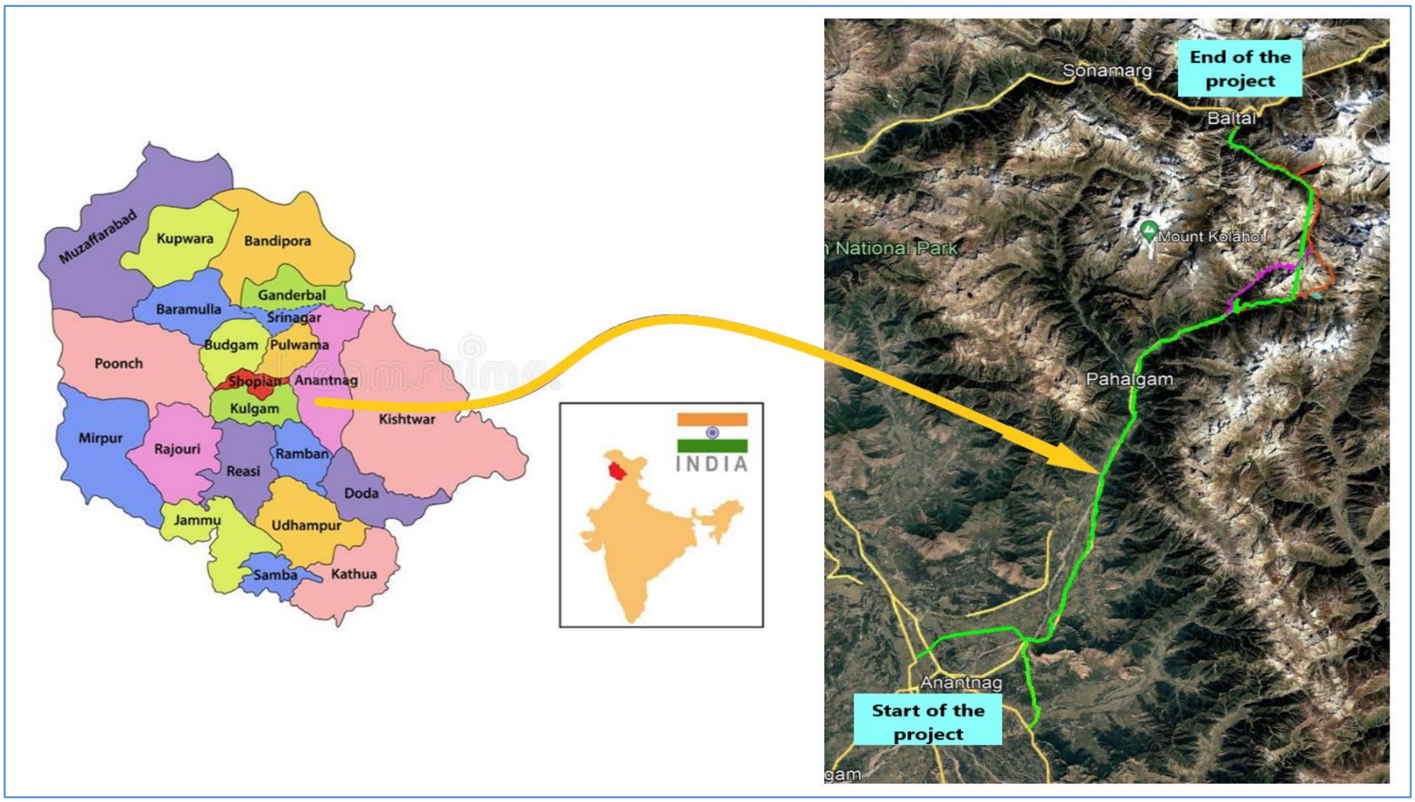
National Highways & Infrastructure Development Corporation Limited

BUILDING INFRASTRUCTURE - BUILDING THE NATION

Ministry of Road, Transport & Highways,
(Govt. of India)

Consultancy Services for ‘‘Preparation of Detailed Project Report for 2/4 laning of Khanabal to Baltal section on NH-501 (Ex. Length – 90 Km) with paved shoulder in the UT of Jammu and Kashmir”



Volume II – Design Report (Highways)
Detailed Project Report
January 2024

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CHAPTER - 1

INTRODUCTION

1.1 The Project Road

National Highways & Infrastructure Development Corporation Limited (NHIDCL), Ministry of Road, Transport & Highways, Govt. of India has been assigned the work of preparation of feasibility study / DPR and providing pre-construction services of road stretches/ corridors for up-gradation to two/four laning with paved shoulder according to NH Configuration.

In pursuance of the above, **Redecon (India) Pvt. Ltd., New Delhi** have been appointed as consultants to carry out the **"Consultancy Services for "Preparation of Detailed Project Report for 2/4 laning of Khanabal to Baltal section on NH-501 (Ex. Length – 90 Km) with paved shoulder in the UT of Jammu and Kashmir".** The agreement was signed on 20th September 2022.

The existing stretch of project road is a combination of brown field and green field alignment.

1. **<u>Brown Field: Khanabal (Start Point Jn. with NH - 244) to Chandanwadi = 57.400 Km</u>**

➢ It passes through Khanabal – Mattan – Bumzoo – Seer Hamdan – Akad – Aishmuqam – Batkoot – Pahalgam – Laripora – Betab Valley - Phrislan - Chandanwadi

➢ It traverses through the existing road of NH-501 ranging from single lane type to 4 Lane type.

➢ It has three newly proposed bypasses and one realignment for Khanabal - Anantnag, Seer Hamdan, Aishmuqam and Pahalgam.

➢ It also consists of additional connectivity from Achabal (on NH – 244) to Bumzoo near Mattan (on NH – 501) via Martand Sun Temple and Ranbirpora.

2. **<u>Green Field: Chandanwadi to Baltal (End point on NH-1) = 32.600 Km (Tentative)</u>**

➢ It traverses along the traditional route of Shri Amarnath ji yatra viz Chandanwadi - Pissu Top – Jojibal – Sheshnag – Ganesh Top – Panchatarani – Sangamtop Base – Domail and Baltal

➢ After Chandanwadi the project road traverses completely as a green field alignment where there is no existing road only the foot trails of Shri Amarnath Ji Yatra can be followed.

➢ This part traverses completely in mountainous terrain of high Himalayan Mountain range where the highest point is Ganesh top with elevation around 4400 mt.

- It traverses along the foot trails of Shri Amarnath holy cave yatra with a proposal of tunnel of 10.8 km length from Jojibal near Sheshnag Lake to Panchatarani.

3. <u>Achabal – Bumzoo connectivity – 12.6 Km</u>

- The project road also consists of additional connectivity from Achabal (on NH – 244) to Bumzoo near Mattan (on NH – 501) via Martand Sun Temple and Ranbirpora.
- It will boost the tourism industry and economy around the project influenced area.

As per contract an approx. length of 90 km had been considered from Khanabal to Baltal keeping in mind of traditional route of Shri Amarnath Ji Yatra since there is no existing road after Chandanwadi. Hence during the final design of alignment, the proposed length may vary from said existing length of 90 kms.

The project road has been divided into four different packages which are as follows:

Sr. No	Section		Proposed Lane configuration	Design Ch.					Name of the Ex. Road	Package
	From	To		From (Km)	Coordinate	To (Km)	Coordinate	Proposed Length (Km)		
Brown Field Part										
1	Start Point – Near Sursunoo village on NH – 44, Ex. Km. 244+060	End Point- End of Seer Hamdan Bypass	New 4 lane with paved shoulder road	0.000	33.756734°, 75.103578°	16.700	33.797520° 75.246289°	16.700	NH - 501	**IA**
2	Start Point- End of Seer Hamdan Bypass	End Point- Start of Pahalgam bypass near Sarbal shrine	New 4 lane with paved shoulder road	16.700	33.797520° 75.246289°	39.450	33.981141°, 75.320171°	22.750	NH-501	**2**
2	Achabal – Mattan Section		2 Lane with Paved Shoulder	0.000	33.688018°, 75.215143°	12.600	33.771290°, 75.211395°	12.600	Achabal - Ranbirpora - Mattan Road	**IC**
	Start point (700 m towards Donipawa from Achabal Jn on NH - 244)	Bumzoo Junction near Mattan on NH - 501								
3	Start of Pahalgam bypass near Sarbal shrine	Chandanwadi (End Point of Brown field) via Phryslan and Betab Valley	2 Lane with Paved Shoulder	39.450	33.981141°, 75.320171°	60.225	34.079281°, 75.418827°	21.230	NH - 501	**3**

Sr. No	Section		Proposed Lane configuration	Design Ch.					Name of the Ex. Road	Package
	From	To		From (Km)	Coordinate	To (Km)	Coordinate	Proposed Length (Km)		
						Total Design Length of Brown Field Part (Km)		**73.280**		
Green Field Part										
4	Chandanwadi (End Point of Brown field) via Phryslan and Betab Valley	Jojibal (Near Sheshnag Lake)	South Portal of proposed Tunnel (2 Lane with Paved Shoulder)	-	34.080247°, 75.417928°	-	34.091018°, 75.475047°	-	NH - 501	**Under Different Project Package**
	Proposed Panchatarani Tunnel			-	34.091018°, 75.475047°	-	34.188821°, 75.493586°	10.80	NH - 501	
	Panchatarani	Sangam Top Base (Near Shri Amarnath Ji Shrine)	North Portal of proposed Tunnel (2 Lane with Paved Shoulder)	-	34.188821°, 75.493586	-	34.203408°, 75.478163°	-	NH - 501	
5	Sangam Top Base (Near Shri Amarnath Ji Shrine)	Baltal (on NH-1 merging with the west approach of Zozilaa Tunnel Portal) via north eastern bank of Sindh River	2 Lane with Paved Shoulder	-	34.203408°, 75.478163°	-	34.258291°, 75.418762°	-	NH - 501	**4**

This report deals with Khanabal- Chandanwadi section (Brown field) from existing. Km. 00+000 (Khanabal Chowk, Junction with NH – 244) to Chandanwadi at Ex. Km. 57.400 Km. The proposed section starts from Design Km 0+000 from Sursunoo Village on NH – 44 at Ex. Km. 244+060 and terminates at Chandanwadi via Khanabal-Anantnag Bypass, Bumzoo, Hutmurah, Seer Hamdan Bypass, Akad, Realignment at Aishmuqam, Ganeshpora, Batkoot, Pahalgam Bypass, Betab Valley and Phryslan.

However, Green field stretch of Project Road from Chandanwadi to Sangam top base is included in different package with a proposal of tunnel of approximately 10.8 Km of length with approach road on both sides. From Sangam top base to Baltal is included in Package IIB as shown in above table. Its design length will be finalised after the completion of detailed survey work once the stretch opens after melting of snow in coming months.

