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E. EXECUTIVE SUMMARY

E.1 Introduction

The Government of India has envisaged to create a world-class infrastructure facility, to boost the economic development in the country, for which National Highways Authority of India (NHAI) plays a key role. NHAI has been entrusted to implement the development of some of the stretches of National Highways under National Highway Development Programme on EPC/BOT basis. As part of this endeavor, the Public Works Department (PWD) of Government of Goa has decided for the development of "Four Laning of Existing Maharashtra/Goa Border - Goa/Karnataka Border of NH-17 from Km 475/040 to 611/000 in the state of Goa on BOT (Toll) basis under NHDP-III (Patradevi to Pollem section)".

Public Works Department (PWD) of Goa has appointed M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd., Hyderabad to provide consultancy services for detailed engineering study for the above road section.

The project stretch excludes following reaches:

1. From Km 515.000 to Km 518.000 (Mandovi Bridge Reach)
2. From Km 523.000 to Km 535.000 (Zuari Bridge Reach)
3. From Km 545.000 to Km 554.000 (Margaon Bypass Reach)
4. From Km 586.000 to Km 603.000 (Canacona Bypass reach)

E.2 Project Description

The Project Highway is a section of NH-17 between Patradevi and Pollem, passing through villages Torxem, Tamboxem, Uguem, Poroscodem, Casnem, Pernem, Virnoda, Dargalim, Colvale, Acola, Mapusa, Bastora, Guirim, Porvorim, Panaji, Santa Cruz Bambolim, Siridao, Palem, Cortalim, Nagoa, Verna, Nuvem, Fatorda, Margao, Navelim, Sirlim, Chinchinim, Panzarconi, Cuncolim, Tiloj, Canacona, Macem, Kalmath, Pollem. It connects Panvel (South of Mumbai city) to Kochi in Kerala, passing through the states of Maharashtra, Goa, Karnataka, and Kerala. The Project stretch is an important link connecting the states of Maharashtra, Goa and Karnataka starts at Patradevi Maharashtra-Goa border to Pollem, Goa-Karnataka border with length of 135.96 km. It has a great potential of growth in the passenger as well as freight

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movement in future due to tourism, agriculture and industrial growth in the project influence area. From Km 475.040 to Km 545.000, the right of way ranges from 8 m to 45m, from Km 555.000 to 585.000 the ROW ranges from 8m to 10m and Km 603.000 to Km 611.000 it is 10m to 30m. From Km 570.000 to Km 585.000 the alignment passes through Ghat Section. The entire alignment passes through hilly and rolling terrain except few reaches in plain terrain.

E.3 Alignment Option Study

Reconnaissance, map studies and detailed investigations of the influence area were carried out for identifying the existing road network, land use pattern and industrial activities along the project corridor. Different alignment options are considered, evaluated and recommendations are presented in the subsequent sections. The improvement scheme of the options are mentioned below.

The Project road has inconsistent terrain conditions with a mix of hilly, highly rolling and plain topography. The following standards have been followed for improving the horizontal geometry. For the purpose of horizontal design, the project road is divided in to following sections

Section I: From Km 475.040 to Km 514.800 (Rolling/Plain terrain).

The Project Highway starts with a mix of rolling/plain terrain from Km 475+040 at Goa/Maharashtra border. Existing alignment has substandard horizontal geometry. The existing speed on the highway is about 50 to 60 kmph. Minor realignments proposed to meet the minimum design speed of 80KMPH at following locations.

1. From Km 477.500 to Km 478.000
2. From Km 485.000 to Km 490.000

The existing alignment in Naibag location has substandard horizontal & vertical curves in particularly from Km 486.500 to Km 490.500. For this stretch a realignment with a 1.10 km length of tunnel proposed to improve the geometry. A comparative study with existing alignment is presented below and alternatives plan is enclosed as

Appendix-A.

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Description	Alternative-I: Existing Alignment	Alternative-II: Realignment with Tunnel
Stability issues	It would not be possible to cut hill to the required slope since that would disturb the railway tunnel below the existing road at Km 488.200.	This realignment would involve insignificant disturbance to the railway tunnel as the highway tunnel is about 1.5 km away from that.
Structures involved	Breast Walls, Soil Nails etc. may be required for ensuring slope.	Earth retaining structures and Tunnel
Environmental issues	<p>This option would involve disturbing of hill as the complete widening on hill side and the entire land will be occupied.</p> <p>In this option revegetation of green cover will not be possible as additional 2 lanes will land on hills.</p>	This option would involve insignificant disturbance to environment and green cover.
Geometric alignment	Will follow the existing alignment; Substandard horizontal and vertical curves will remain.	Sub-standard horizontal and vertical curves will be improved.
Construction time	Less compared to other option	Tunnel formation will be time consuming.
Construction cost	Less	More
Design Speed	50 to 60 kmph	100 kmph
Recommendation	Not Recommended	Recommended

Apart from the above stretches the proposed alignment following the existing alignment with minor curve improvements.

Section II: From Km 514.800 to Km 518.400 – Mandovi Bridge

Four Lane bridge construction is under progress on the River Mandovi from Km 514.800 to Km 518.400.

Section III: From Km 518.400 to Km 523.500 - Bambolim

The project highway passes through plain to rolling terrain in the urban area of Panaji. Vehicular Overpass is proposed in this project stretch.

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Section IV: From Km 523.500 to Km 535.500 – Zuari Bridge

The Project stretch constitutes a major bridge Zuari which is in the initial stage of construction taken up by the Public works department.

