percent of the trips are assumed to be made during non-work hours. Finally, a weighted average of time value per hour has been calculated. Time saving values applicable to 1990 (IRC SP: 30 - 1993) have been adopted. Based on the above considerations, the economic costs estimated for different VOC components are presented in table below.

Table 7-10: Vehicle Characteristics, Utilization Data and Economic Unit Costs

Vehicle Costs at Economic Prices									
Vehicle type	Unit cost (Rs.)			Percent	Time value (per hour) in Rs				
	Vehicles	Tires	Annual Overhead	Annual Interest	Maintenance Labour (INR/hr)	Crew cost (INR/hr)	Passenger*		Cargo time (INR/hr)
							Working	Non-working	
Car	405000	3330	20250	9%	46.00	0.00	81.0	24.0	0
2-Wheeler	43200	1530	2160	9%	32.00	0.00	58.0	17.0	0
Minibus	720000	4050	36000	9%	42.00	120.00	46.0	14.0	0
Bus	1350000	7000	67500	9%	42.00	120.00	46.0	14.0	0
LCV	495000	4050	24750	9%	42.00	50.00	0	0	3.0
2 Axle Truck	1440000	8730	72000	9%	42.00	60.00	0	0	7.0
3 Axle Truck	1620000	8730	81000	9%	42.00	60.00	0	0	7.0
Multi Axle Truck	2250000	8730	112500	9%	42.00	60.00	0	0	16.0
Three-Wheeler	70000	1530	3500	9%	32.00	50.00	58.0	17.0	0
Tractor - Trailer	600000	10000	30000	9%	42.00	50.00	0	0	3.0
Petrol or Fuel (Rs/ltr.)		48.2							
Diesel (Rs/ltr.)		50.1							
Lubricant (Rs/Litre)		102							

Table 7-11: Vehicle Characteristics (Motorized)

Vehicle Type	Operating Weight (Tones)	ESAL Factor	No. of Axles	Type of Tires	No. of Passengers	Private use (%)	Work related passenger-trips (%)	Service Life (Year)	Hour Driven/ Year	Km Driven/ Year	PCSE
Car	1.40	0.00	2	4	3	100	75	10	1950	30000	1.00
2-Wheeler	0.20	0.00	2	2	1.5	100	75	10	800	21000	0.50
Minibus	5.0	0.10	2	4	20	0	75	10	1500	60000	1.50
Bus	13.50	0.70	2	6	40	0	75	10	2250	70000	3.00
LCV	3.50	1.35	2	4	0	0	75	10	1600	60000	1.50
2 Axle Truck	15.50	3.36	2	6	0	0	75	10	2100	85000	1.60
3 Axle Truck	25.00	7.86	3	10	0	0	75	10	2200	85000	3.00
Multi Axle Truck	35.10	6.09	5	18	0	0	75	8	2100	77500	4.50
Three-Wheeler	0.30	0.00	2	3	3	10	60	10	600	15000	0.75
Tractor - Trailer	4.00	0.02	2	4	0	0	75	10	2000	50000	4.50

7.6 Economic Evaluation

7.6.1 Economic Cost

The life cycle economic benefits and costs, ENPV and EIRR are calculated considering:

- VOC savings as a project benefit and
- With all savings (VOC and Travel time) as a project benefit.
- Agency capital costs
- Agency recurrent costs

Economic analysis of the project road has been carried out and the summary of findings is attached in table below.

Table 7-12: Summary of Base Case (NPV and EIRR) of Project Road

Details	EIRR (%)	NPV Discounted 12 % Discount Rate (Rs. million)
Base Case	15.9	19460.95

7.6.2 Sensitivity Analysis

The robustness of economic feasibility of the project road are tested with a sensitivity analysis conducted in the form of risk analysis. These analyses tested the economic feasibility against uncertainties in estimated capital cost and benefits associated with the project road.

- 15% increase in Cost
- 15% decrease in Traffic
- 15% increase in Cost & 15% decrease in Traffic

Table 7-13: Sensitivity Analysis

Description	EIRR (%)	NPV (US\$ millions)
Base Case	15.9%	19460.95
15% Increase in Cost	14.3%	12682.65
15% Decrease in Benefit	14.0%	9790.72
15% increase in Cost and 15% decrease in Benefit	12.6%	3012.42

7.6.3 Conclusion and Recommendation

The project road found economically feasible for the proposed improvement of upgrading to Six lane with four lane service road. Economic analysis results show an EIRR of 15.9% in base case and 12.6% is worst case, which is above the benchmarked IRR of 12%.