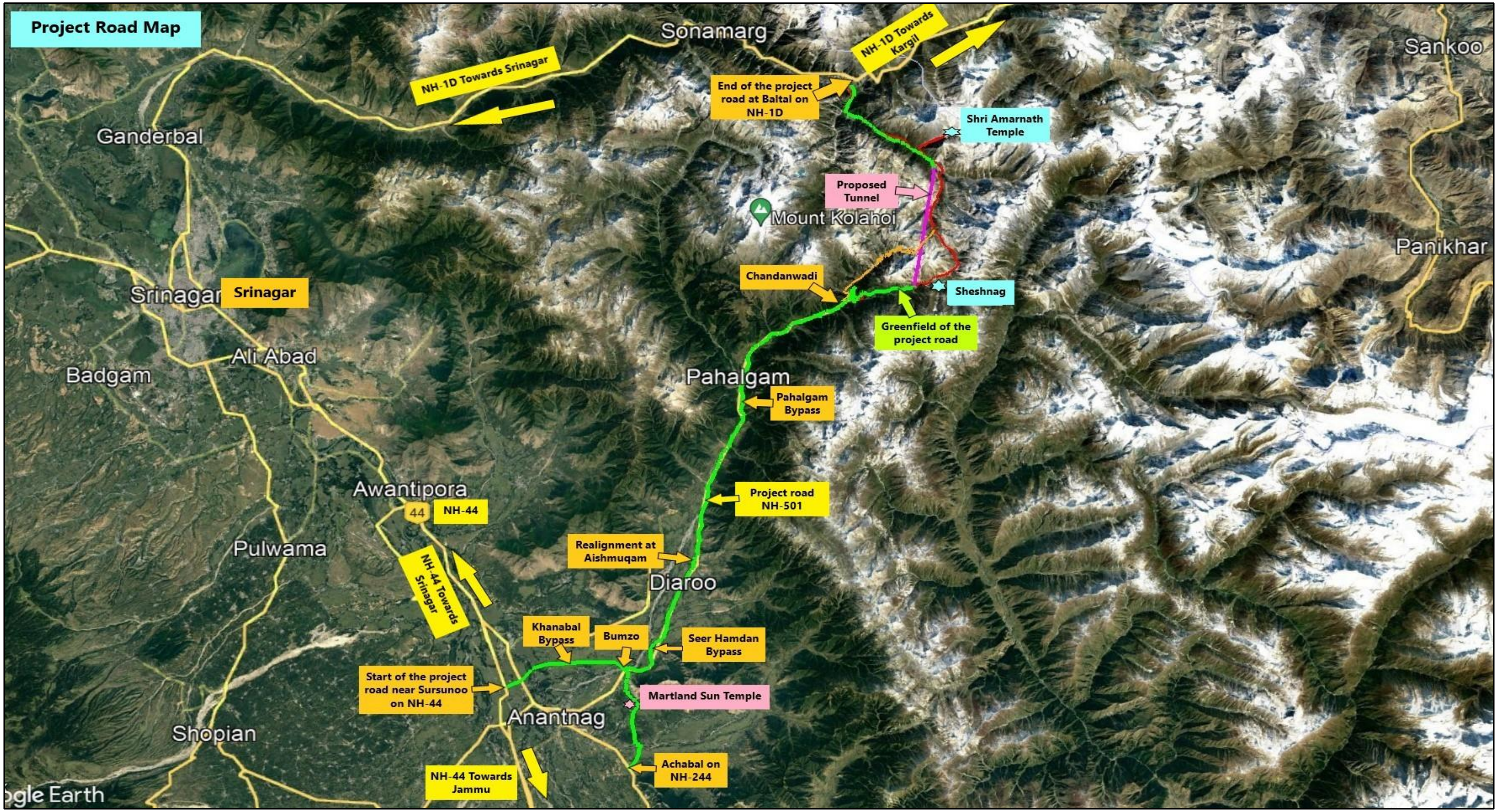


Figure 1.1: Map showing proposed alignment of Project

Proposed improvement under the project

The proposed project road is to be constructed to 2 Lane with paved shoulder and 4 Lane. The geometric designs would be as per recommendations of IRC: SP: 73-2018 & IRC: SP: 84-2019.

1.2 Project Stages and Structure of the Report

1.2.1 Project Stages

The Project has to be completed in eight stages as described herein below:

1. STAGE-I — Quality Assurance Plan (QAP) and Inception Report (IP)
2. STAGE-II — Alignment Options Report and Feasibility Report
3. STAGE-III — Strip Plan, LA Report (3a,3A), Clearances and Utility Shifting
4. STAGE-IV — Detailed Project Report (DPR)
5. STAGE-V — Bid Documents and Technical Specification
6. STAGE-VI — Land Acquisition and Clearances II Report
7. STAGE-VII — Award Determination
8. STAGE-VIII — Land Possession

1.2.2 Structure of the Report

This report constitutes Volume – II of the DPR and Comprises of the Design Report.

Part – 1 : Roads & Highways

Part – 2 : Bridges and CD Structures

Part –1 comprises the following chapters:

Chapter – 1 : Introduction

This chapter provides the location and salient features of the project road and structure of the report.

Chapter – 2 : Design Criteria and Standards

Deals with the design standards propose for the project road and provides the typical cross-sections adopted under different situations.

Chapter – 3 : Geometric Design

Deals with the geometric design of the road proper resulting from the application of the design standards.

Chapter – 4 : Design of Traffic Control and Other Facilities

Deals with Traffic Signs and Road Markings and other Appurtenant.

Chapter – 5 : Pavement Design

Deals with the design of new pavement for widened carriageway, reconstructed carriageways, strengthening, overlays for existing pavement, pavement for service road, etc.

CHAPTER – 2

DESIGN STANDARDS

2.0 General

The improvement point of view two types of standards has been adopted, namely:

- The desirable standards, which could be adopted as a rule.
- The minimum standards in fact a compromise between safety and the operational freedom, which could be accepted for difficult stretches where application of the desirable standards, would lead to high costs.

Accordingly, design standards for geometric elements have been proposed under “desirable” and “minimum” categories. These proposed standards are consistent with the fall within the parameters recommended in the related standards of the Indian Roads Congress (IRC). Considering the practicability of work the adopted values has been listed in the Table 2.1.

Table 2.1 Adopted Design Values

Design Standards			
(i)	Design Speed (Km/hr.) as per IRC SP:84-2019 & IRC: SP:73-2018 Plain and Rolling Terrain	:	100 (Ruling), 80(Minimum)
(ii)	Level of Service	:	B
(iii)	Roadway Widths (m)	:	27 - 30 m for 4-lane divided highway for open countries – Plain terrain as per IRC- SP: 84-2019.
			25 - 38 m for 4-lane divided highway with Service roads and raised median – Built up section - Plain terrain as per IRC- SP: 84-2019.
			12-14 m for 2-lane highway for open countries and eccentrically placed 2 lane bypass/realignment – Plain terrain as per IRC- SP: 73-2018 and MORT&H circular dated 17 July 2020.
	Plain and Rolling Terrain		15 m for 2-lane highway (modified) for built up area – Plain terrain as per IRC- SP: 73-2018 and MORT&H circular dated 17 July 2020.
(iv)	Roadway Elements as per IRC SP:84-2019, IRC SP – 73:2018 and MORT&H circular dated 17 July 2020 (Plain and Rolling Terrain)	:	Carriageway 4-lane: 2X7.0m
			Paved Shoulder: 2.5 m (both side)
			Earthen Shoulder: 1.5 m (both side)
			Raised Median: 5.0 m
			Depressed Median: 7.0 m
			Note; The median width will be decided as per land availability.
			Carriageway 2-lane: 7.0m
			Paved Shoulder: 1.5 m (both side)
			Earthen Shoulder: 1.0 m (both side)

Design Standards			
(v)	Camber as per IRC SP:73-2018 / IRC SP:84-2019		Carriageway
			Flexible- 2.50%
			Rigid - 2.00 %
			Paved Shoulder
			Flexible- 2.50%
			Rigid - 2.00 %
			Unpaved Shoulder
			Flexible- 3.50%
			Rigid - 3.00 %
(vi)	Right of Way		45 m for National Highway with planned capacity to 4 lane and 30 m National Highway with planned capacity to 2 lanes + PS configuration.
(vii)	Embankment/ Cutting Slope		To be designed based on soil parameters, (IRC:75-2015)
	Fill height, up to 3.0 m		In filling- 1V: 2 H
	Fill height from 3.0 m to 6.0 m		In filling- 1V: 1.5 H
	Fill height exceeding 6.0 m		In cutting- 1V:1H
(viii)	Safe Stopping Sight Distance		180 m for design speed of 100 km/hr
			130 m for design speed of 80 km/hr
			90 m for design speed of 60 km/hr
			45 m for design speed of 40 Km /hr
	Desirable Minimum sight distance		360 m for design speed of 100 km/hr
			260 m for design speed of 80 km/hr
			180 m for design speed of 60 km/hr
			90 m for design speed of 40 Km /hr
(ix)	Super-elevation for Plain and Rolling Terrain (As per IRC SP 84: 2019)		7% (When radius of curve is less than desirable minimum)
			5% - (When radius of curve is more than desirable minimum)
(x)	Radii for Horizontal Curves as per IRC: SP:73-2018 / IRC SP:84-2019		Ruling Minimum 400 m
	Plain and Rolling Terrain		Absolute minimum 250 m
(xi)	Gradient (As per IRC: SP:73-2018 / IRC: SP:84-2019)		
	Plain and rolling Terrain		
	Ruling		2.5.%
	Limiting		3.30%
(xii)	Minimum Length of Vertical curve adopted		
	Summit Curve (Plain Terrain)		Desirable: 135.0A (100kmph)
			Minimum: 60.0A (80 kmph)
	Valley Curve (Plain Terrain)		Desirable: 41.5A (100kmph)
			Minimum: 25.3A (80 kmph)

Design Standards			
(xiii)	Bridge Clearance		
	Vehicular underpass		5.5 m
	Light and Smaller Vehicular Underpass		4.0m
(xiv)	Design Flood Frequency		
	Bridges		100 years
	Sewers and Ditches		60 years

2.1 Terrain Classification

The following terrain classification recommended by IRC-38:1988 is proposed to be adopted:

Table 2.2 Terrain Classification

Terrain Classification	Percentage cross slope of the country
Plain	0 – 10
Rolling	10 – 25
Mountainous	25 – 60
Steep	> 60

2.2 Deign Speed

Design speed is the basic parameter, which determines geometric features of the road. The proposed design speeds for different terrain categories are as follows:

Table 2.3 Design Speed

Terrain Classification	Design Speed (km/h)	
	Desirable	Minimum
Plain & Rolling	100	80
Mountainous & Steep	60	40

For road stretches passing through built-up areas, the speeds corresponding to rolling terrain are proposed.

2.3 Cross-Sectional Elements

2.3.1 Lane Width

As per IRC: SP: 84-2019, the standard lane width of the project highway shall be 3.5 m.

2.3.2 Paved Shoulders

Full strength pavement for paved shoulders is proposed. Width of these shoulders will be 1.5 m. This will provide better traffic operation conditions, lower maintenance cost and will be useful at the times of routine/periodic maintenance.

2.3.3 Earthen Shoulders

It is proposed to have 2 m for four lane road and 1 m road for two lane wide earthen shoulders which will provide sufficient space for installing road appurtenant such as traffic signs, crash barriers (where required) etc., and in combination with the paved shoulders for parking of stalled vehicles.

2.3.4 Side Slopes

The slope of embankment is linked with its height. In accordance with the Manual for Safety in Road Design (MoRT&H publication), 2H: 1 V has been proposed for the entire stretch.

