

**National Highways & Infrastructure Development Corporation Limited**

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



**Construction and Upgradation of existing road to 2-lane with paved shoulder from Km 399.000 to Km. 430.000 of Karanpyarag to Chamoli (Excluding Km 420.250 to Km 420.500 and km 423.300 to km 423.650) of NH-07 under Chardham Pariyojna on EPC basis in the state of Uttarakhand. (Pkg-II)**

**Detailed Project Report (DPR)**

**January, 2018**

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## EXECUTIVE SUMMARY

### E.1 Introduction

The President of India acting through Ministry of road transport and highway (MORTH), represented by the Director General & special secretary is engaged in the development of national highway and as a part of this in the state of Uttarakhand, various roads has been selected for strengthening & widening purpose. All these roads are divided in seven packages and bided for detail study. These seven packages are as under.

- (i) Km 228.00 (Rishikesh) to Km 368.00 (Rudraprayag) of NH-58
- (ii) Km 368.00 (Rudraprayag) to Km 528.00 (Mana Village) of NH-58
- (iii) Km 0.00 (Rishikesh) to Km 144.00 (Dharasu) of NH-94
- (iv) Km 0.00 (Dharasu) to Km 124.00 (Gangotri) of NH-108
- (v) Km 144.00 (Dharasu) to Km 220.00 (Yamunotri) of NH-94
- (vi) Km 0.00 (Rishikesh) to Km 76.00 (Gaurikund) of NH-109
- (vii) Km 52.00 (Tanakpur) to Km 202.00 (Pithoragarh) of NH-125

MORTH has awarded package II to Casta Engineering Pvt. Ltd. In JV with Byucksan India Pvt. Ltd as project preparation consultant wide agreement dated for 13 Jan 2014.

### Sub-packaging

The design length of project road is 136.8 km and is divided in five packages. Its packaging is done as per the priority of the ground. Detail of which is tabulated in the **table 1.1 as under**.

**Table 1.1: Divided into five packages**

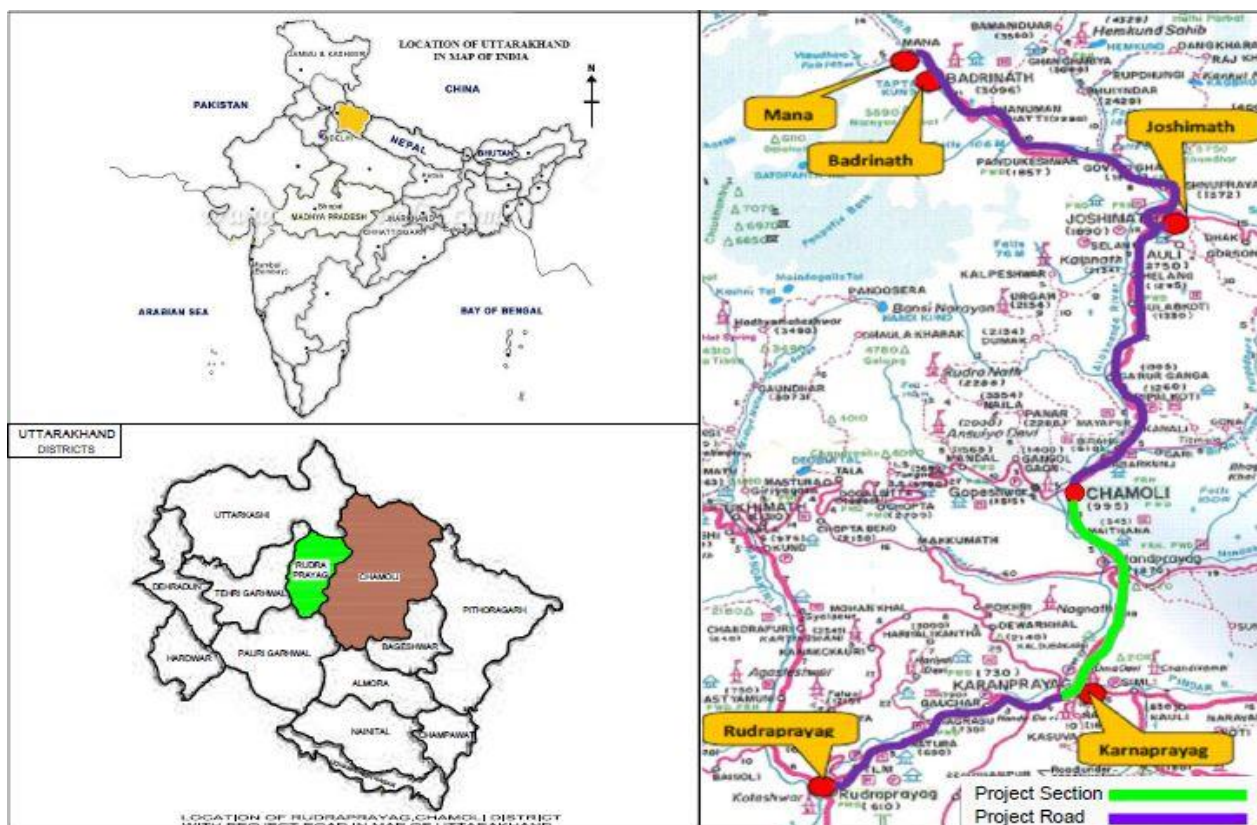
Pkg no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (in km)
1	Km 368.000-Km 399.000	Km 368.000-Km 398.300	Lameri-Karanprayag	Widening to 2-lane+ Geometric Imp+R.S	29.125
2	Km 399.000-Km 430.000	Km 398.300-Km 427.650	Karanprayg-Chamoli	Widening to 2-lane+ Geometric Imp+R.S	28.800
3	Km 430.000-468.000	Km 427.650-Km 465.150	Chamoli-Paini	Widening to 2-lane+ Geometric Imp+R.S	36.675
4	Km 468.000-Km 489.350	Km 465.150-Km 471.400	Joshimath Bypass	New Alignment	6.250

Pkg no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (in km)
5a	Km 489.350- Km 491.600	Km 471.400- Km 473.675	Shingdhar Bridge to Vishnuprayag bridge including Hatipahar landslide	Widening to 2-lane with Paved Shoulder	2.275
5b	Km 491.600- Km 504.600	Km 473.675- Km 486.100	Vishnuprayag bridge to lambagadh	Widening to 2-lane+ Geometric Imp+R.S	12.425
-	Km 504.600-km 505.100	Km 486.100- km486.600	Lambagadh Land Slide	Awarded	500
5c	Km 505.100- Km 509.700	Km 486.600- Km 490.550	Lambagadh to Benakuli including Benakuli landslide	Widening to 2-lane+ Lambagadh Landslide	3.950
5d	Km 509.700- Km 528.000	Km 490.550- Km 507.850	Benakuli Bend to Mana	Widening to 2-lane+ Geometric Imp+R.S	17.300

This report pertains to Sub-Package-II the Design length of the road in this package is 28.8 km i.e from km 398.300 to km 427.650 (Excluding Km 420.250 to Km 420.500 and Km 423.300 to km 423.650) in the state of Uttarakhand.

## E.2 Project road

The project lies in the north-eastern part of Uttarakhand and is a part of Char Dham Yatra. It's the only connecting road to Badrinath Dham. The Project road passes through two districts of Uttarakhand namely, Rudraprayag & Chamoli. These districts are in the Garhwal division of State. The location of project road is shown in **Fig. 1.1** below:



**Fig. 1.1 Alignment Map**

This report pertains to Sub-Package-II the Design length of the road in this package is 28.8 Km i.e from Km 398.300 to Km 427.650 (Excluding Km 420.250 to Km 420.500 and Km 423.300 to km 423.650) in the state of Uttarakhand.

### E.3 Project Terrain

The terrain along the project road has been identified as per method suggested by IRC SP 48:1998 (Hill Road Manual) in **table 1.3** below:

**Table 1.3: Terrain classification**

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

As per above condition this section of road comes under steep terrain having cross slope more than 60%

### E.4 Land use

The land use along the project road is mainly Forest or barren except in some reaches where habitation with commercial establishments in built up areas is existing.

## E.5 Right Of Way

ROW could not be obtained from the Department as they are not having these details with them .As per reconnaissance survey the ROW available is 7 to 18 m. But in dense areas it is even less than this due to encroachments.

## E.6 Pavement

The present road is single lane with variable width due to extra widening on the deficient curves. The thickness and composition of the pavement crust is given the **table 1.4** below:

**Table 1.4 Thickness and composition of the pavement crust**

S No	Pavement composition	Min. Thickness (mm)
1	Bituminous Concrete	40
2	DBM	90
3	WMM	250
4	Granular Sub Base	260

## E.7 Horizontal Alignment

Generally the horizontal alignment of the project section is poor with number of deficient curves and hair pin curves.

## E.8 Vertical Alignment

The vertical gradient of the project varies from 0.5% to 12.0%.

## E.9 Traffic Survey and Analysis

The survey schedule and survey was conducted at locations presented in **Table 1.5** below:

**Table 1.5 Type of Traffic Surveys and its Locations**

Type of Survey	Duration	Location	Chainage (Km)
Classified Traffic Volume Count Survey	7 Days	VillageRatura	374.000
		Village Dhungwali	410.000
		Village Maithana	425.500
		Village Agthala	444.000
		Village Pandukehwar	501.000
O D Survey	24 Hrs	VillageRatura	374.000
		Village Dhungwali	410.000
		Village Maithana	425.500
		Village Agthala	444.000
		Village Pandukehwar	501.000
Speed & Delay Survey	-	Project Road Length	368.000 to 528.000
Turning Movement Survey	8 Hours	Karanprayag, Leads to Almora	398.600
		Karnprayag (Leads to Ranikhet)	399.000
		Nandprayag (Leads to Ghat)	418.800

Type of Survey	Duration	Location	Chainage (Km)
Pedestrian Traffic Count	8 Hours	Chamoli (Leads to Gopeshwar – SH- 36)	430.800
		Joshimath (Leads to Auli)	478.800
		Gochar	389.000
		Karnprayag	399.000
		Nandprayag	418.000
		Chamoli	430.000
		Joshimath	480.000

**Table 1.6 Daily Variation of Traffic:**

Location	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7
<b>Village Ratura (Km 374.000)</b>							
Motorized Passenger Vehicle	2041	1929	1790	2208	1870	1952	1872
Motorised Goods Vehicle	340	337	381	381	374	366	355
Non-Motorized Vehicle	0	0	0	0	0	0	0
Total Vehicle	2381	2266	2171	2589	2244	2318	2227
<b>Total PCU</b>	<b>2990</b>	<b>2819</b>	<b>2806</b>	<b>3350</b>	<b>2904</b>	<b>3052</b>	<b>2546</b>
<b>Village Dhungwali (Km 410.000)</b>							
Motorized Passenger Vehicle	1863	1683	1915	2050	1949	2073	1860
Motorised Goods Vehicle	345	252	316	356	377	342	311
Non-Motorized Vehicle	0	0	0	0	0	0	0
Total Vehicle	2208	1935	2231	2406	2326	2415	2171
<b>Total PCU</b>	<b>2689</b>	<b>2206</b>	<b>2662</b>	<b>2991</b>	<b>2907</b>	<b>2981</b>	<b>2619</b>
<b>Village Mainatha (Km 425.000)</b>							
Motorized Passenger Vehicle	1431	1297	1440	1553	1511	1695	1656
Motorised Goods Vehicle	285	234	247	292	297	331	261
Non-Motorized Vehicle	0	0	0	0	0	0	0
Total Vehicle	1716	1531	1687	1845	1808	2026	1917
<b>Total PCU</b>	<b>2179</b>	<b>1890</b>	<b>2062</b>	<b>2306</b>	<b>2268</b>	<b>2592</b>	<b>2384</b>
<b>Village Agthala (Km 444.000)</b>							
Motorized Passenger Vehicle	1154	1244	1193	1524	1437	1384	1239
Motorised Goods Vehicle	208	249	188	231	252	229	218
Non-Motorized Vehicle	0	0	0	0	0	0	0
Total Vehicle	1362	1493	1381	1755	1689	1613	1457
<b>Total PCU</b>	<b>1674</b>	<b>1929</b>	<b>1681</b>	<b>2112</b>	<b>2095</b>	<b>2019</b>	<b>1866</b>
<b>Village Pandukeshwar (Km 501.000)</b>							
Motorized Passenger Vehicle	417	496	531	428	479	443	368
Motorised Goods Vehicle	0	21	12	18	13	21	19
Non-Motorized Vehicle	0	0	0	0	0	0	0
Total Vehicle	417	517	543	446	492	464	387
<b>Total PCU</b>	<b>428</b>	<b>550</b>	<b>569</b>	<b>476</b>	<b>510</b>	<b>492</b>	<b>404</b>

## Growth Rate

The traffic growth rate of all vehicles plying on the project road worked out from registered motor vehicles has been utilized to arrive at rational traffic projections. A comparative statement on the growth rates and proposed growth rate for the traffic loading on the project road is presented below in **table 1.7** below:

**Table 1.7 Growth Rate**

Vehicle Type/Year	Trend Based			Econometric Method		
	2014-2019	2019-2024	2024-2029	2014-2019	2019-2024	2024-2029
Car, Jeep, Vans etc	1.940	2.136	2.351	6.94	7.63	8.39
Motor cycle Scooters	1.420	1.523	1.635	7.98	8.78	9.66
LCV	1.000	1.050	1.105	5.96	6.56	7.22
Buses	1.000	1.050	1.105	5.30	5.83	6.41
2-Axle, Multi Axle Truck	0.300	0.305	0.310	5.96	6.56	7.22
Non-Motorised Vehicles	1.000	1.050	1.105	2.00	2.00	1.00

The above growth rates have been followed for traffic projection considering the following factors:

- The Indian economy as a whole is officially expected to enter a period of more rapid growth, owing largely to the progressive implementation of liberalization policies.
- A falling population growth rate, allowing a greater proportion of available savings to be deployed for the improvement of living standards.

In the short term the established shift towards 2-wheelers will continue, with consequent slow growth of bus traffic.

Looking at the current scenario in manufacturing industries two axle trucks' production is reducing and three axle trucks' production is increasing.

Traffic growth is unlikely to continue indefinitely at the exponential growth rates that have been experienced in India to date.

## E.10 Traffic Forecast & Projection

The growth rate of traffic has been derived from the trend based & econometric method & the result is presented in **Table1.8** below:



**Table 1.8 Trend based & econometric method**

Vehicle Type/Year	Trend Based			Econometric Method		
	2014-2019	2019-2024	2024-2029	2014-2019	2019-2024	2024-2029
Car, Jeep, Vans etc	1.940	2.136	2.351	6.94	7.63	8.39
Motor cycle & Scooters	1.420	1.523	1.635	7.98	8.78	9.66
LCV	1.000	1.050	1.105	5.96	6.56	7.22
Buses	1.000	1.050	1.105	5.30	5.83	6.41
2-Axle, Multi Axle Truck	0.300	0.305	0.310	5.96	6.56	7.22
Non-Motorised Vehicles	1.000	1.050	1.105	2.00	2.00	1.00

Mode wise traffic projected considering econometric growth rate on the project corridor for each year to 2044 is presented in Appendix 6.1 of Volume-I (Appendix Volume to Main Report) and presented in the **table 1.9** below:

**Table 1.9 Projected Traffic per Year**

Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LCV	2-Axle, 3-Axle	MAV	Total Vehicle	Total PCU
2014	510	1326	36	108	78	201	14	2273	2742
2015	551	1419	39	114	83	214	15	2435	2929
2016	595	1518	42	121	88	228	16	2608	3130
2017	643	1640	46	131	96	247	18	2821	3390
2018	816	2063	58	163	120	309	23	3552	4258
2019	882	2207	62	172	128	328	25	3804	4546
2020	953	2361	66	182	136	348	27	4073	4852
2021	1037	2542	71	193	145	371	29	4388	5207
2022	1129	2736	76	205	155	396	31	4728	5590
2023	1229	2945	81	217	166	423	34	5095	6003
2024	1337	3170	87	230	177	452	37	5490	6447
2025	1467	3436	94	245	190	486	40	5958	6969
2026	1609	3725	101	261	204	522	43	6465	7530
2027	1765	4038	109	278	219	560	47	7016	8138
2028	1936	4377	117	296	235	601	51	7613	8794
2029	2124	4745	126	315	252	646	55	8263	9505

Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LC V	2-Axle, 3-Axle	MAV	Total Vehicle	Total PCU
2030	2330	5144	136	336	271	694	59	8970	10275
2031	2556	5576	146	358	291	745	64	9736	11107
2032	2803	6044	157	381	313	800	69	10567	12004
2033	3074	6552	169	406	336	858	74	11469	12972
2034	3371	7102	182	433	361	921	80	12450	14024
2035	3697	7698	196	461	388	989	86	13515	15160
2036	4055	8344	211	491	417	1061	93	14672	16388
2037	4447	9045	227	523	448	1138	100	15928	17714
2038	4877	9804	244	557	481	1221	108	17292	19150
2039	5349	1062	262	593	516	1310	116	18773	20700
2040	5866	1151	281	632	554	1405	125	20382	22378
2041	6433	1248	302	673	594	1508	135	22131	24197
2042	7055	1353	324	717	637	1618	145	24030	26161
2043	7737	1467	348	763	683	1736	156	26093	28284
2044	8485	1590	374	812	733	1862	168	28335	30582

From Table 1.10 above it can be inferred that the project road requires 2 laning with paved shoulder, which caters the need of traffic volume till year 2030 and requires 4 laning with paved shoulder after that. Therefore, it is recommended to construct the project road with **two lane with paved shoulder facility** for Level of service B (LOS “B”).

### E.11 Results of Engineering Survey and Investigations

The various investigations carried out so far include Road inventory, condition surveys for bridges and culverts, traffic surveys, Topographical surveys, and pavement investigations have since been completed. Various field and testing activities i.e. sub soil investigations for bridges, tests on existing subgrade and tests on soil samples have since been completed. The field survey data are being utilized for preliminary design of various road and bridges components.

### E.12 Alignment and Engineering Geometric Design Standards

Existing alignment of the project road is very poor comparing to IRC codes. So the design is made to match the requirement of horizontal design with the latest IRC Specifications and to match vertical profile to the latest code specified by IRC for vertical design. Both the horizontal and vertical design is explained below.



### E.13 Horizontal Alignment

Out of the several existing curves present there along the project road, many curves are deficient, with respect to minimum design speed of 20-40 km/hr.

All the curves have been improved to meet design standard requirements as per IRC. At some of the locations, broken back curves have been observed and have been replaced with a single curve of sufficient radii, however, there are 6 curves which have been improved at the maximum extent but don't satisfy the IRC standard due to some restrictions like huge cut, habitation or to maintain the approach of retained bridges.

### E.14 Vertical Alignment

The project road is predominantly on steep terrain. Vertical profile has been designed in accordance with the guidelines and geometric standards have been discussed in this report. Exceptional maximum gradient of 8% have been followed for a few sections of the project road.

It can be seen that the project road is generally in steep terrain and therefore a ruling gradient of 6% has been adopted for design. In order to avoid such huge cutting/ filling, which is also not economically desirable, an exceptional maximum gradient of 8% have been allowed for the design of vertical profile.

### E.15 widening scheme

The widening scheme for the project corridor involves 2 lane configurations with 1.5 m wide paved shoulders on both sides, 1.0 m wide hard shoulder on valley side and 1.0 m for drain on valley side. These TCS have been considered with a view to minimize land acquisition & cutting of hills and utilize the existing carriageway to the maximum extent possible.

The design standards adopted for the study have been evolved on the basis of a study of the existing standards and practices in the country keeping in view the standards recommended by IRC.

**Table 1.10: Standard evolved**

S. No.	Description	Unit	Proposed Standards			
			Mountainous		Steep	
1	<b>Design speed</b>					
	Ruling	km/hr	50		40	
	Minimum	km/hr	40		30	
2	<b>Right of Way (ROW)</b>	m	12 to 18			
3	<b>Cross sectional elements</b>					
(a)	<b>Carriage way width</b>					
	Two lane	m	7		7	
(b)	<b>Shoulder width</b>	m	Hill Side	Valley Side	Hill Side	Valley Side
			1.9	1.9	1.9	1.9
(c)	Drain	m	0.6	-	0.6	-
(d)	Parapet	m	-	0.6	-	0.6
(e)	<b>Cross Slope</b>					

S. No.	Description	Unit	Proposed Standards	
			Mountainous	Steep
	Carriageway	%	2.5	2.5
	Paved Shoulder	%	2.5	2.5
(f)	<b>Extra Widening of pavement at curves</b>		As per IRC: 38 -1988	
4	<b>Horizontal curve</b>			
(a)	Radius			
	Ruling Minimum	m	90	60
	Absolute Minimum	m	60	30
(b)	Super elevation (max)	%	7	7
5	<b>Vertical curve</b>			
(a)	Length (min)			
	Ruling Minimum	m	30	20
	Absolute Minimum	m	20	15
6	<b>Maximum grade change not requiring vertical curve</b>	%	1.0% – 1.5%	
7	<b>Rate of change of super elevation</b>	m	1 in 60	
8	<b>Intersections</b>			
i)	Minimum length of acceleration lane	m	60m	
ii)	Minimum length of deceleration lane	m	70m	
iii)	Minimum radius for left turn	m	20m	
iv)	Minimum radius for right turn	m	15m	
v)	Width of turning lane (inner radius of 30 m)	m	4.5m	
vi)	Rate of taper (min)	m	1 in 15	
9	<b>Bus-shelters</b>			
i)	Min. length of bus bay	m	15 m	
ii)	Maximum length of pedestrian guard rail on either side of the bus bay	m	22 x 2 m	
10	<b>Truck Lay bye</b>			
i)	Min length of lay bye	m	100m	
ii)	Min parking length for each vehicle	m	15m	
iii)	Min parking width for each vehicle	m	2.75m	

S. No.	Description	Unit	Proposed Standards	
			Mountainous	Steep
iv)	Min. width of raised separator between lay bye and carriageway	m	1m	
v)	Rate of taper (min)	m	1 in 10	
<b>11</b>	<b>Safety barriers</b>			
i)	Bridge approaches and high embankments	m	3m and above	
<b>12</b>	<b>Clearance for Utility Lines</b>			
A)	Horizontal		As per IRC 32-1969	
i)	Street lighting poles	m	1.5m min from edge of carriageway	
ii)	Overhead power and telecommunication lines	m	10m min. from edge of roadway	
B)	Vertical		As per IRC 32-1969	
i)	Ordinary wires/lines carrying voltage upto and including 110 volts and telecommunication lines	m	5.5m minimum.	
ii)	Electric power lines carrying voltage upto and including 650 volts	m	6.0m minimum.	
iii)	Electric power lines carrying voltage exceeding 650 volts	m	6.5m minimum.	

## E.16 Improvement Proposal

### E.16.1 Typical Cross Section

The typical cross section for project alignment has been planned as proposed two lane carriageways. Twenty Two types of typical cross sections have been proposed for the project alignment. The detail drawing of typical cross section is attached in drawing volume. Type of typical cross section with their description is tabulated in **table 1.11** given below:

**Table 1.11: Summary of Typical Cross Sections**

S No	Type	Description
1	I	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side cut upto 4.0m (Soft rock + Soil)
2	IA	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side upto 4.0m (Soft rock + Soil)

S No	Type	Description
3	IB	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 4 m and Hill side upto 4.0m protection (Soft rock + Soil)
4	IC	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 4 m protection (Soft rock +Soil)
5	ID	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling >4 m protection (Soft rock +Soil)
6	II	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side cut in hard rock
7	IIA	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side upto 4m protection hard rock
8	IIB	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side upto 4m protection and hill side cut in hard rock
9	IIC	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side filling>4m protection in hard rock
10	III	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side cut upto 4m (Soft rock+ Soil)
11	IIIA	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side upto 4m protection (Soft rock+ Soil)
12	IIIB	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m cutting (Soft rock+ Soil)
13	IIIC	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m protection (Soft rock+ Soil)
14	IIID	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
15	IV	Typical Cross Section for realignment and bypass Valley side Filling upto 1m and hill side cut hard rock)
16	IVA	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side cut in hard rock)
17	IVB	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
18	V	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (12.0m formation width)
19	VA	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (hill side upto 4m protection) (12.0m formation width)
20	VB	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (valley side upto 4m protection and hill side no protection) (12.0m formation width)
21	VC	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (both side protection upto 4m) (12.0m formation width)
22	VD	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area)

S No	Type	Description
		(valley side protection > 4.0m) (12.0m formation width)

### E.17 Materials

During preliminary surveys and investigations suitable source of all construction materials was identified. Samples were collected from all the identified sources. Based on the results of the investigations it was confirmed that sufficient sources of construction materials are available in and around the project site as given below:

1. Moorum (Granular Deposit for construction of Sub-Base) – Local
2. Aggregates (For Base and wearing courses) - Pipalkothi
3. Sand - Local
4. Water – Local
5. Bitumen – Panipat
6. Cement – Rishikesh
7. Steel – Rishikesh

### E.18 Pavement Design

The aim of the project is to improve the existing carriageway for smooth and safe movement of traffic. Based on the pavement condition surveys and further investigations the pavement design for the new carriageway/ strengthening overlay has been carried out. The thicknesses required for the flexible pavement have been worked out based on the guidelines stipulated in the IRC: 37-2012. The details of proposed pavement composition of project road and their corresponding thickness is tabulated in **table 1.12** given below:

**Table 1.12: Flexible Pavement Design (Main carriageway)**

S No	Pavement composition	Min. Thickness (mm)
1	Bituminous Concrete	40
2	Treated RAP/BSM	100
3	CT Sub Base	200
	<b>Total</b>	<b>340</b>

### E.19 Proposal for Bridges

There are 11 nos of Bridges proposed for new construction.