HDM - 4 Economic Analysis Summary

ROADWAY DEVELOPMENT & MANAGEMENT

Study Name: Delhi Katra Ph-II
Run Date: 01-02-2022
Currency: Indian Rupee (millions)
Discount: 12.00%
Analysis Mode: Analysis-by-Project

Alternative: Improvement Case vs Alternative: Base Case
Sensitivity Scenario: Base Sensitivity Scenario

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Cost	Savings in NMT Travel & Operating Cost	Reduction in Accident Cost	Net Social / Exogenous Benefit	Net Economic Benefit (NPV)
	Capital	Recurrent	Special						
Undiscounted	36,355.11	-425.22	0.00	233,363.06	154,879.23	0.00	0.00	0.00	300,336.42
Discounted	45,190.65	-191.36	0.00	36,699.32	27,779.93	0.00	0.00	0.00	19,880.95

Economic Internal Rate of Return (EIRR) = 15.9% (No. of solutions = 1)

Alternative: Improvement Case vs Alternative: Base Case
Sensitivity Scenario: Case I

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Cost	Savings in NMT Travel & Operating Cost	Reduction in Accident Cost	Net Social / Exogenous Benefit	Net Economic Benefit (NPV)
	Capital	Recurrent	Special						
Undiscounted	44,111.83	-425.22	0.00	233,363.06	154,879.23	0.00	0.00	0.00	344,584.88
Discounted	51,995.96	-191.36	0.00	36,699.32	27,779.93	0.00	0.00	0.00	12,852.85

Economic Internal Rate of Return (EIRR) = 14.3% (No. of solutions = 1)

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HDM - 4 Economic Analysis Summary

Alternative: Improvement Case vs Alternative: Base Case
Sensitivity Scenario: Case II

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Cost	Savings in NMT Travel & Operating Cost	Reduction in Accident Cost	Net Social / Exogenous Benefit	Net Economic Benefit (NPV)
	Capital	Recurrent	Special						
Undiscounted	36,355.11	-425.22	0.00	198,364.12	131,646.48	0.00	0.00	0.00	292,097.72
Discounted	45,190.65	-191.36	0.00	31,105.07	23,812.94	0.00	0.00	0.00	9,790.72

Economic Internal Rate of Return (EIRR) = 14.0% (No. of solutions = 1)

Alternative: Improvement Case vs Alternative: Base Case
Sensitivity Scenario: Case III

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Cost	Savings in NMT Travel & Operating Cost	Reduction in Accident Cost	Net Social / Exogenous Benefit	Net Economic Benefit (NPV)
	Capital	Recurrent	Special						
Undiscounted	44,111.83	-425.22	0.00	198,364.12	131,646.48	0.00	0.00	0.00	296,344.02
Discounted	51,995.96	-191.36	0.00	31,105.07	23,812.94	0.00	0.00	0.00	3,012.42

Economic Internal Rate of Return (EIRR) = 12.6% (No. of solutions = 1)

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7.7 Financial Analysis

7.7.1 Introduction

The purpose of financial analysis is to optimize the project from the perspective of its financial feasibility as a PPP project considering the cost of developing the project and the expected revenue stream over a period of time. It also includes study of different scenarios from the Concessionaire's perspective and to assess whether the Concessionaire gets a reasonable return on his equity.

The analysis builds on several important elements:

- The technical options developed in the preceding sections of this report.
- The traffic and toll rate forecast developed in the preceding sections of this report.
- Assumptions (Debt Financing, Taxation, O&M Estimates, etc.) as shown in the coming sections.

Discounted Cash Flow (DCF) method has been used in financial analysis. The cost of equity ranges from 12% to 18% based on sector of the project⁴. The analysis has been carried out to assess the viability of the project based on threshold Equity IRR of 15% which is also in line with NHAI Circular⁵

The capital cost of the project packages for financial analysis comprising of cost of civil works for roads, culverts, bridges, road furniture etc. The cost of land acquisition, utility shifting, environmental management, resettlement and rehabilitation etc. is not included in the financial analysis as per the prevailing norms of PPP Projects.

7.7.2 Concept and Methodology

Discounted Cash Flow (DCF)

Discounted Cash Flow (DCF) Analysis is a method of valuing a project, company, or asset using the concepts of the time value of money. All future cash flows are estimated and discounted to give their present values (PVs) – the sum of all future cash flows, both incoming and outgoing, is the net present value (NPV), which is taken as the value or price of the cash flows in question. DCF analysis is the most widely accepted valuation method in the fields of investment finance, real estate development, and corporate financial management.

Internal Rate of Return (IRR)

The Internal Rate of Return is related to the NPV but it is expressed as a percentage. The IRR is that rate of return at which the NPV from the investments will become zero. It should be compared with the investor's required rate of return.

- If **IRR = the desired rate of return**: means the project repays original investment the desired rate of return.
- If **IRR > the desired rate of return**: means the project repays original investment a better return as compared to the desired rate of return.

⁴Survey by EY, India's Cost of Capital

⁵Appraisal of PPP Projects – Standardize the formulation and appraisal parameters – NH37012/09/2009-H

- If **IRR < the desired rate of return**: means a worse return as compared to the required rate.

If the IRR is higher than the required rate of return of the investor, it means the project is attractive to that investor (since the project offers a higher return). If the IRR is lower than the required rate of return of the investor, it means that the investor would not be interested in pursuing the project.

Project-IRR and Equity-IRR

Project IRR = Rate of Returns to all Investors (has to be compared with the Weighted Average Cost of Capital). IRR of the post-tax discounted project cash flows (Project IRR) is considered as basic indicator of financial feasibility of a project, which indicates whether the project is capable enough to ensure a return equivalent to the weighted average cost of capital. The surplus and deficit in the Project IRR as compared with the weighted average cost of capital directs a “Go” or “No Go” decision for the project respectively.