2.3.5 Typical Cross-section

For application to different situations, a number of typical cross-sections have been prepared and these are listed in the Table 2.4. Figures of different typical cross sections showing following different types of road features have been presented in Volume-IX: Drawings.

TCS Schedule						
Sr No	**Design Chainage**		**Proposed Length**	**TCS No**	**TCS Type**	**PROW (m)**
	From	**To**				
1	00+000	00+075	75	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
2	00+075	00+323	248	TCS 3	Approach to VUP with RE wall & Slip Road	45
3	00+323	00+338	15	SVUP	SVUP	SVUP
4	00+338	00+585	247	TCS 3	Approach to VUP with RE wall & Slip Road	45
5	00+585	00+920	335	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
6	00+920	01+277	357	TCS 3	Approach to VUP with RE wall & Slip Road	45
7	01+277	01+297	20	VUP	VUP	VUP
8	01+297	01+700	403	TCS 3	Approach to VUP with RE wall & Slip Road	45
9	01+700	02+159	459	TCS 2	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
10	02+159	02+182	23	MNB	MNB	MNB
11	02+182	02+371	189	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
12	02+371	02+381	10	SVUP	SVUP	SVUP
13	02+381	02+495	114	TCS 3	Approach to VUP with RE wall & Slip Road	45
14	02+495	02+605	110	MJB	MJB	MJB
15	02+605	02+641	36	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
16	02+641	02+672	31	MNB	MNB	MNB
17	02+672	03+090	418	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
18	03+090	03+110	20	MNB	MNB	MNB

TCS Schedule						
Sr No	**Design Chainage**		**Proposed Length**	**TCS No**	**TCS Type**	**PROW (m)**
	From	**To**				
19	03+110	03+415	305	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
20	03+415	03+455	40	MNB	MNB	MNB
21	03+455	03+707	252	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
22	03+707	04+297	590	TCS 3	Approach to VUP with RE wall & Slip Road	45
23	04+297	04+307	10	SVUP	SVUP	SVUP
24	04+307	04+580	273	TCS 3	Approach to VUP with RE wall & Slip Road	45
25	04+580	04+620	40	MNB	MNB	MNB
26	04+620	05+025	405	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
27	05+025	05+268	243	TCS 3	Approach to VUP with RE wall & Slip Road	45
28	05+268	05+280	12	SVUP	SVUP	SVUP
29	05+280	05+535	255	TCS 3	Approach to VUP with RE wall & Slip Road	45
30	05+535	05+800	265	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
31	05+800	06+295	495	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
32	06+295	06+542	247	TCS 3	Approach to VUP with RE wall & Slip Road	45
33	06+542	06+558	16	SVUP	SVUP	SVUP
34	06+558	06+805	247	TCS 3	Approach to VUP with RE wall & Slip Road	45
35	06+805	06+956	151	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
36	06+956	06+974	18	MNB	MNB	MNB
37	06+974	07+225	251	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
38	07+225	07+570	345	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
39	07+570	07+817	247	TCS 3	Approach to VUP with RE wall & Slip Road	45
40	07+817	07+827	10	SVUP	SVUP	SVUP
41	07+827	08+152	325	TCS 3	Approach to VUP with RE wall & Slip Road	45
42	08+152	08+164	12	SVUP	SVUP	SVUP
43	08+164	08+420	256	TCS 3	Approach to VUP with RE wall & Slip Road	45
44	08+420	08+580	160	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
45	08+580	08+829	249	TCS 3	Approach to VUP with RE wall & Slip Road	45
46	08+829	08+842	13	SVUP	SVUP	SVUP
47	08+842	09+090	248	TCS 3	Approach to VUP with RE wall & Slip Road	45
48	09+090	09+230	140	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45

TCS Schedule						
Sr No	Design Chainage		Proposed Length	TCS No	TCS Type	PROW (m)
	From	To				
49	09+230	09+480	250	TCS 3	Approach to VUP with RE wall & Slip Road	45
50	09+480	09+490	10	SVUP	SVUP	SVUP
51	09+490	09+800	310	TCS 3	Approach to VUP with RE wall & Slip Road	45
52	09+800	09+950	150	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
53	09+950	10+088	138	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
54	10+088	10+119	31	MNB	MNB	MNB
55	10+119	10+606	487	TCS 3	Approach to VUP with RE wall & Slip Road	45
56	10+606	10+630	24	VUP	VUP	VUP
57	10+630	10+740	110	TCS 3	Approach to VUP with RE wall & Slip Road	45
58	10+740	10+980	240	MJB	MJB	MJB
59	10+980	11+900	920	TCS 5	Reconstruction of 4 Lane divided road with P.S along Hill Side (Open Area, MSA-20, CBR-8 %)	30
60	11+900	13+115	1215	TCS 4	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
61	13+115	13+126	11	MNB	MNB	MNB
62	13+126	13+850	724	TCS 4	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
63	13+850	14+200	350	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
64	14+200	14+754	554	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
65	14+754	14+773	19	MNB	MNB	MNB
66	14+773	15+500	727	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
67	15+500	16+200	700	TCS 1	New Construction of 4-Lane divided road with P.S (Bypass portion, MSA 20, CBR-8%)	45
68	16+200	16+443	243	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
69	16+443	16+454	11	MNB	MNB	MNB
70	16+454	16+700	246	TCS 2	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
	Total Length		16+700			

TCS Schedule						
Sr No	Design Chainage		Proposed Length	TCS No	TCS Type	PROW (m)
	From	To				
1	16+700	18+193	1493	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
2	18+193	18+208	15	MNB	MNB	MNB
3	18+208	18+615	407	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
4	18+615	18+635	20	MNB	MNB	MNB
5	18+635	18+800	165	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
6	18+800	19+600	800	TCS 5	Re Construction of 4-Lane divided road with P.S along and Toe Wall (Open Area, MSA 20, CBR-8%)	30
7	19+600	20+300	700	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
8	20+300	20+640	340	Toll Plaza	Toll Plaza	Toll Plaza
9	20+640	21+108	468	TCS 5	Re Construction of 4-Lane divided road with P.S along and Toe Wall (Open Area, MSA 20, CBR-8%)	30
10	21+108	21+118	10	MNB	MNB	MNB
11	21+118	21+150	32	TCS 5	Re Construction of 4-Lane divided road with P.S along and Toe Wall (Open Area, MSA 20, CBR-8%)	30
12	21+150	21+518	368	TCS 2	Re Construction of 4-Lane divided road with P.S along existing Martand Canal (Open Area, MSA 20, CBR-8%)	30
13	21+518	21+534	16	MNB	MNB	MNB
14	21+534	22+208	674	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
15	22+208	22+223	15	MNB	MNB	MNB
16	22+223	23+950	1727	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
17	23+950	24+443	493	TCS 3	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
18	24+443	24+473	30	MNB	MNB	MNB
19	24+473	24+606	133	TCS 3	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
20	24+606	24+614	8	MNB	MNB	MNB
21	24+614	24+775	161	TCS 3	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
22	24+775	24+796	21	MNB	MNB	MNB
23	24+796	24+869	73	TCS 3	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45

TCS Schedule						
Sr No	**Design Chainage**		**Proposed Length**	**TCS No**	**TCS Type**	**PROW (m)**
	From	**To**				
24	24+869	24+911	42	MNB	MNB	MNB
25	24+911	25+038	127	TCS 3	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
26	25+038	25+082	44	MNB	MNB	MNB
27	25+082	25+300	218	TCS 3	New Construction of 4-Lane divided road with P.S and Toe wall (Bypass portion, MSA 20, CBR-8%)	45
28	25+300	28+655	3355	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
29	28+655	28+665	10	MNB	MNB	MNB
30	28+665	28+950	285	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
31	28+950	28+978	28	TCS 5	Re Construction of 4-Lane divided road with P.S along and Toe Wall (Open Area, MSA 20, CBR-8%)	30
32	28+978	29+011	33	MNB	MNB	MNB
33	29+011	29+200	189	TCS 5	Re Construction of 4-Lane divided road with P.S along and Toe Wall (Open Area, MSA 20, CBR-8%)	30
34	29+200	32+092	2892	TCS 4	Reconstruction of 4 Lane divided road with P.S along Hill Side (Open Area, MSA-20, CBR-8 %)	30
35	32+092	32+104	12	MNB	MNB	MNB
36	32+104	32+600	496	TCS 4	Reconstruction of 4 Lane divided road with P.S along Hill Side (Open Area, MSA-20, CBR-8 %)	30
37	32+600	34+800	2200	TCS 1	Re Construction of 4-Lane divided road with P.S (Built-up portion, MSA 20, CBR-8%)	24
38	34+800	36+175	1375	TCS 4	Reconstruction of 4 Lane divided road with P.S along Hill Side (Open Area, MSA-20, CBR-8 %)	30
39	36+175	36+225	50	MNB	MNB	MNB
40	36+225	38+276	2051	TCS 4	Reconstruction of 4 Lane divided road with P.S along Hill Side (Open Area, MSA-20, CBR-8 %)	30
41	38+276	38+286	10	MNB	MNB	MNB
42	38+286	39+450	1164	TCS 4	Reconstruction of 4 Lane divided road with P.S along Hill Side (Open Area, MSA-20, CBR-8 %)	30
	Total Length		22+750			

2.4 Sight Distance

Safe stopping sight distance, both in the vertical and horizontal directions will apply in design. The sight distance values as per IRC recommendations are as follows:

Table 2.5 SSD and ISD as per IRC SP 23:1993

Design Speed	IRC SP 23:1993	
Km/h	Stopping Sight Distance (m)	Intermediate Sight Distance (m)
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120
60	90	180
80	120	240
100	180	360

2.5 Horizontal Alignment

The horizontal alignment of a road usually compromises a series of straights (tangents) and circular curves which has been connected by transition curves. The following section outlines design criteria which have been considered when developing the horizontal alignment.

Further it has been ensured that the alignment would enable consistent, safe and smooth movement of vehicles operating at the design speed.

Super elevation and side Friction details

Super elevation is the cross fall this is provided on the pavement on a horizontal curve in order to assist a vehicle to maintain a circular path, and partially compensate the centrifugal force.For normal values of super elevation, side friction and radius, the following formula is adopted

$$e + f = V^2/127R$$

e = pavement superelevation (m/m)

f = coefficient of side friction force developed between the vehicle tyres and the road pavement. This is taken as positive if the frictional force on the vehicle acts towards the centre of the curve.

R = curve radius (m)

Maximum side friction of 0.15 is adopted for the project road as per IRC: SP: 73-2018 and IRC: SP: 84-2019

Super Elevation shall be limited to 7 percent, if radius of curve is less than desirable minimum radius. It shall be limited to 5 percent, if radius is more than desirable minimum and also at section where Project Highway passes through an urban section or falls on a major junction.

Super elevation has been developed by rotating the carriageway about edge.

Minimum rate of change for attainment of super elevation is adopted as 1 in 150 in maximum condition.

Positioning of super elevation development in transitions is kept so that 0 % cross fall corresponds to the start of the transition and full super elevation for the curve (e %) is attained at the end of the transition. In circular curves, 2/3 of the super elevation is achieved on the tangent i.e. at the start of the curve 2/3 e% is achieved. In case of compound curves (curves in same direction) where proper super elevation runoff length is not available, full super elevation on sharper curve is retained on the common tangent.