### E.20 Culverts

The existing culverts which are mostly RCC Slab culverts and some is stone masonry arch culverts are old and damaged. They are proposed to be replaced with new box culverts and run through both the carriageways. The summary for the box culverts which is reconstructed and their proposals are given below in this package in the **table 1.13** below:

**Table 1.13: Summary of Proposed Box Culverts Structures**

<b>S. No</b>	<b>Size</b>	<b>Number</b>	<b>Remarks</b>
1	1 x 2 x 2	51	New Proposal / Reconstruction
2	1 x 4 x 4	87	New Proposal / Reconstruction
3	1 x 6 x 6	8	New Proposal / Reconstruction

## **E.21 REALIGNMENT**

The existing road has very poor horizontal as well as vertical geometry. Most of the places it is following existing track at the edge of hills make lot of unnecessary curves. Many compromises has been made in providing cross drainages structures. So overcome with this alignment has been corrected at many places by providing sufficient length of cross drainage and also made alignment correct by providing structure at village.

## **E.22 ROAD APPURTENANCES**

The provisions of following road fixtures have been considered in this package:

### **Type of structure**

- Kilometre Stone
- Hectometre Stone
- Guard Stone
- Boundary Stone
- Information Sign Board / Direction / Destination Board
- Mandatory Signs
- Cautionary Signs
- Over Head Gantry

## **E.23 Environmental and Social Aspects:**

Based on the environmental assessment and surveys conducted for the project, associated Potential adverse environmental impacts can be mitigated to an acceptable level by adequate Implementation of the measures as stated in the EIA Report. An adequate provision has been made in the cost estimate to cover the environmental mitigation and monitoring requirements and their associated costs as suggested in environmental budget.

A Resettlement Action Plan has been prepared for the project stretch for the Project affected Persons based on baseline socio-economic survey and census survey data. This resettlement plan (RP) has been prepared in accordance with, National Policy on Resettlement and Rehabilitation (NPRR), and State Governments framework of resettlement policies and other social safeguard policies to protect the rights of the affected persons and communities.

### **Expected Benefits from the Project**

Following are the expected benefits occur due to the improvement of the project road:

- a) Better Level of Service in terms of improved riding quality and smooth traffic flow.

- b) Faster transportation will ultimately lead to massive savings in the form of reduced wear and tear of vehicles, reduced vehicle operating costs (VOCs) and total reduction in transportation costs etc. With the improvement of road surface, the traffic congestion due to obstructed movement of vehicles will be minimized and thus wastage of fuel emissions from the vehicles will be reduced. Increased road landscaping and safety features.
- c) Enhanced connectivity between rural & urban population which will benefit the all sections of the society like general population, small-medium-large scale industries, farmers, businessmen etc.
- d) Improved access to higher education facilities & modern health facilities.
- e) Strengthening of both rural & urban economies which in turn will improve economic scenario of the state and country.
- f) Improved road connectivity helps in better implementation and management of government schemes.
- g) With improvement in economy, more generation of employment opportunities. Overall improvement of the region.

## E.24 Summary of Cost Estimates

The preliminary cost estimate presented in this report has been prepared from the quantities of the different items of works derived from the preliminary designs and unit rates worked out. The unit rates have been adopted from the unit rates presented in the SOR UK PWD for the year 2017-18. The rate analysis has been carried out as per the standard data book of MORTH. The summary of the project cost is presented below. The major components of the project which figure in the cost stream for the improvement of the project are :

- Treatment to landslide
- Road Work
- Structures

The detail of Cost Estimate is given in separate volume. The summary of cost estimate is tabulated in **table 1.14** given below.

**Table 1.14: Summary of Cost Estimate**

Bill No.	Description	Item Price (Cr.)
1	SITE CLEARANCE	3.96
2	EARTH WORK AND DRAINAGE	30.89
3	CEMENT TREATED SUB BASE & BASE COURSE	17.48
4	SURFACE COURSES (BITUMEN)	43.04
5	TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES	18.91

Bill No.	Description	Item Price (Cr.)
6	DRAINAGE & PROTECTION WORKS	105.22
7	STRUCTURE	61.93
	<b>Total Civil Cost (A)</b>	<b>281.423</b>
	Maintenance during DLP (4 years) payable to contractor @5% of 'A'	14.07
	<b>Cost put to tender (A+B)</b>	<b>295.49</b>
	Add Contingencies over civil cost @2.80% of (A)	7.88
	Construction Supervision Charges @ 3% of (A)	8.44
	Administrative Charges @3% of (A)	8.44
	Quality Control @0.25% on 'A'	0.7
	Road Safety Cell Audit Charges @ 0.25% of 'A'	0.7
	Escalation @ 5% per annum for 1.5 years during construction payable to contractor of (A)	21.11
	Total cost of civil works including centage charges (C+D+E+F+G+H+I)	342.11
	Land Acquisition and Structure Cost	59.00
	Utility and Shifting	1.00
	<b>Total project cost (J+K+L)</b>	<b>404.77</b>



## CHAPTER 1: PROJECT BACKGROUND

### 1.1 General

The President of India acting through Ministry of road transport and highway (MORTH), represented by the Director General & special secretary is engaged in the development of national highway and as a part of this in the state of Uttarakhand, various roads has been selected for strengthening & widening purpose. All these roads are divided in seven packages and bided for detail study. These seven packages are as under.

- Km 228.00 (Rishikesh) to Km 368.00 (Rudraprayag) of NH-58
- Km 368.00 (Rudraprayag) to Km 528.00 (Mana Village) of NH-58
- Km 0.00 (Rishikesh) to Km 144.00 (Dharasu) of NH-94
- Km 0.00 (Dharasu) to Km 124.00 (Gangotri) of NH-108
- Km 144.00 (Dharasu) to Km 220.00 (Yamunotri) of NH-94
- Km 0.00 (Rishikesh) to Km 76.00 (Gaurikund) of NH-109
- Km 52.00 (Tanakpur) to Km 202.00 (Pithoragarh) of NH-125

MORTH has awarded package II to Casta Engineering Pvt. Ltd. In J V with Byucksan India Pvt. Ltd as project preparation consultant wide agreement dated for 13 Jan 2018.

### Sub-packaging

The design length of project road is 139.8 km and is divided in five packages. Its packaging is done as per the priority of the ground. Detail of which is tabulated in the table 1.1 as under.

**Table 1.1 Divided into five packages**

Pkg. no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (Km)
1	Km 368.000-Km 399.000	Km 368.000-Km 398.300	Lameri-Karanprayag	Widening to 2-lane+ Geometric Imp + R.S	29.125
2	Km 399.000-Km 430.000	Km 398.300-Km 427.650	Karanprayg-Chamoli	Widening to 2-lane + Geometric Imp + R.S	28.800
3	Km 430.000-468.000	Km 427.650-Km 465.150	Chamoli-Paini	Widening to 2-lane+ Geometric Imp + R.S	36.675
4	Km 468.000-Km 489.350	Km 465.150-Km 471.400	Joshimath Bypass	New Alignment	6.250

Pkg. no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (Km)
5a	Km 489.350- Km 491.600	Km 471.400- Km 473.675	Shingdhar Bridge to Vishnuprayag bridge including Hatipahar landslide	Widening to 2-lane with Paved Shoulder	2.275
5b	Km 491.600- Km 504.600	Km 473.675- Km 486.100	Vishnuprayag bridge to lambagadh	Widening to 2-lane+ Geometric Imp+R.S	12.425
-	Km 504.600-km 505.100	Km 486.100- km486.600	Lambagadh Land Slide	Awarded	500
5c	Km 505.100- Km 509.700	Km 486.600- Km 490.550	Lambagadh to Benakuli including Benakuli landslide	Widening to 2-lane+ Lambagadh Landslide	3.950
5d	Km 509.700- Km 528.000	Km 490.550- Km 507.850	Benakuli Bend to Mana	Widening to 2-lane+ Geometric Imp+R.S	17.300

This report pertains to Sub-Package-II the Design length of the road in this package is 28.8 km i.e from km 398.300 to km 427.650 (Excluding Km 420.250 to Km 420.500 and Km 423.300 to km 423.650) in the state of Uttarakhand.

## 1.2 Project Location

The project road section (km 399.300 to km 427.650 of NH-58) is in the state of Uttarakhand. The project lies in the north-eastern part of Uttarakhand and is a part of Char Dham Yatra. It's the only connecting road to Badrinath Dham. The Project road passes through two districts of Uttarakhand namely, Rudraprayag & Chamoli. These districts are in the Garhwal division of State. The location of project road is shown in **Fig. 1.1** :

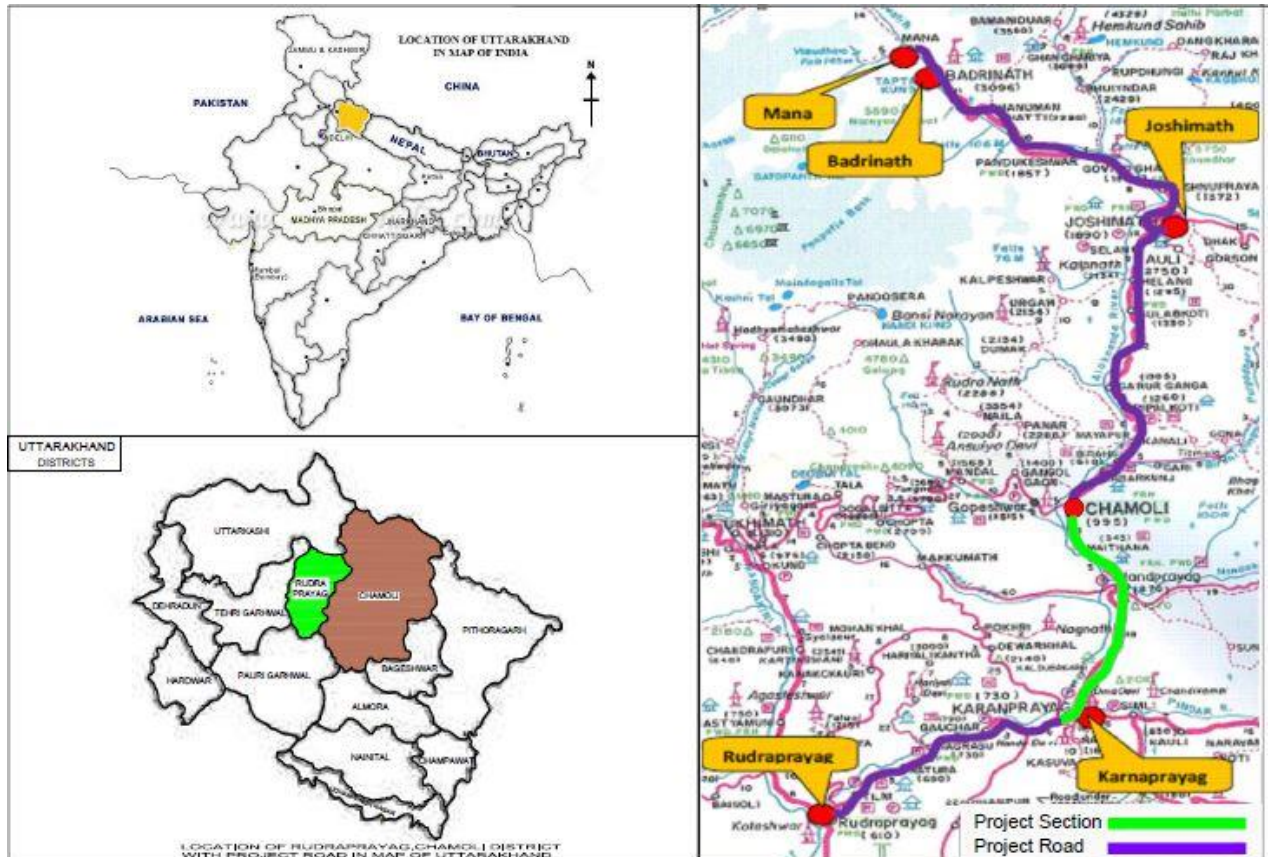


Fig. 1.1 Alignment Map

### 1.3 Objective

The main objective of the project is to provide sound and appropriate engineering solutions for the rehabilitation and improvement of the present road deficiencies through conducting comprehensive studies, assessing the importance of the corridor and comprehensive analysis of data collected.

- Comprehensive review of existing and feasible alternate alignments for construction of all weather connectivity roads leading to such adverse climatic regions. Improvement of safety and sustainability of NH network by incorporating Tunnels, Bypasses, Viaducts and long bridges, shelters and rest areas, operation & maintenance system. Correction of geometrics of existing highway and inclusion of alternate feasible alignments to the extent possible. This study intends to have special emphasis on inclusion of safety features in NH network for safety of road users.
- The Detailed Project Report would inter-alia include detailed highway design, design of pavement and overlay with options for flexible or rigid pavements, design of bridges, tunnels and cross drainage structures, quantities of various items, detailed working drawings, detailed cost estimates, EPC schedules, economic and financial viability analyses, environmental feasibility, environmental action plans appropriate and documents required for tendering the project on commercial basis for international / local competitive bidding.
- The DPR consultant should ensure detailed project preparation incorporating aspects of value engineering, quality audit and safety audit requirement in design and implementation.

## **1.4 SCOPE OF PROJECT SERVICES**

- a. As far as possible, the widening/improvement work to 2 lane/2 lane with paved shoulder shall be within the existing right of way avoiding land acquisition, except for locations having inadequate width and where provisions of short bypasses, alignment corrections, improvement of intersections are considered necessary and practicable and cost effective. However bypasses proposals should also be considered, wherever improvement to 2 lane of the existing road is not possible due to land constraints. The Consultant shall furnish land acquisition details (i.e. All necessary schedules as per L.A. act) as per revenue records/maps.
- b. Wayside amenities required shall also be planned.
- c. The entire scope of services would, inter-alia, include the items mentioned in the TOR (Terms of Reference). The Consultant will also make suitable proposals for widening/improvement of the existing road to 2 lane/2 lanes with paved shoulder etc. and strengthening of the carriageways, as required at the appropriate time to maintain the level of service over the design period.
- d. All ready to implement 'good for construction' drawings shall be prepared.
- e. Environmental Impact Assessment, Environmental Management Plan shall be carried out by the Consultant meeting the requirements of the State/ Central Environment Authorities/Ministries.
- f. Wherever required, consultant will liaise with concerned authorities and arrange all clarifications. Consultant will also obtain 'NO Objection Certificate' from Ministry of Environment and Forest and also incorporate the estimates for shifting of utilities of all types involved from concerned local authorities in the DPR. Consultant is also required to prepare all Land Acquisition papers (i.e. all necessary schedules as per L.A. act) for acquisition of land either under NH Act or State Act.
- g. Consultant shall obtain all types of necessary clearances required for implementation of the project on the ground from the concerned agencies. The clients shall provide the necessary supporting letters and any official fees as per the demand note issued by such concerned agencies from whom the clearances are being sought to enable implementation. In case Consultant does not obtain all the necessary clearances up to the completion of the assignment, deduction upto 5% amount will be made from the final payment. The amount thus deducted will be released after all necessary clearances have been obtained.

## 1.5 CONTRACT PACKAGES

### Sub-packaging

The design length of project road is 139.8 km and is divided in five packages. Its packaging is done as per the priority of the ground. Detail of which is tabulated in the table 1.1 as under.

**Table 1.1 Divided into five packages**

Pkg. no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (km)
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2	Km 399.000-Km 430.000	Km 398.300-Km 427.650	Karanprayag-Chamoli	Widening to 2-lane+ Geometric Imp+R.S	28.800
3	Km 430.000-Km 468.000	Km 427.650-Km 465.150	Chamoli-Paini	Widening to 2-lane+ Geometric Imp+R.S	36.675
4	Km 468.000-Km 489.350	Km 465.150-Km 471.400	Joshimath Bypass	New Alignment	6.250
5a	Km 489.350-Km 491.600	Km 471.400-Km 473.675	Shingdhar Bridge to Vishnuprayag bridge including Hatipahar landslide	Widening to 2-lane with Paved Shoulder	2.275
5b	Km 491.600-Km 504.600	Km 473.675-Km 486.100	Vishnuprayag bridge to lambagadh	Widening to 2-lane+ Geometric Imp+R.S	12.425
-	Km 504.600-km 505.100	Km 486.100-km486.600	Lambagadh Land Slide	Awarded	500
5c	Km 505.100-Km 509.700	Km 486.600-Km 490.550	Lambagadh to Benakuli including Benakuli landslide	Widening to 2-lane+ Lambagadh Landslide	3.950
5d	Km 509.700-Km 528.000	Km 490.550-Km 507.850	Benakuli Bend to Mana	Widening to 2-lane+ Geometric Imp+R.S	17.300

This report pertains to Sub-Package-II the Design length of the road in this package is 28.8 km i.e from km 398.300 to Km 427.650 (Excluding Km 420.250 to Km 420.500 and Km 423.300 to km 423.650) in the state of Uttarakhand

The Consultants submit hereby the Draft Detailed Project Report for the above mentioned packages in the following volumes:

Detailed Project Report (DPR) consists of following Volumes as per TOR:-

S. No	Volume No.	Description
1	Volume-I	Main Report
2	Volume-I/A	Appendix
3	Volume-II	Design Report(Road)
4	Volume-IIB	Design Report(Bridge)
5	Volume-II	Material Report
6	Volume-IV	Environmental Assessment Report
7	Volume-V	Technical Specifications
8	Volume-VI	Rate Analysis
9	Volume-VII	Cost Estimates
10	Volume-VIII	Bill of Quantities
11	Volume-IX	Drawing Volume
12	Volume-X	Civil Work Contract Agreement
12	Volume-XI	Project Clearances

Volume-I: Main Report will contain following chapters:

S. No.	Chapter No.	Description
1	Chapter-1	Project Background
2	Chapter-2	Social And Demographic Features
3	Chapter-3	Engineering Survey And Investigation
4	Chapter-4	Analysis And Interpretation of Survey And Investigation
5	Chapter-5	Traffic Survey And Forecast
6	Chapter-6	Design Standards
7	Chapter-7	Improvement Proposal
8	Chapter-8	Cost Estimation

S. No.	Chapter No.	Description
9	Chapter-9	Environmental Aspects
10	Chapter-10	Economic & Financial Analysis
11	Chapter-11	Conclusions And Recommendation

## **1.6 PROJECT ROAD DESCRIPTIONS**

### **1.6.1 General**

The project road, which is a part of NH-58, is vital for providing connected to Badrinath. The detailed reconnaissance and topographic survey has been carried out along the Project road. Consultants' understanding of the project road based on in-depth study of Secondary data and information, inquiries, inspection, detailed reconnaissance and Project road inventory is presented in the subsequent paragraphs.

### **1.6.2 The Package Road**

The entire project road pertaining to Pkg-II starting from Karanprayag and ending at Chamoli Km 399.300 to km 427.65.00 from is passing through some of the steepest terrain and most complex geological condition at few locations of its alignment. The length of road under this Contract Package is 28.8 km.

### **1.6.3 Pavement**

The present road is single lane with variable width due to extra widening on the deficient curves. The thickness and composition of the pavement crust is given the table 1.2 below.

**Table 1.2 Thickness and composition of the pavement crust**

S No	Pavement composition	Min. Thickness (mm)
1	Bituminous Concrete	40
2	DBM	90
3	WMM	250
4	Granular Sub Base	260

### **1.6.4 Alignment and Geometry**

#### **Horizontal Alignment**

Generally the horizontal alignment of the project section is poor with number of deficient curves and hair pin curves.

#### **Vertical Alignment**

The vertical gradient of the project varies from 0.5% to 12.0%



### 1.6.5 Bridges

There are 11 No of Bridges proposed for new construction.

### 1.6.6 Cross Drainage Structures

The existing culverts which are mostly RCC Slab culverts and some is stone masonry arch culverts are old and damaged.

The summary for culvert is given in **Table 1.3 below:**

**Table 1.3: Summary of Culverts Structures**

S. No	Type of Culvert	Number	Remark
1	Arch	1	Reconstruction
2	Arch Bridge	2	Reconstruction
3	Box	1	Reconstruction
4	Pipe	9	Reconstruction
5	Scooper	12	Reconstruction
6	Slab	59	Reconstruction
7	Stone	8	Reconstruction

### 1.6.7 Traffic on the Project Road

To comprehensively appreciate the traffic and travel characteristics on the project corridor from Km 368.000 to Km 528.000 of National Highway No. 58, the type of surveys, locations and duration, identified at the inception stage of the study have been followed during data collection exercise with minor modifications on account of site conditions. With a view to capture section wise traffic flow characteristics, the total stretch has been segmented into five homogeneous sections, based upon the major intersections that act as main collectors or distributors of traffic along the project corridor; i.e., sections of more or less similar traffic characteristics. The homogeneous sections identified are tabulated below Table1.4.

**Table.1.4: Homogeneous Section**

Homogeneous Section	Existing Chainage	Length (km)	Name Of Location
Section 1	368.000 – 399.000	31.00	Rudraprayag to Karanprayag
Section 2	399.000 – 418.000	19.00	Karnprayag to Nandprayag
Section 3	418.000 – 430.000	12.00	Nandprayag to Chamoli
Section 4	430.000 – 480.000	50.00	Chamoli to Joshimath
Section 5	480.000 – 527.000	47.00	Joshimath to Mana



### 1.6.8 Road Junctions

There is no major and 06 minor junctions along this road section

#### Major Junctions

There is no major junction along the project road which is tabulated in table 1.5

**Table 1.5 Major Junction**

S. No	Existing Chainage (km)	At Grade	Grade Separated	Category of Cross Road+			
				NH	SH	MDR	Others
NIL							

#### Minor Junctions

There are 06 minor junctions along the project road. The list of minor junctions is presented in table 1.6:

**Table 1.6: Minor Junction**

SI. No.	Existing Chainage (km)	Type	
		Junction	Cross Road
1	400+000	T	Village Road
2	412+700	Y	Village Road
3	418+850	Y	Village Road
4	418+950	T	Village Road
5	423+600	Y	Village Road
6	424+150	Y	MDR

### 1.6.9 Utilities and Services

The utilities requiring shifting from the proposed ROW comprise the following:

1. Shifting of OFC Cables pertaining to the Indian Army
2. Shifting of OFC Cables pertaining to the BSNL
3. Shifting of 33 KVA Cables.
4. Shifting of 11 KVA Cables.
5. Shifting of Public Health Utilities (Water Line).The consultant approached the concerned Authorities, the Project Director, NHAI for relocation. The concerned administrative authorities have given the estimates which have been provided for in the cost estimate.

### 1.6.10 Environmental and Social Aspects

Based on the environmental assessment and surveys conducted for the project, associated Potential adverse environmental impacts can be mitigated to an acceptable level by adequate

Implementation of the measures as stated in the EIA Report. An adequate provision has been made in the cost estimate to cover the environmental mitigation and monitoring requirements and their associated costs as suggested in environmental budget. Environmental clearance is not required as length of the road

A Resettlement Action Plan has been prepared for the project stretch for the Project affected Persons based on baseline socio-economic survey and census survey data. This resettlement plan (RP) has been prepared in accordance with, National Policy on Resettlement and Rehabilitation (NPRR), and State Governments framework of resettlement policies and other social safeguard policies to protect the rights of the affected persons and communities.

## CHAPTER 2: SOCIAL BACKGROUND AND DEMOGRAPHIC FEATURES

### 2.1 PROJECT INFLUENCE AREA

- **District Rudraprayag**

Rudraprayag district, is a district of Uttarakhand state of northern India. The district occupies an area of 2439 km<sup>2</sup>. Rudraprayag town is the administrative headquarters of the district. The district is bounded by Uttarkashi District on the north, Chamoli District on the east, Pauri Garhwal District on the south, and Tehri Garhwal District on the south. Rudraprayag District was established on 16th September 1997. The district was carved out from the following areas of three adjoining districts. 1. Whole of Augustmuni & Ukhimath block and part of Pokhri & Karnprayag block from Chamoli District. 2. Part of Jakholi and Kirtinagar block from Tehri District. 3. Part of Khirsu block from Pauri District

- **District Chamoli**

Chamoli, the district of “Garhwal” the land of forts. Today’s Garhwal was known as Kedarkhand in the past. In puranas kedar-khand was said to be abode of God. It seems from the facts vedas puranas, Ramayna and Mahabharata that these Hindu scriptures are scripted in kedar-khand.

According to Rigveda(1017-19) after Inundation (Jalprlya) Sapt-Rishis saved their lives in the same village Mana. Besides there the roots of Vedic literature seems to be originated from Garhwal because the Garhwali language has a lot of words common with Sanskrit .

The work place of vedic Rishis are the prominent pilgrim places in Garhwal specially in chamoli like Atrimuni Ashram in Anusuya about 25 km. from Chamoli town and work place of Kashyap Rishi at Gandhmadan parwat near Badrinath. According to Aadi-Puran vedvyasa scripted the story of Mahabharata.

### 2.2 Economic

#### 2.2.1 Agriculture

Agriculture is one of the most significant sectors of the economy of Uttarakhand and Agro food processing is one of the most important industries of the state. To boost the agro food processing industries agri exports zones have been setup in the state for leechi, horticulture, herbs, medicinal plants and basmati rice. Fruits likeapple, orange, pear, peach and plum are grown widely in the state giving immense opportunity for food processing industry.