Equity IRR = Rate of Returns to Equity holders (Has to be compared with the rate of return required by the investor on its equity). IRR of the post-tax discounted equity cash flows (Equity IRR) is considered as indicator of surplus generated from project, which indicates whether the project is capable enough generate surplus after ensuring desired return on the Concessionaire's equity. This indicates whether the project is attractive enough for the private sector investors.

Decision Rule for Project Viability (P-IRR and E-IRR)

Two of the most important decision rules for project viability are:

- Project IRR should be greater than the weighted average cost of capital
- Equity IRR should be greater than 15% (assumed desired rate of return for investors)

7.7.3 Financing Mechanism

The section presents the project structuring options based on consultant's experience for similar projects

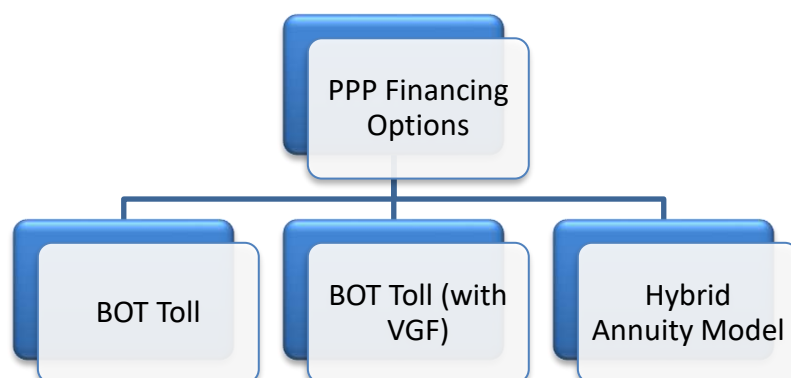


Figure 7-1 : PPP Financing Options

Option 1: BOT Toll

Build-Operate-Transfer Toll (BOT Toll) model allows the developer to design, build and operate the highway and recover its equity through collection of toll. The toll rates are pre-defined as part of the Concession Agreement (CA). The developer will be allowed to collect the toll for a pre-defined period as part of the CA.

Option 2: BOT (with VGF)

In case where the project revenues aren't enough for the Concessionaire to recover its equity, highway project becomes unviable on BOT Toll model. The project sponsor (the Government/ Authority) provides a grant called the Viable Gap Funding (VGF) to meet a part of the construction costs. The Viability Gap Funding Scheme of the Government of India for Financial Support to Public Private Partnerships in Infrastructure, provides financial support of up to 40% of the Total Project Cost in the form of grant (one time or deferred) to infrastructure projects undertaken through public private partnerships with a view to making them commercially viable.⁶

Option 3: Hybrid Annuity Model (HAM)

Another model for the proposed project is the Hybrid Annuity Model, which is being used heavily in financing highway projects. HAM is a mix of the EPC (engineering, procurement and construction) and BOT (build, operate, transfer) Annuity Model. The salient features of the model are explained in the following figure:

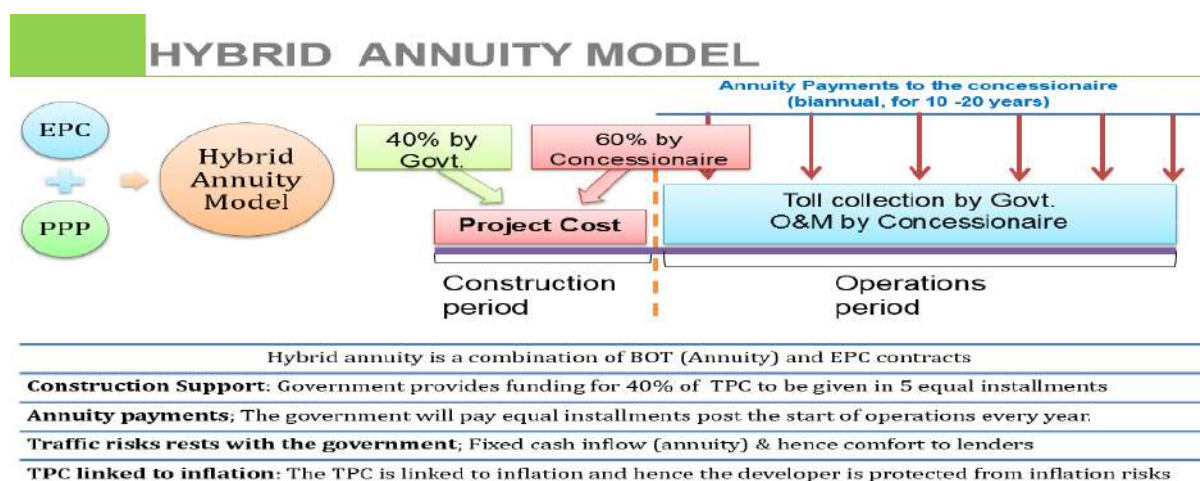


Figure 7-2 : Hybrid Annuity Model (HAM)

7.7.4 Civil Cost

The base civil construction cost for the project has been assessed as following:

⁶ <https://www.pppinindia.gov.in/faqs#q5>

Table 7-14: Civil Cost

Sl. No.	Description	Length	Civil Cost (INR Cr) (incl GST)
1	Package 13	25.8	702.93
2	Package 14	44.60	1792.53
3	Package 15	35.15	1739.53
4	Package 17	28.53	1576.94