Transition curves

Transition curves have some advantages which can be summed up into the following:

- To introduce gradually the centrifugal force between the tangent point and the beginning of the circular curve, to provide smooth entry to curve.
- To enable gradual introduction of the designed super elevation and extra widening of pavement at the start of the circular curve.
- To improve the aesthetic appearance of the road.

Almost all curves in the project road are provided with transition except at larger radius where transition is not required as per requirement of IRC Code.

Set Back Distance

It is the clear distance between the centreline of a horizontal curve to an obstruction on the inner side of the curve. This is considered in design so that adequate sight distance is available while negotiating the curve.

Recommended Elements of Horizontal Alignment:

Study of the limiting values for various elements of horizontal alignments recommended by various international standards reveals that, besides the general factors described above, conditions specific to the country have also a role to play in determining the boundaries of the standards. The standards proposed to suit the project road, are presented below:

Table 2.6 Horizontal Radii Criteria

Type of Terrain	Minimum Radii of Horizontal Curve	
	Desirable Minimum	Absolute Minimum
Mountainous	150	75
Plain	400	250

The value of 7% for maximum super elevation has been adopted as a general rule to provide for better operational conditions for heavy trucks which generally move at lower speeds.

2.6 Vertical Alignment

The vertical alignment has been designed to be generally compatible with the horizontal alignment and consistent with the topography to achieve a free-flowing profile. The following criteria shall in general be followed while designing vertical curves:

- Generally vertical curve is designed based upon SSD

2.6.1 Gradient

As per IRC: SP: 73- 2018 and IRC: SP: 84- 2019 the gradient to be followed is as given below:

Table 2.7 Gradient

Terrain	Ruling (%)	Limiting (%)
Plain Terrain	2.5	3.3
Mountainous Terrain	5.0	6.0
Steep Terrain	6.0	7.0

2.6.2 Summit or Crest Curves

A curve with convexity upwards is called as summit curve.

2.6.3 Valley or Sag Curves

A vertical curve concave upwards is known as a valley curve, dip or sag.

2.6.4 Length of vertical curves

Length of vertical curve for different speeds when length of curve is greater than sight distances as shown in table below as per IRC:SP:23-1993.

Table 2.8 Length of Vertical curves for Different speeds

Design Speed (km/hr)	Length of summit curve (metre) for			Length of Valley Curve (metre) for headlight distance
	Stopping sight distance	Intermediate sight distance	Overtaking sight distance	
20	0.9A	1.7A	-	1.8A
25	1.4A	2.6A	-	2.6A
30	2.0A	3.8A	-	3.5A

Design Speed (km/hr)	Length of summit curve (metre) for			Length of Valley Curve (metre) for headlight distance
	Stopping sight distance	Intermediate sight distance	Overtaking sight distance	
35	3.6A	6.7A	-	5.5A
40	4.6A	8.4A	28.4A	6.6A
50	8.2A	15.0A	57.5A	10.0A
60	14.5A	26.7A	93.7A	15.0A
65	18.4A	33.8A	120.4A	17.4A
80	32.6A	60.0A	230.1A	25.3A
100	73.6A	135A	426.7A	41.5A

Note: 'A' in the above Table is the algebraic difference in grades expressed as percentage.

In some cases the length of the curve needed for providing the required sight distance would be very small. Further in flat grades no vertical curve may be necessary for visibility; but for comfort in driving and to avoid shock, it is necessary to introduce a vertical curve except perhaps in very flat grades. The minimum length of the curve should be as indicated in Table below as per IRC: SP: 23-1993.

Table 2.9 Minimum Length of vertical curve

Design Speed (km/hr.)	Maximum grade change (per cent) not requiring a vertical curve	Minimum length of vertical curve
Up-to 35	1.5	15
40	1.2	20
50	1.0	30
65	0.8	40
80	0.6	50
100	0.5	60

2.7 Cross-fall

The cross-fall on straight sections of road carriage-way, paved shoulders and paved portion of median shall be 2.5 percent for bituminous surface and 2.0 percent for cement concrete surface.

2.8 Geometric Design Control

Geometric design relates to design of all visual elements of the road. For the project road, this includes:

- Design of horizontal alignment which considers improvement of sub-standard curves, removal of kinks, realignment due to improvement of geometrics, considering the upgrading proposal to 4 Lane Carriageway with/without service road. The geometric designs would be as per recommendations of IRC: SP: 73-2018.
- Design of vertical profile which considers flattening of steep and impermissible grades,

provision of adequate sight distance and removal of dangerous dips and profile irregularities as per pavement design.

2.9 Roadway Width at Cross-Drainage Structures

2.9.1 Culverts

The culverts will be built/widened to the same width as the flanking roadway.

2.9.2 Bridges

The bridges will be built/widened as per guidelines of IRC: SP: 73:2018 and IRC: SP: 84-2019.

2.10 Loading Standards for Bridge Structures

These will be according to IRC standards for bridges on National Highways.

2.11 Standards for At-Grade Intersections

The standards proposed in IRC SP: 41-1994 "Guidelines for the Design of At-Grade Intersection in Rural and Urban Areas" will be applied.

2.12 Drainage

Earthen/Natural soil cut to Trapezoidal shape will form the open drain in general connected to natural out fall. Wherever required, lined drains with suitable locally available materials will be provided to accommodate higher discharge. The drain will be lined with suitable material. These are:

Earthen Trapezoidal drain	:	This will generally apply for stretches with low to medium discharge
Lined drain with or without cover	:	This will apply in urban areas. Covers will be provided at places involving high pedestrian activities or where pedestrian footpath is desired.

CHAPTER – 3

GEOMETRIC DESIGN

3.1 General

Geometric design relates to design of all visual elements of the road. For the project road, this includes:

- Design of horizontal alignment which considers improvement of sub-standard curves, removal of kinks, realignment due to improvement of geometrics, considering the upgrading proposal to 2 Lane with paved shoulder and 4 Lane Carriageway with/without service road. The geometric designs would be as per recommendations of IRC: SP: 73-2018 and IRC: SP: 84-2019.
- Design of vertical profile which considers flattening of steep and impermissible grades, provision of adequate sight distance and removal of dangerous dips and profile irregularities as per pavement design.

3.2 Design of Horizontal Alignment

The topographic survey data from total station survey equipment have been downloaded into computer to prepare Digital Terrain Model (DTM). Based on the decision taken on the side of widening, the center line of the carriageway was finalized in the light of the design standards in the form of smooth flowing line compromising tangents and curves. A template of the cross section appropriate to the location was then superimposed to develop all other lines such as kerb lines, pavement/roadway lines etc. MX software was used to prepare the design.

3.3 Design of Vertical Profiles

Vertical alignment has been carried out at the centre line where it is proposed to be 2 Lane with paved shoulder and 4 Lane Carriageway with/without service road. It has been properly designed based on the vehicle speed, acceleration, deceleration, stopping distance, sight distance and comfort in vehicle movements at high speeds.

The following criteria in general were followed while designing the vertical profile.

i) The Project stretch is 2 Lane with paved shoulder and 4 Lane Carriageway with/without service road. So stopping sight distance are provided wherever possible.

ii) For the new carriageway, the levels have been decided based on requirement due to combination of spans, which results in increase in girder depth and any other hydrological requirement. A maximum super elevation of 7% has been provided after giving rotation at median edges.

iii) Ggradients in accordance with the adopted standards were maintained considering SSD.However, to avoid any additional cutting and filling on proposed alignment due to adherence of recommendations of IRC: SP-84-2019, some minor compromise has been made.

iv) Grade compensation is considered in adherence to IRC: SP:23 which states "Since grade compensation is not necessary for gradients flatter than 4%, when applying grade compensation correction, the gradients need not be eased beyond 4%".

3.4 HIP and VIP details

The entire project road has been designed with the use of windows-based software Civil 3D.

The details of HIP and VIP Package wise is provided in Annexure 3.

CHAPTER – 4

DESIGN OF TRAFFIC CONTROL AND OTHER FACILITIES

4.1 General

The up-gradation and widening of the project road, would transform it into a high-speed corridor for which an efficient traffic control system is essential. The main purpose of traffic control system is to provide the road users a smooth, hazard free passage, together with ensuring adequate safety to all concerned, including the pedestrians. Since the project roadway crosses many populated villages and towns, the designing of traffic control measures assumes paramount importance.

The various traffic control measures adopted for the project road are described in the succeeding paragraphs. These comprise the designs of:

(i) Traffic Signs and Road Markings

(ii) Bus bays, Truck Lay bye.

(iii) Street Lighting

(iv) Other Appurtenances

4.2 Traffic Signs and Road Markings

4.2.1 Traffic Signs

The traffic signs on the project roads have been provided in accordance with the IRC Code of Practice for Road Signs (IRC 67-2022).

The various types of road signs as presented in the above-mentioned standard and introduced in the project roads are described below. The main categories of road signs are;

- Mandatory or Regulatory Signs (MS)
- Warning or Cautionary Signs (WS)
- Informatory Signs (IS)

Mandatory Signs /Regulatory Signs and Compulsory Signs

The Mandatory Signs are meant to convey to road users a definite instruction they must follow e. g. octagonal 'STOP' sign, circular signs for speed or other restrictions etc. Compulsory signs such as "Keep Left" compel the drivers to follow a definite route.

Warning Signs

The Warning Signs are meant to convey to road users a warning about dangers/hazards ahead. These are triangular signs warning about 'School Zone', 'cross road' and other hazards lying ahead.

Informatory Signs

The Informatory Signs are provided to convey to road users' information on places of interest, services and facilities etc. This also includes other signs which are useful to the drivers like Direction signs, parking signs etc.

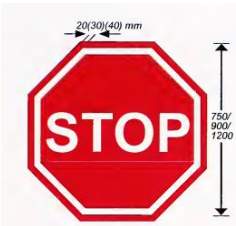
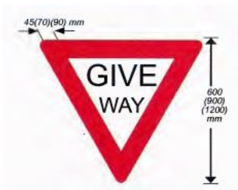
Design and Siting

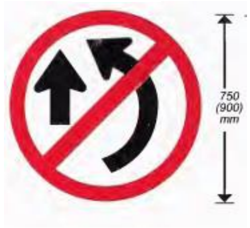
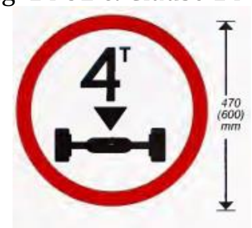
The road signs shall be of the retro-reflectorized type and made of high intensity grade with encapsulated lens type reflective sheeting fixed over aluminium sheets. The sign post would be of aluminium alloy posts or steel posts or hollow section of cast or sheet metal.

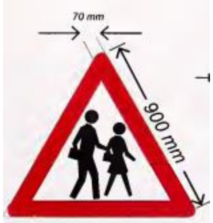
Locations of signs have been marked on plan and profile drawings of the project road as also in the individual intersection drawings.

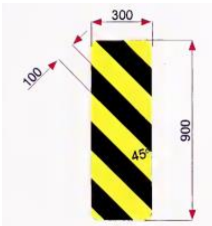
All the road signs selected are proposed to be erected on a refuge or on an island or on earthen shoulder of the road and will be mounted on ground. Orientation and siting of signs with respect to the carriageway will be carried out conforming to IRC standard with due care to adjoining land use on urban and semi urban areas.