Section V: From Km 535.500 to Km 545.000

The Project stretch passes through Verna Industrial area. The Proposed alignment follows the existing alignment with minor curve improvements within the available ROW. Elevated Corridor is proposed in this location to segregate the Airport traffic and Verna Industrial Estate traffic plying on NH-17B.

Section VI: From Km 545.000 to Km 555.000

The Project stretch constitutes Margao bypass which is under construction taken up by Public works department to bypass the heavily congested Margao City traffic.

Section VII: From Km 555.000 to Km 587.000

In this stretch the project highway passing through the congested villages namely Chinchinim, Panzorconi, Cuncolim and Bali from Km 557.800 to Km 567.700. Thereafter it passing through the dense forest area of Kharmal Ghat from Km 572.000 to Km 582.000.

The consultants have proposed 4 alternatives to bypass for the above 4 villages and recommended Alternative-IV. The merits and demerits of the above 4 alternatives are presented below and alternatives plan is enclosed as **Appendix-B**.

Description	Alternative-I	Alternative-II	Alternative-III	Alternative-IV
Length	9.810 km	10.485 km	10.960 km	11.000 km
Alignment	Existing alignment passing through urban area	Passing through open lands except few locations where habitation exists.	Entire alignment passing through open lands	Entire alignment passing through open lands

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Geometrics	Poor geometrics, since it is passing through urban areas. Many standard curves and scope for improvement within available ROW.	Since it is new alignment, it will have well defined geometrics complying with IRC SP 84-2014 other than at start point.	Since it is new alignment, it will have well defined geometrics complying with IRC SP 84-2014 other than at start point.	Since it is new alignment, it will have well defined geometrics complying with IRC SP 84-2014
Design speed	20 to 50kmph	100kmph	100kmph	100kmph
Congestion/ interference of local traffic	Though traffic will experience, congestion due to existence of local traffic movement	No or minimum interference of local traffic and future development will be planned way.	No or minimum interference of local traffic and future development will be planned way.	No or minimum interference of local traffic and future development will be planned way
Future widening	Difficult to for any future widening	Adequate ROW will be acquired so that it easy to widen the highway in future if required	Adequate ROW will be acquired so that it easy to widen the highway in future if required	Adequate ROW will be acquired so that it easy to widen the highway in future if required
Additional land required	Less than the Alt-II and Alt - III	Less than Alt-III but more than Alt-I	More than Alt-II and Alt-I	More than all alternatives.
Recommendation	Not Recommended	Not Recommended	Not Recommended	Recommended

The existing alignment in Kharmal Ghat stretch has substandard horizontal & vertical curves in particularly from Km 579 to Km 582. For this stretch a realignment with a 1.45 km length of tunnel proposed to improve the geometry. A comparative study with existing alignment is presented below and alternatives plan is enclosed as **Appendix-C.**

Description	Alternative-I: Existing Alignment	Alternative-II: Realignment with Tunnel
Traffic Management	Road closure during blasting and removal of debris operations	Road closure while forming ramps on the valley side

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Stability issues	It would not be possible to cut hill to the required slope since that would disturb road on the hill side. Thus, adequate slope stabilizing structures are to be provided to prevent landslides.	Construction of viaduct and Tunnel may not involve any stability related concerns.
Structures involved	Breast Walls, Soil Nails etc. may be required for ensuring slope.	Viaduct structure ; earth retaining structures and Tunnel
Environmental issues	This option would involve disturbing of hill slopes in the forest.	This option would involve insignificant disturbance to environment during construction time.
Extra Forest Land to be acquired	<p style="text-align: center;">11.7 hectares.</p> This option would involve disturbing of hill as the complete widening on hill side and the entire land will be occupied. In this option revegetation of forest cover will not be possible as additional 2 lanes will land on hills.	<p style="text-align: center;">13.5 hectares.</p> After the construction the vegetation of forest cover will be reinstated over the tunnel of length 1.45 km.
Geometric alignment	Will follow the existing alignment; Substandard curves will remain.	Sharp sub-standard curves will be improved.
Construction time	Less compared to other two options	Tunnel formation will be time consuming.
Design Speed	30 to 40 kmph	100 kmph
Recommendation	Not Recommended	Recommended

There are some minor realignments has been proposed to improve the geometry or make use of existing 4 Lane RUBs at following locations.

1. From Km 569.200 to Km 570.600: existing 4 lane RUB in skew.
2. From Km 573.700 to Km 574.000: Substandard existing curves.
3. From Km 574.300 to Km 574.700: Substandard existing curve.
4. From Km 575.500 to Km 576.000: Substandard existing curves.
5. From Km 577.100 to Km 578.100: Substandard existing curves.
6. From Km 578.600 to Km 579.000: Substandard existing curves.

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7. From Km 582.200 to Km 583.700: Substandard existing curves.

Section VIII: From Km 587.000 to Km 603.000

The Project Stretch from Km 587.000 to Km 603.000 is awarded and is under construction.

Section IX: From Km 603.000 to Km 611.000

In this stretch the project highway passes through rolling terrain. The consultants have proposed realignment from Km 606.100 to Km 607.000 to improve the existing horizontal curves.

E.4 Surveys and Investigations

The studies and investigations carried out during the feasibility study comprised mainly of the following:

- Detailed Inventory & Condition Surveys for Road
- Detailed Inventory & Condition Survey for Bridges
- Topographic Surveys along the existing alignment
- Traffic surveys viz., Classified Traffic Volume Count, Turning Movement Count, Axle Load, Origin Destination and Commodity Movement, Willingness to Pay etc., including collection of secondary data for traffic projections
- Investigations of the existing pavement and sub grade involving BBD test
- Collection and laboratory testing of soil samples from pits adjacent to the existing road
- Identification of borrow areas for different types of pavement and bridge construction material, collection of samples and their analysis
- Environmental baseline studies
- Public Consultations

E.5 Existing Condition of Road & Bridges

E.5.1 Inventory & Condition surveys for Existing Road

The existing NH-17 is having two lane and four lane configuration. Carriageway width was measured at every 100m interval. Width of shoulders on either side was measured separately along with carriageway measurements. The overall condition of pavement is good and is of flexible type. The existing two lane carriageway width is 7.0m with earthen shoulders of about 0.3 to 2.0m width on either side and paved

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shoulder exists of around 0.4 to 5.0m width on either side and at few parts of the stretch are existing with 4 lane road also.