7.7.5 Assumptions for Financial Analysis

Phasing of Capital Expenditure

It has been assumed that the Highway shall be constructed in a period of 30 months (2.5 years) for in the base case scenario. The consultants have assumed the dates for various milestone activities as provided in the following table:

Table 7-15 : Implementation Schedule

Milestone Activity	Assumed Date	FY
Agreement Signing Date*	01-Jul-22	2023
End of Construction	31-Dec-24	2025

*Assuming Agreement signing date is same as appointed date

The phasing of Capital Expenditure (CAPEX) is assumed to be equally distributed over the 30 months in the following fashion:

Table 7-16 : CAPEX Phasing

	FY 2023	FY 2024	FY 2025
Construction Phasing	20%	40%	40%

Capital Structure, Cost of Capital and Financing

Financing of BOT projects is typically done through a combination of debt and equity. The typical Debt-Equity ratio for infrastructure projects in India is 70:30 and the same has been considered for the analysis. The cost of debt has been assumed to be 8.46%⁷ and the cost of equity as 15% (as per Industry practice).

Table 7-17 : Capital Structure and Cost of Capital

	Proportion	Cost
Debt	70%	8.46%
Equity	30%	15%

Depreciation

Large infrastructure capital projects are depreciated over its usable life. Following depreciation rates have been used for the purpose of financial analysis:

⁷ Based on the directions provided for financial analysis of hybrid annuity projects, i.e. RBI Bank Rate + 1.25% margin

Table 7-18 : Depreciation rules

Depreciation	
As per Companies Act	Straight line method: Depreciated over the O&M Period
As per Income Tax Act	10% (WDV method)

Taxation

The applicable tax has been applied for financial analysis:

Table 7-19 : Tax Rates

	Corporate Tax Rate	MAT Rate
Base	30.00%	18.50%
Surcharge	12.00%	12.00%
Total (Base Surcharge)	33.60%	20.72%
Education Cess	3.00%	3.00%
Net Tax Rate	34.61%	21.34%

7.7.6 Total Project Cost (TPC)

Further, the following costs have been taken into consideration to arrive at the Total Project Cost (TPC) as per the NHAI Circular⁸ "Updating the cost norms in respect of National Highways Projects":

- Contingency Expenses:
- Financing and Documentation Cost
- Pre-operative expense:
- Escalation Cost
- Interest During Construction (IDC)

Table 7-20 : Total Project Cost Abstract (TPC) Abstract

Total Project Cost Abstract for Package 13 –

Major Costs	Assumptions	INR Cr
Civil Construction Costs		702.93
Contingency Expenses (% of Civil Construction Costs)	1%	7.03
EPC Cost		709.96
Financing and Documentation Costs	On Debt Amount	8.88
Pre- Operative Expenses	1% of EPC Cost	7.10
Inflation Considered for Escalation Calculations	5% per annum	80.528
Interest During Construction (IDC)	Calculated on the debt amount	32.93
Total Project Cost (TPC)⁹		839.40

⁸RW/NH-24036/27/2010-PPP dated 10th Aug 2016

⁹ Calculated with 0% VGF and as per the NHAI circular - Cost norms for NH 10.08.2016

Total Project Cost Abstract for Package 14 –

Major Costs	Assumptions	INR Cr
Civil Construction Costs		1,792.43
Contingency Expenses (% of Civil Construction Costs)	1%	17.92
EPC Cost		1810.35
Financing and Documentation Costs	On Debt Amount	15.04
Pre- Operative Expenses	1% of EPC Cost	18.10
Inflation Considered for Escalation Calculations	5% per annum	205.341
Interest During Construction (IDC)	Calculated on the debt amount	83.83
Total Project Cost (TPC)¹⁰		2,132.66

Total Project Cost Abstract for Package 15 –

Major Costs	Assumptions	INR Cr
Civil Construction Costs		1,739.80
Contingency Expenses (% of Civil Construction Costs)	1%	17.40
EPC Cost		1757.20
Financing and Documentation Costs	On Debt Amount	14.60
Pre- Operative Expenses	1% of EPC Cost	17.57
Inflation Considered for Escalation Calculations	5% per annum	199.311
Interest During Construction (IDC)	Calculated on the debt amount	81.36
Total Project Cost (TPC)¹¹		2,070.04

Total Project Cost Abstract for Package 17 –

Major Costs	Assumptions	INR Cr
Civil Construction Costs		1,576.94
Contingency Expenses (% of Civil Construction Costs)	1%	15.77
EPC Cost		1592.71
Financing and Documentation Costs	On Debt Amount	13.23
Pre- Operative Expenses	1% of EPC Cost	15.93
Inflation Considered for Escalation Calculations	5% per annum	180.654
Interest During Construction (IDC)	Calculated on the debt amount	73.75
Total Project Cost (TPC)¹²		1,876.27

7.7.7 Operation and Maintenance (O&M) Estimates

The Operation & Maintenance Cost for the base case (rigid pavement all throughout) have been assumed for the Highway as following:

Table 7-21 : O&M Assumptions – I

Lane	Flexible Pavement in FY 2024 for Routine Maintenance (INR Cr/km/annum)	Flexible Pavement in FY 2024 for Periodic Maintenance (INR Cr/km/annum)
4 Lane	0.06	0.60

¹⁰ Calculated with 0% VGF and as per the NHA circular - Cost norms for NH 10.08.2016