Table 4.1: Road Signs for a Road Project

Type of Sign Board	Shape & Size of Sign Board	Figure & Clause in IRC 67: 2012	Remarks
Stop Sign (Regulatory)	Octagonal (750mmx 750mm)	Fig. 14 .01 & Clause 14.5 	This is for indicating priority for the right of way. The sign is intended for use on roadways where traffic is required to stop before entering a major road, and where it is intended that the vehicle shall proceed past the stop line only after ascertaining that this will not cause danger to traffic on the main road.
Give Way Sign (Regulatory)	Triangular (Side 600 mm)	Fig. 14.01 & Clause 14.5 	The GIVE WAY sign is used to assign right-of-way to traffic on certain roadways at inter-sections, the intention being that the vehicles controlled by the sign must give way ie. yield to other traffic having the right of way. Vehicles controlled by this sign need to slow do n or stop when necessary to avoid interfering with conflicting traffic.

Type of Sign Board	Shape & Size of Sign Board	Figure & Clause in IRC 67: 2012	Remarks
Overtaking Prohibited (Prohibitory)	Circular (Dia 750mm)	Fig. 14.23 & Clause 14.7.20 	The sign shall be erected at the beginning and at intervals within, of such sections of highways where sight distance is restricted, and overtaking will be hazardous.
Blowing Horn Prohibited (Prohibitory)	Circular (Dia 750mm)	Fig. 14.18 & Clause 14.7 	These signs generally give instructions regarding manoeuvre that must not be made. Prohibitory signs indicate a forbidden manoeuvre.
No Standing Sign (Prohibitory)	Circular (Dia 600mm)	Fig. 14.27 & Clause 14.8 	This sign shall be erected where the controlling authority has decided to prohibit standing of vehicle even for a very short duration.
No Parking Sign (Prohibitory)	Circular (Dia 600mm)	Fig. 14.29 & Clause 14.8.5 	These signs generally give instructions regarding manoeuvre that must not be made. Prohibitory signs indicate a forbidden manoeuvre.
Maximum Speed Limit (Prohibitory)	Circular (Dia 600mm)	Fig. 14.37 & Clause 14.9.8 	The sign shall be located at the beginning of the section of the road or area covered by a speed restriction, with numerals indicating the speed limit in km per hour. The speed limit should be marked in multiples of 5 km per hour.
Axle Load Limit (Prohibitory)	Circular (Dia 600mm)	Fig. 14.32 & Clause 14.9.3 	The sign shall be erected where entry is prohibited for vehicles whose axle load exceeds a particular limit. To indicate the presence of any weak bridge ahead a definition plate with "Weak Bridge Ahead" may be posted.

Type of Sign Board	Shape & Size of Sign Board	Figure & Clause in IRC 67: 2012	Remarks
Restriction End Sign (Prohibitory)	Circular (Dia 600mm)	Fig. 14.40 & Clause 14.10 	This sign shall indicate the point at which all prohibitions notified by Prohibitory signs for moving vehicles ceases to apply.
School Ahead (Cautionary)	Triangular (Side 600 mm)	Fig. 15.34 & Clause 15.28 	The sign should be erected where school buildings or grounds are adjacent to the road, and where passing traffic can create a hazard to children.
Pedestrian Crossing (Cautionary)	Triangular (Side 600 mm)	Fig. 15.33 & Clause 15.27 	The sign should be erected in advance on both approaches to uncontrolled pedestrian Crossing.
Built Up Area (Cautionary)	Triangular (Side 600 mm)	Fig. 15.35 & Clause 15.29 	The sign shall be used to caution the vehicles about Built up Area. The sign shall be placed at the beginning of such area.
Side Road Left (Cautionary)	Triangular (Side 600 mm)	Fig. 15.10 & Clause 15.9 	The sign should be erected in advance of the main road intersections where a sufficiently large volume of entering traffic together with restricted sight distance is likely to constitute a hazard.
Side Road Right (Cautionary)	Triangular (Side 600 mm)	Fig. 15.09 & Clause 15.28 	The sign should be erected in advance of the main road intersections where a sufficiently large volume of entering traffic together with restricted sight distance is likely to constitute a hazard.

Type of Sign Board	Shape & Size of Sign Board	Figure & Clause in IRC 67: 2012	Remarks
Right Hairpin Bend (Cautionary)	Triangular (Side 600 mm)	Fig. 15.03 & Clause 15.5 	The sign should be used to mark curves of small radi, where the change of direction is so considerable as to amount to a reversal of direction
Left Hairpin Bend (Cautionary)	Triangular (Side 600 mm)	Fig. 15.04 & Clause 15.5 	The sign should be used to mark curves of small radi, where the change of direction is so considerable as to amount to a reversal of direction
Series of Bends (Cautionary)	Traingular (Side 600 mm)	Fig. 15.07 & Clause 15.7 	This sign should be used to caution the driver of the presence of zig-zag for a long distance over the section of road ahead. The sign may be posted 50-100 m ahead of the section under question.
Staggered Inter-section (Cautionary)	Traingular (Side 600 mm)	Fig. 15.21 & Clause 15.16 	The sign should be used to indicate junctions where the distance between two junctions does not exceed 60 m
Hazard Marker (Cautionary)	Rectangular (300mmx 900mm)	Fig. 15.76 & Clause 15.77 	Road side hazard like bridges, trees which are coming in the roadway are to be illuminated by retro reflective Object Hazard Markers (OHM).
Hospital (Informatory)	Rectangular (450mmx 600mm)	Fig. 17.07 & Clause 17.8 	The sign should be used to notify drivers of vehicles that they should take the precautions required near medical establishments and in particular that they should not make any unnecessary noise. The sign also serves to indicate the location of hospital where medical facilities will be available.

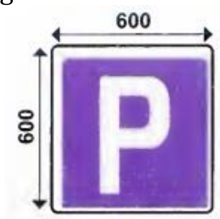
Type of Sign Board	Shape & Size of Sign Board	Figure & Clause in IRC 67: 2012	Remarks
Bus Stop (Informatory)	Rectangular (450mm x 600mm)	Fig. 17.35 & Clause 17.36 	The sign should be erected at the places where the buses are designated to stop.
Filling Station (Informatory)	Rectangular (450mmx 600mm)	Fig. 17.06 & Clause 17.7 	The sign should be erected on long stretches of roads in rural and urban areas at the entry to the road leading to the facility including CNG filling stations.
Place/City Identification (Informatory)	Rectangular (300mmx 900mm)	Fig. 16.06& Clause 16.3.5 	The sign should be used along highways to mark entrance to the place or city. It should be erected at the entrance to the area under the jurisdiction of the local authority.
Parking Signs (Informatory)	Rectangular (600mmx 600mm)	Fig. 18.01 & Clause 18.1 	The parking sign, which may be set up parallel to the axis of the road, should indicate the places where parking of vehicles is authorized. The background colour shall be blue with white border.

Table 4.2: Clearances with respect to carriageway

1. Section with shoulders and verges	2-3 m lateral clearance of nearest point of sign plate from carriageway edge.
	1.5 m vertical clearance of the lowest point of the sign plate from the crown of the carriageway.
2. Section with footpath or separator	0.6 m lateral clearance of the lowest point of the sign plate from kerb edge.
	2.0 m vertical clearance of the lowest point of the sign plate from top of footpath/separator.

Care would have to be taken in selecting locations of signs posts, particularly in urban stretches, that the sign post is not lost amidst other sign or advertising posts, and the siting distances will be adjusted for better visibility.

4.2.2 Road Markings

It will be essential to provide suitable carriageway markings for conveying to traffic on roads warning, a requirement or information of the descriptions necessary for smooth and hazard-free movement. These are provided also to ensure safety and orderly use of the carriageway in accordance with traffic regulations, to define lanes and guide/regulate vehicles at junction and to complement the traffic signs. IRC standards have been followed in general.

The carriageway markings as suggested should be simple, clear to purpose and type, hard wearing and skid resistant in both dry and wet weather conditions.

Provisions have been made for Road Marking on the entire length of the project road which, inter alia, includes centre line, carriageway edge-lines, lane line, pedestrian crossings etc.

Hot applied thermoplastic Materials (Superimposed Type) has been proposed for road marking purpose to be applied with the help of marking machines after trials.

Carriageway Edge Line

Carriageway Edge lines are specifically required to define edges of the carriageway wherever there are paved shoulders or slow/parking lanes. Carriageway edge lines recommended are 150mm wide, white in colour and continuous along both sides of the carriageway except at junctions where a broken edge line is used to provide continuity in case of minor junctions and discontinued across major ones. Edge lines have also been provided around directional traffic islands and rotary islands.

Centre Lines

The Centre Line has been suggested to be 100mm wide in broken or continuous-single or twin lines depending upon the zonal restriction requirements as mentioned below:

- Broken single line will indicate that crossing centre-line is not hazardous and permitted to do so with adequate caution. This type has been normally provided in rural straight stretches of 2-lane roads.
- Continuous single line provided at all sharp curves and on all bridge structures, will indicate crossing is permitted only for right turning vehicles.

Other Markings

Other markings such as Directional Arrows, Chevron and Diagonal markings, Lane markings, Pedestrian crossing, Zebra Control areas and other related signs required for smooth operation of traffic have been provided in accordance with IRC standard code of practice (IRC 35-2015) or as per other recommendations.

4.3 Street Lighting

Adequate lighting is important for safe operation and making proper manoeuvres at those locations where the road passes through urban stretches. At such locations due to higher share of local traffic, slow traffic and large pedestrian movement, the drivers need to take correct decisions avoiding sudden braking and swerving. Need for adequate street lighting exists at such urban locations along the project corridor. However, electric light posts have already been provided locally in these urban stretches which would be suitably relocated.

4.4 Other Appurtenances

4.4.1 Guard Posts

Standard Guard posts made of M 20 grade concrete resting on M15 Grade concrete foundation have been proposed on approaches to structure, high embankment area where height of embankment is more than 3m and in sharp curve locations. These guard stones shall be painted with alternate black and white stripes and placed at intervals of 1.5m with an offset of 2m from carriageway edge.

4.4.2 5th Kilometre, Kilometre and 200m stones

These have been proposed as per the required provision in IRC 8-1980 and IRC 26-1967 and as per standard practice in the country. These should be made of precast concrete and lettering/numbering shall be as per IRC codes mentioned above.

4.4.3 Roadside Safety Barriers

There are two types of safety barriers viz. longitudinal road side safety barriers and median safety barriers. There are broadly three types of longitudinal road side safety barriers. These safety barriers will be provided on embankment height more than 3 m, sharp curves, approaches of bridges, cut slopes etc.,

4.4.4 Delineators

Delineators provide visual assistance to drivers about the alignment of road ahead, particularly at night. This is particularly useful at curves.

Two types of delineators have been proposed on the project road, namely:

- Triangular red reflectors as object markers provided at the heads of medians and directional islands

- Circular red reflectors fixed on guard posts at prescribed spacing to delineate the alignment in sharp curves and high embankments.

The guidelines of IRC: 79-2019 have been followed in selecting the types and locations.