S. No.	Existing Chainage (Km)		Length (m)	Lane Configuration	Condition of the Road
	From	To			
1	475.000	489.100	14100	2 lane carriageway	Good
2	489.100	490.100	1000	4 lane carriageway	Good
3	490.100	507.100	17000	2 lane carriageway	Good
4	507.100	510.800	3700	4 lane carriageway	Good
5	510.800	513.000	2100	2 lane carriageway	Good
6	513.000	515.000	2000	4 lane carriageway	Good
7	515.000	521.500	6500	2 lane carriageway	Good
8	521.500	522.800	1300	4 lane carriageway	Good
9	535.000	537.000	2000	2 lane carriageway	Good
10	537.000	538.400	1400	4 lane carriageway	Good
11	538.400	542.800	4400	2 lane carriageway	Good
12	555.000	557.200	2200	2 lane carriageway	Good
13	570.000	585.000	15000	2 lane carriageway	Good
14	603.000	611.000	8000	2 lane carriageway	Good

E.5.2 Inventory & Condition surveys for Bridges

The detailed inventory and condition survey of structures are discussed in Volume-II Investigation Report. Total numbers of Structures on the Site are noted below:

- a) Total number of Major Bridges - 1no
- b) Total number of
 - ROBs - 1nos.
 - RUBs - 3nos.
- c) Total number of Minor Bridges - 18nos.
- d) Total number of Slab/Box Culverts - 88nos.
- e) Total number of Pipe Culverts - 235nos.
- f) Total number of Grade Separators - Nil
- g) Total number of Vehicular and Non Vehicular Underpasses - 1 (2 Lane)

E.6 Traffic Studies

Based on reconnaissance studies, the locations for conducting various traffic surveys were finalized. The traffic surveys viz., Classified Traffic Volume Count, Turning

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Movement Count, Axle Load, Origin Destination and Commodity Movement, Willingness to Pay, etc., including collection of secondary data for traffic projections were carried out in the month of June in 2015. Secondary data was collected for the purpose of determining the Seasonal Variation Factors and Growth Rates at various count stations for different vehicle categories.

E.6.1 Average Annual Daily Traffic (AADT)

The Annual Average Daily Traffic (AADT in no of vehicles) at the survey locations is obtained by multiplying the Average Daily Traffic (ADT) with the seasonal correction factor. The AADT of vehicles for the year 2015 at eight survey locations of traffic volume count survey along the Project corridor is presented below.

Table E.2: Average Annual Daily Traffic

Mode	Km 493.0	Km 511.0	Km 522.0	Km 537.0	Km 544.0	Km 556.0	Km 588.0	Km 610.0	
Two Wheelers	6132	17062	12232	9385	11411	10243	5777	3390	
Three Wheelers	12	154	68	37	54	108	196	4	
Car / Jeep / Van	5231	16337	14586	10892	13092	9386	4754	2166	
Car Yellow board	176	2026	4647	2169	2026	527	808	148	
Tata Magic	19	9	3	59	2	4	54	11	
RTC Bus	155	474	767	461	595	189	257	91	
Private Bus	237	655	330	406	455	487	402	45	
School/College bus	3	15	8	9	7	14	25	9	
Mini Bus	80	148	272	270	171	109	146	18	
2 Axle	706	738	110	143	1660	310	255	146	
3 Axle	149	293	29	21	488	171	179	82	
M Axle	197	186	2	5	318	66	150	83	
HEM	15	72	7	5	21	13	56	2	
LCV/LGV	787	1539	711	931	1451	543	486	127	
Mini LCV	466	1803	1605	1591	2069	750	621	140	
Three Wheeler goods	2	42	39	18	23	46	64	7	
Tractor	5	2	6	0	2	5	6	1	
Tractor with trailer	2	12	5	5	0	1	1	0	
Non-Motorized Vehicles	7	20	11	31	19	56	56	25	
Govt. Exempted Vehicles	28	193	147	55	47	42	52	8	
Tollable Traffic (vehicles)	8220	24294	23079	16960	22355	12567	8192	3069	
Tollable Traffic (PCU's)	11894	30389	26091	19672	30761	15510	11463	4187	
Total Vehicles	Motorized	14400	41758	35575	26459	33892	23012	14288	6479
	Non-Motorized	7	20	11	31	19	56	56	25
	Total Traffic	14407	41778	35586	26490	33911	23068	14344	6504
Total PCUs	Motorized	15024	39439	32573	24522	36615	20853	14687	5905
	Non-Motorized	26	20	8	25	10	44	30	12
	Total Traffic	15050	39459	32581	24547	36625	20897	14717	5917

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E.6.2 Zuari Bridge Traffic (Heavy Vehicle Traffic)

Zuari Bridge, the main connecting link between North & South Goa is closed for heavy vehicular traffic (above 12 tonnes) since 1997 as it was found structurally not sound to cater to heavy traffic loads prevailing.