**Table 2.1: Summary of Agro Statistics**

Sr. No.	Components	Growth/Ratio/Production
1	Agricultural GSDP at current prices (FY 2009)	Rs. 6228 Crore
2	Growth of Agricultural and allied GSDP (Avr. From FY.2001 to FY.2009)	1.98%

Sr. No.	Components	Growth/Ratio/Production
3	Agricultural sector's contribution in GSDP (FY 2009)	15.50 %
4	Food Grain production (FY2010)	1780 (Thousand Tonnes)
5	State's contribution to national food grain production (FY2010)	0.81%
6	State's rank in national food grains production (FY2010)	17
7	Yield --total food grains (FY2010)	1781 (Thousand Tonnes)
8	Gross area irrigated (FY2009)	569769 (Hectare)
9	Area under wells and tube well irrigation (Hectare) FY2009	213780 (Hectare)
10	Population dependent on agriculture	$\frac{3}{4}$
11	Rice Production (FY2010)	610 (Thousand Tonnes)
12	Wheat Production (FY2010)	831 (Thousand Tonnes)
13	Coarse Cereals (FY2010)	297 (Thousand Tonnes)
14	Pulses (FY2010)	42 (Thousand Tonnes)
15	Oil Seeds (FY2010)	29 (Thousand Tonnes)
16	Sugarcane (FY2010)	5058 (Thousand Tonnes)
17	Rank in Sugarcane production (FY2010)	8

Sugarcane, rice and wheat are cultivated largely in Uttarakhand. Since almost 90% of the terrain of Uttarakhand is hilly, yield per hectare is not very high. There is a disparity between the gross cropped area between hills and plains. Hills comprises only 14% whereas the plains comprise of the 86% of the gross cropped area.

**Table 2.2: Foodgrain Production in Uttarakhand**

Year	Uttarakhand	India	Share of Uttarakhand in India
FY 2001	1.72	196.81	0.88
FY 2002	1.7	212.85	0.79
FY 2003	1.55	174.78	0.88
FY 2004	1.72	213.19	0.8
FY 2005	1.76	198.36	0.88
FY 2006	1.59	208.59	0.76
FY 2007	1.73	217.28	0.79
FY 2008	1.79	230.78	0.77
FY 2009	1.76	234.47	0.75
FY 2010	1.78	218.2	0.81

### **2.2.2 Industries**

The Industrial policy of the state was announced in 2003. The policy focuses on the sectors where Uttarakhand has inherent advantage like Agro and Food Processing, Floriculture, Handloom, Hydropower, Khadi and Village Industries and Tourism. Subsequent to this, Integrated Industrial Development Policy was launched in February 2008. This policy aimed to accelerate industrial development in the industrially backward and remote hill districts of Uttarakhand. The policy focuses to develop industrial infrastructure, to encourage entrepreneurial development through market encouragement and to provide financial support to entrepreneurs.

In order to promote Industrial development in the State, State Infrastructure & Industrial Development Corporation of Uttarakhand Ltd (SIDCUL) was incorporated. SIDCUL provides financial assistance in the form of debt, equity and venture capital to facilitate the development of infrastructure in the state. It also provides assistance to private initiative in Industry and Infrastructure. SIDCUL facilitates implementation and management of projects.

Major financial incentives provided by the state government are as follows

- 100 % income tax exemption for first five years and 30% for next five years for the companies and 25% for others.
- 100% central excise exemption for ten years on items other than those mentioned in the negative list in the concessional industrial package announced by the Central Government.
- Exemption from entry tax on Plant & Machinery for setting up industry or undertaking substantial expansion and modernization.
- Capital investment subsidy @ 15%, subject to a maximum of Rs. 30 Lakhs.

The economic agenda of Uttarakhand focuses on tourism, higher education, IT & ITES, food processing and biotech industry. Uttarakhand have been able to pull huge investments in the last few years due to favourable policies of the government.

#### **The Key Strategic Thrust Area**

Agriculture and Food processing	State government provides assistance in establishing SME units for agro parks and food parks. Incentive from MoFPI for setting up units in Uttarakhand.
Biotechnology	Biotechnology parks are to be developed to integrated resources and to provide a focused institutional setup for accelerated commercial growth of biotechnology a bioinformatics.
Higher Education	122 Institutes for higher education, including 1 central, 6 states, 5 private and 4 deemed universities and one IIT at Roorkee.
IT and ITES	The vision of the State government of Uttarakhand is to promote the development of Information Technology industry in the State. It plans to develop a state-of-the-Art & Information Technology Park in more than 60 acres at Sahastradhara road, Dehradun.

Manufacturing and hydroelectricity	Strong focus on automobile industry proven by the presence of big players like Tata, Ashok Leyland, Mahindra etc. Uttarakhand is being developed as an ‘energy state’ to tap its huge hydro-electric power (HEP) potential of over 15,000 MW.
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Uttarakhand is poised for very high growth in the coming years. To promote Uttarakhand as an attractive destination for industrial investments, the state policy aims to promote public private partnership to boost infrastructure and industrial development.

## 2.3 INFRASTRUCTURE

### 2.3.1 Roads

The Roads are the major mode of transportation service available in the Uttarakhand. The road network in the state is at developing stage. Several national highways from neighbouring state connecting Uttarakhand to other parts of country. The list of National Highways is shown in table 2.3

**Table 2.3: List Of National Highways**

National Highway Number	Length of NH in KM	States NH Passing-Through	Main Cities/Places in National Highway
NH 58	538	Uttar Pradesh, Uttarakhand	Delhi - Ghaziabad - Meerut - Haridwar -Badrinath - Mana Pass
NH 72	200	Haryana, Himachal Pradesh, Uttarakhand	Ambala - Nahan - Paonta Sahib - Dehradun – Haridwar
NH 72A	45	Uttarakhand, Uttar Pradesh	Chhutmalpur - Biharigarh - Dehradun
NH 73	188	Haryana, Uttar Pradesh, Uttarakhand	Roorkee - Saharanpur - Yamuna Nagar - Saha - Panchkula
NH 74	300	Uttar Pradesh, Uttarakhand	Haridwar - Nagina - Kashipur - Kichha - Pilibhit - Bareilly
NH 87	83	Uttar Pradesh, Uttarakhand	Rampur - Pantnagar - Haldwani - Nainital
NH 94	160	Uttarakhand	Hrishikesh - Ampata - Tehri - Dharasu - Kuthanur - Yamunotri
NH 108	127	Uttarakhand	Dharasu - Uttarkashi - Yamunotri - GangotriDham
NH 109	76	Uttarakhand	Rudraprayag - Guptkashi - KedarnathDham
NH 119	260	Uttarakhand, Uttar Pradesh	Pauri - Najibabad - Meerut
NH 121	252	Uttarakhand	Kashipur - Bubakhal

National Highway Number	Length of NH in KM	States NH Passing-Through	Main Cities/Places in National Highway
NH 123	95	Uttarakhand, Himachal Pradesh	Barkot - Vikasnagar
NH 125	201	Uttarakhand	Sitarganj - Pithorgarh

The general terrain of Uttarakhand is hilly. So, the roads are the major mode of transport of passengers and goods in the state. Different categories of roads are present in the State. Total 26800.85 Kms of road network reported in the State.

The categorywise breakup to roads is presented in table 2.4

**Table 2.4: Category of Road**

S.No	Category of Road	Length in Kms
1	National Highways	1375.76
2	State Highways	3788.20
3	Major District Roads	3289.74
4	Other district roads	2945.04
5	Rural roads	14543.89
6	Light Vehicles road	858.22
<b>Total</b>		<b>26800.85</b>

The State of Uttarakhand is emerged as a separate state from Uttar Pradesh in the Nov 2000. The comparison of categorywise length of roads from Nov 2000 to 2012 is tabulated below:

S. No	Category of Road	Road length as on 01.04.2000	Road Length as on 31.03.2012
1	National Highway	526.00 km	1375.76 km
2	State Highway	1235.04 km	3788.20 km
3	Major District Road	1364.15 km	3289.74 km
4	Other District Road	4583.01 km	2945.04 km
5	Village Road	7446.23 km	14543.89 km
6	Light Vehicle Road	315.77 km	858.22 km
7	Bridle Roads/Border Tracks	3970.00 km	3729.83 km

The Public Works Department and Boader road organisation are the major agencies responsible for the maintenance of road network in the State.

### Road Vehicle Fleet

On the project stretch Cars/jeep/taxi comprise a significant share, ranging between 41% of the total vehicles, followed by two-wheelers, LCVs and Buses, in the range of 10-23%. The share of commercial traffic (Buses and Trucks) is almost 32% of the total traffic. Non-motorized traffic, primarily cycles, are merely 1%.

### **2.3.2 Railways**

Uttarakhand is a hilly state and around 90% terrain is hilly. Therefore the railway services are very limited in the state and are largely confined to the plains. Total length of railways in the state was 345 Kms in the year 2006-07. Recently, Uttarakhand is focussing on expanding the share of railway services in cargo transport and passenger transport

### **2.4 TOURISM**

Uttarakhand is very well known tourist destination for both domestic and international tourists. The state has enormous resources for cultural, pilgrimage, adventure, wildlife, and leisure tourism. The state is the first in the country to have created a tourism development board by legislation. The state was awarded the prestigious National Tourism Award by the Government of India in 2003 in the category of “Best practices by the state government”. The state in nutshell has a potential for tourism related services and scope to develop niche markets.



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## **CHAPTER 3: ENGINEERING SURVEYS AND INVESTIGATIONS**

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### **3.1 General**

The Consultant has carried out various field studies, engineering surveys and investigations to collect the necessary data for use in detailed design and subsequent preparation of DPR for the project. The investigations were carried out to generate adequate supportive database for preparing the most appropriate proposal to meet the functional and structural efficiency and safety requirements. The various engineering surveys and investigations have been carried out following the relevant MORT&H/ IRC codes and QAP Standards.

### **3.2 PRELIMINARY SURVEYS & INVESTIGATIONS**

The various investigations and surveys, which have been carried out by the Consultant, are as follows:

- I. Reconnaissance survey;
- II. Road Inventory;
- III. Road and Pavement Conditions survey;
- IV. Topographical Surveys;
- V. Material Investigations and Surveys;
- VI. Inventory of Bridges, Culverts & Structures;
- VII. Condition Survey of Bridges & Structures’
- VIII. Hydrological Investigations;
- IX. Sub-soil / Geo-tech Investigations;
- X. Traffic Surveys

### **3.3 Reconnaissance survey**

The main objective of reconnaissance survey is to examine the general characteristics of the area, along the project road, for the purpose of identification of the cost effective method of widening of existing two lane roads to four lane highway, and feasible realignment route for further investigations and detailing. Prior to taking up the ground reconnaissance survey, maps

### **3.4 Road Inventory**

The inventory of the project road for assessment of the road has been carried out through measurements and visual inspection. Features like land use, settlements, terrain width of pavement and shoulders, geometric deficiencies, junctions, utilities etc. were recorded.

### 3.4.1 Project Road

The project road lies in the north-eastern part of Uttarakhand and is a part of Char Dham Yatra. It is the only connecting road to Badrinath Dham. The Project road passes through two districts of Uttarakhand namely, Rudraprayag & Chamoli. These districts are in the Garhwal division of State.

This report pertains to Sub-Package-II the Design length of the road in this package is 28.8 km i.e from km 398.300 to 427 (Excluding Km 420.250 to Km 420.500 and Km 423.300 to km 423.650) in the state of Uttarakhand

### 3.4.2 Terrain

The terrain along the project road has been identified as per method suggested by IRC SP 48:1998 (Hill Road Manual) is given in **table 3.1** below:

**Table 3.1: Terrain Classification**

Terrain Classification	Percentage cross slope of the country	Gradient Classification	
		Gradient classification	Average Longitudinal Slope
Plain	0 – 10	Ruling	< 5.0%
Rolling	> 10 – 25	Limiting	6.0%
Mountainous	> 25 – 60	Steep	> 7.0%
Steep	> - 60		

As per above condition this section of road comes under steep terrain having cross slope more than 60%

Details are attached as **Appendix 3.2 of Volume-I (Appendix Volume of the Main Report)**.

**Table 3.2 Type of terrain**

S. No	Start Chainage (Km)	End Chainage (Km)	Length (Km)	Snow affected area	Terrain
1	400+000	407+000	7.00	No	Steep
2	407+000	414+000	7.00	No	Hilly
3	414+000	424+000	10.00	No	Steep
4	424+000	425+000	1.00	No	Hilly
5	425+000	435+000	10.00	No	Steep

### 3.4.3 Land Use

The Land use along the project road is mainly forest or barren except some town like habitation and some village like habitation. There are major settlements along the package road. The summary of land use is presented in table 3.3:

**Table 3.3: Land Use**

S. No.	Existing Chainage (km)		ROW (m)
	From	To	
1	399+000	400+000	6 to 12
2	400+000	401+000	6 to 12
3	401+000	402+000	6 to 8
4	402+000	403+000	6 to 8
5	403+000	404+000	6 to 8
6	404+000	405+000	6 to 8
7	405+000	406+000	6 to 8
8	406+000	407+000	6 to 8
9	407+000	408+000	6 to 8
10	408+000	409+000	6 to 8
11	409+000	410+000	6 to 8
12	410+000	411+000	6 to 8
13	411+000	412+000	6 to 8
14	412+000	413+000	6 to 8
15	413+000	414+000	6 to 8
16	414+000	415+000	6 to 8
17	415+000	416+000	6 to 8
18	416+000	417+000	6 to 8
19	417+000	418+000	6 to 8
20	418+000	419+000	6 to 8
21	419+000	420+000	6 to 8
22	420+000	421+000	6 to 8
23	421+000	422+000	6 to 8

S. No.	Existing Chainage (km)		ROW (m)
	From	To	
24	422+000	423+000	6 to 8
25	423+000	424+000	6 to 8
26	424+000	425+000	6 to 8
27	425+000	426+000	6 to 8
28	426+000	427+000	6 to 8
29	427+000	428+000	6 to 8
30	428+000	429+000	6 to 8
31	429+000	430+000	6 to 8

### 3.4.3.1 Settlements

There are 17<sup>th</sup> numbers of settlements along the project road out of which 03 number are urban habitation and 14 numbers are rural habitations shown in the table 3.4 to 3. 5

**Table 3.4: Urban Settlements**

S. No	Chainage	Village Name	District
1	407+000	Langasu	Chamoli
2	417+000	Nandprayag	Chamoli
3	429+000	Chamoli	Chamoli

**Table 3.5: Rural Settlements**

S. No	Chainage	Village Name	District/Taluka
1	400+300	Rajnagar	Chamoli
2	402+950	Humatha	Chamoli
3	403+200	Kalpeshwar	Chamoli
4	405+300	Jaikandigad	Chamoli
5	409+450	Baidanu	Chamoli
6	410+700	Bakuda	Chamoli
7	411+550	Virajgang	Chamoli
8	413+000	Devli	Chamoli
9	414+000	Sonla	Chamoli
10	421+000	Pursadi	Chamoli
11	424+000	Mathana	Chamoli
12	426+000	Bazbara	Chamoli

S. No	Chainage	Village Name	District/Taluka
13	427+000	Kuher	Chamoli
14	428+000	Bachpur	Chamoli

### 3.4.4 Horizontal Alignment

Generally the horizontal alignment of the project section is poor with number of deficient curves and hair pin curve which is given in table 3.6:

**Table 3.6: Deficient Curves**

S. No.	Design Chainage(km)		Design radius	Existing Radius (m)	Grade In	Grade Out	Remarks
	From	To					
1	398+326	398+331	20	20	2.8%	2.8%	Approach of retained bridge in habitation of Karanparyag
2	398+906	398+944	17.5	17	3.4%	3.4%	Dense Habitation
3	410+068	410+102	20	20	-4.0%	-4.0%	Hair Pin Bend, deep valley on both side
4	410+794	410+820	20	16	2.0%	2.0%	Deep Valley on left side and huge SMB cutting in right side
5	410+906	410+945	20	16	2.0%	2.0%	Both side Valley
6	411+358	411+393	17.5	16	4.0%	4.0%	Hair Pin Bend, deep valley on both side
7	411+435	411+475	20	20	4.0%	4.0%	Bridge Approach, vertical hill, huge cutting involve,
8	418+180	418+182	20	16	5.0%	0.0%	
9	418+233	418+256	20	16	0.0%	6.5%	Bridge Approach, vertical hill, huge cutting and Habitation involve

### **3.5 Road and Pavement Conditions survey**

The survey, in general pavement conditions was primarily a visual exercise undertaken by means of slow drive-over survey, and supplemented with measurements where necessary. Visual assessment was carried out from a vehicle, with speed not exceeding 20 - 30 km/hr and stopping at various locations at suitable intervals and wherever necessary, by variations in pavement conditions. At the points of stoppage, simple measurements using measuring tape; straight edge was carried out to quantify pavement deficiency on a representative basis. Aspects of pavement conditions assessed include surface defects, rut depth, cracking, potholes, patched areas, shoulder condition etc. An overall assessment of performance – serviceability of the road was also done to qualitatively rate the existing pavement and shoulder condition.

All the distress conditions were estimated by carrying out visual condition survey and taking measurements wherever necessary after dividing each distress mode of the Pavement in categories by studying, the pavement condition of the project road which is given in table 3.7:

**Table 3.7: Classification System of Pavement Defects. Types and Severity of Defects**

<b>Distress Type</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>
Cracking	0-5%	5 – 10 %	10 - 15%	15 - 25%	> 25%
Ravelling	0- 5%	5 – 10 %	10 - 15%	15 - 25%	> 25%
Rutting	0– 5 mm	5– 10 mm	10 – 15 mm	15 – 25 mm	> 25 mm
Potholes	0-5%	5 – 10 %	10 - 15%	15 - 25%	> 25%
Patching	0-5%	5 – 10 %	10 - 15%	15 - 25%	> 25%

### **3.6 Material Investigations and Surveys**

During preliminary surveys and investigations suitable source of all construction materials was identified. Samples were collected from all the identified sources. Based on the results of the investigations it was confirmed that sufficient sources of construction materials are available in and around the project site as given below:

1. Moorum (Granular Deposit for construction of Sub-Base) – Local
2. Aggregates (For Base and wearing courses) - Pipalkothi
3. Sand - Local
4. Water – Local
5. Bitumen – Panipat
6. Cement – Rishikesh
7. Steel – Rishikesh

### **3.7 PAVEMENT SURVEYS AND INVESTIGATIONS**

The survey on general pavement condition was primarily a visual exercise undertaken by means of slow drive-over survey, and supplemented with measurements where necessary. Visual assessment was carried out from a vehicle, with speed not exceeding 15 km/hr and stopping at various locations at suitable intervals and wherever necessary, to assess variations in pavement conditions. At the points of stoppage, simple measurements using measuring tape and straight edge were carried out to quantify pavement deficiency on a representative basis. Aspects of pavement conditions assessed include surface defects, rut depth, cracking, potholes, patched areas, shoulder condition etc. An overall assessment of performance – serviceability of the road was also done to qualitatively rate the existing pavement and shoulder condition.

#### **3.7.1 Benkelman Beam Deflection Test:**

The rebound deflection measurements, using Benkelman Beam Deflection method in accordance to CGRA procedure stipulated in IRC-81:1997 (“Guidelines for strengthening of flexible pavement using Benkelman Beam Deflection Technique”), for the stretches of the Project road where bypass or realignment is not provided, in both directions along outer wheel path. The exact length for which BBD Test would be conducted in Km.

Following procedure has been adopted.

- One set of ten readings in 250 m for every 1000 m were taken
- Temperature correction with respect to standard temperature of 35°C was applied
- Considering moisture content of sub-grade soil and rainfall of the area, further corrections have been applied. Results of the deflection tests are included in the Appendix 3.7 of Volume-I (Appendix Volume of Main Report). The characteristic deflection values for homogeneous sections for use in design are shown in Appendix 3.7.
- Test pits at every 2.5 km interval to obtain pavement composition details so as to be able to study the correlation between deflection & composition.

### **3.8 HYDROLOGICAL INVESTIGATIONS**

Detailed hydraulic investigations have been carried out for the bridges falling on the project road. Topographic maps of the project area have been collected. Hydraulic parameters like HFL, LWL, cross sections and L-section of streams have been collected from site. Calculation of the discharge of the streams by rational method and Empirical formula has been carried out using catchment areas worked out from topographic maps. Discharge calculations by area velocity method have also been completed. The detailed calculations and results have been presented in “*Volume-II: Design Report, Part C: Hydrology Report.*”

### 3.9 CONDITION SURVEY OF BRIDGES & STRUCTURES

A project team was formed to carry out the inventory and visual condition survey of existing bridges and culverts as per guidelines stipulated in IRC-SP: 35-1990. Project team has inspected all the culverts and bridges on the project road.

Commonly found defects in the structures on the existing road were as follows-

- Honeycombing
- Exposure of Reinforcement
- Damaged stone masonry parapets
- Damaged Hand Railing
- Damaged/missing protection works
- Rusted metallic bearings
- Settlement of approach slab
- Damaged wearing coat
- Washed out mortar between stone masonry joints
- Large size boulders restricting free flow of water
- Vegetation growth on wing wall and arches
- Vegetation growth at up-stream and down-stream
- Partially choked openings in culverts
- Excessive Vibration
- Damaged/Chocked Weep Holes
- Erosion of Banks
- Excessive noise and wearing out of expansion joints
- Clogging and damaged drainage spouts
- Cracks, pot holes in wearing course
- Settlement of approach slab

Brief details of the existing bridges collected from Condition Survey/local inquiries on project road is given in Table 3.8.

**Table 3.8: Minor bridges**

S. No.	Existing Chainage (km)	Type of Structure			No. of Spans with span length (c/c of exp gap)	Total Width (m)
		Foundation	Sub-Structure	Super-Structure		
1	402+805	Open	Brick Masonry	RCC Girder	1 x 9.0	6.0
2	403+475	Open	Brick Masonry	RCC Girder	1 x 9.0	7.5
3	405+505	Open	Brick Masonry	RCC Girder	1 x 9.0	6.0
4	408+085	Open	PCC	CC Arch	1 x 12.0	5.5
5	411+570	Open	PCC	CC Arch	1 x 12.0	4.5
6	412+610	Open	RCC	RCC Girder	1 x 21.0	12.0
7	418+970	Open	RCC	PSC Girder	1 x 38.0	8.5
8	419+120	Open	RCC	RCC Girder	1 x 28.0	8.5
9	421+460	Open	RCC	RCC Girder	1 x 12.0	6.0



S. No.	Existing Chainage (km)	Type of Structure			No. of Spans with span length (c/c of exp gap)	Total Width (m)
		Foundation	Sub-Structure	Super-Structure		
10	422+420	Open	RCC	PSC Girder	1 x 42.0	8.5
11	427+225	Open	PCC	CC Arch	1 x 12.0	5.0
12	427+675	Open	PCC	CC Arch	1 x 12.0	5.0

### 3.10 TRAFFIC SURVEYS

Traffic surveys are essential to appreciate the prevailing traffic and travel characteristics of the project influencing area. Traffic surveys were conducted during the month of June 2004. The following surveys were conducted for the assessment of traffic characteristics and travel pattern.

- Classified Traffic Volume Count
- Origin-Destination and Commodity Movement Characteristics
- Turning Movement Surveys
- Axle Load Surveys
- Speed Delay Survey
- Pedestrian Volume Surveys
- Opinion Survey

All these traffic surveys have been carried in accordance with the guidelines specified of IRC: 9-1972 and IRC: 102-1988. The survey schedule has been presented in table below. The methodology adopted for conducting these surveys is briefly described below:

The PCU's adopted for the analyses are as per the IRC - 64 "Capacity of Rural Roads". The PCU factors for different vehicle type are presented in Table 3.9.

**Table 3.9: PCU Factors for Different Modes**

Vehicle Type	PCU Equivalent	Vehicle Type	PCU Equivalent
Two-wheeler	0.5	3-Axle Truck	3.0
Auto Rickshaw	1.0	M-Axle Truck	4.5
Tempo	1.0	LCV/Tempo	1.5
Car/Jeep/Van	1.0	Tractor Without Trailer	1.5
Standard Roadways Bus	3.0	Tractor with Trailer	4.5
Mini Bus	1.5	Cycle	0.5
Private Bus	3.0	Cycle Rickshaw	1.5
2-Axle Truck	3.0	Animal Drawn	6.0

After thorough site inspection, the project corridor has been divided in to five homogeneous sections accordingly with reference to traffic movements. The five homogeneous sections of the study corridor are given in Table 3.10

**Table 3.10: Homogeneous Links**

Homogeneous Section	Existing Chainage	Length (km)	Name Of Location
Section 1	368.000 – 399.000	31.00	Rudraprayag to Karanprayag
Section 2	399.000 – 418.000	19.00	Karnprayag to Nandprayag
Section 3	418.000 – 430.000	12.00	Nandprayag to Chamoli
Section 4	430.000 – 480.000	50.00	Chamoli to Joshimath
Section 5	480.000 – 527.000	47.00	Joshimath to Mana

Consultants have identified five locations for carrying out “Classified Traffic Volume Survey” for above said two road-segments.

**Table 3.11: Traffic Volume Count Survey Locations**

Location Code	Chainage	Corridor Section	Date		Duration
			From	To	
TVC –1	374.000	Village Ratura	16-05-2014	23-05-2014	7 Days
TVC –2	410.000	Village Dhungwali	16-05-2014	23-05-2014	7 Days
TVC –3	425.500	Village maithana	16-05-2014	23-05-2014	7 Days
TVC –4	444.000	Village Agethala	16-05-2014	23-05-2014	7 Days
TVC –5	501.000	-	16-05-2014	23-05-2014	7 Days

The Origin Destination (O-D) surveys were conducted at all selected locations for a period of 24 hours through a pre-designed format on a normal working day.

The Detailed Traffic Analysis are summarised in Chapter- 5 of this report

## CHAPTER – 4: ANALYSIS AND INTERPRETATION OF SURVEY & INVESTIGATIONS

### 4.1 General

The President of India acting through Ministry of road transport and highway (MORT&H), represented by the Director General & special secretary is engaged in the development of national highway and as a part of this in the state of Uttarakhand, various roads has been selected for strengthening & widening purpose. All these roads are divided in seven packages and bided for detail study. These seven packages are as under.