¹¹ Calculated with 0% VGF and as per the NHA circular - Cost norms for NH 10.08.2016

¹² Calculated with 0% VGF and as per the NHA circular - Cost norms for NH 10.08.2016

Table 7-22 : O&M Assumptions – II

Other Operational Expenditures	Assumption (2019-20 prices)	Precedence
Electricity and Patrolling Expenses (INR Cr/ km/ annum)	0.04	Consultant's experience from due diligence of similar highway assets
Toll Plaza Maintenance (INR Cr/ toll plaza/ annum)	4.20	Consultant's working for a 32 lane toll plaza
Insurance Expenses (as a % of TPC/ annum)	0.15%	Consultant's experience from due diligence of similar highway assets

An escalation of 5% per annum has been assumed while projecting the Operations and Maintenance Cost Estimates throughout the period of analysis.

7.7.8 Revenue Estimates

As the project highway is an access-controlled highway, toll plazas will be installed at all entry and exit points along the highway.

Schedule of user fee

As per Schedule of user fee proposed by Department of Road Transport and Highways, Govt. of India, the fee per km as applicable in 2007-08 has to be revised every year through the prescribed method using whole sale price index (WPI). The toll rates per km are revised to 2018-19 and 2022-23 as per the new amendments to 2007-08 policy and WPI values. The fee per km and revised rates per km is presented in **Table 7-23** below.

Table 7-23: Toll rate per km (INR) for base year and revised rates

Category of Vehicle	Base rate per km for 2007-08	Toll rate per km for 2018-19
Car, Jeep, Van, LMV	0.65	1.108
LCV, LGV, Mini Bus	1.05	1.790
Bus, 2A Truck	2.20	3.750
3A Truck	2.40	4.091
MAV	3.45	5.881
Oversized Vehicles	4.20	7.159

**inflation rate of 5% adopted to revise WPI values after FY19*

Tollable traffic

- **Discounts:** The discounts allowed for local traffic/frequent users as per toll policy are given below:

The executing authority shall upon request provide a pass for multiple journeys to cross a toll plaza within the specified period at the rates specified below

- A driver, owner or person in charge of a mechanical vehicle who makes use of the section of national highway, permanent bridge, bypass or tunnel, may opt for such pass and he or she shall have to pay the fee in accordance with the following rates, namely:-

Amount Payable	Maximum number of one way journeys allowed	Period of Validity
One and half times of the fee for one-way journeys	Two	Twenty-four hours from the time of payment
Two-third of amount of the fee payable for fifty single journeys	Fifty	One month from date of payment

- A person who owns a mechanical vehicle registered for non-commercial purposes and uses it as such for commuting on a section of national highway, permanent bridge, bypass or tunnel, may obtain a pass, on payment of fee at the base rate for the year 2007-2008 of rupees one hundred and fifty per calendar month and revised annually, authorizing it to cross the toll plaza specified in such pass:

Provided that such pass shall be issued only if such driver, owner or person in charge of such mechanical vehicle resides within a distance of twenty kilometers from the toll plaza specified by such person and the use of such section of national highway, permanent bridge, bypass or tunnel, as the case may be, does not extend beyond the toll plaza next to the specified toll plaza.

Provided further that no such pass shall be issued if a service road or alternative road is available for use by such driver, owner of person in charge of a mechanical vehicle.

- A person who owns a commercial vehicle, excluding vehicle plying under national permit, registered with address on the registration certificate of a particular district and uses such vehicle for commuting on a section of national highway, permanent bridge, tunnel or bypass, as the case may be, which is located within that district shall be levied user fee on all toll plazas which are located within the district as the rate of 50 % of the prescribed rate of fee.

No pass shall be issued of fee collected from a driver, owner or person in charge of a mechanical vehicle that uses part of the section of a national highway and does not cross a toll plaza.

▪ Tollable components

Generally, the total traffic plying on the road will have components of certain through traffic, return traffic, discounted pass users and exempted vehicles. The share of tollable traffic will varies based on number of trips and trip distances. A non-commercial road user who is residing within not more than 20 km distance is considered to be a local user.

Certain vehicles of those who prefer monthly pass will be returning on same day. Similarly, some of through vehicles who are returning within 24 hours will take daily ticket. That means same vehicles will be crossing toll plaza more than once. But, in the volume count they will be counted separately, as many times they pass the count locations. Buses will be crossing the toll plaza many times a day. As stated above, the commercially operated vehicles registered in the same district may be availing 50 % concession on the ticket / pass they go for subjected their possession of national permit.

The numbers and frequency of trips of vehicles of various categories needed to be estimated near accurately to arrive at the toll revenue estimates. For the study, the percentages are assumed based on the O – D surveys conducted on surrounding road network.