As per above context, the Consultants presumed that once Zuari bridge construction gets completed and is thrown open to traffic, the truck traffic which is currently plying on alternative routes is expected to use this bridge again. Considering this, Consultants have collected traffic census data when Zuari Bridge was open to heavy vehicular traffic and the same has been projected to 2015 the base year, with a growth rate of 5% per annum.

Table E.3: Heavy Vehicle Traffic along Project Stretch when Zuari Bridge is under Operation

S. No.	Vehicles	Traffic when Zuari bridge is under operation	Regular Traffic (Actual)	Total Traffic
Km 493, Malpem				
1	Trucks (2 or 3 AT)	1282	857	2139
2	Multi Axle Trucks	314	212	526
3	Total	1596	1069	2665
Km 511, Porvorim				
1	Trucks (2 or 3 AT)	1403	1042	2445
2	Multi Axle Trucks	371	258	629
3	Total	1774	1300	3074
Km 537, Cortalim				
1	Trucks (2 or 3 AT)	1289	174	1463
2	Multi Axle Trucks	171	10	181
3	Total	1460	184	1644
Km 556, Navelim/Dharmapur				
1	Trucks (2 or 3 AT)	554	482	1036
2	Multi Axle Trucks	611	79	690
3	Total	1164	561	1725

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S. No.	Vehicles	Traffic when Zuari bridge is under operation	Regular Traffic (Actual)	Total Traffic
Km 588, Canacona				
1	Trucks (2 or 3 AT)	560	437	997
2	Multi Axle Trucks	259	206	465
3	Total	818	643	1461

E.6.3 Vehicle Damage Factors (VDF)

The VDF calculated for different categories of commercial vehicles are shown below and the detailed analysis is presented in Traffic Report.

Table E.4: Vehicle Damage Factor (VDF)

S. No.	Mode	Km 475.000			Km 610.000		
		To Panaji	To Patradevi	Adopted	To Karwar	To Canacona	Adopted
1	2 Axle	3.37	1.02	3.37	2.40	3.78	3.78
2	3 Axle	3.74	3.91	3.91	3.53	4.53	4.53
3	M axle	6.28	4.92	6.28	4.58	5.19	5.19
4	LCV	2.41	1.14	2.41	0.33	0.74	0.74

E.6.4 Traffic Growth Rates (%)

Traffic growth rates are an important parameter for projecting the traffic for the design life of pavement. The projected traffic, in turn, will form the basis for capacity assessment, pavement design, and financial viability analysis.

Table E.5: Traffic Growth Rates (%)

S. No.	Period	2 Wheeler	3 Wheeler	Cars/Jeeps	Buses	Trucks			
						2 Axle	3 Axle	M Axle	LCV and Mini LCV
1	Up to 2016	7.0	5.0	10.0	8.0	5.0	5.0	5.0	5.0
2	2017 -2021	6.5	5.0	9.5	7.5	5.0	5.0	5.0	5.0
3	2022 – 2026	6.0	5.0	9.0	7.0	5.0	5.0	5.0	5.0
4	2027 – 2031	5.5	5.0	8.5	6.5	5.0	5.0	5.0	5.0
5	Beyond 2031	5.0	5.0	8.0	6.0	5.0	5.0	5.0	5.0

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E.6.5 Capacity of the Highway

The project road has been divided into homogeneous road sections on the basis of traffic generation and dispersal nodes located along the project road. Considering the above mentioned traffic generation/ distribution points, total project road are divided into three homogeneous road sections for the purpose of analysis and presentation of traffic and travel characteristics.

Table E.6: Traffic Homogeneous sections (HS)

S.No.	Sections	HS	From (Km)	To (Km)	Length (Km)	Remarks
1	NH-17: From Patradevi to Pollem	HS-1	475.040	503.250	28.210	SH-1 to Bicholim
2		HS-2	503.250	517.500	14.250	NH-4A, Old Goa-Belgaum Road
3		HS-3	517.500	533.400	15.900	NH-17A to Vasco
4		HS-4	533.400	537.500	4.100	NH-17B to Vasco
5		HS-5	537.500	546.850	9.350	Arlem Bypass, SH-5 to Borim & Ponda
6		HS-6	546.850	563.500	16.650	Cuncolim
7		HS-7	563.500	592.300	28.800	Canacona, MDR-50
8		HS-8	592.300	611.000	18.700	End of Project Stretch

The Highway Capacity Manual has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating conditions and traffic volumes. It is defined as a qualitative measure describing the operational conditions with in a traffic stream and their perception by motorists. The level of service for urban and suburban roads can be related to the flow conditions, average overall travel speed, load factor at intersections, peak hour factor and service volume to capacity ratio. National and State Highways in rural areas are normally designed for LOS B giving a design service volume of 40000 PCUs per day for 4 lane divided carriageway and 57000 PCUs per day for 6 lane divided carriageway based on level of service criteria with a V/C ratio less than 0.5. If we go for V/C ratio criteria, we can go up to LOS C with V/C ratio of less than 0.7. The LOS and capacity analysis for the proposed project stretch is presented.

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Table E.7: Capacity analysis with Total Traffic

S. No.	HS	Chainage		Present Traffic		Year Attaining 15,000 PCU's (Capacity of 2 lane With LOS B)		Year Attaining 40,000 PCU's (Capacity of 4 lane With LOS B)	
		From Km	To Km.	PCUs	Year	PCUs	Year	PCUs	Year
1	HS-1	475.040	503.250	20316	2015	-	-	38713	2025
2	HS-2	503.250	517.500	45298	2015	-	-	45298	2015
3	HS-3	517.500	533.400	38817	2015	-	-	38817	2015
4	HS-4	533.400	537.500	29169	2015	-	-	39192	2019
5	HS-5	537.500	546.850	36522	2015	-	-	39323	2016
6	HS-6	546.850	563.500	25263	2015	-	-	38855	2021
7	HS-7	563.500	592.300	17501	2015	-	-	39551	2027
8	HS-8	592.300	611.000	8754	2015	15669	2024	39379	2039

By considering 75% of cars, 2W, 3W, Tractors and Slow moving vehicles on service roads from Km 503.250 to Km 546.850 (Urban portion from Karaswada Junction to Arlem Bypass) where 4 lane with service roads are proposed and the 6 lane requirement shall be after year 2030.