- i. Km 228.00 (Rishikesh) to Km 368.00 (Rudraprayag) of NH-58
- ii. Km 368.00 (Rudraprayag) to Km 528.00 (Mana Village) of NH-58
- iii. Km 0.00 (Rishikesh) to Km 144.00 (Dharasu) of NH-94
- iv. Km 0.00 (Dharasu) to Km 124.00 (Gangotri) of NH-108
- v. Km 144.00 (Dharasu) to Km 220.00 (Yamunotri) of NH-94
- vi. Km 0.00 (Rishikesh) to Km 76.00 (Gaurikund) of NH-109
- vii. Km 52.00 (Tanakpur) to Km 202.00 (Pithoragarh) of NH-125

### Sub-packaging

The design length of project road is 139.8 km and is divided in five packages. Its packaging is done as per the priority of the ground. Detail of which is tabulated in the **table 4.1 below**.

**Table 4.1: Divided into five packages**

Pkg. no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (in km)
1	Km 368.000-Km 399.000	Km 368.000-Km 398.300	Lameri-Karanprayag	Widening to 2-lane+ Geometric Imp+R.S	29.125
2	Km 399.000-Km 430.000	Km 398.300-Km 427.650	Karanprayg-Chamoli	Widening to 2-lane+ Geometric Imp+R.S	28.800
3	Km 430.000-468.000	Km 427.650-Km 465.150	Chamoli-Paini	Widening to 2-lane+ Geometric Imp+R.S	36.675
4	Km 468.000-Km 489.350	Km 465.150-Km 471.400	Joshimath Bypass	New Alignment	6.250
5a	Km 489.350- Km 491.600	Km 471.400-Km 473.675	Shingdhar Bridge to Vishnuprayag bridge including	Widening to 2-lane with Paved Shoulder	2.275

Pkg. no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (in km)
			Hatipahar landslide		
5b	Km 491.600- Km 504.600	Km 473.675- Km 486.100	Vishnuprayag bridge to lambagadh	Widening to 2-lane+ Geometric Imp+R.S	12.425
-	Km 504.600-km 505.100	Km 486.100- km486.600	Lambagadh Land Slide	Awarded	500
5c	Km 505.100- Km 509.700	Km 486.600- Km 490.550	Lambagadh to Benakuli including Benakuli landslide	Widening to 2-lane+ Lambagadh Landslide	3.950
5d	Km 509.700- Km 528.000	Km 490.550- Km 507.850	Benakuli Bend to Mana	Widening to 2-lane+ Geometric Imp+R.S	17.300

This report pertains to Sub-Package-II the Design length of the road in this package is 28.8 km i.e from km 398.300 to 427 (Excluding Km 420.250 to Km 420.500 and Km 423.300 to km 423.650) in the state of Uttarakhand

## 4.2 IMPROVEMENT / CONSTRUCTION PROPOSALS

It is pertinent to discuss improvement proposals because these need to address present conditions, account for the sustenance of desired Levels of Service with respect to both capacity and pavement condition, and be achieved in a phased manner so as to stagger investments. Based on existing road and traffic conditions and traffic on the project corridor over the project duration, capacities have been reassessed and improvement proposals have been worked out.

### 4.2.1 Geometric Improvement

#### 4.2.1.1 Horizontal Alignment

Out of the several existing curves present there along the project road, many curves are deficient, with respect to minimum design speed of 20-30 km/hr.

All the curves have been improved to meet design standard requirements as per IRC. At some of the locations, broken back curves have been observed and have been replaced with a single curve of sufficient radii, however, there are 6 curves which have been improved at the maximum extent but don't satisfy the IRC standard due to some restrictions like huge cut, habitation or to maintain the approach of retained bridges. The list of such curves is presented below in the **table 4.2**.

**Table 4.2 Details of deficient curves in horizontal alignment.**

S. No.	Design Chainage(km)		Design radius	Existing Radius (m)	Grade In	Grade Out	Remarks
	From	To					
1	398+326	398+331	20	20	2.8%	2.8%	Approach of retained bridge in habitation of Karanparyag
2	398+906	398+944	17.5	17	3.4%	3.4%	Dense Habitation
3	410+068	410+102	20	20	-4.0%	-4.0%	Hair Pin Bend, deep valley on both side
4	410+794	410+820	20	16	2.0%	2.0%	Deep Valley on left side and huge SMB cutting in right side
5	410+906	410+945	20	16	2.0%	2.0%	Both side Valley
6	411+358	411+393	17.5	16	4.0%	4.0%	Hair Pin Bend, deep valley on both side
7	411+435	411+475	20	20	4.0%	4.0%	Bridge Approach, vertical hill, huge cutting involve,
8	418+180	418+182	20	16	5.0%	0.0%	
9	418+233	418+256	20	16	0.0%	6.5%	Bridge Approach, vertical hill, huge cutting and Habitation involve

#### 4.2.1.2 Vertical Alignment / Gradient

The project road is predominantly on steep terrain. Vertical profile has been designed in accordance with the guidelines and geometric standards have been discussed in this report. Exceptional maximum gradient of 8% have been followed for a few sections of the project road.

It can be seen that the project road is generally in steep terrain and therefore a ruling gradient of 6% has been adopted for design. In order to avoid such huge cutting/ filling, which is also not economically desirable, an exceptional maximum gradient of 8% have been allowed for the design of vertical profile for the stretches presented in Table 4.3:

**Table 4.3 Vertical Alignment Deficient Curves**

S. No	Vertical Tangent Points					Grade (%)	Length of Element	Remarks/Reason
	Start Chainage	Elevation (M)	End Chainage	Elevation (M)	Elevation Difference			
1	395771.617	827.395	396428.97	774.807	52.588	-8	657.352	Continuous Steep Slope, Steep Terrain

#### 4.2.2 Junctions

There are no major and 06 minor junctions along this road section. The detail of which is attached at Appendix 3.3 of Volume-I (Appendix Volume of Main Report).

#### Major Junctions

There is no major junction along the project road in tabulated in table 4.4:

**Table 4.4: Major Junction**

S. No.	Name of Intersection	Chainage	Leading to	Intersecting with	Type of Intersection
NIL					

#### Minor Junctions

There are 06 minor junctions along the project road. The list of minor junctions is presented in **Table 4.5** below.

**Table 4.5: Minor Junction**

SI. No.	Existing Chainage (km)	Type	
		Junction	Cross Road
1	400+000	T	Village Road
2	412+700	Y	Village Road
3	418+850	Y	Village Road
4	418+950	T	Village Road
5	423+600	Y	Village Road
6	424+150	Y	MDR

### 4.3 PAVEMENT

The present road is single lane with variable width due to extra widening on the deficient curves. The thickness and composition of the pavement crust is given the table 4.6 below.

**Table 4.6: Thickness and composition of the pavement crust**

S No	Pavement composition	Min. Thickness (mm)
1	Bituminous Concrete	40
2	DBM	90
3	WMM	250
4	Granular Sub Base	260

#### 4.3.1 Salient Features of Existing Bridges

There are total 12 minor bridges along the project road which is given below:

**Table 4.7: Existing Major Bridges**

S. No.	Existing Chainage (km)	Type of Structure			No. of Spans with length (m)	Width (m)
		Foundation	Sub-Structure	Super-Structure		
NIL						

**Table 4.8: Existing Minor Bridges**

S. No.	Existing Chainage (km)	Type of Structure			No. of Spans with span length (c/c of exp gap)	Total Width (m)
		Foundation	Sub-Structure	Super-Structure		
1	402+805	Open	Brick Masonry	RCC Girder	1 x 9.0	6.0
2	403+475	Open	Brick Masonry	RCC Girder	1 x 9.0	7.5
3	405+505	Open	Brick Masonry	RCC Girder	1 x 9.0	6.0
4	408+085	Open	PCC	CC Arch	1 x 12.0	5.5
5	411+57	Open	PCC	CC Arch	1 x 12.0	4.5
6	412+61	Open	RCC	RCC Girder	1 X 21.0	12.0
7	418+97	Open	RCC	PSC Girder	1 X 38.0	8.5
8	419+120	Open	RCC	RCC Girder	1 X 28.0	8.5
9	421+460	Open	RCC	RCC Girder	1 x 12.0	6.0
10	422+420	Open	RCC	PSC Girder	1 X 42.0	8.5
11	427+225	Open	PCC	CC Arch	1 x 12.0	5.0
12	427+675	Open	PCC	CC Arch	1 x 12.0	5.0

#### **4.4 CULVERTS**

The existing culverts which are mostly RCC Slab culverts and some is stone masonry arch culverts are old and damaged

The Summary is given in table 4.9:

**Table 4.9: Summary of Culverts Structures**

<b>S. No</b>	<b>Type of Culvert</b>	<b>Number</b>	<b>Remark</b>
1	Arch	1	Reconstruction
2	Arch Bridge	2	Reconstruction
3	Box	1	Reconstruction
4	Pipe	9	Reconstruction
5	Scooper	12	Reconstruction
6	Slab	59	Reconstruction
7	Stone	8	Reconstruction

#### **4.5 ROAD SIDE DRAINAGE**

An effective drainage system has been planned for the drainage of roadway as per stipulations of IRC SP: 42-1994 for maintaining structural soundness and functionality of the project road. The following types of drains have been provided for surface drainage of roadway and ROW:

Longitudinal trapezoidal 0.6m x 0.65m x 0.90m (top width) stone masonry lined drains at the toe of the hill, with outfalls at cross-drainage structures. Cement concrete rectangular section of 0.6m x 0.65m is proposed on the side of median and north bound carriageway.

The drain size, shape and material is adequate to take design run off, and prevent soil erosion and stagnation of water.

#### **4.6 RETAINING STRUCTURES AND SLOPE PROTECTION WORKS**

Retaining walls and Slope Protection/ Stabilizations are common feature of road construction in mountainous regions and will account for a substantial portion of total construction costs. They are constructed for the following situations:

- to support a road either wholly or partly on fill when the ground profile is too steep (usually greater than 30 degrees) to allow an embankment slope
- to support the toe of a slope that has failed or is likely to fail
- to support cut slopes that would otherwise require a low, uneconomic angle of cut
- when there are constraints on the permissible plan extent of earthworks
- As revetments to prevent erosion on steeply sloping cut faces as part of a slope stabilization scheme.



## **4.7 TRAFFIC CONTROL AND SAFETY MEASURES**

### **4.7.1 General**

The existing single lane road is proposed for improvement to two lane with paved shoulder system in order to provide a high-speed facility to the existing national highway corridor. It is being designed, duly considering the following basic 2-laning carriageway parameters:

- High operating speeds of traffic;
- Partially access control;
- Highest standards of safety; and
- Highest maintenance standards;

The geometric characteristics of roads affect the risk and severity of the accidents. Accordingly, the package road is designed in such a way that sudden elements of surprise are avoided and that information acquisition and decision-making are facilitated. This has been achieved by providing sufficient road width, engineered alignment. The package road is proposed for extended facilities.

### **4.7.2 Cross-section**

The width of roadway affects the drivers' abilities to manoeuvre and to overcome potentially hazardous situation. Narrow lanes and carriageway imply restricted clearances for manoeuvring during overtaking operations. It is therefore, reasonable to deduce that increased lane; shoulder and total roadway width will reduce accidents. The project road has been provided with dual carriageway separated by median to ensure segregation of directional traffic and headlight glare during night driving besides obvious risk of head-on collision from the vehicles from the opposite direction plying on the same carriageway.

### **4.7.3 Width of carriageway**

Two- Laning [with] paved shoulders shall be undertaken. The paved carriageway shall be [10(Ten) m] wide in (Type-I to Type-IV-B) and 9 m wide in (Type-V to Type-V-D) accordance with the typical cross sections drawings in the Manual.

### **4.7.4 Cross Slope and Lateral Unevenness**

Flat cross slopes on horizontal road section would cause accumulation of water on the road surface during heavy rains and could thereby contribute to hydroplaning accidents. The project road proposed pavement would have very high quality bituminous surfacing (concrete) that ensures necessary friction for vehicular movements. Pavement surface would have minimum camber of 2.0% for efficient drainage of surface water and ensure safe traffic flow.

### **4.7.5 Alignment**

Studies conducted on the relationship between horizontal alignment and accidents show that accident rate increase with reduction in curve radii and it is more so in case of sudden appearance of sharp bend after long straight sections. However, long straight sections are also prone to cause accidents out of monotony.

#### **4.7.6 Sight distances**

Inadequate sight distance reduces the driver's perception to prepare himself for, necessary manoeuvres. It is therefore, very plausible that increased sight distances would reduce accidents, unless it results in higher speeds. Such factors have duly been considered while formulating design standards.

#### **4.7.7 Road Signs and Markings**

Adequate road signs and markings have been proposed for the package road in order to provide advance information to regulate/control traffic flow and ensure safety of operations. The criteria and other details have already been discussed in preceding paragraphs.

### **4.8 TRAFFIC MANAGEMENT**

#### **4.8.1. General**

Traffic would be under taken during scheduled and unscheduled construction work and maintenance activities and also during any emergency. Traffic management during emergency would be undertaken with consultation with the client. The extent of the traffic management would be addressed as per the site conditions.

#### **4.9.2. Traffic**

Before the commencement of construction activities, an overall traffic management plans and programme for a planned scheduled construction and / or operations and maintenance activities of the existing shall be prepared in consultation with the client. The plan would be based on the following operation parameters:

- The maximum two lane carriageway would be utilized to the maximum extent possible;
- At major intersections / junctions all traffic turning movements would be allowed at all times;
- Lane closer would not be adopted for two lane road traffic during construction works, by providing alternative route or diversion;
- The two lane traffic would be adequately controlled by signing and flagmen;
- The activity of renewal or strengthening for two lane road would not be carried out in a continuous length of more than 2.0km in rural section and 1.0km in urban section and traffic would be adequately controlled by signing and flagmen;
- Traffic speed through the construction zone would be reduced to 20-30km per hour for two lane road by designing speed bumps and warning signs;
- Adequate advance warning and information signs would be incorporated in the traffic management plan I accordance with IRC / MORT&H Standards and Specifications;

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## CHAPTER 5: TRAFFIC SURVEY & FORECAST

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### 5.1 APPRECIATION OF THE PROJECT CORRIDOR

#### 5.1.1 Regional Consideration

To comprehensively appreciate the traffic and travel characteristics on the project corridor from Km 368.000 to Km 528.000 of National Highway No. 58, the type of surveys, locations and duration, identified at the inception stage of the study have been followed during data collection exercise with minor modifications on account of site conditions. With a view to capture section wise traffic flow characteristics, the total stretch has been segmented into five homogeneous sections, based upon the major intersections that act as main collectors or distributors of traffic along the project corridor; i.e., sections of more or less similar traffic characteristics.

#### 5.1.2 Homogeneous sections of Study Corridor

**Fig. 5.1** presents homogeneous sections of the project corridor along with the adjoining networks in the project influence area. The homogeneous sections identified are tabulated below **Table 5.1**.

**Table 5.1: Homogeneous Section**

Homogeneous Section	Existing Chainage	Length (km)	Name Of Location
Section 1	368.000 – 399.000	31.00	Rudraprayag to Karanprayag
Section 2	399.000 – 418.000	19.00	Karnprayag to Nandprayag
Section 3	418.000 – 430.000	12.00	Nandprayag to Chamoli
Section 4	430.000 – 480.000	50.00	Chamoli to Joshimath
Section 5	480.000 – 527.000	47.00	Joshimath to Mana

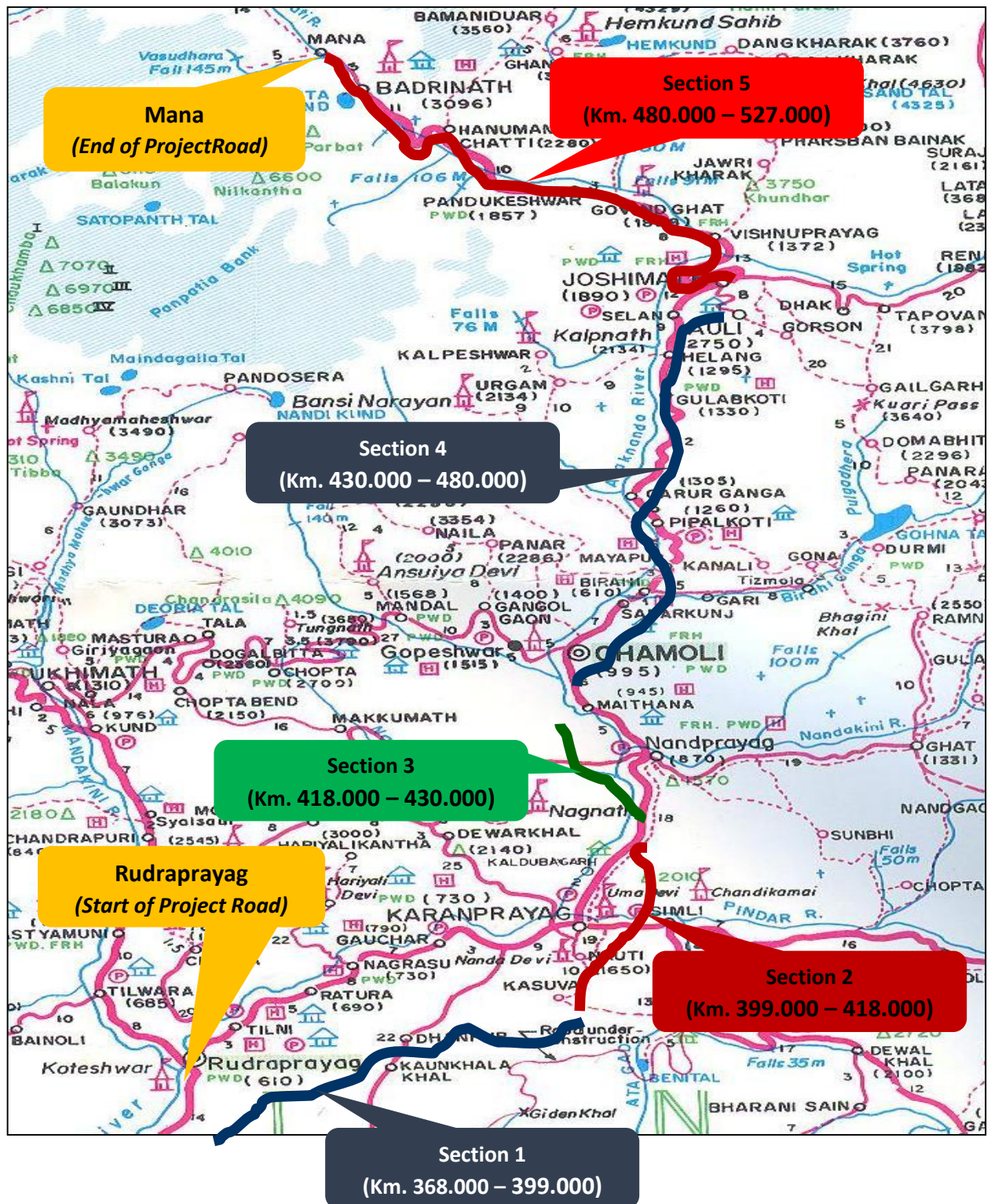


Fig 5.1: Homogeneous Sections for Traffic Survey

### 5.1.3 Objective of Traffic Surveys

The traffic surveys have been carried out along the corridor to establish base year traffic as well as travel characteristics. The baseline traffic characteristics are very important for the assessment of future traffic and travel pattern. The primary objectives of the traffic surveys are to:

- Determine the motorized and non-motorised traffic volumes along the corridor
- Determine the travel patterns of passenger as well as commodity movements
- Determine turning movements at major intersections
- Determine axle loads distribution and vehicle damage factor required for pavement design
- Determine areas of bottlenecks and roadside activities
- Determine improvements for accident black-spots
- Determine parking areas, truck/bus-lay-byes requirements and other data required for highway design.

### 5.2 Traffic Surveys

Traffic surveys are essential to appreciate the prevailing traffic and travel characteristics of the project influencing area. Traffic surveys were conducted during the month of June 2004. The following surveys were conducted for the assessment of traffic characteristics and travel pattern.

- Classified Traffic Volume Count
- Origin-Destination and Commodity Movement Characteristics
- Turning Movement Surveys
- Axle Load Surveys
- Speed Delay Survey
- Pedestrian Volume Surveys
- Opinion Survey

All these traffic surveys have been carried in accordance with the guidelines specified of IRC: 9-1972 and IRC: 102-1988. The survey schedule has been presented in table below. The methodology adopted for conducting these surveys is briefly described below:

The PCU's adopted for the analyses are as per the IRC - 64 "Capacity of Rural Roads". The PCU factors for different vehicle type are presented in Table 5.2.

**Table 5.2: PCU Factors for Different Modes**

Vehicle Type	PCU Equivalent	Vehicle Type	PCU Equivalent
Two-wheeler	0.5	3-Axle Truck	3.0
Auto Rickshaw	1.0	M-Axle Truck	4.5
Tempo	1.0	LCV/Tempo	1.5
Car/Jeep/Van	1.0	Tractor Without Trailer	1.5
Standard Roadways Bus	3.0	Tractor with Trailer	4.5



Vehicle Type	PCU Equivalent	Vehicle Type	PCU Equivalent
Mini Bus	1.5	Cycle	0.5
Private Bus	3.0	Cycle Rickshaw	1.5
2-Axle Truck	3.0	Animal Drawn	6.0

### 5.2.1 One Week Classified Traffic Counts

Mid-block volume count surveys were conducted at seven locations along the project road, one in each homogeneous section. The survey was conducted round-the-clock over 7 consecutive days. For recording classified mode-wise information, vehicles were grouped under the categories as given below in Table 5.3.

**Table 5.3: Vehicle Classification System adopted**

Motorised Traffic		Non-Motorised Traffic
2 wheelers		Bicycle
Auto Rickshaw		Cycle Rickshaw/ Rickshaw Van
Passenger Car : Car, Jeep, Taxi		Animal Drawn/Hand Cart
Van/Tempo		Others
Bus	Mini Bus	
	Standard Bus	
Truck	Light Commercial Vehicle (LCV)	
	2 – Axle Rigid Chassis Truck	
	3 – Axle Rigid Chassis Truck	
	4-6 Axle Trucks	
	> 7 Axle Trucks	
Tractor	Agriculture Tractor	
	Tractor & Trailer	

Enumerators were locally recruited and trained to conduct traffic counts. For the purpose of counting, a day was divided into three shifts of 8 hours each and separate enumerators with a Supervisor were assigned for each shift. The count data were recorded within 15-minute intervals for each vehicle group in each direction.

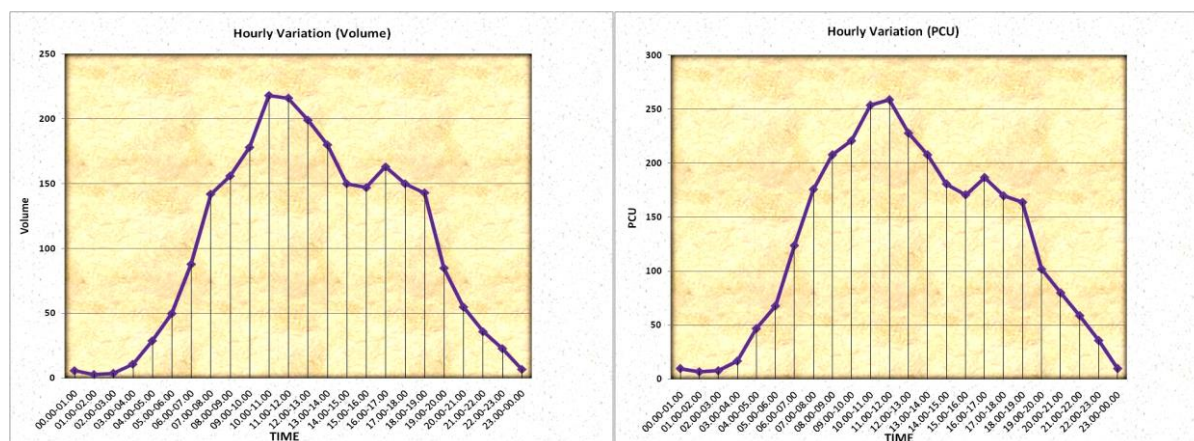
**Table 5.4 : Traffic Volume Count Survey Locations**

Location Code	Chainage	Corridor Section	Date		Duration
			From	To	
TVC –1	374.000	Village Ratura	16-05-2014	23-05-2014	7 Days
TVC –2	410.000	Village Dhungwali	16-05-2014	23-05-2014	7 Days
TVC –3	425.500	Village maithana	16-05-2014	23-05-2014	7 Days
TVC –4	444.000	Village Agethala	16-05-2014	23-05-2014	7 Days
TVC –5	501.000	-	-	-	7 Days

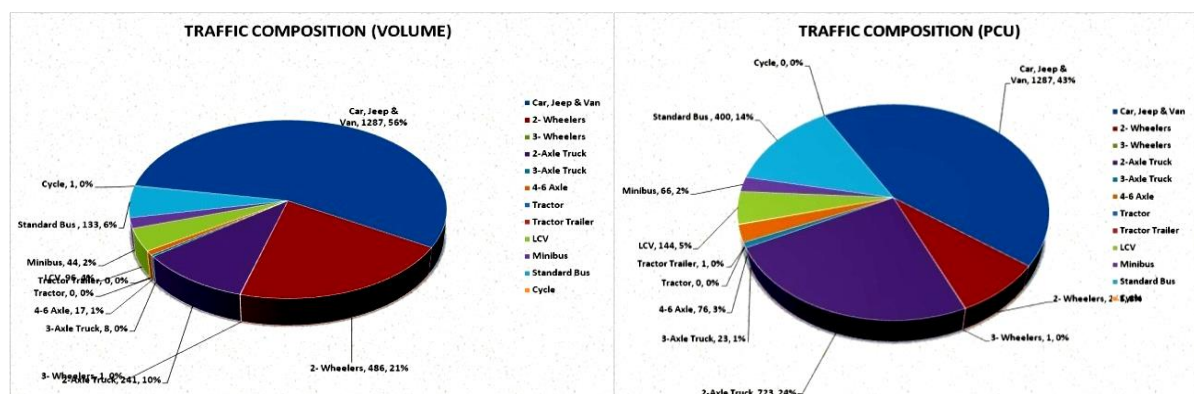
Location wise analysis of one-week counts is presented in the following section of the report.