The following revenue¹³ has been used for the purpose of financial analysis with traffic growth rate of 5%¹⁴ across all categories:

Table 7-24 : Toll Revenue Projections (in INR Crores)

Start Year	End Year	Pkg 13	Pkg 14	Pkg 15	Pkg 17
01 April 2022	31 March 2023	45.62	105.74	138.70	120.24
01 April 2023	30 March 2024	49.78	115.99	152.56	132.35
01 April 2024	31 March 2025	57.58	132.49	173.69	151.89
01 April 2025	31 March 2026	61.94	144.13	189.10	164.33
01 April 2026	31 March 2027	67.63	158.66	206.20	180.46
01 April 2027	30 March 2028	73.17	172.43	223.27	197.06
01 April 2028	31 March 2029	80.49	187.46	244.90	215.16
01 April 2029	31 March 2030	86.42	203.81	265.44	232.91
01 April 2030	31 March 2031	93.99	219.10	287.26	250.64
01 April 2031	30 March 2032	102.11	237.37	310.17	273.95
01 April 2032	31 March 2033	109.94	258.03	336.48	294.44
01 April 2033	31 March 2034	119.49	277.68	364.35	319.72
01 April 2034	31 March 2035	128.93	299.75	393.35	344.07
01 April 2035	30 March 2036	137.47	324.39	424.42	370.79
01 April 2036	31 March 2037	148.37	350.07	457.68	399.60
01 April 2037	31 March 2038	160.69	376.64	493.36	427.94
01 April 2038	31 March 2039	173.44	408.13	529.70	463.60
01 April 2039	30 March 2040	185.74	434.96	569.49	496.72
01 April 2040	31 March 2041	199.50	465.87	613.01	530.18
01 April 2041	31 March 2042	213.44	498.47	654.52	569.70
01 April 2042	31 March 2043	228.87	537.84	701.99	608.39
01 April 2043	31 March 2044	244.87	575.62	753.54	651.41
01 April 2044	31 March 2045	261.71	615.58	808.05	694.39
01 April 2045	31 March 2046	280.05	659.31	862.07	742.38
01 April 2046	31 March 2047	297.75	704.30	922.05	787.74
01 April 2047	31 March 2048	317.73	753.38	988.16	842.68
01 April 2048	31 March 2049	341.07	805.44	1054.91	900.91
01 April 2049	31 March 2050	363.98	860.01	1127.79	959.50
01 April 2050	31 March 2051	387.72	918.42	1205.89	1025.91
01 April 2051	31 March 2052	416.39	986.41	1292.51	1090.97
01 April 2052	31 March 2053	444.86	1055.80	1382.73	1166.57
01 April 2053	31 March 2054	476.19	1130.51	1480.85	1243.28

In the above table cells highlighted in blue depicts the year in which traffic capacity is getting breached, that point marks the end of concession.

7.7.9 Financial Analysis Results

This section presents the financial analysis of various scenarios which have been analysed. For the project to be financially viable, the calculated Equity IRR should be greater than the

¹³In the base case, the revenue has been worked out excluding the development/ generated traffic

¹⁴NHAI Circular No. NH 37012/09/2009-H/ Appraisal of PPP Projects – standardize the formulation and appraisal parameters

threshold Equity IRR of 15% where the equity IRR has been calculated on the basis of the free cash flow generated by the project and available to Equity shareholders (or Free Cash Flow to Equity – FCFE).

As per the national PPP Guidelines, any PPP project can get up to 40% of the Total Project Cost in the form of grant with a view to make them commercially viable. Using the financial model, we will explore the possibility of VGF, if required.

Table 7-25 : Financial Analysis BOT Summary

For Package 13

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	702.93	702.93
Total Project Cost (TPC)	839.40	827.66
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	40%
Project IRR	5.66%	5.73%
Equity IRR	3.05%	14.72%
Conclusion	Not Viable	Not Viable

For Package 14

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	1792.53	1792.53
Total Project Cost (TPC)	2132.66	2105.50
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	40%
Project IRR	5.51%	5.57%
Equity IRR	2.74%	14.31%
Conclusion	Not Viable	Not Viable

For Package 15

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	1739.80	1739.80

	Option 1A	Option 1B (VGF)
Total Project Cost (TPC)	2070.04	2060.91
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	14%
Project IRR	9.58%	9.58%
Equity IRR	10.83%	15.19%
Conclusion	Not Viable	Not Viable

For Package 17

	Option 1A	Option 1B (VGF)
Project Description	Construction of 4 lane Greenfield Expressway	Construction of 4 lane Greenfield Expressway
Pavement Type	Flexible	Flexible
Construction period (months)	30	30
Civil Cost (2022-23 Prices)	1576.94	1576.94
Total Project Cost (TPC)	1876.27	
Concession period	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25	Concession Period: FY 2023 – FY 2041 Construction- FY 23, 24, 25 1 st year of operations: FY25
VGF	0%	29%
Project IRR	3.70%	3.77%
Equity IRR	Negative	15.35%
Conclusion	Not Viable	Not Viable

From the above results obtained from financial analysis are as following

- packages 13 and 14 are not viable on BOT Toll even with 40% VGF
- packages 15 and 17 are not viable on BOT Toll mode without VGF, however with VGF of 14% & 29% the viability is achieved respectively.
- though with VGF, package 15 & 17 yield target EIRR of 15% but the PIRR could not achieve WACC (Weighted Average Cost of Capital = 8.37%).
Hence, the project is not viable on BOT Toll mode.

7.7.10 Conclusion

The consultant has carried out the financial analysis with the following two options:

1. Option 1A: Without VGF
2. Option 1B: With VGF (maximum of 40%)

Even with the maximum allowable limit of VGF, i.e 40%, the project gives an E-IRR below the target E-IRR of 15% for package 13 & 14. However, with VGF package 15 & 17 are viable but unable to achieve target WACC. Hence it would not be accepted by the private party. The project is, therefore, unviable on BOT Toll mode.