E.7 Pavement Design

E.7.1 Introduction

The Preliminary Pavement design is done for both flexible and rigid options. The flexible pavement is designed as per IRC: 37-2012. The rigid pavement is designed using IRC and CMA methods. The Sub grade CBR for the new carriage way is considered 10%. Sub grade thickness of 500 mm is considered for both flexible and rigid pavement options.

E.7.2 Million Standard Axles (MSA)

Design traffic in terms of Million Standard Axles has been determined at 8 locations based on traffic homogeneous sections, where volume count and axle load surveys were conducted.

Table E.8: Million Standard Axles (MSA)

S.No.	Homogeneous Sections	From (Km)	To (Km)	Length (Km)	5 Years MSA	10 Years MSA	15 Years MSA	20 Years MSA
1	HS-1	475.040	503.250	28.210	13	30	50	76

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S.No.	Homogeneous Sections	From (Km)	To (Km)	Length (Km)	5 Years MSA	10 Years MSA	15 Years MSA	20 Years MSA
2	HS-2	503.250	517.500	14.250	18	40	70	105
3	HS-3	517.500	533.400	15.900	12	26	45	70
4	HS-4	533.400	537.500	4.100	10	23	40	60
5	HS-5	537.500	546.850	9.350	16	35	60	95
6	HS-6	546.850	563.500	16.650	10	20	35	55
7	HS-7	563.500	592.300	28.800	10	20	30	46
8	HS-8	592.300	611.000	18.700	6	12	20	31

E.7.3 Flexible Pavement

For the design traffic estimated for a life of 15 years and a sub grade CBR of 10%, the pavement composition with granular base & sub-base option as follows:

Table E.9: Pavement Composition details for Main Carriageway

HS	Reach		Eff. CBR (%)	Design Life in Years	MSA	Bitumen Grade	Crust Composition in mm				
	From	To					BC	DBM	WMM	GSB	Total
HS-1	475.04	503.25	10%	15 Y	50	VG-40	40	95	250	200	585
HS-2	503.25	517.50	10%	15 Y	70	VG-40	40	105	250	200	595
HS-3	517.50	537.50	10%	15 Y	45	VG-40	40	95	250	200	585
HS-4	537.50	546.85	10%	15 Y	60	VG-40	40	100	250	200	590
HS-5	546.85	592.30	10%	15 Y	35	VG-40	40	95	250	200	585
HS-6	592.30	611.00	10%	15 Y	20	VG-30	40	80	250	200	570

E.7.4 Rigid Pavement

For the design traffic estimated for a life of 30 years and a sub grade CBR of 10%, the pavement composition with granular base & DLC is as follows:

Table E.10: Rigid Pavement Design with Tied Concrete Shoulders

S.No.	Item	Km 475 to Km 592.3	Km 592.3 to Km 611.0
1	PQC of M40 grade, mm	270	250
2	DLC of M10 grade, mm	150	150
3	GSB, mm	150	150
4	Dia. of Dowel bar, mm	36	32

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S.No.	Item	Km 475 to Km 592.3	Km 592.3 to Km 611.0
5	Length of Dowel bar, mm	450	450
6	Spacing of Dowel bar, mm	300	300
7	Dia. of Tie bar, mm (Plain bars)	12	12
8	Length of tie bar, mm	580	580
9	Spacing of tie bar, mm	415	445

E.7.5 Recommended Pavement Option

Based on the life cycle cost analysis, Net Present Value (NPV) of rigid pavement is less than the flexible pavement. The life cycle cost for 30 years' period analysed for flexible pavement comes to Rs. 746.84 crores. Whereas for rigid pavement the cost comes to Rs. 718.64 crores.

As per **MoRTH** circular no. RW/NH-33044/53/2013-S&R(R) Pt. dated 20th November, 2013 (Appendix IIA) has advocated the use of environment friendly construction practices for reduction of greenhouse gases and had also in-ter-alia specified the life cycle cost analysis as an essential component of infrastructure design.

“Considering the issue related to longer service life, fuel consumption, resistance to extreme weather condition, saving of natural resources and maintenance etc. the obvious advantages of rigid pavement cannot be denied.”

MoRTH circular no. RW/NH-33044/31/2014-S&R(R) Pt. dated 04th August, 2014 states that “The price of cement vis-à-vis bitumen varies widely in different parts of the country depending upon the lead from the production centers/refineries etc. This variation would be required to be mapped out and unless there is price comparison within an acceptable limit up to 20%, the use of flexible pavements may perhaps require to be continued.” It means that rigid pavement could be considered when the cost of construction with rigid pavement doesn't exceed that of flexible pavement by more than 20%.

By considering the life cycle cost analysis, heavy load traffic and as mentioned in Ministry circulars it is recommended to construct Rigid pavement for the entire stretch.

E.7.6 Crust Composition for Service Roads

Design of pavement for service road has been carried out in accordance with clause 5.5.5 of IRC: SP:84-2014 for a design traffic 10 msa and CBR of 10%.