#### One-week Counts at Km. 374.000

Classified Traffic Volume Counts were carried out at km 374.000 from 17/07/2004 to 24/07/2004 as mentioned in the above table. Details of daily variations, average hourly variations and composition of traffic volume have been presented in **Figure 5.2, Figure5.3.**



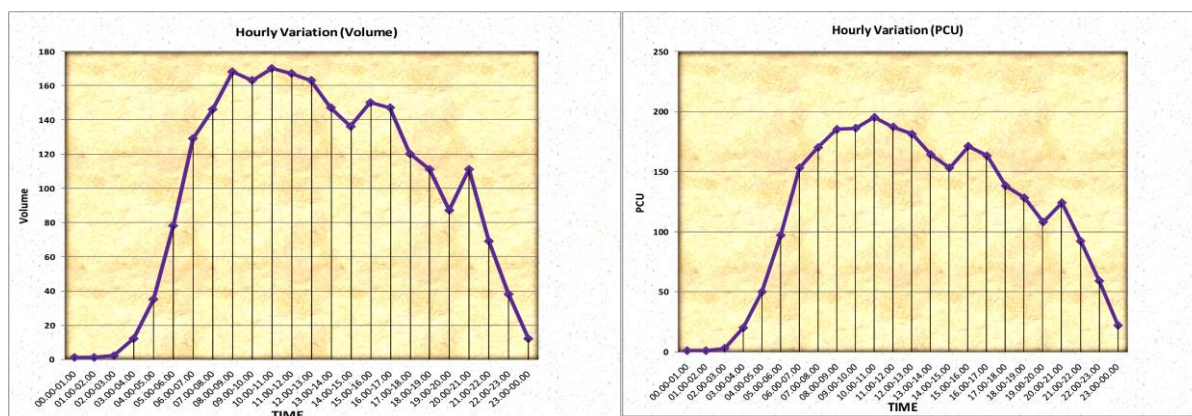
**Fig.5.2:Graphical representation of Hourly Variation (Volume and PCU wise) (374.000)**



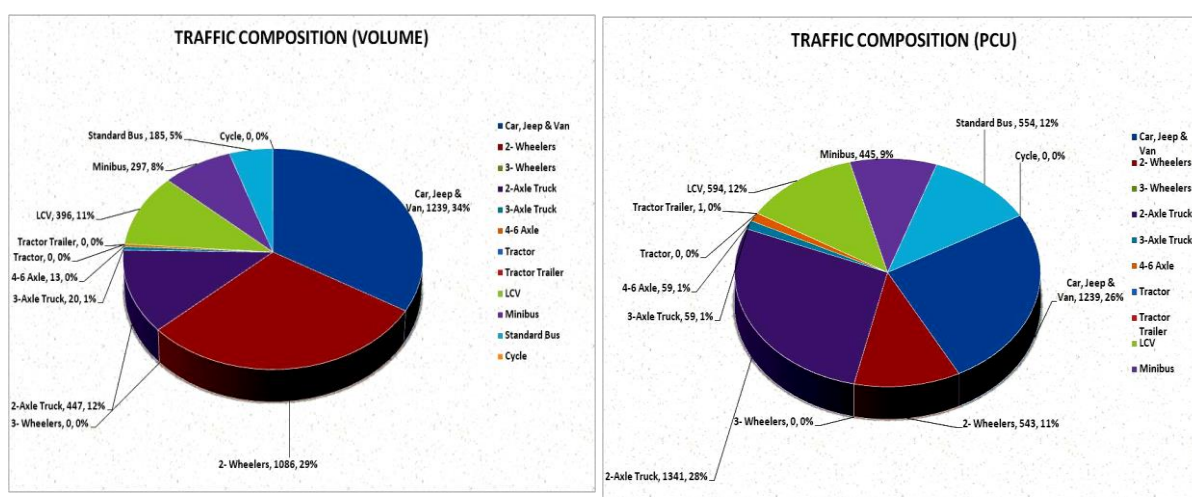
**Fig.5.3:Graphical representation of Traffic Composition (Volume and PCU wise) (374.000)**

### One-week Counts at Km. 410.000

Classified Traffic Volume Counts were carried out at km 410.000 from 17/07/2004 to 24/07/2004 as mentioned in the above table. Details of daily variations, average hourly variations and composition of traffic volume have been presented in **Figure5.4** and **Figure 5.5**.



**Fig.5.4:Graphical representation of Hourly Variation (Volume and PCU wise) (Km 410.000)**



**Fig.5.5: Graphical representation of Traffic Composition (Volume and PCUwise) (Km 410.000)**

### One-week Counts at Km. 425.500

Classified Traffic Volume Counts were carried out at km 425.500 from 17/07/2004 to 24/07/2004 as mentioned in the above table. Details of daily variations, average hourly variations and composition of traffic volume have been presented in **Figure5.6** and **Figure 5.7**.



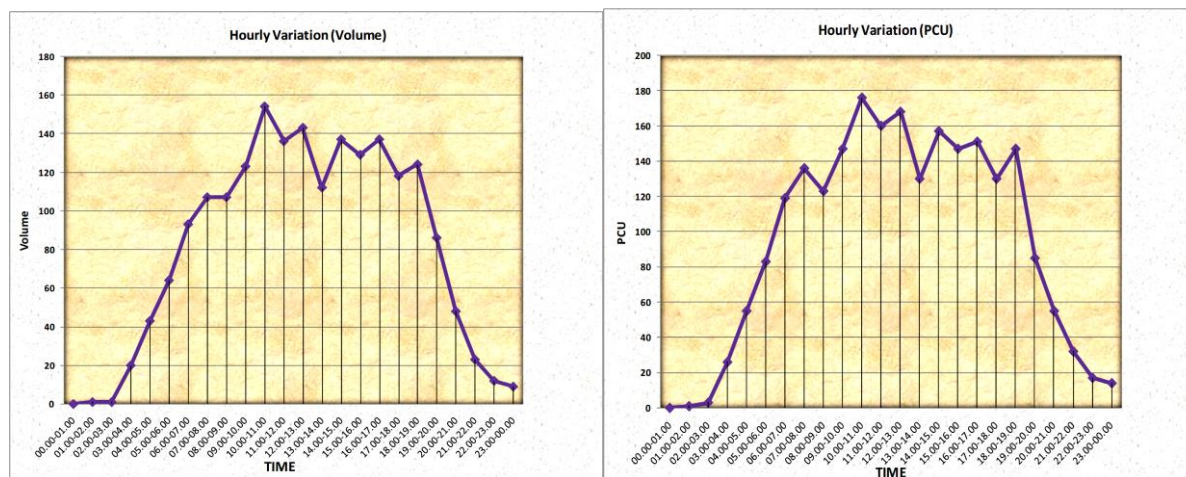


Fig.5.6: Graphical representation of Hourly Variation (Volume and PCU wise) (Km 425.000)

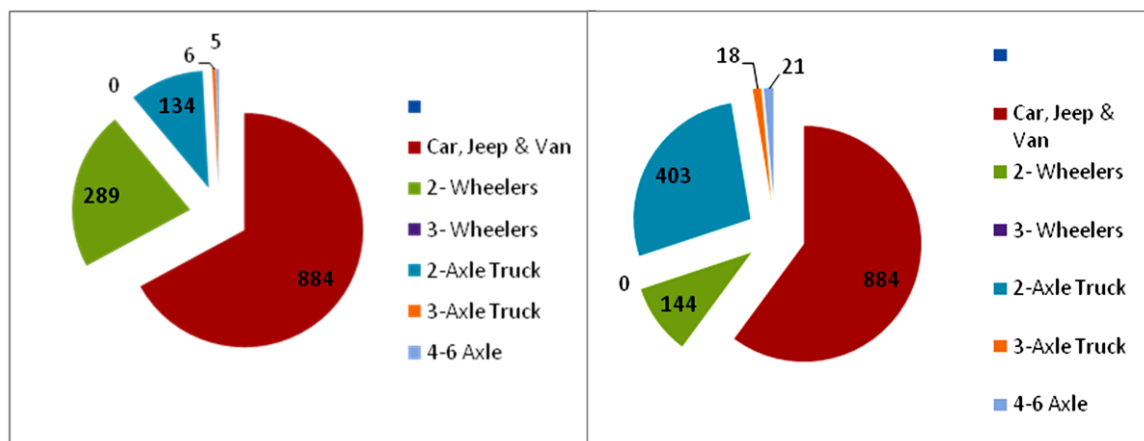
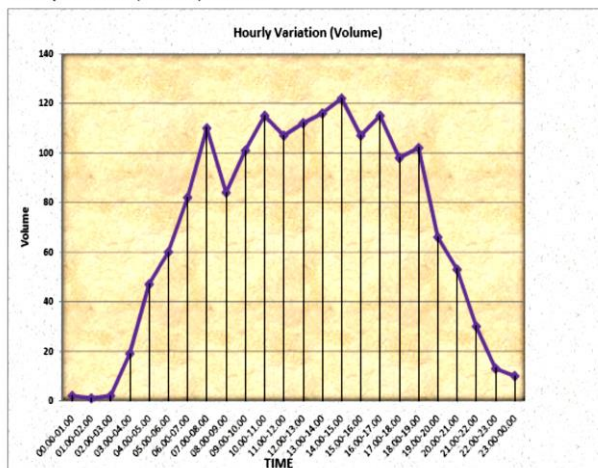


Fig.5.7: Graphical representation of Traffic Composition (Volume and PCU wise) (Km 425.000)

One-week Counts at Km. 444.000

Classified Traffic Volume Counts were carried out at km 444.000 from 17/07/2004 to 24/07/2004 as mentioned in the above table. Details of daily variations, average hourly variations and composition of traffic volume have been presented in **Figure 5.8** and **Figure 5.9**.

Hourly Variation (Volume)CHART-3



Hourly Variation (PCU)CHART-4

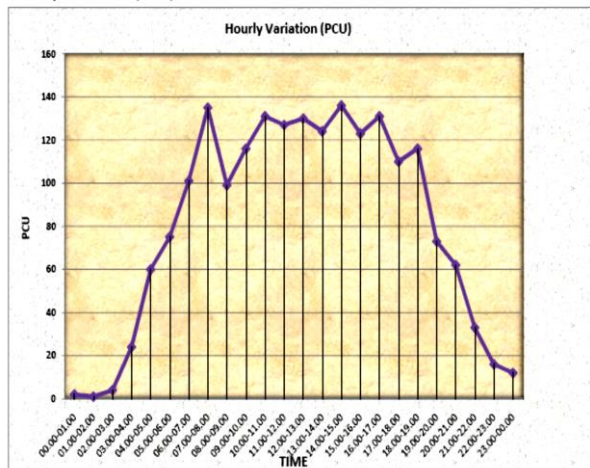


Fig.5.8:Graphical representation of Hourly Variation (Volume and PCUwise) (Km 444.000)

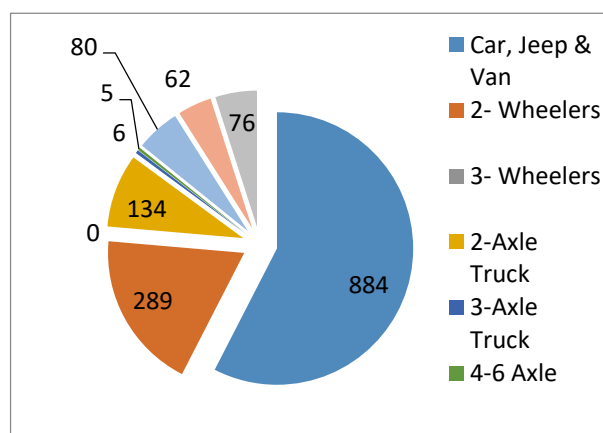
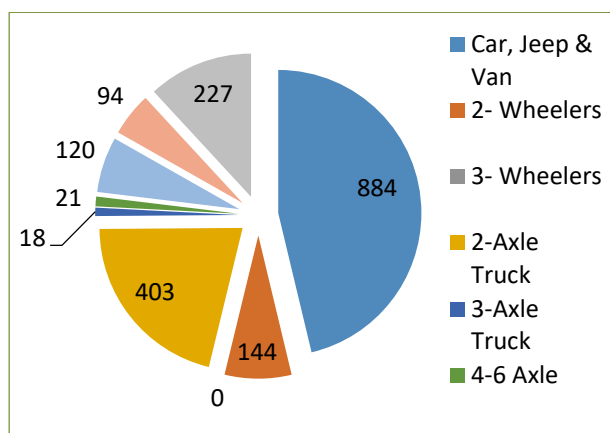
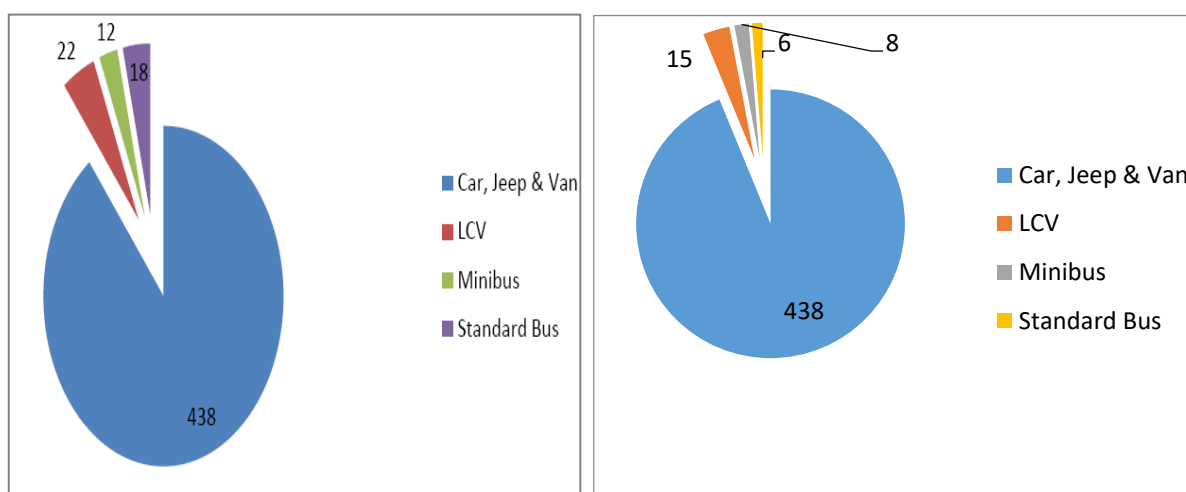
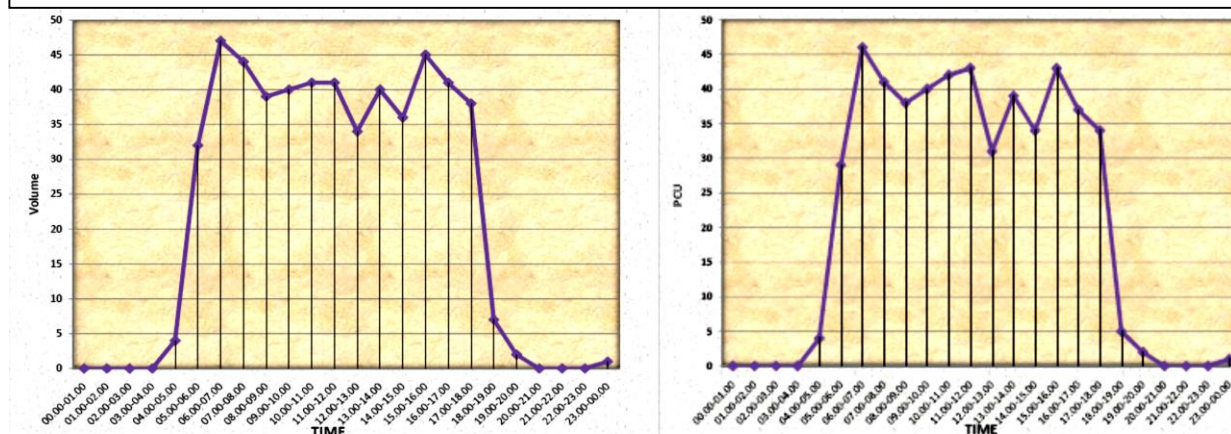


Fig.5.9: Graphical representation of Traffic Composition (Volume and PCUwise) (Km 444.000)

#### One-week Counts at Km. 501.000

Classified Traffic Volume Counts were carried out at km 501.000 from 17/07/2004 to 24/07/2004 as mentioned in the above table. Details of daily variations, average hourly variations and composition of traffic volume have been presented in **Figure 5.10** and **Figure 5.11**.

**Fig.5.10: Graphical representation of Hourly Variation (Volume and PCUwise) (Km 501.000)**



**Fig.5.11: Graphical representation of Traffic Composition (Volume and PCU wise) (Km 501.000)**

**Appendix 4.1** of Volume II: (Appendix Volume of Main Volume) presents location wise traffic volume survey analysis summary sheet that comprise averaged (7 day) mode wise hourly traffic (Both Directions) in terms of total vehicles and PCU, peak hour traffic, traffic composition, mode wise hourly variation, and other salient features.

### 5.2.2 Origin-Destination Survey

The project corridor in its influence area serves as the main spine of traffic movement. Preliminary network analysis in the influence area and travel patterns on the same did not indicate any through traffic movement on the road sections other than the project corridor, and hence no divertible traffic from the surrounding network onto the project corridor has been envisaged in case of further improvement to the project corridor. Further to understand the desire pattern of traffic, the Origin-Destination Survey was conducted at 5 locations on the project corridor for 24 hours continuously, in a manner so as to coincide with the representative volume counts. The road-side direct interview

method was adopted to conduct the survey on a pre-designed Performa. The survey sample was captured uniformly following a systematic random approach for all modes, with due care to avoid duplication of samples and undue weightage to any particular mode.

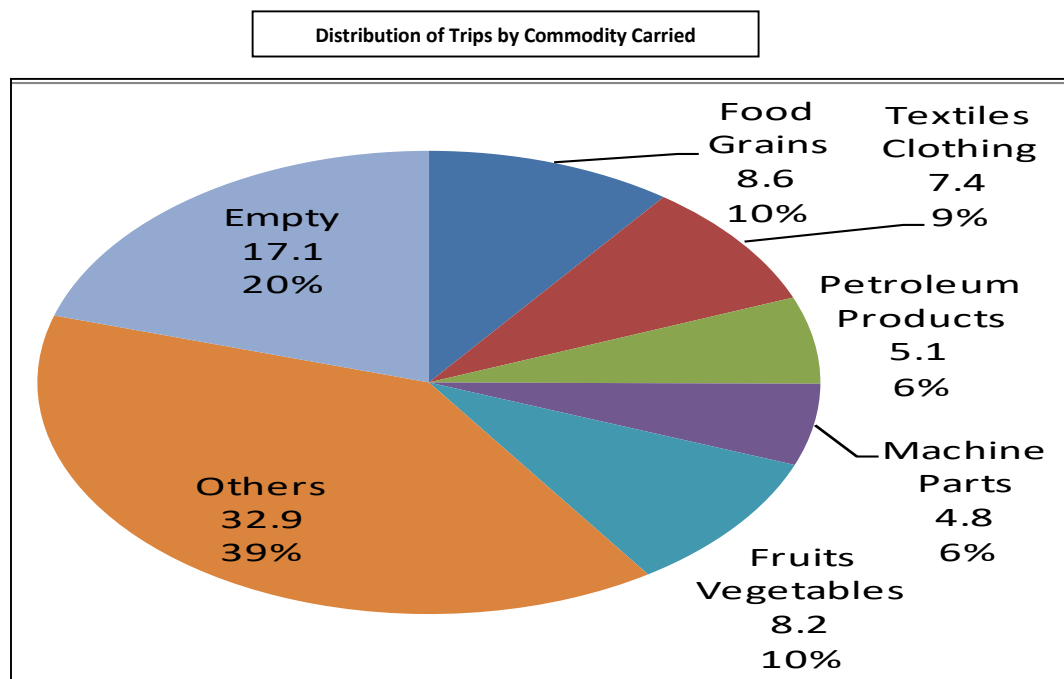
### 5.2.3 Delineation of Traffic Zones

A traffic zoning system is essential for the appreciation of the travel pattern, which reflects direct and indirect impacts of the project. Keeping in view the impact of the project corridor, which falls in Rudraprayag and Chamoli district, the study area (India) is divided into a three-stage zoning system. The first stage is at the district level where taluka(s) or even a portion of the taluka has been considered as a traffic zone. In the second-stage (i.e. at state level) individual or groups of districts form a traffic zone. In the third-stage of the zoning system (i.e. at national level), individual states or group of states form a traffic zone based on their influence on the project corridor.

Considering the traffic scenario along the project road zones are divided as the **Table 5.6** below.

**Table 5.6: List of Traffic Zones**

Zone No.	Zone Name	District/ State	Places
1	Rudraprayag	Rudraprayag	Rudraprayag, Kedarnath, Gaurikund, Ukhimath
2	Joshimath	Chamoli	Joshimath, Pipalkothi
3	Badrinath	Chamoli	Badrinath
4	Karnaprayag	Chamoli	Karnaprayag, Nainital, Ranikhet, Almora, Chamoli, Gopeshwar, Govindghat, Gochar
5	Other 11 districts of Uttarakhand	Uttarakhand	Almora, Bageshwar, Champawat, Dehradun, Haridwar, Nainital, PauriGarhwal, Pithoragarh, TehriGarhwal, Udham Singh Nagar, Uttarkashi, Roorkee, Rishikesh, Kotdwar, Devprayag
6	Neighbouring State	India	Himanchal Pradesh, Haryana, Uttarpradesh
7	Other Three States	Groups of States	Punjab, J& K, Delhi



The corridor, being part of National Highway-58 from Rishikesh to Mana (Badrinath), caters to a variety of transported goods. Though being very tough to classify all varieties into categories, effort has been made to group the various types of goods into 7 categories to cover broad cross-section of the various commodities in transit. From figure 5.24, it can be observed that major commodity types carried by goods vehicles are Fruits and Vegetables (10%) followed by textile clothing (9%). The considerable share of fruits/vegetables, Textile/clothing and Petroleum products can be attributed by existing agricultural development along the project corridor. Significant other commodities include building materials viz. cement, bricks and stone and household goods. However, the seventh category, i.e. others, which constitutes the remainder of the 6 categories discussed, has a considerable share (39%).

#### 5.2.4 Desire Pattern

##### Frequency Distribution of Trips:

Fig.5.12 and 5.13 present the Trip length and time frequency distribution curves for passenger vehicles on the project corridor. From the figures it can be observed that 60% of the trips are performed within a 50 km trip length and one-hour time range. Around 12% of the passenger trips have a mean trip length of 150 km followed by 5% of trips at 250 km. Only 11% of the trips have a trip length of more than 250 km.