The best suited mode of procurement for this project would be EPC (Engineering Procurement and Construction) or Hybrid Annuity Model (HAM). For ease of decision for the authority, we have analysed the project packages on Hybrid Annuity Model in the next section.

7.7.11 Hybrid Annuity Model

As an additional option, project was analyzed on Hybrid Annuity Model for PPP projects. Hence, the project financials have been worked out as per the Model Concession Agreement for PPP in Hybrid Annuity Projects issued in November 2015 by Government of India.

Key Assumptions

The main assumptions made for undertaking the financial analysis are as follows:

- **Civil Cost:** The EPC/civil cost with GST of the project has been considered as given in table below:

Sl. No.	Description	Length	Civil Cost (INR Cr) (incl GST)
1	Package 13	25.8	702.93
2	Package 14	44.60	1792.53
3	Package 15	35.15	1739.53
4	Package 17	28.53	1576.94

- **Period of Analysis:** The construction period for the project has been assumed as 610 days (as per the latest circular on HAM MCA). Total concession period including construction period is considered as 16.5 years (1.5 Years Construction Period 15 Years Operation Period)
- **Project Phasing:** The development phasing for the Project has been considered is given in following table:

Table 7-26 : CAPEX Phasing

	FY 2023	FY 2024	FY 2025
Construction Phasing	40%	40%	20%

- **A Debt-Equity** ratio of 70:30 has been assumed.
- **An inflation factor** of 5% (and hence, price index multiple of $(1.05)^n$, where 'n' is number of years from appointed date, is considered. This factor is used to ascertain year on year escalation in O&M Costs*.
- **Bid variable** for the project is considered to be the **Bid Project Cost** and **O&M Cost** (for first year) as determined by various bidders at the time of bidding.
- 40% of **Bid Project Cost** as bid by the Concessionaire adjusted to price index multiple will be payable to the Concessionaire by the Authority in five equal instalments during construction period. Remaining 60% of the same will be payable over next 10 years of operation period along with applicable interest and O&M support.

- An interest component is considered to be payable to the concessionaire at the rate of Bank Rate (7.23%) plus 1.25% on outstanding balance of the Completion Cost after payment of annuity every six months till the end of concession period. Such interest amount is payable along with every biannual instalment of annuity payment as per the provisions of Model Concession Agreement.
- Operation & Maintenance Cost, Depreciation, Taxation: As assumed in the previous section

Total Project Cost (TPC) Calculation

These assumptions taken as per MORT&H Circular dated 10th August 2016. The Total Project Cost is calculated in table below:

Table 7-27 : HAM – TPC Calculation

Package 13

Total Project Cost (TPC) Calculation (INR crores)		
1	Civil Construction cost	702.93
2	Escalation	35.15
3	Contingency expenses @ 1% Total civil cost	7.0293
4	Total EPC cost (1+2+3)	745.1058
5	IDC	11.48
6	IC/Pre Operative Expenses	7.45
7	Financing Charges @1% of debt	4.09
8	Centages over EPC Cost (5+6+7)	23.03
	Estimated Project Cost (4+8)	768.13

Package 14

Total Project Cost (TPC) Calculation (INR crores)		
1	Civil Construction cost	1792.53
2	Escalation	89.63
3	Contingency expenses @ 1% Total civil cost	17.9253
4	Total EPC cost (1+2+3)	1900.082
5	IDC	28.77
6	IC/Pre Operative Expenses	19.00
7	Financing Charges @1% of debt	10.37
8	Centages over EPC Cost (5+6+7)	58.14
	Estimated Project Cost (4+8)	1958.22

Package 15

Total Project Cost (TPC) Calculation (INR crores)		
1	Civil Construction cost	1739.8
2	Escalation	86.99
3	Contingency expenses @ 1% Total civil cost	17.398
4	Total EPC cost (1+2+3)	1844.188
5	IDC	28.20
6	IC/Pre-Operative Expenses	18.44
7	Financing Charges @1% of debt	10.10
8	Centages over EPC Cost (5+6+7)	56.74
	Estimated Project Cost (4+8)	1900.93

Package 17

Total Project Cost (TPC) Calculation (INR crores)		
1	Civil Construction cost	1576.94
2	Escalation	78.85
3	Contingency expenses @ 1% Total civil cost	15.7694
4	Total EPC cost (1+2+3)	1671.556
5	IDC	24.55
6	IC/Pre Operative Expenses	16.72
7	Financing Charges @1% of debt	9.03
8	Centages over EPC Cost (5+6+7)	50.29
	Estimated Project Cost (4+8)	1721.85

The Bidding parameter consists of two parameters:

- Bid Project Cost (BPC) and
- O &M payment for the 1st year

Bids would be evaluated on the basis of the lowest assessed Bid Price (the “Bid Price”). The Bid Price shall be summation of (a) Net Present Value (NPV) of Bid Project Cost during the Concession Period and (b) NPV of O&M cost (the “O&M Cost”) during the O&M Period, required by a Bidder for implementing the Project and shall be paid as per the provisions of Article 23 of the Concession Agreement. For a project to be financially viable the Equity IRR should be a minimum of 15%.