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Table E.11: Pavement Composition for Service Roads

HS	Eff. CBR	MSA	Bitumen Grade	Crust Composition in mm				
				BC	DBM	WMM	GSB	Total
Service Roads	10%	10	VG-30	40	50	250	200	540

E.7.7 Design of Shoulders

Paved Shoulder: The shoulder would be useable during all seasons of the year and hence as per Clause 5.10 of IRC:SP:84-2014, the crust composition and specification of paved shoulder shall be same as of the main carriageway.

Earthen Shoulder: Earthen shoulder shall be covered with 150 mm thick layer of granular material confirming to the requirements given in Clause 401 of MORTH specifications.

E.7.8 Crust Composition for Bus bays

Bus bays have been designed for 10 MSA and shall be of a flexible pavement. The crust composition for the bus bay is same as service road crust and given in table above.

E.7.9 Crust Composition for Truck Lay Bys

Pavement Design for Truck Lay byes shall be same as that for main carriageway in the relevant sections.

E.8 Highway Improvement Proposals

E.8.1 General

Primarily, the scope of the project is '4laning' of the existing 2-lane carriageway. The project corridor is to be designed as a 'partially access controlled highway' by providing service roads, grade separated intersections, acceleration and deceleration lanes, vehicular and pedestrian underpasses / overpasses etc. with an objective to segregate the local traffic from the through traffic.

The various upgrades required for enhancing the project road to 4 lane configuration as per the guidelines given in the Four laning manual (IRC-SP:84-2014) are brought out. In congested locations, various alternative upgrade options such as bypasses or elevated highway have been considered before recommending the feasible option.

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E.8.2 Typical Cross Sections

It is proposed to widen the existing 2-Lane carriageway to 4-lane carriageway with two lane service road on either side of the project highway where ever required. The existing right of way varies from 8 m to 65 m for the project stretch. Typical Cross Sections (TCS) have been developed duly considering various aspects. From Km 572.000 to Km 585.000 the alignment passes through Karmal Ghat Section where right of way ranges from 7 m to 10 m and acquiring the land will be difficult as it comes under Reserve Forest/Wild Life Sanctuary. The entire alignment passes through hilly and rolling terrain except few reaches in plain terrain. Description of each type of cross section is listed in the Table shown below.

Table E.12: Typical Cross Section (TCS)

TCS type	Description
I	4 Lane Cross section-Concentric widening-4m median-45m PROW
II	4 Lane Cross section-Symmetrical widening-1.5m median-Service roads on both sides-45m PROW
III	4 Lane Cross section-Eccentric Widening (LHS)-4.0m median-45m PROW
IV	4 Lane Cross section-Eccentric Widening (RHS)-4.0m median-45m PROW
V	4 Lane Cross section-Realignment/Bypass-4.0m median-45m PROW
VI-a	6 Lane Cross section-Approaches to PUP/ LVUP/VUP/Flyover -0.6m median-Slip roads(7.0m) on both sides-45m PROW in Existing Alignment
VI-b	6 Lane Cross section-Approaches to PUP/ LVUP/VUP/Flyover -0.6m median-Slip roads(7.0m) on both sides-45m PROW in Bypass
VII	6 Lane Cross section-Approaches to VOP-1.5m median-Slip roads(7.0m) on both sides-60m PROW
VIII	4 Lane Cross section for Mountainous terrain in cut and fill sections-1.5m median-30m PROW
IX	4 Lane Cross section for Mountainous terrain in cut section(both sides)-1.5m median-30/45m PROW
X	4/6 Lane Cross section with Elevated Corridor in Urban Area-30m PROW
XI	6 Lane Twin Tunnel Cross Section in Ghat Section-65m PROW

E.8.3 Service Roads/Slip Roads

As per clause 2.1.ii (a) of four lane manual (IRC: SP-84-2014), service roads shall be provided on both sides of the main highway in built-up areas and interconnected through underpasses, overpasses and grade separators. However, keeping the project viability in view, service roads have been proposed at built-up locations and major villages along the project corridor on both sides of the 4 lane carriageway depending on the nature and extent of village/town development. Service roads are

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designed to carry two-way traffic with turning areas where required and are linked to the main carriageway by one-way deceleration and acceleration lanes with 'taper-merge' arrangements. Service roads are generally kept at existing ground level to serve the adjacent properties, whereas the main carriageway is constructed as per the requirements of design vertical profile of highway. Service roads are proposed in the following locations as shown in Table below.

Table E.13: Service Roads/Slip Roads

S. No.	Ex. Chainage (km)		De. Chainage (km)			Slip/Service Road	Remarks
	From	To	From	To	Length		
1	475.000	475.800	475.000	475.800	0.800	Slip Road	VUP (to Patradevi)
2	479.900	480.510	480.100	480.710	0.610	Slip Road	VUP (to Mopa village and Tambosa village)
3	481.000	481.700	481.300	482.000	0.700	Slip Road	LVUP (Uguem village & Temple)
4	483.850	484.910	484.200	485.260	1.060	Slip Road	Road to MH border(Naibag junction)
5	489.824	490.494	487.190	487.860	0.670	Slip Road	VUP Pernem
6	490.494	491.934	487.860	489.300	1.440	Slip Road	LVUP – Govt. College
7	494.036	494.816	491.380	492.160	0.780	Slip Road	Elevated Corridor(Road to Mopa New Airport)
8	495.420	495.950	492.720	493.250	0.530	Slip Road	PUP (School)
9	495.950	496.900	493.250	494.200	0.950	Slip Road	VUP (Road to Industrial Area, Tuem village)
10	498.535	499.085	495.790	496.340	0.550	Slip Road	LVUP (Colvale-Chicali)
11	499.085	499.915	496.340	497.170	0.830	Slip Road	2 Lane PUP
12	499.915	500.585	497.170	497.840	0.670	Slip Road	FO/Viaduct (GOAIDC, Binani Fibre Glass Factory)
13	500.585	502.245	497.840	499.500	1.660	Slip & Service Road	VUP (Road to Central Jail)
14	502.245	504.595	499.500	501.850	2.350	Slip Road	EC(Karaswada Jn. (SH-1 to Bicholim Sports Complex)
15	504.595	506.315	501.850	503.570	1.720	Slip Road	VUP (Bastora-Mapusa)
16	506.315	509.465	503.570	506.720	3.150	Slip Road	EC to Mapusa and Guirim
17	509.465	514.920	506.720	512.120	5.400	Service Road	EC (Urban Porvorim)
18	518.400	520.250	518.400	520.250	1.850	Service Road	VUP (Road to Mercedes)
19	520.250	520.970	520.250	520.970	0.720	Slip Road	VUP (Road to Durgawadi)