CHAPTER – 5

PAVEMENT DESIGN

5.1 Introduction

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favourable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the subgrade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This chapter provides the detail design of flexible pavement as this pavement type is being used in the whole stretch of project road except at the toll plaza location where rigid pavement type for just 750 metre is being primarily used. Improper design of pavements leads to early failure of pavements affecting the riding quality.

The project road will be provided with paved shoulders, and it has been proposed that these will be constructed as per IRC specification.

5.2 Pavement Design Objective

Pavement is the most significant component of a road and therefore its design strengths must be assured to support the projected traffic loading throughout the design period. The objective is to determine the total thickness of the pavement structure as well as thickness of individual structural layer components. Design strength of pavement must be adequate to support the projected traffic loading throughout the operation period.

For the project, pavement design is required for the following cases:

- Pavement for new carriageway.

The Consultant has worked out the designs for the above case based on result of survey/investigations regarding traffic, axle load spectra, pavement condition and strength, sub-grade/material properties etc.

As mentioned in TOR, the overlay as well as new pavement has been designed primarily as per IRC guidelines.

5.3 General Design Guidelines

A. New pavements shall be designed in accordance with IRC: 37-2018, IRC:58-2015 or any other international standard method/guidelines, subject to the condition that the overall pavement composition shall not be less than the minimum requirement specified in IRC standards.

B. Clause 5.3, IRC: SP. 73-2018 and IRC: SP. 84-2019 states that "Flexible pavement shall be designed in accordance with IRC: 37-2018 – "Guidelines for the Design of flexible Pavements". Strengthening of existing pavement shall be designed based on procedure outlined in IRC: 81-1997. Rigid Pavement shall be designed in accordance with the method prescribed in IRC: 58-2015. "Guidelines for the Design of Plain Jointed Rigid Pavements for Highways"

- Clause 5.4.1 and 5.4.2 of IRC: SP: 73-2018 and IRC: SP. 84-2019, states that "Flexible pavement shall be designed for a minimum design period of 15 years, subjected to the condition that design traffic shall not be less than 20 MSA. Stage construction shall not be permissible. Rigid Pavements shall be designed for a minimum design period of 30 years. The stage construction shall not be permitted.

C. The whole pavement design concept has been divided into two parts:

- Flexible pavement design for new two-lane carriageway.
- Future overlays to be provided (after 10, 15 & 20 years) by component analysis method using the residual strength of the pavement material.

5.4 Pavement Composition

As per the guidelines of IRC: 37-2018, five different combinations of layers of pavement options are available for classified traffic and various material properties. The combinations contain layers of sub base, base, binder and surface courses.

Each combination of layers has been suggested for different environmental conditions and traffic. A flexible Pavement covered in these guidelines consist of different layers as shown in fig. below-

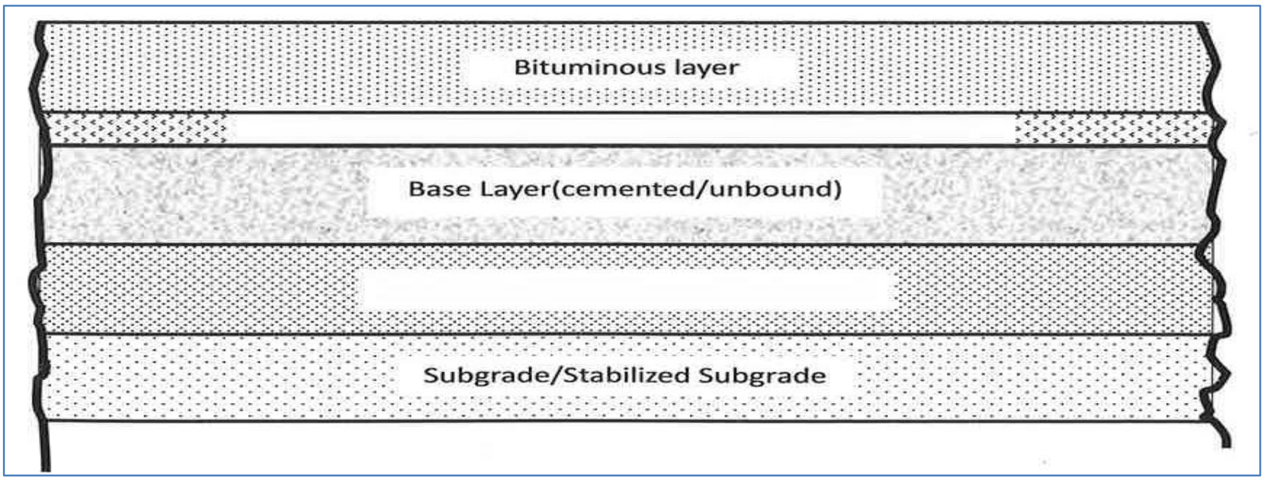


Fig 5.1: Flexible Pavement Layers

The Sub-base and the base layer can be unbound (e.g. granular) or chemical stabilized with stabilizer such as cement, lime, fly ash and others Cementous stabilizer. Flexible Pavement with unbound Sub-base and base layer has been proposed here to adopt in the project.

5.4.1 Bituminous Pavement with Unbound Base and Sub Base Layer

5.4.1.1 Sub-base Layer- Unbound

The sub-base material may consist of granular material or as confirming to MORTH specification for Road and Bridge Works. The sub-base should have enough strength and thickness to serve the construction traffic.

5.4.1.2 Base layer- Unbound

The base layer may consist of wet mix macadam, water bound macadam, crusher run macadam etc. Relevant specification of IRC/ MORTH are to be adopted for the construction.

5.4.1.3 Bituminous Layers

Bituminous layers consist of Dense Bituminous macadam and Bituminous Concrete which thickness varying as per design stipulation.

5.5 Recommended Pavement Option

5.5.1 Flexible Pavement:

Design of flexible pavement applies to the new carriageway. The new pavements have been designed following guidelines of IRC: 37-2018.

5.5.2 Rigid Pavement:

No rigid pavement is proposed in the main project stretch except at Toll Plaza location where provision of rigid pavement is must. Toll Plaza starts from Des. Ch. 20+300 to Des. Ch. 20+640. Total length of toll plaza is 340 m.

5.6 Parameters for Design

5.6.1 Design Life

The design life adopted in the analysis is 20 years for flexible pavement.

5.6.2 Traffic Homogenous Sections

The following stretch has been adopted for traffic homogenous sections:

- Khanabal Jn – Mattan Jn
- Mattan Jn – Chandanwadi Jn

5.6.3 No. of Lanes for Proposed Carriageway

The Packagewise sections as mentioned above will be designed and constructed as following:

- Package IA (Near Sursunoo to End of Seer Hamdan Bypass): 4-Lane road.
- Package 2 (Seer Hamdan to Start of Pahalgam Bypass): 4-Lane road.

5.7 Functional and Structural Overlay

The requirement of structural and functional overlays is discussed in the following sections.

5.7.1 Functional Overlay

It may be noted that due to the high ambient temperature as a result of exposure to sun, the bitumen from top surface of the BC layer of pavement gets gradually oxidized with passage of time. Rain also causes the stripping of bitumen from the pavement surface gradually. The process of oxidation and stripping makes the top BC layer of the pavement bitumen hungry, which may lead to ravelling, potholes & other defects in the pavement, thereby affecting the function of the pavement in the form of poor riding quality.

It is proposed that during the design life period, functional overlay will be provided on the pavement after every 5 years (approx.) from the date of the opening of road to traffic. Minimum 25 mm SDBC functional overlay must be provided for the case of no requirement of structural overlay. The pavement will be provided with 25 mm thick functional SDBC surfacing.

5.7.2 Structural Overlay

If the pavement is not strengthened before the expiry of its design life (15 years) for the future traffic loading, then the underlying layers of the pavement will be overstressed. The over stressing of pavement layers including sub grade will damage the physical condition of the pavement in the form of occurrence of cracks, faulting, ravelling, rutting or other conditions, which would affect the load carrying capabilities of the pavement structures.

So, in order to ensure the desired level of structural strength and riding quality of the pavement after the expiry of design life, it is essential to provide a structural overlay on the pavement as a part of rehabilitation.

Since there is no IRC design standards/methodology/manual for the design of future overlay on the pavement beyond its design life, the future structural overlay design has been carried out by Component Analysis Method described in AASHTO Guide for Design of Pavement Structures 1993. Since, it is difficult to assess the deflection values at the design life of 10, 15 and 20 years, whereas the structural coefficients can be assessed to a fair degree of reliability. Therefore, the component analysis method has been used.

5.8 Preliminary Investigation

5.8.1 TRAFFIC

5.8.1.1 Commercial Vehicles:

The base year traffic has been assessed by carrying out traffic surveys at Location – Near Mattan, and Near Ganeshpora. For pavement design purpose, commercial vehicles of laden weight more than 8 tonnes have been considered.

Such vehicles consisted of buses, LCVs, 2 Axle trucks, 3 Axle trucks and 4 Axle trucks. The summary of AADT (No.) of commercial vehicles is given in Table below:

Table 5.1: Traffic Data

Existing Chainage	Location	Total Commercial Vehicles
6+500	Near Mattan	1070
26+200	Near Ganeshpora	587

5.8.1.2 VDF:

VDF has been calculated on the basis of Axle Load Survey carried on various types of vehicles.

The summary of the Calculated VDF location wise is shown in below table:

Table 5.2: Summary of VDF

	Summary	LCV	Bus	2-Axle	3 Axle	MAV
Near Mattan	Average V.D.F (Direction Up+Down)	0.351	0.142	2.224	1.307	1.286
Near Ganeshpora		0.355	0.136	2.640	0.649	-

5.8.1.3 Cumulative Million Standard Axle:

Based on the commercial vehicles per day (CVPD) for the project road and VDF, Cumulative Million Standard Axle of the Project Road has been calculated with a growth rate of 5.0% for 20 years design period time. The Calculation of the MSA is as follows:

Table 5.3: Summary of MSA

Location	MSA	
	Calculated MSA	Adopted Design MSA as per IRC:37-2018
Near Mattan	5.28	20
Near Ganeshpora	2.08	20

5.9 Design CBR:

For new constructions, the soil support value pertains to the strength of the subgrade in terms of CBR. Materials from borrow areas will be used for constructing the subgrade, and accordingly, the engineering characteristics of these materials are relevant. For this purpose, as a part of the soils and materials survey, the Consultants have identified possible borrow areas all along the project road and have carried out laboratory tests on representative samples from these, including 4-day soaked CBR on specimens compacted at 97% MDD (heavy compaction). Besides these, suitable material available from roadway excavation for widening the road formation may be also used, subject to fulfilment of requirement of the soil parameters.

During the material investigations survey carried out on the project road site, it is found that the existing ground CBR value as per DCP test lies between from 8 % to 10.0 % and as per soil investigation in laboratory the CBR value lies between from 8.0 % to 9.0 %.

Although 8% of CBR value at majority of locations were found. Hence, keeping in view the availability of material within the permissible leads, for the safety measures and on conservative basis of design, the CBR value of 8 % has considered for the Pavement design for different homogeneous sections.

5.10 Design of Flexible Pavement by IRC Method

5.10.1 Pavement Model

The flexible pavement is modelled as an elastic multilayer structure. Stresses and strains at critical locations (fig. showing below) are computed using linear layered elastic model. The stress - strain analysis software IITPAVE has been used for the computation of stress and strain in flexible pavements as mentioned below.

i. Tensile Strain ($€_t$) at bottom of bituminous layer, which can cause cracking in the bituminous layer.

ii. And Vertical Compressive Strain ($€_v$) at the top of sub grade, which can cause rutting failure of pavement layers.