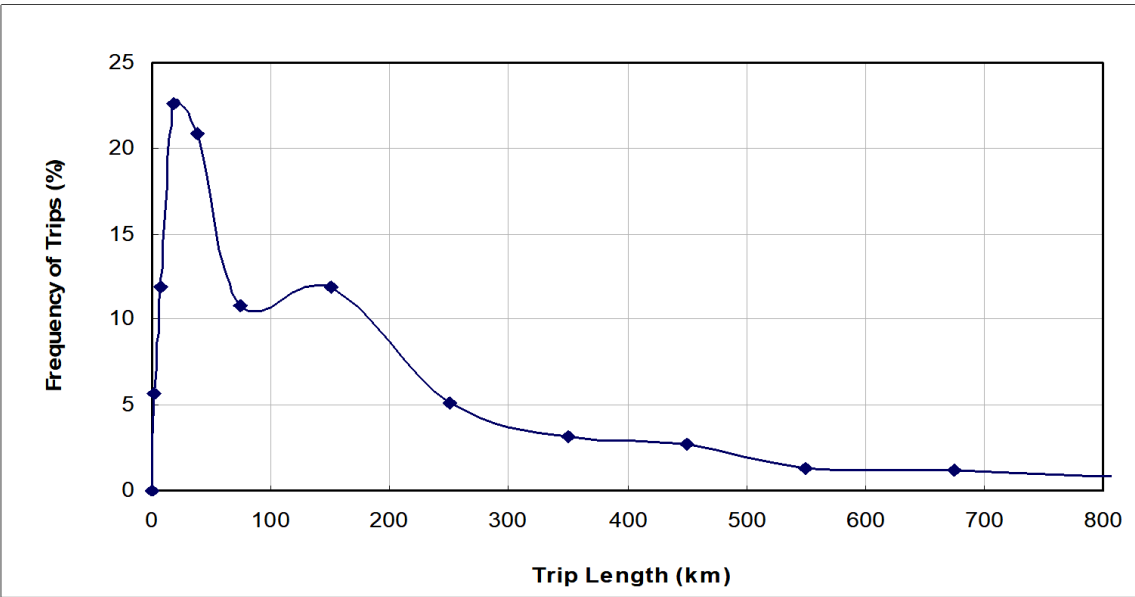


Fig.5.12: Trip Length Frequency Distribution Curve for Passenger Vehicles

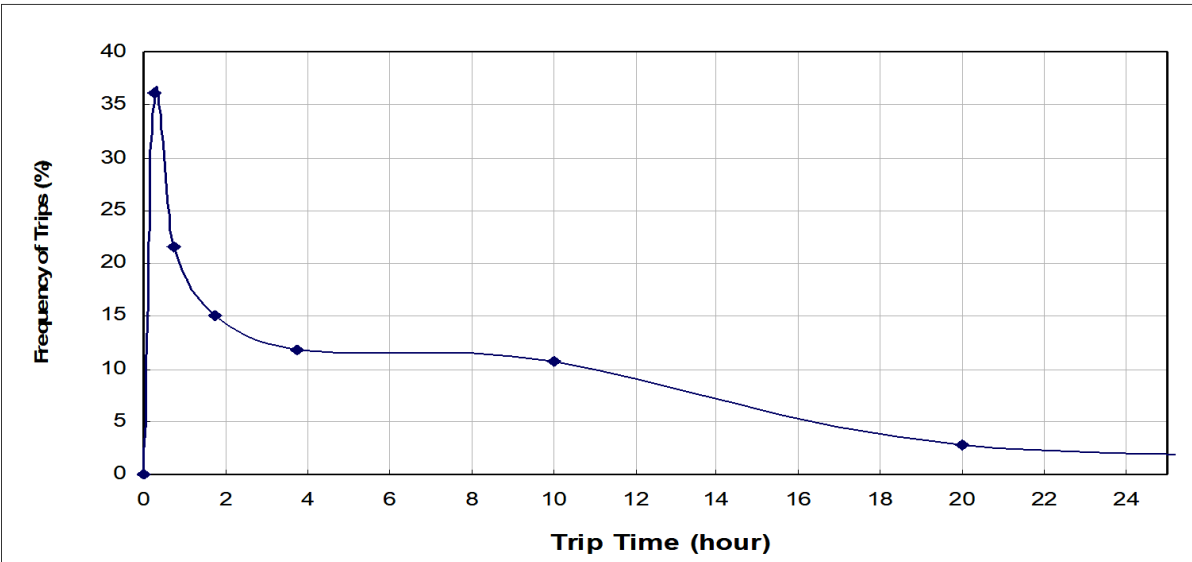


Fig. 5.13: Trip Time Frequency Distribution Curve for Passenger Vehicles



Fig.5.14 and 5.15 present the trip length and time frequency distribution curves for goods vehicles on the project corridor. From the figures it can be observed that only 28% of the trips are performed within 200 km and a 5-hour time range. Around 16% of the trips have a mean trip length of 600 km, followed by 8% of trips with 1,500 km trip length. Only 6% of the goods vehicles are observed to be having a trip length of more than 1,500 km.

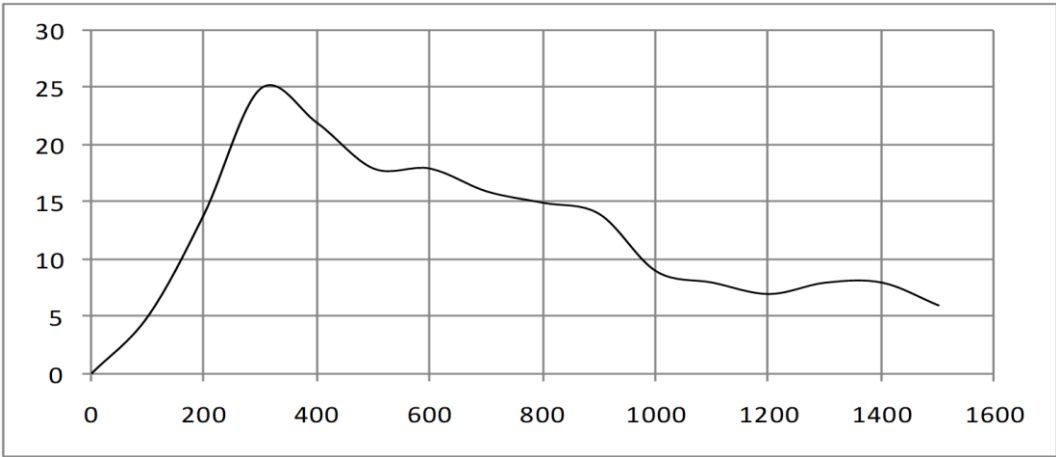


Fig.5.14: Trip Time Frequency Distribution Curve for Goods Vehicles

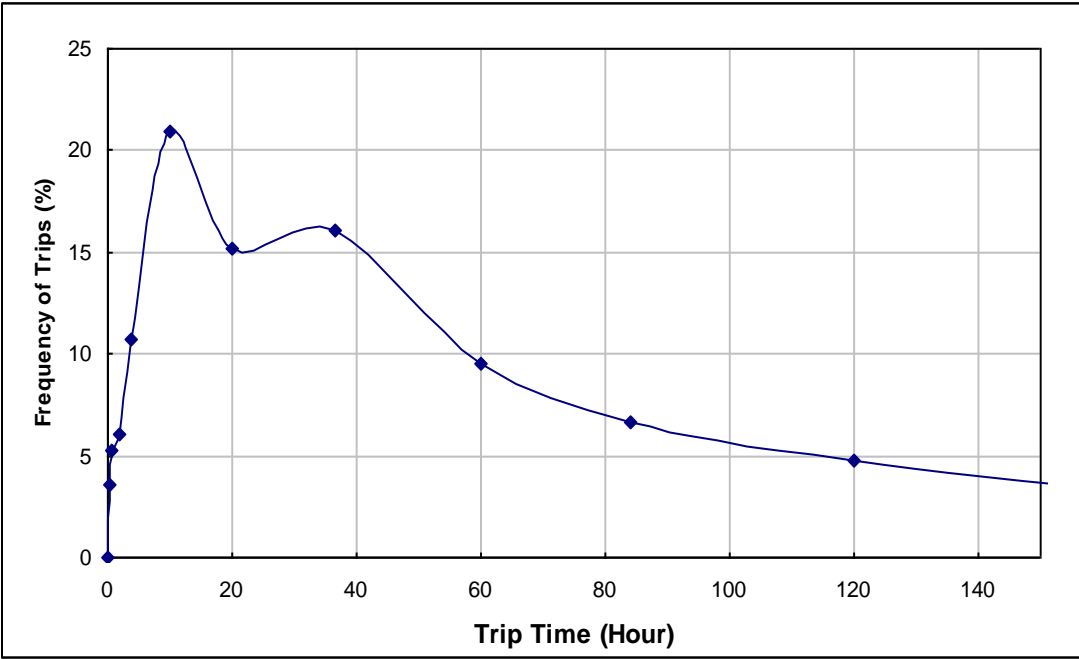


Fig.5.14: Trip Time Frequency Distribution Curve for Goods Vehicles

### 5.2.5 Turning Movement Survey

Turning Movement Surveys were conducted at five major intersections falling on the project corridor for 8 hours (8:00 – 18:00 hrs.) covering all movement combinations. These intersections are three-arm junction type. The salient features of volume characteristics are presented in **Table 5.7** below.

**Table 5.7: Traffic Volume Characteristics at Intersections**

SI. No.	Name of Intersection	Type of Intersection	Survey Duration (hrs)	Total volume (PCU)	Peak Volume (PCU)	Peak hour	% Right Turning Traffic
1	Karanprayag (Leads to Almora)	3-arm	8	638	121	07:00-08:00	11
2	Karnprayag (Leads to Ranikhet)	3-arm	8	599	92	07:00-08:00	10
3	Nandprayag (Leads to Ghat)	3-arm	8	826	125	07:00-08:00	12
4	Chamoli (Leads to Gopeshwar – SH- 36)	3-arm	8	1150	198	16:00-17:00	31
5	Joshimath (Leads to Auli)	3-arm	8	839	129	13:00-14:00	1

The peak hour flow has been observed to maximum at Chamoli (198 PCU). The share or quantity of right turning traffic in peak flow is the index value, which indicates the intensity of vehicle-vehicle conflict at the intersection. The highest share of right turning traffic has been observed at Chamoli, followed by Nandprayag.

**Appendix 4.2** of Volume II: Appendices to Main Report presents location-wise Turning Movement Survey analysis summary sheets. Each sheet provides mode wise hourly total intersection traffic volume, direction-wise traffic in terms of total vehicles and PCU, peak hour turning traffic characteristics, traffic composition, hourly variation and a Peak Hour Flow Diagram (PHFD) for one intersection.

### 5.2.6 Speed and Delay Survey

Journey speed (Length of any section divided by total time including delay spent to negotiate the same) is one of the basic parameters revealing the Level of Service (LOS) provided by the facility to the road users, and is of extreme significance in the economic analysis of a highway project. For this purpose, further to the two homogeneous section, entire project corridor was divided into five homogeneous sub-sections and a speed and delay survey has been carried out by moving car observer method in



which (Scorpio) was used as the test car. During the survey, inter-nodal distance, journey time, and delay along with its reason, have been recorded on a pre-designed format. The survey was conducted during day and night peak hours. Four round trips have been made to have a better average figure and to minimize temporal effect on the road section. The outputs in terms of Journey Speed, Running Speed (length of any section divided by net time excluding delay spent to negotiate the same), and Delay, for each homogeneous sub-section have been presented in **Table 5.8** below.

**Table 5.8: Journey and Running Speeds on the Project Corridor**

S No	From	To	Distance (km)	Journey Speed (kmph)	Running Speed (kmph)
1	368.000	399.000	31.00	48	48
2	399.000	446.000	47.00	45	45
3	446.000	461.000	15.00	37	37
4	461.000	489.000	28.00	32	32
5	489.000	504.000	15.00	40	40
6	504.000	510.000	6.00	12	12
7	510.000	528.000	18.00	20	20

### 5.2.7 Pedestrian Survey

The pedestrian count surveys were conducted at five locations where there is a high concentration of pedestrians crossing the project corridor due to the urbanized nature of the road section. The survey has been conducted to estimate quantum of pedestrians crossing the project corridor and therefore to estimate a hazard index (an indicator of the level of conflict between pedestrian and vehicle). The peak hour pedestrian flows at both intersections and mid-block are presented in **Table 5.9** below.

**Table 5.9: Peak Hour Pedestrian Flows at Different Locations**

S No.	Location	Chainage	Peak Flow (Pedestrians/hr.)	
			Rudraprayag Badrinath side	Badrinath – Rudraprayag side
1	Gochar	389.000	112	98
2	Karnprayag	399.000	158	183
3	Nandprayag	418.000	97	102
4	Chamoli	430.000	126	109
5	Joshimath	480.000	259	241

With reference to the table-1 of IRC 103:1988 regarding capacity of sidewalks, the pedestrian volume along the project road does not require pedestrian facilities.

However, we suggest providing walkways along the project road in densely habitated areas to take care of along the road pedestrian movement.

### **5.2.8 Axle Load Survey**

The current traffic of the project does not represent the actual traffic scenario. However, axle load survey has been performed for assessing traffic load pattern. The detail of axle load survey is presented as Appendix 3.12 of Volume-I (Appendix Volume to Main report) and summary of vehicle damage factor (VDF) analyzed after axle load survey is presented in **Table 5.10** below:

**Table 5.10: Axle Load Survey**

<b>S. No</b>	<b>Type of Vehicle</b>	<b>VDF</b>
1	Light commercial vehicle (LCV)	0.30
2	Standard two axle truck (2 Axle truck)	1.32
3	Three axle truck (3 Axle truck)	2.14

### **5.2.9 Road User Opinion Survey**

Opinion surveys were conducted along with the O-D surveys on the study road as well as at selected locations along the study corridor. In view of significant movement of interstate traffic, additional interviews were conducted at major roadside facilities such as hotel and garage etc.

## **5.3 TRAFFIC VOLUME CHARACTERISTICS**

### **5.3.1 Introduction**

The appreciation of traffic characteristics is essentially to evaluate the potential of the existing network and identify the major issues so as to develop a rational policy for designing various components of the proposed project corridor. The classified traffic volume count data collected has been analysed by location and include – Average Daily Traffic (ADT), hourly variation in total traffic, vehicular composition, peak hour traffic etc. The traffic data has been converted into Passenger Car Unit (PCU) to determine the relative effect of different types of vehicle on the traffic flow as compared to car as a standard vehicle.

### **5.3.2 Seasonal Correction Factor (SCF)**

For the present study, firstly the petrol and diesel sale figures have been used from three different petrol pumps on the project road. The petrol and diesel fuel sale data for the years 2012, 2013 & 2014 have been collected and analyzed for estimation of Average Seasonal Correction Factor (ASCF) and Peak Seasonal Correction Factor (PSCF). As the traffic surveys were conducted in the month of March, the above factors for the month of March is considered. The fuel sales figures at the filling station in the region are presented season wise in **Table 5.11** below.

**Table 5.11:- Detail of fuel sales figures at the filling station in the region**

Village - Raitoli, Rudraprayag			Village –Sonla		
Month	Diesel	Petrol	Month	Diesel	Petrol
Apr- 12	136607	23063	Apr- 12	108879	24484
May - 12	259868	40896	May - 12	191011	31192
June - 12	245678	42481	June - 12	234114	30964
July - 12	118767	24864	July - 12	102089	23299
Aug - 12	92122	15951	Aug - 12	72954	16195
Sep - 12	110119	17438	Sep - 12	96907	18411
Oct - 12	130329	24736	Oct - 12	117007	22787
Nov - 12	126342	27543	Nov - 12	107207	23729
Dec - 12	119480	24304	Dec - 12	11046	23055
Jan - 13	116132	22616	Jan - 13	109516	22466
Feb - 13	99409	21230	Feb - 13	92297	17602
March - 13	130067	28509	March - 13	128514	24005
Apr - 13	177869	31597	Apr - 13	147120	23724
May - 13	315372	41657	May - 13	302961	38014
June - 13	308975	42151	June - 13	291557	37232
July - 13	129500	17194	July - 13	61331	12098
Aug - 13	151318	21481	Aug - 13	65709	12298
Sep - 13	135799	25884	Sep - 13	108678	20745
Oct - 13	146180	34451	Oct - 13	131807	27414
Nov - 13	148825	34095	Nov - 13	123900	28151
Dec - 13	155248	32029	Dec - 13	124738	25018
Jan - 14	143264	32173	Jan - 14	122382	26856
Feb - 14	128544	29447	Feb - 14	121977	23050
March - 14	150901	33284	March - 14	146805	24795

Month	Diesel			Petrol		
	Sale (in litre)	Seasonal Index	Average Seasonal Correction Factor	Sale (in litre)	Seasonal Index	Average Seasonal Correction Factor
1	2	3	4	6	7	8
<b>April</b>	142,619	0.53	1.01	25,717	0.68	1.03
<b>May</b>	267,303	<b>1.00</b>	<b>0.54</b>	37,940	<b>1.00</b>	<b>0.70</b>
<b>June</b>	270,082	1.01	0.53	38,207	1.01	0.69
<b>July</b>	102,922	0.39	1.40	19,364	0.51	1.36
<b>August</b>	95,526	0.36	1.50	16,482	0.43	1.60
<b>September</b>	112,876	0.42	1.27	20,620	0.54	1.28
<b>October</b>	131,331	0.49	1.09	27,348	0.72	0.96
<b>November</b>	126,569	0.47	1.14	28,380	0.75	0.93
<b>December</b>	102,628	0.38	1.40	26,102	0.69	1.01
<b>January</b>	122,824	0.46	1.17	26,028	0.69	1.01
<b>February</b>	110,557	0.41	1.30	22,833	0.60	1.16
<b>March</b>	139,072	0.52	1.03	27,649	0.73	0.95

The **Average Seasonal Correction Factor (ASCF)** has been applied on the ADT observed at the count locations to derive **AADT** which will be used for **pavement design and Economic Analysis**.

The following observation can be made from the above table

- An Average Seasonal Correction Factor (ASCF) of 0.54 (i.e. a decrease of 46%) for vehicles runs on Diesel (like LCV, 2-Axle, 3-Axle trucks etc) & ASCF of 0.70 (i.e. a decrease of 30%) for vehicles runs on petrol (like Two wheelers & Cars etc).

The Average seasonal correction factors for petrol and diesel driven vehicles, described in the previous sections have been applied to ADT to derive AADT. The AADT, thus derived is given in **Table 5.12**. Shown below:

**Table 5.12: AADT Survey**

<b>Vehicle Type</b>	<b>Km 374</b>	<b>Km 410</b>	<b>Km 425</b>	<b>Km 444</b>	<b>Km 501</b>
Car, Jeep & Van	884	854	685	619	307
2- Wheelers	340	335	264	202	0
3- Wheelers	1	0	0	0	0
2-Axle Truck	130	94	92	73	0
3-Axle Truck	4	7	3	3	0
4-6 Axle	9	2	4	2	0
Agricultural Tractor	0	0	0	0	0
Tractor	0	0	0	0	0
LCV	52	73	51	43	8
Minibus	24	61	36	34	4
Standard Bus	72	55	48	41	3
By-Cycle	0	0	0	0	0
Cycle Rickshaw	0	0	0	0	0
Animal / Hand Cart	0	0	0	0	0
<b>Total Motorised Vehicles (Number)</b>	<b>1516</b>	<b>1481</b>	<b>1183</b>	<b>1017</b>	<b>322</b>
<b>Total Non-Motorised Vehicles (Number)</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Motorised Vehicles (PCU)</b>	<b>1828</b>	<b>1700</b>	<b>1395</b>	<b>1196</b>	<b>334</b>
<b>Total Non-Motorised Vehicles (PCU)</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Commercial Vehicle per day</b>	<b>292</b>	<b>292</b>	<b>234</b>	<b>196</b>	<b>15</b>

The above discussed traffic scenario doesn't represent the actual traffic in the project area as the traffic is significantly low after the major natural disaster that comes in June 2013 during char dhamyatra. Therefore, the traffic data from year 2010–2013 at Km 444.00 near Pipalkothi is collected from Border Road Organization (BRO).

### 5.3.4 Average Annual Daily Traffic

The traffic data collected from actual traffic survey and traffic data received from BRO shows huge variation among them. Hence, it is assumed that both of data does not represent actual traffic on the project road. The AADT presented earlier in this chapter shows that at Km 374.00 between Chamoli to Helang traffic is maximum. Therefore, the AADT of Km 374.00 with 50% induced traffic for the season of Char Dhamyatra is considered for future projections and analysis. The AADT, thus derived is given in **Table 5.13** below:

**Table 5.13:- Detail of Average Annual Daily Traffic derived from Secondary Traffic Data**

Vehicle Type	Km 374.00 (near Ratura)	Induced traffic @ 50% of current traffic	AADT
Car, Jeep, Vans, three wheelers	884	442	1326
Motor cycle & Scooters	340	170	510
LCV	76	38	114
BUS	72	36	108
Two Axle Truck, Multi Axle Truck	143	71	215
Agriculture Tractor with Trailer	0	0	0
Cycle/Cycle Rikshaw	0	0	0
Animal Driven Vehicles	0	0	0
Other vehicle (Plz Specify)	0	0	0
<b>Total Motorised Vehicles (Number)</b>	<b>1515</b>	<b>-</b>	<b>2773</b>
<b>Total Non-Motorised Vehicles (Number)</b>	<b>0</b>	<b>-</b>	<b>0</b>
<b>Total Motorised Vehicles (PCU)</b>	<b>1827</b>	<b>-</b>	<b>2742</b>
<b>Total Non-Motorised Vehicles (PCU)</b>	<b>0</b>	<b>-</b>	<b>0</b>
<b>Total Commercial Vehicle per day</b>	<b>291</b>	<b>-</b>	<b>437</b>

## **5.4 TRAFFIC VOLUME PROJECTIONS**

### **5.4.1 General**

Developing nation needs to allocate investments in an efficient manner. For developing nations, transport is a catalyst for development and is one of the basic physical infrastructures. When capital availability is scarce and has competing demands, investments in transport projects have to be planned carefully, keeping in view not only the present demand but also the forecast requirements over reasonable future period. The accurate estimation of future traffic is required, to plan for the construction of new facilities and/or the improvement of existing facilities. To a great extent, the accurate estimate of future traffic influences the engineering design of the facility and the economic decision whether to take up the project or not. Earlier sections of the chapter describe traffic volume variations, ADT calculations, development of O/D matrices and seasonal variations for the stretches under Study. In this section, the Consultants focus on the estimation of future growth rates and the projections of traffic by type for various horizon years.

### **5.4.2 Background**

A highway project of this nature calls for significant investment. Prediction of traffic demand hence becomes an important task and should be carried out accurately. The estimation of future traffic levels forms the basis for the design of the facility and impacts the viability of the project. Recognizing this, efforts have been made to carefully assess the main parameters that govern the traffic demand in the future.. The basic theme is to relate forecast economic growth to vehicular growth. The traffic has been projected to the year 2038, i.e., 35 years hence.

### **5.4.3 Capacity Analysis**

The main reference for the determination of standard capacities for roads in India is the Indian Road Congress code (IRC: 64-1990). The recommended Design Service volumes for Level of Service (LOS) C were presented in **Table 5.14** below.

**Table 5.14: Design Service Volumes and Capacity Standards for Various Road**

Type	Carriageway width	Design Service Volume PCU/Day	
		Low curvature 0-200 degrees/km	High curvature >200 degrees/km
Single Lane	3.8	1500	1400
Intermediate Lane	5.5	5200	4500
Two Lane	7.0	7000	5000

The initial capacity analysis has been performed for the corridor for the assessment of upgradation requirements. The analysis has revealed, the corridor section warrants capacity augmentation since the road is already carrying the traffic, which is higher than the design service volume.

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***Project: 2-Laning of NH-58 from Rudraprayag to Mana***  
***Document: 2017-18 /DPR/Sub-package-II (Km399.0 to Km 430.0)***  
***Project Description Including Realignment/Bypasses***

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***Date: June 17***  
***Revision: R1***



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## **CHAPTER 6: DESIGN STANDARDS**

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### **6.1 General**

As highway designers, highway engineers should strive to provide for the needs of highway users while maintaining the integrity of the environment. Unique combinations of design requirements result in unique solutions to the design problems. The current project contains a wide variety of problems to be solved, and a cost effective design is emphasized.

This chapter discusses the basis on which the various components of road design, including route selection, geometric design and pavement design, have been carried out. Structures design is also addressed, including bridges, viaducts, retaining structures and slope protection works.

### **6.2 Geometric Design**

#### **6.2.1. Selection and Application of Standards**

The main objective of the project is to upgrade the existing road to two lane with paved shoulder. The application of design standards is inherently different for a rehabilitation project versus a new or reconstruction project. Thus, although the following text provides design guidelines, economic considerations will likely result in slightly differing geometrics between the rehabilitated road and the new road.

The Indian Roads Congress has produced several publications which address the issue of geometric design for roads. Some of these deal specifically with rural roads, or roads through hill terrain. The pertinent source documents investigated in setting standards for the project road include:

IRC: 73-1980: Geometric Design Standards for Rural (Non-Urban) Highways

- ☐ IRC: 52-2001: Recommendations about the Alignment Survey and Geometric Design of Hill Roads (2nd Revision)
- ☐ IRC SP 20: Rural Roads Manual, 2002
- ☐ IRC SP 48:1998: Hill Road Manual
- ☐ IRC SP 20: Rural Roads Manual, 2002

The geometrics determined using the above sources for this project have also been compared to an internationally accepted modern standard - the American "AASHTO Standards".

#### **6.2.2 Road Classification**

The design standards provide differing parameters and in particular varying design speeds according to the functional classification of the road. The project road is a national highway, and hence the values associated with this classification have been selected.

### 6.2.3 Design Capacity

The main reference for the determination of standard capacities for roads in India is the Indian Road Congress code (IRC: 64-1990). The recommended Design Service volumes for Level of Service (LOS) C were presented in **Table 6.1** below.

**Table 6.1: Design Service Volumes and Capacity Standards for Various Road**

Type	Carriageway width	Design Service Volume PCU/Day	
		Low curvature 0-200 degrees/km	High curvature >200 degrees/km
Single Lane	3.8	1500	1400
Intermediate Lane	5.5	5200	4500
Two Lane	7.0	7000	5000

The initial capacity analysis has been performed for the corridor for the assessment of up gradation requirements. The analysis has revealed, the corridor section warrants capacity augmentation since the road is already carrying the traffic, which is higher than the design service volume

As per projected traffic volume studies it can be seen that two lane will be able to cater the traffic upto the year 2030 beyond which four laning will be required which is presented in **table 6.2** below:

**Table 6.2 Projected Traffic per Year**

Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LCV	2-Axle, 3-Axle	MAV	Total Vehicle	Total PCU
2014	510	1326	36	108	78	201	14	2273	2742
2015	551	1419	39	114	83	214	15	2435	2929
2016	595	1518	42	121	88	228	16	2608	3130
2017	643	1640	46	131	96	247	18	2821	3390
2018	816	2063	58	163	120	309	23	3552	4258
2019	882	2207	62	172	128	328	25	3804	4546
2020	953	2361	66	182	136	348	27	4073	4852
2021	1037	2542	71	193	145	371	29	4388	5207
2022	1129	2736	76	205	155	396	31	4728	5590
2023	1229	2945	81	217	166	423	34	5095	6003
2024	1337	3170	87	230	177	452	37	5490	6447
2025	1467	3436	94	245	190	486	40	5958	6969
2026	1609	3725	101	261	204	522	43	6465	7530

Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LCV	2-Axle, 3-Axle	MAV	Total Vehicle	Total PCU
2027	1765	4038	109	278	219	560	47	7016	8138
2028	1936	4377	117	296	235	601	51	7613	8794
2029	2124	4745	126	315	252	646	55	8263	9505
2030	2330	5144	136	336	271	694	59	8970	10275

#### 6.2.4 Tabular Presentation

A presentation of selected main parameters associated with each of the above-referenced design standards for this dual carriageway national highway through mountainous and steep terrains is presented in **Table 6.3 & Table 6.4** below.