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S. No.	Ex. Chainage (km)		De. Chainage (km)			Slip/Service Road	Remarks
	From	To	From	To	Length		
20	520.970	522.800	520.970	522.840	1.870	Slip Road	VOP (Road to Donapaula on RHS)
21	535.600	538.660	535.600	538.660	3.060	Service Road	EC (NH-17B, Vasco Road & NH-17B Ponda missing link)
22	538.660	542.800	538.660	542.840	4.180	Service Road	EC (Cansaulim Junction, Verna Rly. Station road)
23	554.801	555.131	554.900	555.230	0.330	Service Road	End of Margao Bypass
24	555.760	556.580	555.900	556.720	0.820	Slip Road	VUP (Dramapur)
25	556.580	557.536	556.720	557.700	0.980	Slip Road	Start of Cuncolim Bypass
26	558.736	559.686	558.900	559.850	0.950	Slip Road	VUP (Chinchinim)
27	564.236	564.836	564.400	565.000	0.600	Slip Road	VUP (Quepem)
28	567.446	567.806	567.610	568.200	0.590	Slip Road	VUP (Bali)
29	567.284	567.834	568.200	568.750	0.550	Slip Road	Cuncolim bypass end
30	603.640	604.490	603.600	604.450	0.850	Slip Road	LVUP (Mashem)
31	607.350	608.100	606.950	607.700	0.750	Slip Road	LVUP (Lollem)

E.8.4 Underpass/Overpass/Elevated Corridors

In order to avoid conflict of traffic on project road with the traffic on cross roads, Vehicular underpasses (VUPs) or Vehicular Overpass (VOPs) or Elevated Corridors are proposed at the intersections of major cross roads with the project highway. It is proposed to provide 15 no's of VUPs, 5 no's of LVUPs, 3 no's of PUP/CUPs, 1 no's VOPs, 1 Fly Over and 6 no's Elevated Corridors along the project highway at the following locations as given in below.

Table E.14: Vehicular Underpasses (VUP)

S. No.	Existing Chainage (Km)	Design Chainage (Km)	Span / Opening (m)	Underpass	Remarks
1	475.400	475.400	1 x 20.0 x 5.5	VUP	To Patradevi
2	480.829	480.520	1 x 20.0 x 5.5	VUP	To Mopa - Tambovem
3	481.800	481.600	1 x 10.5 x 4.5	LVUP	To Uguem
4	486.100	484.590	1 x 20.0 x 5.5	VUP	To Shiroda
5	490.200	487.557	1 x 20.0 x 5.5	VUP	To Pernem

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S. No.	Existing Chainage (Km)	Design Chainage (Km)	Span / Opening (m)	Underpass	Remarks
6	491.600	488.952	1 x 10.5 x 4.5	LVUP	To Govt. College
7	495.500	492.860	1 x 7.0 x 3.0	PUP	To School
8	496.400	493.656	1 x 20.0 x 5.5	VUP	To Industrial Area
9	497.800	495.083	1 x 7.0 x 3.0	CUP	Access for Cultivation
10	498.850	496.115	1 x 10.5 x 4.5	LVUP	To Colvale - Colvale
11	499.450	496.670	1 x 7.0 x 3.0	PUP	Existing 2 Lane PUP
12	501.850	499.108	1 x 40.0 x 5.5	VUP	To Central Jail
13	505.900	503.133	1 x 20.0 x 5.5	VUP	To Bastora - Mapusa
14	519.800	519.813	1 x 20.0 x 5.5	VUP	To Mercedes
15	520.600	520.610	1 x 20.0 x 5.5	VUP	To Durgawadi
16	556.200	556.280	1 x 20.0 x 5.5	VUP	To Dramapur
17	557.261	557.400	1 x 20.0 x 5.5	VUP	Cuncolim Bypass Start
18	-	559.350	1 x 20.0 x 5.5	VUP	To Chinchinim
19	-	564.660	1 x 20.0 x 5.5	VUP	To Quepem
20	-	567.800	1 x 20.0 x 5.5	VUP	To Bali
21	567.556	568.450	1 x 20.0 x 5.5	VUP	Cuncolim Bypass End
22	604.000	603.980	1 x 10.50 x 4.5	LVUP	Mashem
23	607.651	607.250	1 x 10.50 x 4.5	LVUP	Pollem

Table E.15 (a): Vehicular Overpasses (VOP)

Sl. No.	Existing Chainage (Km)	Design Chainage (Km)	Span / Opening (m)	Remarks
1	521.900	521.770	1 x 30.00 x 5.5	To Donapaula – MDR 3

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Table E.15 (b): Fly Over

Sl. No.	Existing Chainage (Km)	Design Chainage (Km)	Span / Opening (m)	Remarks
1	500.048	497.300	15 + 30 + 15	Binani – GOA IDC