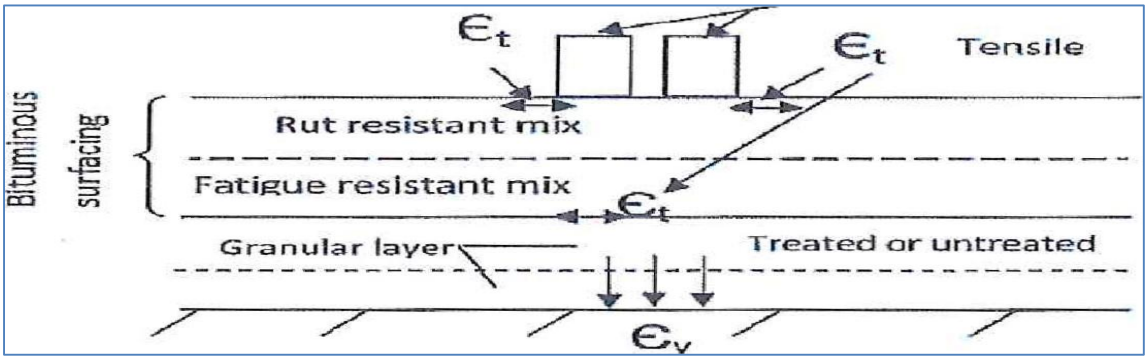


Fig 5.2: Pavement Model

5.10.2 Fatigue in Bottom Layer of Bituminous Pavement and Fatigue Life

With every load repetition, the tensile strain developed at the bottom of the bituminous layer develops micro cracks, which go on widening and expanding till the load repetitions are large enough for the cracks to propagate to the surface over an area of the surface that is unacceptable from the point of view of long-term serviceability of the pavement. The phenomenon is called fatigue of the bituminous layer and the number of load repetitions in terms of standard axles that causes fatigue denotes the fatigue life of the pavement.

Fatigue Model- Fatigue model has been calibrated in the R-56 (54) studies using the pavement performance data collected during the R-6 (57) and R-19 (58) studies sponsored by MORTH. Two fatigue equations were fitted, one in which the computed strains in 80 per cent of the actual data in the scatter plot were higher than the limiting strains predicted by the model (and termed as 80 per cent reliability level in these guidelines) and the other corresponding to 90 per cent reliability level. The two equations for the conventional bituminous mixes designed by Marshall Method are given below-

$N_f = 1.6064 * C * 10^{-04} \times [1/€_t]^{3.89} * [1/M_{Rm}]^{0.854}$ ………. (80 percent reliability)

$N_f = 0.5161 * C * 10^{-04} \times [1/€_t]^{3.89} * [1/M_{Rm}]^{0.854}$ ……….. (90 percent reliability)

Where,

$C = 10^M$, and $M = 4.84 \{[V_{be}/(V_a + V_{be})] - 0.69\}$

V_a = percent volume of air void in the mix used in the bottom bituminous layer;

V_{be} = per cent volume of effective bitumen in the mix used in the bottom bituminous layer;

N_f = fatigue life in number of standard axis;

$€_t$ = Maximum tensile strain at the bottom of the bituminous layer;

M_R = Resilient modulus of the bituminous layer.

The flexible pavement has low flexural strength and hence layers reflect the deformation of the lower layers/subgrade on to the surface layer after the withdrawal of wheel load. To control the deflections in the subgrade so that no permanent deflections results the pavement thickness is so designed that the stresses on the sub grade soil are kept within its bearing power. Loading of bituminous pavement requires the stiffest layers to be placed at the surface with successive weaker layers down to sub grade.

For structural design, only the number of commercial vehicles of laden weight of 8 tonnes or more and their axle loading will be considered.

5.11 Sub Base Layer

The sub-base layer serves three functions like to protect the sub-grade from over stressing, to provide a platform for the construction traffic and to serve as drainage and filter layer.

5.11.1 Unbound Sub-Base Layer:

Material passing through 0.425mm (425 micron), LL & PI shall not more than 25 and 6 %. Material shall have a minimum 10% fines value of 50 KN when tested in compliance with BS:812. The water absorption value (as per IS 2386) of the coarse aggregate shall be less than 2%, if not soundness test shall be carried out as per IS 383. 100% sample should pass through 75mm sieve and only 3-10% sample should pass through 0.075mm sieve for all the three grades. When coarse graded sub base is used as a drainage layer, Loss Angels abrasion value should be less than 40, so that there is no crushing during the rolling and the permeability is retained. The sub-base should be composed of two layers, the lower layer forms the separation/filter layer to prevent intrusion of sub grade soil into the pavement and upper layer forms the drainage layer to drain away any water that may enter through surface cracks.

Strength Parameter: Resilient Modulus (M_{Rgsb})

$M_{Rgsb} = 0.2 \text{ X } h^{(0.45)} \text{ X } M_{R\ subgrade}$, where h is thickness of subbase layer in mm.

MR value of subbase is dependent on MR value of subgrade since weaker subgrade does not permit higher modulus of the upper layer because of deformation under loads.

$M_{R\ subgrade} = 10 \text{ X CBR}$ if Subgrade CBR is <=5

$M_{R\ subgrade} = 17.6 \text{ X } (CBR)^{0.64}$ if subgrade CBR is >5

5.12 Base Layer:

5.12.1 Unbound Base Layer:

Base layer consists of WMM, WBM, Crusher run macadam, reclaimed concrete etc. Relevant specifications of IRC/MORTH are to be adopted for the construction.

When both sub-base and base layers are made up of unbound granular layers, the composite resilient modulus of the granular subbase and base are as follows:

$M_{R\ granular} = 0.2 \text{ X } h^{0.45} \text{ X } M_{R\ subgrade}$,

where 'h' is combined thickness of subbase and base layers in mm.

Poisson's ration of granular bases and sub-base is recommended as 0.35.

5.13 Bituminous Layers (Binder and Surface)

Binder layer consists of DBM and BM are to be adopted for construction. It is act like as load distribution and supporting layer.

Surface layer consists of BC, SDBC and PC are to be adopted for construction.

Strength Parameter: Resilient Modulus (MRBC/DBM)

The strength of bituminous mix based on extensive laboratory testing of Resilient Modulus Test. Based on the study data of India, IRC: 37-2018 recommended resilient modulus (in MPa) for different mix types and temperatures are given below.

Table 5.4: Recommended resilient modulus (in MPa)

Mix Type	Temperature ^{0}C				
	20	25	30	35	40
BC and DBM for VG 1O bitumen	2300	2000	1450	1000	800
BC and DBM for VG30 bitumen	3500	3000	2500	1700	1250
BC and DBM for VG 40 bitumen	6000	5000	4000	3000	2000
BC and DBM for Modified bitumen	5700	3800	2400	1650	1300
BM with VG 1O bitumen	500 MPa at 35^0 C				
BM with VG 30 bitumen	700 MPa at 35^0 C				
WMM/RAP treated with 3 percent bitumen emulsion/foamed bitumen	600 MPa at 35^0 C (laboratory values vary from 600 to 1200 MPa for water saturated samples				

5.14 Pavement design as per IRC 37:2018:

Pavement design is carried out in accordance with IRC: 37:2018 for the following base and sub-base options.

- Unbound - Granular base and sub-base

Table – 5.5: Inputs for the Pavement Design

Design Inputs	Total Construction
Design Life	20 years
Design MSA	100
Design CBR	8 %

5.15 Methodology for Pavement Sections with Design CBR of 8 %

Pavement design procedures for the total stretch were accomplished using the principles of mechanistic design and were in general accordance with the postulates of IRC: 37-2018. The IITPAVE software was used for this evaluation.

The allowable strains in pavement layers were calculated in terms of two primary pavement distress criteria: fatigue cracking and rutting. The actual strains arising in the pavement layers due to traffic loading were then calculated, assuming suitable thickness values for different pavement layers. The assumed pavement crust was deemed to be safe for the design loads if the actual strains were less that the allowable strains.

5.15.1 Allowable Strains in the Pavement Structure

The allowable strains in the pavement layers were calculated primarily based on two pavement distress criteria: fatigue cracking and rotting. The distress of fatigue cracking is more critical in the bituminous layer in the pavement crust. This type of cracking is usually initiated at the bottom of the bituminous layer after repeated application of the axle loads. This initiation means that the actual horizontal tensile strain at the bottom of the bituminous layer has exceeded a certain limit, which is the allowable strain.

The allowable tensile strains were calculated using the fatigue criteria equation as outlined in the Appendix I of IRC: 37-2018. The equation is as follows.

$N_f = 1.6064 * C * 10^{-04} \times [1/€t]^{3.89} * [1/M_{Rm}]^{0.854}$ ……… (80 percent reliability)

$N_f = 0.5161 * C * 10^{-04} \times [1/€t]^{3.89} * [1/M_{Rm}]^{0.854}$ ………. (90 percent reliability)

Equation No. 1 is recommended for use for traffic up to 20 MSA where normal bituminous mixes with VG

10 bitumen can be used.

The distress of rutting is more critical in the subgrade under the pavement crust. This type of cracking is usually initiated at the top of the subgrade layer after repeated application of the axle loads. This initiation means that the actual vertical compressive strain at the top of the subgrade layer has exceeded a certain limit, which is the allowable strain.

The allowable compressive strains were calculated using the rutting criteria equation as outlined in the Appendix I of IRC:37-2018. The equation is as follows.

$N_r = 4.1656 X 10^{-8} X (1/E_z)^{4.5337}$-----------3 (80% Reliability)

$N_r = 1.41 X 10^{-8} X (1/E_z)^{4.5337}$---------------4 (90% Reliability)

N_r = Number of cumulative standard axles to produce 20 mm rutting.

E_z = Maximum Vertical subgrade strain (micro strain)

Equation No. 3 is recommended for use for traffic up to 20 MSA where normal bituminous mixes with VG 10 bitumen can be used.

5.15.2 Actual Strains in the Pavement Structure

The actual tensile strains were calculated using the various pavement design parameters as inputs in the IITPAVE programs. The actual strains are computed using various trial pavement structural layer combinations.

The average temperature are noted as 200 C in the project area respectively. An average pavement temperature of 200 C has been considered for pavement design and selection of modulus of bitumen.

The tyre pressure used in the analysis was 0.56 MPa (560 K.pa). Standard axle used was dual type, having a mass of 8160 kg. This resulted in a single tyre load of 20,000 N. The Poisson's ratio of bituminous layer, granular layer and sub-grade layers is taken as 0.35.

The pavement layer thickness is derived for the traffic volume of 20 MSA corresponding to 8 % CBR, the pavement crust thickness is tabulated below according to IRC: 37 - 2018.