**Table 6.3: Geometric Standards-Mountainous Terrain**

Designation	IRC 52-2001	IRCSP20-2002	IRCSP48-1998	IRC 73-1980	Selected
Design speed- ruling (kph)	50	N/A	50	50	50
Design speed- minimum (kph)	40	N/A	40	40	40
Ruling Min. radius (m)	80	N/A	80	80	80
Absolute Min. radius (m)	50	N/A	50	50	50
Max. super-elevation (%)	7	N/A	10	10	7
Min. vert. Curve radii: Crest (m)	See Plate 2	Same	Same	Same	Same
Min. vert. Curve radii: Sag (m)	See Plate 4	Same	Same	Same	Same
Min. vert. Curve length: (m)	20	20	20	20	20
Ruling gradient (%)	5	5	5	5	5
Limiting gradient (%)	6	6	6	6	6
Exceptional gradient (%)	7	7	7	7	7

Designation	IRC 52-2001	IRCSP20-2002	IRCSP48-1998	IRC 73-1980	Selected
Ruling stopping sight distance (m)	60	N/A	60	60	60
Min. stopping sight distance (m)	45	N/A	45	45	45
Lane width for multi-lanes (m)	3.5	N/A	3.5	3.5	3.5
Cross-fall (%)	2-2.5	N/A	1.7-2	1.7-2	2.0
Shoulder width (m)	0.9	N/A	0.9	0.9	0.9/1.8
Shoulder cross-fall: Sealed (%)	2.5/4.5	N/A			3.0

**Table 6.4: Geometric Standards - Steep Terrain**

Designation	IRC 52-2001	IRCSP20-2002	IRCSP48-1998	IRC 73-1980	Selected
Design speed- ruling (kph)	40	N/A	40	40	40
Design speed- minimum (kph)	30	N/A	30	30	30
Ruling Min. radius (m)	50	N/A	50	50	50
Absolute Min. radius (m)	30	N/A	30	30	30
Max. super-elevation (%)	7	N/A	10	10	7
Min. vert. Curve radii: Crest (m)	See Plate 2	Same	Same	Same	Same
Min. vert. Curve radii: Sag (m)	See Plate 4	Same	Same	Same	Same
Min. vert. Curve length: (m)	15	20	15	15	15
Ruling gradient (%)	6	6	6	6	6
Limiting gradient (%)	7	7	7	7	7
Exceptional gradient (%)	8	8	8	8	8

Designation	IRC 52-2001	IRCSP20-2002	IRCSP48-1998	IRC 73-1980	Selected
Ruling stopping sight distance (m)	45	N/A	45	45	45
Min. stopping sight distance (m)	30	N/A	30	30	30
Lane width for multi-lanes (m)	3.5 each	N/A	3.5	3.5	3.5
Cross-fall (%)	2-2.5	N/A	1.7-2	1.7-2	2.0
Shoulder width (m)	0.9	N/A	0.9	0.9	1.0/2.0
Shoulder cross-fall: Sealed (%)	2.5/4.5	N/A			3.0

### 6.2.5 Design Speed

The IRC standards recommend design speeds based on functional classification and terrain. The Consultants field trip revealed that the project road traverses terrain with a natural ground slope of typically 40 degrees. Hence, design speeds were selected from a review of standards for mountainous (cross slope 25-60%) and steep (cross slope >60%) terrain

The initial capacity analysis has been performed for the corridor for the assessment of up gradation requirements. The analysis has revealed, the corridor section warrants capacity augmentation since the road is already carrying the traffic, which is higher than the design service volume

The IRC standards recommend a ruling/minimum design speed of 50/40 km/h for mountainous terrain, and a ruling/minimum design speed of 40/30 km/h for steep terrain.

### 6.2.6 Horizontal Elements

#### 6.2.6.1 Minimum Horizontal Radius

The same formula is used in all references for computing the minimum horizontal radius, and agrees with AASHTO usage. It is dependent upon the maximum super-elevation rate employed, and the friction factor. In the final selection for this radius parameter, the following have been noted:

- IRC references indicate a 7% maximum super elevation rate. The project road traverses lower elevations, and hence snow and ice are not a factor during the winter months.
- Heavily loaded trucks, and particularly timber trucks, are in danger of overturning on super elevations above 7%. Hence, certain parameters suggested in IRC for increased super elevation through hairpin bends will be ignored.

#### 6.2.6.2 Spiral Transitions

The IRC references state that spiral curves are a requirement. AASHTO states that in some instances they may be appropriate: in practicality, they are more often specified than not. In mountain and steep terrain, they often become difficult to incorporate in the design, with insufficient tangent

lengths between curves. In such terrain, although sharper curves would auger for their use, the lower speeds.

The Consultants suggest that spiral curves be used as described in the IRC references.

#### **6.2.6.3 Curve widening**

the curve widening has been accomplished as described in the IRC references. However, for hairpin curve of smaller radii, the rules for hairpin curves take precedent over the widening table in IRC.

#### **6.2.6.4 Maximum Super elevation**

for normal conditions, IRC specifies 7%. AASHTO has values between 6-8%. Values of 8% can create problems with overloaded trucks having protruding loads. The AASHTO values are comparatively high, and based on rather dated test references.

In urban areas where traffic friction or extensive roadside ribbon development acts to curb vehicle running speeds and super elevation rates, it is common practice to utilize a low maximum rate of super elevation, usually 4 percent. Similarly, either a low maximum rate of super elevation or no super elevation is employed within important intersection areas or where there is a tendency to drive slowly because of turning and crossing movements, warning devices, and signals. This has been a feature of the design of the project road.

### **6.2.7 Vertical Elements**

#### **6.2.7.1 Minimum Vertical Curve Radii**

Minimum lengths of crest and sag vertical curves have been recommended based on design speeds and stopping sight distance requirements. They provide for riding comfort, appearance, The widely used AASHTO standard use a parabolic shaped vertical curve and expresses these curves in terms of K-values. The design is based on minimum allowable "K values", as defined by the formula:

$$K = L/A$$

Where K = limiting value, horizontal distance required to achieve a 1% change in grade

L = length of vertical curve (m)

A = Algebraic difference in approach and exit grades (%)

In the IRC standards, crest and sag vertical curves are developed as parabolic curves, but are not expressed in K-values. They are derived from the formulae:

Crest (summit) curves

Where  $L > S$ : Where  $L < S$ :

$$L = 2S - 4.4/N$$

Where N = algebraic difference in grades,

% L = length of curve in meters

S = sight distance in meters

Valley (sag) curves

Where  $L > S$ : Where  $L < S$ :

$$L = 25 - (1.5 + 0.035S)/N$$

Where,

L = length of curve in meters

S = sight distance in meters

### **6.2.7.2 Vertical Clearance**

The vertical clearances as per the “MORTH and Pocket Book for Highway Engineers” (Second Revision) published by the IRC, New Delhi in 2002, shall be adopted:

Vertical clearance for power/ telecommunication lines

Lines carrying low voltage up to 110V	5.5m minimum
Electric power lines up to 650V	6.0m minimum
Electric power lines > 650V	6.5m minimum

### **6.2.7.3 Maximum Gradient**

Vehicle operations on gradients are complex and depend on a number of factors: severity and length of gradient; level and composition of traffic; and the number of overtaking opportunities on the gradient and in its vicinity, the latter however are not applicable for a 4-lane highway. Maximum vertical gradient is an extremely important criterion that greatly affects both the serviceability and cost of the road. Due to this consideration, the IRC standards give a total of three controlling values of gradients: “ruling gradients,” the guiding criterion as was the case for horizontal geometry; “limiting gradient,” for limited application where adoption of the ruling gradient would add enormously to the cost; and “exceptional gradient,” of short lengths not exceeding 100 meters. The gradient standards as per IRC give values of 5, 6, and 7, respectively, for mountain terrain, and 6, 7, and 8, respectively, for steep terrain, and these have been adopted for the design of the project.

### **6.2.7.4 Grade Compensation**

For gradients steeper than 4 percent, grade compensation shall be provided as per the following:

Grade Compensation (Percent) =  $\frac{30 + R}{R\%}$ , where R is the radius of the horizontal curve in meters.

## **6.2.8 Cross Sections**

### **6.2.8.1 Lane Width**

The cross-section design is consistent with guidelines indicated in all IRC standard references for multi-lane facilities. Generally, this will consist of:

- 2x 3.5m traffic lanes for the dual carriageway sections, mountainous and steep terrain

#### **6.2.8.2 Median width**

Median widths would greatly increase the construction costs in the project's mountain and steep terrain areas, it is proposed to adopt a reduced width of 1.2m (including the lane clearance to the median). The median width therefore varies with the topography.

However the median width will be largely dictated by the topography, since individual carriageways are very often proposed to be at different levels along the route.

#### **6.2.8.3 Cross Fall**

The cross slopes recommended in IRC references, are as follows:

- 2 - 2.5% for AC roadway surface (IRC: 52-2001)
- 1.7 – 2.0% for AC roadway surface (IRC: 73-1980; IRC: SP: 48-1998)
- 3 - 3.5% for AC roadway surface (IRC: SP20-2002)

The standard which should give the most relevant value is that of the hill road standard, IRC: SP: 48-1998. However, it is noted that the road project is in a relatively high rainfall area, and hence the value chosen should be on the high side. It is also noted that often in this terrain a uni-directional cross fall rather than a normal crown camber across both carriageways may be specified, furthering the need to remove the volume of runoff more quickly.

#### **6.2.8.4. Shoulder**

A shoulder is the portion of the roadway contiguous to the carriageway for the accommodation of stopped vehicles; traditional and intermediate non-motorized traffic, animals, and pedestrians; emergency use; the recovery of errant vehicles; collision avoidance; and lateral support of the pavement courses.

AASHTO suggests a usable shoulder width for rural arterials based on traffic volumes, with an absolute minimum paved width of 0.6m. This excludes the portion of the shoulder used for side slope rounding, which would further add to the width.

#### **6.2.8.5 Side Slope and back Slope**

Site investigation and analysis has revealed that slope protection measures are necessary for most side slopes and back slopes. Both hillside and valley side slopes are to be protected with recognized techniques, such as RCC retaining walls and RE walls etc. Masonry stone retaining and revetment walls are to be used for downhill and river protection works.

#### **6.2.9 Safety Barrier**

Safety barriers, or guardrails, are a compromise between the conflicting demands of construction costs and safety, and are themselves a hazard. To be warranted, guardrails should be a lesser hazard than that which they are intended to mitigate.

Short sections of guardrail have been provided on the approaches to all bridges. Without these, an errant driver can impact on the blunt end of the bridge rail or proceed down the steep side slope into the watercourse. Guardrails should be used at all four corners of the bridges, and should be of a



parabolic end section configuration so that the guardrail is offset from the edge of the lane. The opposing end treatment should not be blunt, but should be buried into the ground. The section closest to the bridge railing should be strengthened by decreasing the spacing of the guardrail posts to provide a transition from the deformable rail section to the solid bridge railing. The end of the last rail should be dowelled into the face of the bridge rail or a fixed to a bridge parapet end post.

Where guardrails are employed, they include reflectors to aid in the guidance of vehicles at night. Guard posts have been provided on the longitudinal median drain to avoid the wheels of vehicles falling into the drain.

#### **6.2.10 ROW and Setback**

Right-of-ways are provided in order to accommodate the road width and to enhance the safety, operation and appearance of the roads. The width of the right-of-way depends on the cross-section elements of the highway, topography and other physical controls, together with economic considerations. It has been established, from information supplied by BRO that the existing right of way is 7 m, however there are many places where buildings and walls encroach within a few meters of the edge of the pavement.

In addition to these requirements, the IRC further mandates that buildings shall be set-back a further 3 – 5 m beyond the Right-of-Way lines, for both open and built-up areas, in mountainous and steep terrain. It may not be practical to adopt this standard for the project. The ROW provided for the proposed 4-lane road is 12/14/18.

#### **6.2.11 Markers and delineators**

Reflective markers are generally used to indicate the occurrence of drainage structures, and delineators on sharp curves. Markers and delineators are constructed of reinforced concrete, while serving primarily as safety devices, have adverse safety implications inherent in their construction and placement. The steel pipe (80 mm dia) delineator, with reflectorized tape, are recommended for installation on the inner walls of drain runs and bridge parapets on the valley side.

### **6.3 JUNCTIONS**

**Junctions:** With generally mountainous terrain and very limited available land along the road corridor, it is not possible to provide full grade separation or access control.

### **6.4 PROPOSED TYPICAL CROSS SECTION**

The typical cross section for project alignment has been planned as proposed two lane carriageways. Twenty Two types of typical cross sections have been proposed for the project alignment. The detail drawing of typical cross section is attached in drawing volume. Type of typical cross section with their description is tabulated in **table 6.5** given below:

**Table 6.5: Summary of Typical Cross Sections**

S No	Type	Description
1	I	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling up to 1m and Hill side cut up to 4.0m (Soft rock + Soil)
2	IA	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling up to 1m and Hill side up to 4.0m (Soft rock + Soil)
3	IB	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling up to 4 m and Hill side up to 4.0m protection (Soft rock + Soil)
4	IC	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling up to 4 m protection (Soft rock +Soil)
5	ID	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling >4 m protection (Soft rock +Soil)
6	II	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling up to 1m and Hill side cut in hard rock
7	IIA	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling up to 1m and Hill side up to 4m protection hard rock
8	IIB	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side up to 4m protection and hill side cut in hard rock
9	IIC	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side filling>4m protection in hard rock
10	III	Typical Cross Section for realignment and bypass (Valley side filling up to 1m and hill side cut up to 4m (Soft rock+ Soil)
11	IIIA	Typical Cross Section for realignment and bypass (Valley side filling up to 1m and hill side up to 4m protection (Soft rock+ Soil)
12	IIIB	Typical Cross Section for realignment and bypass (Valley side filling up to 4m and hill side up to 4m cutting (Soft rock+ Soil)
13	IIIC	Typical Cross Section for realignment and bypass (Valley side filling up to 4m and hill side up to 4m protection (Soft rock+ Soil)
14	IIID	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
15	IV	Typical Cross Section for realignment and bypass Valley side Filling up to 1m and hill side cut hard rock)
16	IVA	Typical Cross Section for realignment and bypass (Valley side filling up to 4m and hill side cut in hard rock)
17	IVB	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
18	V	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (12.0m formation width)
19	VA	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (hill side up to 4m protection) (12.0m formation width)

S No	Type	Description
20	VB	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (valley side up to 4m protection and hill side no protection) (12.0m formation width)
21	VC	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (both side protection up to 4m) (12.0m formation width)
22	VD	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (valley side protection > 4.0m) (12.0m formation width)

### 6.4.1 Widening principles

The new southbound carriageway alignment will almost run parallel to the existing road. The general approach is that the widening will be done at the hill side. Widening of the road on the valley side is generally not possible due to steep slopes, which will require high retaining walls for the widening. This may also destabilize the existing road in the construction period, especially in locations where there is thick overburden, as the foot will have to be cut for the foundation of the retaining wall. It is therefore, envisaged that the widening will be done on the uphill side, with elevated new carriageway of 2.0 to 4 m in average height.

This will reduce the volume of cut, will provide a more pragmatic and cost effective approach to construction methodology as well. However, the existing road has a poor geometry as earlier described in chapter 4. It is therefore not possible to provide a 4-lane highway with an appropriate geometry without also improving the existing road geometry.

The conclusions of the field studies and preliminary survey shows that the most optimal rehabilitation method not necessarily is to widen the road entirely at one side. At many locations, it will be favourable to also use the valley side for improvement of the existing road geometry. Part of the “left over” space can be used for the new carriageways to traffic management.

### 6.5 ROAD AESTHETICS AND LANDSCAPING

Good aesthetics are now almost globally considered to be an integral part of any engineering design. Some of the points to be considered during the design phase with regards to aesthetics are as follows:

- Huge cuts along with extensive retaining walls and protection measures are necessary along a major part of the alignment. Slope protection works have been carefully designed to minimize impact on the environment, and along with plantations of local E species of scrubs and trees, will have the desired effect.
- Enhancement of the view by preserving characteristic features in the landscape have been taken into consideration when choosing the alignment, as well as preservation and enhancement of scenic spots.
- The decision on bridge type is largely influenced by its location. Emphasis on the aesthetics of a particular bridge has been considered for structures that are readily viewed from the road and surrounding habitations.

- Traffic environment and traffic safety are integrated issues. Consideration has been given on the selections of guardrails, safety barriers and road marking.

## **6.6 ROAD SIDE DRAINAGE**

An effective drainage system has been planned for the drainage of roadway as per stipulations of IRC SP: 42-1994 for maintaining structural soundness and functionality of the project road. The following types of drains have been provided for surface drainage of roadway and ROW:

Longitudinal trapezoidal 0.6m x 0.65m x 0.90m (top width) stone masonry lined drains at the toe of the hill, with outfalls at cross-drainage structures. Cement concrete rectangular section of 0.6m x 0.65m is proposed in the built up areas. The drain size, shape and material is adequate to take design run off, and prevent soil erosion and stagnation of water.

## **6.7 PAVEMENT DESIGN**

For the purposes of pavement design, flexible type with a 15 years design life has been adopted.

### **6.7.1 New flexible pavement**

New flexible pavement has been designed as per IRC: 37-2001. New flexible pavement shall comprise of Bituminous Concrete (BC) using (CRMB60) wearing course over laid on Dense Bituminous Macadam (DBM). Underneath the DBM, Wet Mix Macadam (WMM) shall be provided to act as a base course. The sub-base shall comprise of granular material conforming to the grading, density and other physical requirements stipulated in MORTH Specifications. The material selected for sub-grade shall have C.B.R not less than 10% at 97% modified dry density.

## **6.8 DESIGN STANDARDS FOR BRIDGES AND OTHER STRUCTURES**

### **6.8.1 General requirement**

The preliminary design has been carried out to generally satisfy the following requirements:

- Sufficiency, adequacy and suitability
- Soundness of the structure, durability and architectural harmony of the surroundings
- Minimum number of expansion joints for better riding quality.
- To meet all the codal requirements.

The cross drainage structures have been classified as culverts, minor bridges and major bridges depending upon the length of structures as per IRC Standards. Structures up to 6m length fall in the category of culverts, more than 6m and up to 60m in length as minor bridges and more than 60.0m in length as major bridges.

The formation width of the proposed bridges is kept as 9.50m for straight bridges. Widening of carriageway is provided wherever required as per the radius of horizontal curve. The road cross section is continued over the bridge.

The breakup of formation width of bridges based on cross section of the road is as follows

- Kerb shyness - 0.50 m from the outer face of the median kerb
- Carriageway width - 7.0 m
- Width of paved shoulder - 1.0 m

- Width of concrete crash barrier - 0.5 m (both sides)

Therefore the overall width of bridge from the outer face of crash barrier to outer face of crash barrier is 9.50m excluding widening required due to horizontal curves. The carriageway width of proposed bridges is kept as 8.50m and crash barrier on each end is kept as 0.50m. The design standards and loading considered for design of culverts and bridges is as per latest IRC Codes.

## **6.9 ENVIRONMENTAL AND SOCIAL ASSESSMENT**

Based on detailed report on environmental and social assessment of potential critical impacts complying with State, GOI and ADB environmental requirements, environmental design for enhancement of areas within the ROW which would have suffered environmental degradation as a result of the proposed highway improvement has been included in the Environmental Management Plan.

### **6.10 SPECIFICATIONS**

The material to be used in the Project work and the specifications for execution of work shall conform to "MORTH Specifications for Road and Bridge Works 5th Rev. April 2005". However special Technical Specifications have been framed wherever MORTH specifications required changes. Where MORTH specifications are silent with regard to certain specifications for the material in question, in that case, specifications under Bureau of Indian Standards/AASHTO/ASTM/BS or any other international standard shall apply. But where these specifications are also silent, the specifications based on sound engineering practices have been resorted to.

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## CHAPTER 7: IMPROVEMENT PROPOSAL

### 7.1 General

This chapter addresses three important geometric design aspects: geometric design standards for the project corridor, detailing of highway design elements, and improvement proposals.

**Geometric Design Standards:** Geometric Standards form the basis of any design in a particular project. The formulation of these design standards is done with the objective to set standards/guidelines for designs, to avoid any inconsistency in design from one section to the other, and to provide a desired level of service and safety. The Terms of Reference for this project not only list a brief with regard to design requirement, but also specify the codes on the basis of which designs are to be carried out.

Design Standards given in relevant IRC codes, guidelines and special publications, and MORT&H circulars as applicable to the National Highways have been followed.

**Highway Design Elements:** With improvement proposals being finalized, and categorization of elements for design standards complete, the various highway design elements have been detailed.

**Improvement Proposals:** It is pertinent to discuss improvement proposals because these need to address present conditions, account for the sustenance of desired Levels of Service with respect to both capacity and pavement condition, and be achieved in a phased manner so as to stagger investments. Based on existing road and traffic conditions and traffic on the project corridor over the project duration, capacities have been reassessed and improvement proposals have been worked out.

### 7.2 Design Standards and Methodology for Roads

#### 7.2.1 Codes and Guidelines

The Highway design using the Indian Road Congress “IRC:38-1988 (Guidelines for the Design of Horizontal Curve for Highways)”, “IRC:SP:23-1983 (Vertical Curves for Highways)” and IRC:73-1980 (Geometric Design for Rural Highways)” have been followed.

The pavement has been designed using the Indian Road Congress “IRC: 37-2012 (Tentative Guidelines for the Design of Flexible Pavements)”.As this method has been developed in India to suit local conditions and the traffic composition, it is considered to be the most appropriate.

#### 7.2.2 Geometric Design Standards

The project road section qualifies partly, the criteria as per hill road terrain and mostly as per steep terrain. So, the geometric design standards set for the project have been elaborated in the table below for quick reference, in addition to which “IRC: SP: 48-1998 (Hill Road Manual)” as well as “ IRC: SP: 73-2015 (Manual of Specification & Standards for Two Lanning of Highways with Paved Shoulder) has been consulted as required is given in **Table 7.1** below:

**Table: 7.1 Adopted Geometric Design Standards for the Project Corridor**

S. No.	Description	Unit	Proposed Standards			
			Hilly		Steep	
1	Design Speed					
	Ruling	km/hr	50		40	
	Minimum	km/hr	40		30	
2	Right of Way (ROW)	M	12 in Urban/Semi-Urban Section 15-18 in Rural Section			
3	Cross Sectional Elements					
(a)	Carriage Way Width					
	Two lane	M	7		7	
.(b)	Paved Shoulder	M	Hill Side	Valley Side	Hill Side	Valley Side
			1.5	1.5	1.5	1.5
(c)	Granular Shoulder	M	-	1.0	-	1.0
(d)	Drain (KC-type)	M	0.6	-	0.6	-
	Drain (U-type)	M	1.0	-	1.0	-
(e)	Cross Slope					
	Carriageway	%	2.5		2.5	
	Paved Shoulder	%	2.5		2.5	
(f)	Extra Widening of pavement at curves	As per IRC: 38 -1988				
4	Horizontal Curve					
(a)	Radius					
	Ruling Minimum	M	90		60	
	Absolute Minimum	M	60		30	
(b)	Super-elevation (max)	%	7		7	
5	Vertical Curve					
(a)	Length (min)					
	Ruling Minimum	M	30		20	
	Absolute Minimum	M	20		15	



S. No.	Description	Unit	Proposed Standards	
			Hilly	Steep
(c)	Maximum grade change not requiring vertical curve	%	1.0% – 1.5%	
(d)	Rate of change of super-elevation	M	1 in 60	
8	Intersections			
i)	Minimum length of acceleration lane	M	60m	
ii)	Minimum length of deceleration lane	M	70m	
iii)	Minimum radius for left turn	M	20m	
iv)	Minimum radius for right turn	M	15m	
v)	Width of turning lane (inner radius of 30 m)	M	4.5m	
vi)	Rate of taper (min)	M	1 in 15	
9	Bus-shelters			
i)	Min. length of bus-bay	M	15 m	
ii)	Maximum length of pedestrian guard rail on either side of the bus-bay	M	22 x 2 m	
10	Truck Laybye			
i)	Min length of layby	M	100m	
ii)	Min parking length for each vehicle	M	15m	
iii)	Min parking width for each vehicle	M	2.75m	
iv)	Min. width of raised separator between layby and carriageway	M	1m	
v)	Rate of taper (min)	M	1 in 10	
11	Safety barriers			
i)	Bridge approaches and high embankments	M	3m and above	
12	Clearance for Utility Lines			
A)	Horizontal		As per IRC 32-1969	

S. No.	Description	Unit	Proposed Standards	
			Hilly	Steep
i)	Street lighting poles	m	1.5m min from edge of carriageway	
ii)	Overhead power and telecommunication lines	M	10m min. from edge of roadway	
B)	Vertical		As per IRC 32-1969	
i)	Ordinary wires/lines carrying voltage upto and including 110 volts and telecommunication lines	M	5.5m minimum.	
ii)	Electric power lines carrying voltage upto and including 650 volts	M	6.0m minimum.	
iii)	Electric power lines carrying voltage exceeding 650 volts	M	6.5m minimum.	

### 7.2.3 Alignment Design

Existing alignment of the project road is very poor comparing to IRC codes. So the design is made to match the requirement of horizontal design with the latest IRC Specifications and to match vertical profile to the latest code specified by IRC for vertical design. Both the horizontal and vertical design is explained below.