Table E.16: Elevated Corridors

S. No.	Location	Elevated Corridors (Design Chainages) (km)			Proposed Span Arrangement	Total width of Structure
		From	To	Length		
1	Mopa Airport	491.610	491.915	305	30+50+40+65+40+50+30	29
2	Karaswada Jn	500.140	501.595	1455	30+5x50+40+65+40+20x50+30	29
3	Mapusa City	504.897	506.297	1400	30+2x50+40+65+40+15x50+40+65+40+4x50+30	29
4	Porvorim	507.851	511.551	3700	30+47x50+40+65+40+13x50+40+65+40+7x50+30	29
5	Airport Link	537.540	538.390	850	30+50+40+65+40+8x50+40+65+40+50+30	29
6	Verna	539.297	540.897	1600	30+12x50+40+65+40+12x50+40+65+40+50+30	29

E.8.5 Tunnel

The existing alignment in Kharmal ghat stretch has sub-standard horizontal & vertical curves in particularly from Km 579 to Km 582. For this stretch a realignment with a 1.45 km length of tunnel is proposed to improve the geometry.

Table E.17: Tunnel

S. No.	Location	Starts at proposed Chainage	Ends at Proposed Chainage	Length (km)	Single/Twin
1	Naibag Tunnel	485.630	486.450	0.820	3 lane Twin Tunnels
2	Karmal Ghat Tunnel	579.950	581.490	1.540	3 lane Twin Tunnels

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E.9 Structures Improvement Proposals

Recommendation of structure improvements, including widening, repair and reconstruction / new construction of bridges, other cross drainage structures and the proposals are given below. Where Minor bridges are proposed to be widened, it is recommended that the existing railing to be replaced with RCC crash barrier by chipping the edge of deck and exposing the reinforcement and then casting the RCC crash barrier.

Widening of existing pipe culverts smaller than 900 mm shall be replaced with 1200 mm dia Pipe Culverts. Existing 900 mm dia pipe culverts can be widened using 900 mm dia pipes.

E.9.1 Rehabilitation scheme for Existing Structures

Rehabilitation measures for existing bridges & other structures are described briefly below:

The basic measures to be taken into account are:

- Repair of existing scour protection/bed protection or slope protection (wherever necessary).
- Replace existing wearing coat on all structures
- Replace expansion joints in all bridges.
- Replace bearings for bridges.
- Repair corroded reinforcement.
- Repair of cracks by epoxy injection – RCC elements.
- Repair of cracks by PMC mortar – Stone masonry elements.

E.9.2 Major Bridge

A) Construction of New Major Bridge

Sl. No	Ex. Chainage Km	Design chainage km	Proposed structural Configuration	Proposed structure type	Proposed span arrangement	Total Width of the structure(m)	
						LHS	RHS
1	481+385	481+045	4 lane width	PSC I-girder	3x25.0	12.5	12.5

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B) Rehabilitation & Repair of Existing Major Bridges

S. No	Ex. Chainage Km	Design chainage km	Proposed structural Configuration	Proposed structure type	Proposed span arrangement	Total Width of the structure(m)	
						LHS	RHS
1	498+253	495+600	2 lane width	PSC Box girder	1x51+3x60+1x21	12.5	Existing

Note: RR= Repair and Rehabilitation

E.9.3 Minor Bridge

A) New Construction and Reconstruction of New Minor Bridges

S. No.	Existing chainage	Design Chainage (Km)	Proposed structural Type	Existing span arrangement (m)	Proposed span arrangement (m)	Total width (m)
1	-	477+665	Box	-	1x8	12.5+3+12.5
2	-	485+085	Box	-	1x10	12.5+3+12.5
3	492+267	489+620	PSC Girder	2x5.8	1x25	12.5+3+12.5
4	500+520	497+750	Box	1x7.5	1x7.5	12.5+3+12.5
5	505+550	502+800	RCC Girder	13x1.4 dia	3x18	12.5+3+12.5
6	506+580	503+825	RCC Girder	13x1.4 dia	3x18	12.5+3+12.5
7	541+045	541+075	Box	1x6.0	1x6.0	12.5+3+12.5
8	-	558+600	Box	-	1x10	12.5+3+12.5
9	-	562+340	Box	-	1x6	12.5+3+12.5
10	-	562+790	Box	-	1x6	12.5+3+12.5
11	-	563+950	PSC Girder	-	1x25	12.5+3+12.5
12	-	564+805	Box	-	1x6	12.5+3+12.5
13	-	566+550	Box	-	1x10	12.5+3+12.5
14	570+200	571+190	Box	1x10.5	1x10.5	12.5+3+12.5
15	570+830	571+780	Box	1x6.0	1x6.0	12.5+3+12.5
16	-	577+200	PSC Girder	-	1x25	12.5+3+12.5
17	-	578+320	RCC Girder	-	1x20	12.5+3+12.5

B) Widening, Repairs and Rehabilitation of Existing Minor Bridges:

S. No.	Existing chainage	Design Chainage (Km)	structural Type		Existing span arrangement (m)	Proposed span arrangement (m)	Widening width (m)
			Existing	Proposed			
1	540+120	540+150	Box	Box	1x6.0	1x6.0	12.5
2	542+575	542+625	Box	Box	1x6.0	1x6.0	12.5
3	555+620	555+725	slab	Slab	5x8.5	5x8.5	12.5
4	571+560	572+500	slab	Box	1x10.5	1x10.5	12.5
5	584+800	584+125	slab	Box	1x10.0	1x10.0	12.5

Note: 1) RR= Repair and rehabilitation