Table- 5.6: Pavement structural Analysis with 8 % CBR & 20 MSA as per IITPAVE

CBR	MSA	Elastic Modulus			Thickness (mm)					Actual strain (micro)	Allowable strain (micro)	Actual Strains (micro)	Allowable Strains (micro)
		sub-grade	GSB/ WMM	BT layers	BC	DBM	WMM	GSB	Sub Grade	Tensile Strain	Tensile Strain	Vertical Strain	Vertical Strain
8%	20	66.6	208.19	2300	30	90	250	200	500	**246**	**257**	**373**	**454**

Verification of Adequacy of thickness of Layers as per IRC: 37-2018					
Sr. No.	**Description**		**Units**	**Values**	**Clause**
1	Design Period		Year	20	Cl. 4.3
2	Design MSA		MSA	20.00	
3	Effective CBR		%	8.00	
4	Pavement Thickness				Plate 4 (Annexure 1)
	BC		mm	30.00	
	DBM		mm	90.00	
	WMM		mm	250.00	
	GSB		mm	200.00	
5	Resilient Modulus of Subgrade $M_{R\ Subgrade}$ = 10 *CBR < 5 % $M_{R\ Subgrade}$ = 17.6 * $(CBR)^{0.64}$ for CBR > 5 %		MPa	66.60	Cl. 6.3
6	Elastic Modulus of granular layers ($M_{R\ granular} = 0.2 * h^{0.45} * M_{R\ Subgrade}$)		MPa	208.19	Cl. 7.2.3
7	Poisson's ratio for Subgrade		-	0.35	Cl. 6.3
8	Poisson's ratio for granular layer		-	0.35	Cl 7.2.3
9	Poisson's ratio for bituminous layer		-	0.35	Cl. 9.2
10	Bitumen Grade (Adopted)		-	VG 10	Cl. 9.1
11	Pavement Temperature (Mean temperature)		ºC	20.00	Cl. 9.2
12	Resilient Modulus of Bituminous layers		MPa	2300.00	Table 9.2
13	Fatigue & Rutting Strain				
13.1	Allowable Strains :				
(a)	Fatigue, $N_f = 1.6064 * C * 10^{-04} \times [1/€t]^{3.89} * [1/M_{Rm}]^{0.854}$		80% Reliability		Cl.3.6.2
	Fatigue, $N_f = 0.5161 * C * 10^{-04} \times [1/€t]^{3.89} * [1/M_{Rm}]^{0.854}$		90% Reliability	Adopt	Cl.3.6.2
	N_f = Fatigue Life in no. of Std. Axle		Std. Axle	2.0E+07	
	Vbe		%	11.500	Cl. 12.3
	Va		%	3.000	Cl. 9.2
	M = $4.84[V_{be}/(V_a+V_{be})-0.69]$		-	0.499	
	C = 10^M		-	3.155	
	Allowable Fatigue Strain (€t)		µ	**257.788**	
(b)	Rutting, N = 4.1656 x 10-08 [1/€v] 4.5338		80% Reliability		Cl.3.6.1
	Rutting, N = 1.4100 x 10-08 [1/€v] 4.5337		90% Reliability	Adopt	Cl.3.6.1
	Allowable Rutting Strain (€v)		µ	**454.945**	
13.2	Actual Strains generated by IIT PAVE				

Verification of Adequacy of thickness of Layers as per IRC: 37-2018				
Sr. No.	**Description**	**Units**	**Values**	**Clause**
(a)	Fatigue Strain (€t)	µ	246.200	Safe
(b)	Rutting Strain (€v)	µ	373.200	Safe

5.15.3 Recommended Pavement Crust Composition

The traffic volume of 20 MSA and 8 % respectively of CBR being considered as per the availability of material, the actual strains are less than the allowable strains hence the Pavement Design is safe.

Table- 5.8: Recommended Pavement Composition

Package	Design Chainage		CBR	MSA	Crust in mm				Sub-Grade	Total Thickness
	From	To	%		BC	DBM	WMM	GSB	in mm	
Package (IA)	00+000	16+700	8	20	30	90	250	200	500	**1070**
Package (2)	16+700	39+450	8	20	30	90	250	200	500	**1070**

5.16 Conclusions

Recommendations for Pavement Design:

- The flexible pavement has been designed for design life of 20 years and projected traffic.
- The sub base and base courses are designed for 20 years with 20 MSA projected traffic and design CBR of 8 %.

Annexure 4: Pavement Composition

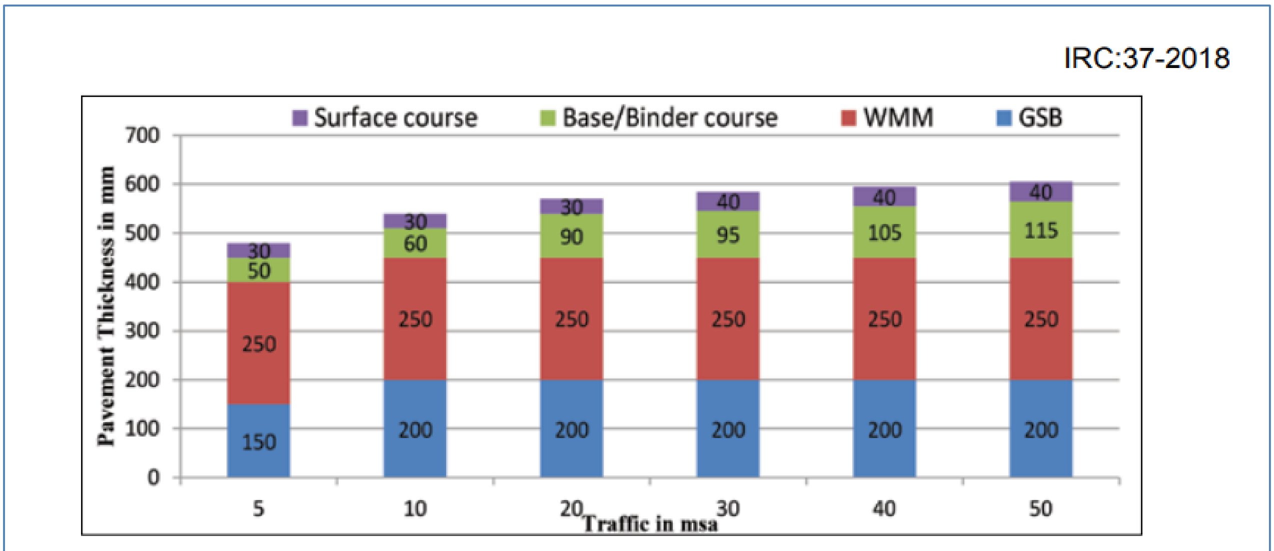


Fig. 12.4 Catalogue for Pavement with Bituminous Surface Course with Granular Base and Sub-base - Effective CBR 8% (Plate-4)

Figure- 01: Pavement Composition

Annexure II: IIT Pave Result for Above Assumed Thickness

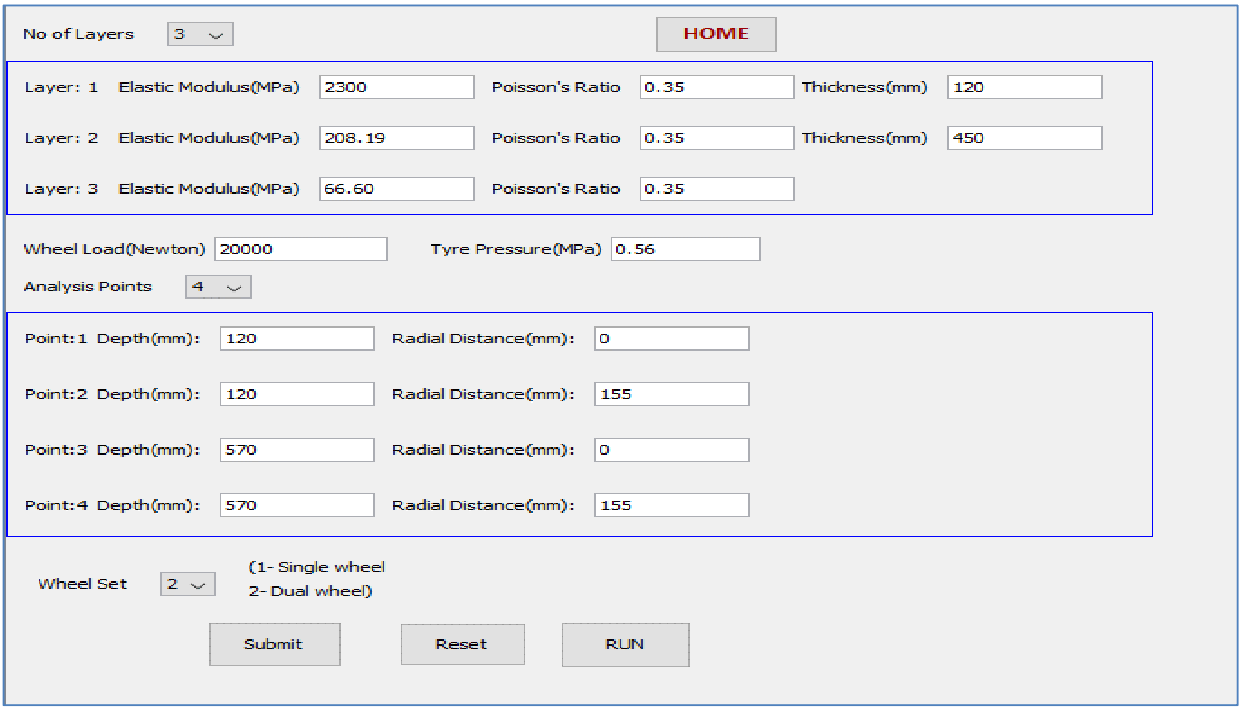


Figure- 02: Input to IITPAVE Software

```
No. of layers              3
E values (MPa)        2300.00  208.19   66.60
Mu values                0.350.350.35
thicknesses (mm)       120.00  450.00
single wheel load (N) 20000.00
tyre pressure (MPa)       0.56
Dual  Wheel
  Z        R      SigmaZ      SigmaT      SigmaR      TaoRZ      DispZ      epZ        epT        epR
120.00    0.00-0.1544E+00 0.7344E+00 0.5843E+00-0.1812E-01 0.4556E+00-0.2678E-03 0.2539E-03 0.1658E-03
120.00L   0.00-0.1544E+00-0.9154E-02-0.2274E-01-0.1812E-01 0.4556E+00-0.6881E-03 0.2539E-03 0.1658E-03
120.00  155.00-0.1259E+00 0.5787E+00 0.1613E+00-0.7074E-01 0.4655E+00-0.1674E-03 0.2462E-03 0.1220E-05
120.00L 155.00-0.1259E+00-0.9288E-02-0.4707E-01-0.7074E-01 0.4655E+00-0.5102E-03 0.2462E-03 0.1220E-05
570.00    0.00-0.2193E-01 0.3197E-01 0.2759E-01-0.3679E-02 0.3093E+00-0.2055E-03 0.1440E-03 0.1157E-03
570.00L   0.00-0.2206E-01 0.2112E-02 0.7030E-03-0.3677E-02 0.3094E+00-0.3460E-03 0.1439E-03 0.1154E-03
570.00  155.00-0.2360E-01 0.3412E-01 0.3112E-01-0.4937E-02 0.3178E+00-0.2231E-03 0.1513E-03 0.1318E-03
570.00L 155.00-0.2360E-01 0.2275E-02 0.1309E-02-0.4957E-02 0.3178E+00-0.3732E-03 0.1513E-03 0.1317E-03
```

Figure- 03: Output from IITPAVE Software