Hybrid Annuity Model Results & Conclusion -

The best suited mode for the execution shall be HAM. To achieve a target IRR of 15%, following is the optimal combination of Bid Project Cost and First Year O&M Quote:

Table 7-28 : HAM Financial Analysis Results

Package 13

HAM Financial Analysis Results		
Bid Project Cost	1192.00	INR Cr
First year O&M Cost	4.760	INR Cr
NPV of (Bid Project Cost + First Year O&M Cost)	1150.39	INR Cr
E-IRR	15.03	%
P-IRR	11.17	%

Package 14

HAM Financial Analysis Results		
Bid Project Cost	2909.47	INR Cr
First year O&M Cost	12.000	INR Cr
NPV of (Bid Project Cost + First Year O&M Cost)	2811.41	INR Cr
E-IRR	15.00	%
P-IRR	11.18	%

Package 15

HAM Financial Analysis Results		
Bid Project Cost	2801.74	INR Cr
First year O&M Cost	11.99	INR Cr
NPV of (Bid Project Cost + First Year O&M Cost)	2711.40	INR Cr
E-IRR	15.00	%
P-IRR	11.20	%

Package 17

HAM Financial Analysis Results		
Bid Project Cost	2620.30	INR Cr
First year O&M Cost	5.000	INR Cr
NPV of (Bid Project Cost + First Year O&M Cost)	2478.50	INR Cr
E-IRR	15.31	%
P-IRR	11.30	%

**The results are obtained after carrying out simulations (varying the bid project cost and the first year O&M quote. It may be noted that any variation in the above-mentioned assumptions or the structure of the project, the results may vary significantly). The O&M Cost has been fixed so as to match the profile of O&M expenditures over the year.*

The Bidding Variables have been set as following in order to achieve the same. Simulations have been carried out in order to achieve the minimum NPV of Bid Project Cost and O&M Cost. A bidder can play with the above two parameters and still get the same NPV.

8 RECOMMENDATIONS AND WAY FORWARD

Based on the findings of this feasibility study, the following recommendations are made:

- Constructing combination of Greenfield and Brownfield Alignment between Gurudaspur to Katra section of Phase II development of Delhi Amritsar Katra Expressway).** The alignment options provided and based on best suited alignment DPR is prepared. The design is based on best alignment chosen in consultation with NHAI.
- 4 lane Highway:** The project shall be developed as a 4-lane facility in greenfield section for plain and rolling terrain, stage I with a 3m wide paved shoulder and 2m wide earthen shoulder on either side. In stage-II the road would be widened to 6 lanes. A depressed median of 12.0m shall be provided to keep provision for future widening.
- 4 lane Highway with Service Road:** The project shall be developed as a 4-lane with service road in brownfield section for mountainous terrain with a 2.5m wide paved shoulder and 2m wide earthen shoulder on either side.
- 6 lane Highway with Service Road:** The project shall be developed as a 6-lane with service road in brownfield section for plain and rolling terrain with a 3m wide paved shoulder and 2m wide earthen shoulder on either side.
- Closed tolling:** Closed tolling system shall be adopted to prohibit interruption of local traffic and slow-moving vehicles with the traffic on main carriageway.
- Interchanges:** Interchanges have been proposed at National Highways crossings, Important State Highways crossings only. Various options have been worked out to optimize the additional land acquisition and the proposals are given below:

IC No.	Design Chainage (Km)	Type of Interchange	Road Crossing
1	424+557	Trumpet	NH-54/ Start of Kathua Bypass
2	428+100	Trumpet	Pathankot Link
3	438+780	Rotary with Ramps	MDR [Kathua-Keerian Gandial road]
4	451+671	Double Trumpet	NH-44/ End of Kathua Bypass
5	465+798	Rotary with Ramps	MDR [Chak Dyala – Hiranagar Road]
6	481+150	Double Trumpet	NH-44/ Start of Sambha Bypass
7	486+993	Rotary with Ramps	Industrial Road in Sambha Bypass
8	552+260	Rotary with Ramps	NH-44 and NH-144
9	563+545	Trumpet	Katra Bus Stand Link

- Economic Analysis:** The project road is economically viable for the proposed construction of combination of Greenfield and Brownfield 4/6 lane Expressway, considering their positive values of feasibility criteria (EIRR and ENPV) both at normal scenario and at worst scenario under sensitivity analysis. In the normal scenario, the project has 15.9% and even at the worst-case scenario (i.e. Base Costs plus 15% and Base Benefits minus 15%) the EIRR is 12.6% and are found much above the required (12%) minimum level. This indicates the necessity of project road from the economy point of view and recommended for construction.

8. **Financial Analysis:** Even with the maximum allowable limit of VGF, i.e 40%, the project gives an E-IRR below the target E-IRR of 15% for package 13 & 14. However, with VGF package 15 & 17 are viable but unable to achieve target WACC. Hence it would not be accepted by the private party. The project is, therefore, unviable on BOT Toll mode. The best suited mode of procurement for this project would be EPC (Engineering Procurement and Construction) or Hybrid Annuity Model (HAM).
9. **Procurement Mode:** Based on the package wise financial analysis best suited mode of procurement for this project would be EPC (Engineering Procurement and Construction) or Hybrid Annuity Model (HAM).