#### 7.2.3.1 Horizontal Alignment

Out of the several existing curves present there along the project road, many curves are deficient, with respect to minimum design speed of 40 km/h for hilly and 30 km/h for steep terrain.

All the curves have been improved to meet design standard requirements as per IRC. At some of the locations, broken back curves have been observed and have been replaced with a single curve of sufficient radii, however, there are 6 curves which have been improved at the maximum extent but don't satisfy the IRC standard due to some restrictions like huge cut, habitation or to maintain the approach of retained bridges. The list of such curves is presented below in the **table 7.2** below:

**Table 7.2: Details of deficient curves in horizontal alignment.**

S. No.	Design Chainage (km)		Design radius	Existing Radius (m)	Grade In	Grade Out	Remarks
	From	To					
1	398+326	398+331	20	20	2.8%	2.8%	Approach of retained bridge in habitation of Karanparyag
2	398+906	398+944	17.5	17	3.4%	3.4%	Dense Habitation
3	410+068	410+102	20	20	-4.0%	-4.0%	Hair Pin Bend, deep valley on both side
4	410+794	410+820	20	16	2.0%	2.0%	Deep Valley on left side and huge SMB cutting in right side
5	410+906	410+945	20	16	2.0%	2.0%	Both side Valley
6	411+358	411+393	17.5	16	4.0%	4.0%	Hair Pin Bend, deep valley on both side
7	411+435	411+475	20	20	4.0%	4.0%	Bridge Approach, vertical hill, huge cutting involve,
8	418+180	418+182	20	16	5.0%	0.0%	
9	418+233	418+256	20	16	0.0%	6.5%	Bridge Approach, vertical hill, huge cutting and Habitation involve

### 7.2.3.2 Vertical Alignment

The project road is predominantly on steep terrain. Vertical profile has been designed in accordance with the guidelines and geometric standards have been discussed in this report. Exceptional maximum gradient of 8% have been followed for a few sections of the project road.

It can be seen that the project road is generally in steep terrain and therefore a ruling gradient of 6% has been adopted for design. In order to avoid such huge cutting/ filling, which is also not economically desirable, an exceptional maximum gradient of 8% have been allowed for the design of vertical profile for the stretches presented in **Table 7.3** below.

**Table 7.3: Vertical Alignment Deficient Curves**

S. No.	Vertical Tangent Points					Grade (%)	Length of Element	Remarks/ Reason
	Start Chainage	Elevation (M)	End Chainage	Elevation (M)	Elevation Difference			
1	395771.617	827.395	396428.97	774.807	52.588	-8	657.352	Continuous Steep Slope, Steep Terrain

### 672.4 Widening Scheme

The details of widening scheme of rural section for the project corridor involve 2 lane configurations as given in **table 7.4** below:

**Table 7.4: Reconstruction/Widening Scheme of Rural Section**

S. No.	Built-up section	Design Chainage (km)		Length (m)	Width of Carriage way (m)	TCS Type
		From	To			
1	Karanprayag	398+300	400+050	1750	9	TYPE-V, V-A, V-B, V-C,V-D
2	Shivai	402+375	402+600	225	9	TYPE-V, V-A, V-B, V-C,V-D
3	Kalarswar	402+950	403+600	650	9	TYPE-V, V-A, V-B, V-C,V-D
4	Langasu	406+450	407+550	1100	9	TYPE-V, V-A, V-B, V-C,V-D
5	Bhakunda	409+550	409+775	225	9	TYPE-V, V-A, V-B, V-C,V-D
6	Sonla	413+675	413+800	125	9	TYPE-V, V-A, V-B, V-C,V-D
7	Nandprayag	417+600	418+175	575	9	TYPE-V, V-A, V-B, V-C,V-D
8	Maithana	422+025	422+450	425	9	TYPE-V, V-A, V-B, V-C,V-D

The finalized treatment options for CD structures viz., rehabilitation and reconstruction as applicable to different stretches of the project corridor. With a view to minimize land acquisition & cutting of hills and utilize the existing carriageway to the maximum extent possible, twenty two typical cross-sections has been proposed and already discussed earlier for improvement of project road is given in **Table 7.5** below:

**Table 7.5: Summary of Carriageway Widening Proposal**

S No	Type	Description
1	I	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side cut upto 4.0m (Soft rock+Soil))
2	IA	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side upto 4.0m (Soft rock+Soil))
3	IB	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 4 m and Hill side upto 4.0m protection (Soft rock+Soil))
4	IC	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 4 m protection (Soft rock+Soil))
5	ID	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling >4 m protection (Soft rock+Soil))
6	II	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side cut in hard rock)
7	IIA	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side Filling upto 1m and Hill side upto 4m protection hard rock)
8	IIB	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side upto 4m protection and hill side cut in hard rock)
9	IIC	Typical Cross Section for widening of existing road to 2 lane with paved shoulder (Valley side filling>4m protection in hard rock)
10	III	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side cut upto 4m (Soft rock+ Soil))
11	IIIA	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side upto 4m protection (Soft rock+ Soil))
12	IIIB	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m cutting (Soft rock+ Soil))
13	IIIC	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m protection (Soft rock+ Soil))
14	IIID	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
15	IV	Typical Cross Section for realignment and bypass Valley side Filling upto 1m and hill side cut hard rock)
16	IVA	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side cut in hard rock)
17	IVB	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
18	V	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (12.0m formation width)
19	VA	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area)

S No	Type	Description
		(hill side upto 4m protection) (12.0m formation width)
20	VB	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area (valley side upto 4m protection and hill side no protection) (12.0m formation width)
21	VC	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area (both side protection upto 4m) (12.0m formation width)
22	VD	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area (valley side protection > 4.0m) (12.0m formation width)

**Table 7.6: Details of widening scheme according to typical cross section.**

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
1	400+050	400+075	TYPE-I-A	25
2	400+075	400+100	TYPE-I-A	25
3	400+100	400+125	TYPE-I-A	25
4	400+125	400+150	TYPE-I-A	25
5	400+150	400+175	TYPE-I-B	14
6	400+175	400+200	TYPE-I-B	25
7	400+200	400+225	TYPE-I-A	25
8	400+225	400+250	TYPE-I-A	25
9	400+250	400+275	TYPE-I-B	14
10	400+275	400+300	TYPE-I-B	25
11	400+300	400+325	TYPE-I-A	25
12	400+325	400+350	TYPE-I-A	25
13	400+350	400+375	TYPE-I-B	14
14	400+375	400+400	TYPE-II-B	25
15	400+400	400+425	TYPE-II	25
16	400+425	400+450	TYPE-II-B	25
17	400+450	400+475	TYPE-II-B	25
18	400+475	400+500	TYPE-II-B	25
19	400+500	400+525	TYPE-II-B	25
20	400+525	400+550	TYPE-II-B	14
21	400+550	400+575	TYPE-II-B	25
22	400+575	400+600	TYPE-II-B	25
23	400+600	400+625	TYPE-II-B	14
24	400+625	400+650	TYPE-II-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
25	400+650	400+675	TYPE-II-C	25
26	400+675	400+700	TYPE-II-C	25
27	400+700	400+725	TYPE-II-C	25
28	400+725	400+750	TYPE-II	25
29	400+750	400+775	TYPE-II	25
30	400+775	400+800	TYPE-II-B	25
31	400+800	400+825	TYPE-II	25
32	400+825	400+850	TYPE-II-B	25
33	400+850	400+875	TYPE-II	14
34	400+875	400+900	TYPE-II	25
35	400+900	400+925	TYPE-II	25
36	400+925	400+950	TYPE-II	25
37	400+950	400+975	TYPE-II	25
38	400+975	401+000	TYPE-II	25
39	401+000	401+025	TYPE-II	14
40	401+025	401+050	TYPE-II-B	25
41	401+050	401+075	TYPE-I-B	25
42	401+075	401+100	TYPE-III-A	25
43	401+100	401+125	TYPE-III-A	25
44	401+125	401+150	TYPE-I-B	25
45	401+150	401+175	TYPE-I-B	25
46	401+175	401+200	TYPE-I-B	25
47	401+200	401+225	TYPE-I-A	25
48	401+225	401+250	TYPE-I-A	25
49	401+250	401+275	TYPE-I-A	25
50	401+275	401+300	TYPE-I-A	25
51	401+300	401+325	TYPE-I-A	25
52	401+325	401+350	TYPE-I-A	25
53	401+350	401+375	TYPE-I-A	25
54	401+375	401+400	TYPE-I-B	25
55	401+400	401+425	TYPE-I-B	25
56	401+425	401+450	TYPE-I-A	25
57	401+450	401+475	TYPE-I-A	25
58	401+475	401+500	TYPE-I-A	25
59	401+500	401+525	TYPE-I-A	14
60	401+525	401+550	TYPE-I-A	25
61	401+550	401+575	TYPE-I-A	25
62	401+575	401+600	TYPE-I-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
63	401+600	401+625	TYPE-I-A	25
64	401+625	401+650	TYPE-I-A	25
65	401+650	401+675	TYPE-I-A	25
66	401+675	401+700	TYPE-I-A	25
67	401+700	401+725	TYPE-I-A	25
68	401+725	401+750	TYPE-I-A	14
69	401+750	401+775	TYPE-I-A	25
70	401+775	401+800	TYPE-I-A	25
71	401+800	401+825	TYPE-I-A	25
72	401+825	401+850	TYPE-I-B	25
73	401+850	401+875	TYPE-I-D	25
74	401+875	401+900	TYPE-I-D	25
75	401+900	401+925	TYPE-I-A	25
76	401+925	401+950	TYPE-I-A	25
77	402+000	402+025	TYPE-II-B	25
78	402+025	402+050	TYPE-II-B	25
79	402+050	402+075	TYPE-I-C	25
80	402+075	402+100	TYPE-I-A	25
81	402+100	402+125	TYPE-I-A	25
82	402+125	402+150	TYPE-I-A	25
83	402+150	402+175	TYPE-II	25
84	402+175	402+200	TYPE-I-C	25
85	402+200	402+225	TYPE-I-C	25
86	402+225	402+250	TYPE-I-C	25
87	402+250	402+275	TYPE-I-C	14
88	402+275	402+300	TYPE-I-C	25
89	402+300	402+325	TYPE-I-C	25
90	402+325	402+350	TYPE-I-A	25
91	402+350	402+375	TYPE-I-A	14
92	402+600	402+625	TYPE-I-C	25
93	402+650	402+675	TYPE-I-C	25
94	402+675	402+700	TYPE-I	25
95	402+700	402+725	TYPE-I	25
96	402+725	402+750	TYPE-I	25
97	402+750	402+775	TYPE-I	25
98	402+775	402+800	TYPE-I	25
99	402+800	402+825	TYPE-I	25
100	402+825	402+850	TYPE-I	25



S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
101	402+850	402+875	TYPE-I	25
102	402+875	402+900	TYPE-I	25
103	402+900	402+925	TYPE-I	25
104	402+925	402+950	TYPE-I-C	25
105	403+600	403+625	TYPE-I-A	25
106	403+625	403+650	TYPE-I-A	25
107	403+650	403+675	TYPE-I-A	25
108	403+675	403+700	TYPE-I-A	14
109	403+700	403+725	TYPE-I-A	25
110	403+725	403+750	TYPE-I-A	25
111	403+750	403+775	TYPE-I-A	25
112	403+775	403+800	TYPE-I-A	25
113	403+800	403+825	TYPE-I-A	25
114	403+825	403+850	TYPE-I-A	14
115	403+850	403+875	TYPE-II	25
116	403+875	403+900	TYPE-II	25
117	403+900	403+925	TYPE-II	25
118	403+925	403+950	TYPE-II	25
119	403+950	403+975	TYPE-II	25
120	403+975	404+000	TYPE-II-B	25
121	404+000	404+025	TYPE-II	25
122	404+025	404+050	TYPE-II	25
123	404+050	404+075	TYPE-II	25
124	404+075	404+100	TYPE-II	25
125	404+100	404+125	TYPE-II	25
126	404+125	404+150	TYPE-II	25
127	404+150	404+175	TYPE-II	25
128	404+175	404+200	TYPE-II-B	25
129	404+200	404+225	TYPE-II-B	14
130	404+225	404+250	TYPE-II-B	25
131	404+250	404+275	TYPE-II-B	25
132	404+275	404+300	TYPE-II	25
133	404+300	404+325	TYPE-II	25
134	404+325	404+350	TYPE-II-B	25
135	404+350	404+375	TYPE-II	25
136	404+375	404+400	TYPE-II	25
137	404+400	404+425	TYPE-II	25
138	404+425	404+450	TYPE-II	14

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
139	404+450	404+475	TYPE-I-A	25
140	404+475	404+500	TYPE-I-A	25
141	404+500	404+525	TYPE-I-A	25
142	404+525	404+550	TYPE-I-A	25
143	404+550	404+575	TYPE-I-B	25
144	404+575	404+600	TYPE-I-B	25
145	404+600	404+625	TYPE-IV	25
146	404+675	404+700	TYPE-IV-B	25
147	404+700	404+725	TYPE-IV	25
148	404+725	404+750	TYPE-IV	25
149	404+750	404+775	TYPE-II	25
150	404+775	404+800	TYPE-I-B	14
151	404+800	404+825	TYPE-I-A	25
152	404+825	404+850	TYPE-I-B	25
153	404+850	404+875	TYPE-I-B	25
154	404+875	404+900	TYPE-I-B	25
155	404+900	404+925	TYPE-II-B	25
156	404+925	404+950	TYPE-II	25
157	404+950	404+975	TYPE-II	25
158	404+975	405+000	TYPE-II	25
159	405+000	405+025	TYPE-I-A	25
160	405+025	405+050	TYPE-I-A	14
161	405+050	405+075	TYPE-I-A	25
162	405+075	405+100	TYPE-I-A	25
163	405+100	405+125	TYPE-I-A	25
164	405+125	405+150	TYPE-I-A	25
165	405+150	405+175	TYPE-I-A	25
166	405+175	405+200	TYPE-I-A	25
167	405+200	405+225	TYPE-I-A	25
168	405+225	405+250	TYPE-I-B	25
169	405+250	405+275	TYPE-I-B	25
170	405+275	405+300	TYPE-I-A	25
171	405+300	405+325	TYPE-I-A	14
172	405+325	405+350	TYPE-I-A	25
173	405+350	405+375	TYPE-I-A	25
174	405+375	405+400	TYPE-I-A	25
175	405+400	405+425	TYPE-I-A	25
176	405+425	405+450	TYPE-I-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
177	405+450	405+475	TYPE-I-B	14
178	405+475	405+500	TYPE-II	25
179	405+500	405+525	TYPE-II	25
180	405+525	405+550	TYPE-II-B	14
181	405+550	405+575	TYPE-II	25
182	405+575	405+600	TYPE-II	25
183	405+600	405+625	TYPE-II-B	14
184	405+625	405+650	TYPE-II	25
185	405+650	405+675	TYPE-II	25
186	405+675	405+700	TYPE-II	14
187	405+700	405+725	TYPE-II-B	25
188	405+725	405+750	TYPE-II	25
189	405+750	405+775	TYPE-II	25
190	405+775	405+800	TYPE-II-B	14
191	405+800	405+825	TYPE-I	25
192	405+825	405+850	TYPE-I	25
193	405+850	405+875	TYPE-I	25
194	405+875	405+900	TYPE-I	25
195	405+900	405+925	TYPE-I	25
196	405+925	405+950	TYPE-I	25
197	405+950	405+975	TYPE-I	25
198	405+975	406+000	TYPE-I	25
199	406+000	406+025	TYPE-I	25
200	406+025	406+050	TYPE-III	25
201	406+050	406+075	TYPE-III	25
202	406+125	406+150	TYPE-III	25
203	406+150	406+175	TYPE-III-B	25
204	406+175	406+200	TYPE-I-A	25
205	406+200	406+225	TYPE-I-A	25
206	406+225	406+250	TYPE-I-B	25
207	406+250	406+275	TYPE-II-B	25
208	406+275	406+300	TYPE-II	25
209	406+300	406+325	TYPE-II-B	25
210	406+325	406+350	TYPE-I-B	25
211	406+350	406+375	TYPE-I-A	25
212	406+375	406+400	TYPE-I-A	25
213	406+400	406+425	TYPE-I-A	14
214	406+425	406+450	TYPE-I-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
215	407+575	407+600	TYPE-I-A	25
216	407+600	407+625	TYPE-I-A	25
217	407+625	407+650	TYPE-I-A	25
218	407+650	407+675	TYPE-I-A	25
219	407+675	407+700	TYPE-I-A	14
220	407+700	407+725	TYPE-I-A	25
221	407+725	407+750	TYPE-I-B	25
222	407+750	407+775	TYPE-I-B	25
223	407+775	407+800	TYPE-I-A	25
224	407+800	407+825	TYPE-I-A	25
225	407+825	407+850	TYPE-II	25
226	407+850	407+875	TYPE-II	25
227	407+875	407+900	TYPE-II	25
228	407+900	407+925	TYPE-II	25
229	407+925	407+950	TYPE-I	14
230	407+950	407+975	TYPE-I-A	25
231	407+975	408+000	TYPE-I-A	25
232	408+000	408+025	TYPE-I-C	12
233	408+025	408+050	TYPE-I-C	25
234	408+050	408+075	TYPE-I	14
235	408+075	408+100	TYPE-I-A	25
236	408+100	408+125	TYPE-I-A	25
237	408+125	408+150	TYPE-I-A	25
238	408+150	408+175	TYPE-I	14
239	408+175	408+200	TYPE-I	25
240	408+200	408+225	TYPE-II-A	25
241	408+225	408+250	TYPE-II-A	25
242	408+250	408+275	TYPE-II	25
243	408+275	408+300	TYPE-II	14
244	408+300	408+325	TYPE-II-A	25
245	408+325	408+350	TYPE-II-A	25
246	408+350	408+375	TYPE-I-A	25
247	408+375	408+400	TYPE-I-A	25
248	408+400	408+425	TYPE-I-A	25
249	408+425	408+450	TYPE-I-A	25
250	408+450	408+475	TYPE-I-A	14
251	408+475	408+500	TYPE-I-A	25
252	408+500	408+525	TYPE-I-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
253	408+525	408+550	TYPE-I	25
254	408+550	408+575	TYPE-I	25
255	408+575	408+600	TYPE-I-A	25
256	408+600	408+625	TYPE-I-A	25
257	408+625	408+650	TYPE-I-A	25
258	408+650	408+675	TYPE-I-A	14
259	408+675	408+700	TYPE-I-A	25
260	408+700	408+725	TYPE-I-A	14
261	408+725	408+750	TYPE-I-A	25
262	408+750	408+775	TYPE-I-A	25
263	408+775	408+800	TYPE-I-A	14
264	408+800	408+825	TYPE-I-A	25
265	408+825	408+850	TYPE-I-A	25
266	408+850	408+875	TYPE-I-A	25
267	408+875	408+900	TYPE-I-A	25
268	408+900	408+925	TYPE-I-A	25
269	408+925	408+950	TYPE-I-A	25
270	408+950	408+975	TYPE-I-C	25
271	408+975	409+000	TYPE-I-C	14
272	409+000	409+025	TYPE-I-C	25
273	409+025	409+050	TYPE-I-C	25
274	409+050	409+075	TYPE-II-B	25
275	409+075	409+100	TYPE-IV-A	25
276	409+150	409+175	TYPE-I	25
277	409+175	409+200	TYPE-I	25
278	409+200	409+225	TYPE-I	25
279	409+225	409+250	TYPE-I	25
280	409+250	409+275	TYPE-I	25
281	409+275	409+300	TYPE-I	25
282	409+300	409+325	TYPE-I	25
283	409+325	409+350	TYPE-I-A	25
284	409+350	409+375	TYPE-I-A	25
285	409+375	409+400	TYPE-I-A	25
286	409+400	409+425	TYPE-I-B	25
287	409+425	409+450	TYPE-I-A	25
288	409+450	409+475	TYPE-I-A	25
289	409+475	409+500	TYPE-I-B	14
290	409+500	409+525	TYPE-I-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
291	409+525	409+550	TYPE-I-B	25
292	409+775	409+800	TYPE-III-A	25
293	409+800	409+825	TYPE-III-A	25
294	409+825	409+850	TYPE-III-A	25
295	409+850	409+875	TYPE-I-C	25
296	409+875	409+900	TYPE-I-B	25
297	409+900	409+925	TYPE-I-A	25
298	409+925	409+950	TYPE-I-A	16
299	409+950	409+975	TYPE-III-C	25
300	409+975	410+000	TYPE-III-B	25
301	410+000	410+025	TYPE-III-C	25
302	410+025	410+050	TYPE-I-A	25
303	410+050	410+075	TYPE-I-C	25
304	410+075	410+100	TYPE-I-C	25
305	410+100	410+125	TYPE-I-C	25
306	410+125	410+150	TYPE-I-B	25
307	410+150	410+175	TYPE-I-B	16
308	410+175	410+200	TYPE-I-B	25
309	410+200	410+225	TYPE-I-B	25
310	410+225	410+250	TYPE-I-B	25
311	410+250	410+275	TYPE-I-B	25
312	410+275	410+300	TYPE-I-B	25
313	410+300	410+325	TYPE-III-B	25
314	410+325	410+350	TYPE-III-B	25
315	410+425	410+450	TYPE-I-C	16
316	410+450	410+475	TYPE-I-C	25
317	410+475	410+500	TYPE-I-C	25
318	410+500	410+525	TYPE-I-C	25
319	410+525	410+550	TYPE-I-C	25
320	410+550	410+575	TYPE-I-C	25
321	410+575	410+600	TYPE-I	25
322	410+600	410+625	TYPE-I	25
323	410+625	410+650	TYPE-I	25
324	410+650	410+675	TYPE-I-B	25
325	410+675	410+700	TYPE-I-B	16
326	410+700	410+725	TYPE-I-A	25
327	410+725	410+750	TYPE-I	25
328	410+750	410+775	TYPE-I	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
329	410+775	410+800	TYPE-I-C	25
330	410+800	410+825	TYPE-I-C	25
331	410+825	410+850	TYPE-I-C	16
332	410+850	410+875	TYPE-I-C	25
333	410+875	410+900	TYPE-I-C	25
334	410+900	410+925	TYPE-I	25
335	410+925	410+950	TYPE-III	25
336	410+950	410+975	TYPE-III-B	25
337	410+975	411+000	TYPE-III-B	16
338	411+000	411+025	TYPE-III-D	25
339	411+025	411+050	TYPE-III-B	25
340	411+050	411+075	TYPE-III-A	25
341	411+075	411+100	TYPE-III-A	25
342	411+100	411+125	TYPE-I-C	25
343	411+125	411+150	TYPE-I	14
344	411+150	411+175	TYPE-III-A	25
345	411+175	411+200	TYPE-III-A	25
346	411+200	411+225	TYPE-III-B	25
347	411+225	411+250	TYPE-III-D	25
348	411+250	411+275	TYPE-III-D	25
349	411+275	411+300	TYPE-III-B	25
350	411+300	411+325	TYPE-I	25
351	411+375	411+400	TYPE-II-B	25
352	411+400	411+425	TYPE-II-B	25
353	411+425	411+450	TYPE-II-B	25
354	411+450	411+475	TYPE-II	25
355	411+475	411+500	TYPE-II	25
356	411+500	411+525	TYPE-II	25
357	411+525	411+550	TYPE-II-B	14
358	411+550	411+575	TYPE-II-B	25
359	411+575	411+600	TYPE-II	25
360	411+600	411+625	TYPE-II	25
361	411+625	411+650	TYPE-II	25
362	411+650	411+675	TYPE-I-A	25
363	411+675	411+700	TYPE-I-A	25
364	411+700	411+725	TYPE-I	25
365	411+725	411+750	TYPE-I-C	16
366	411+750	411+775	TYPE-I-C	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
367	411+775	411+800	TYPE-I	25
368	411+800	411+825	TYPE-I	25
369	411+825	411+850	TYPE-I-B	25
370	411+850	411+875	TYPE-I-B	25
371	411+875	411+900	TYPE-I-B	25
372	411+900	411+925	TYPE-I-B	25
373	411+925	411+950	TYPE-I-C	25
374	411+950	411+975	TYPE-I	16
375	411+975	412+000	TYPE-I	25
376	412+000	412+025	TYPE-I	25
377	412+025	412+050	TYPE-I	25
378	412+050	412+075	TYPE-I	25
379	412+075	412+100	TYPE-I-C	25
380	412+100	412+125	TYPE-I-C	25
381	412+125	412+150	TYPE-I-C	25
382	412+150	412+175	TYPE-I-C	25
383	412+175	412+200	TYPE-I	25
384	412+200	412+225	TYPE-I	14
385	412+225	412+250	TYPE-I	25
386	412+250	412+275	TYPE-I	25
387	412+275	412+300	TYPE-I	25
388	412+300	412+325	TYPE-I	25
389	412+325	412+350	TYPE-I-A	25
390	412+350	412+375	TYPE-I	25
391	412+375	412+400	TYPE-I	25
392	412+400	412+425	TYPE-I-C	16
393	412+425	412+450	TYPE-I-C	25
394	412+450	412+475	TYPE-I-C	25
395	412+475	412+500	TYPE-I-B	25
396	412+500	412+525	TYPE-I-B	16
397	412+525	412+550	TYPE-I-B	25
398	412+550	412+575	TYPE-I-A	16
399	412+575	412+600	TYPE-I-A	25
400	412+600	412+625	TYPE-I-A	25
401	412+625	412+650	TYPE-I-A	25
402	412+650	412+675	TYPE-I	25
403	412+675	412+700	TYPE-I	25
404	412+700	412+725	TYPE-I	16



S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
405	412+725	412+750	TYPE-I	16
406	412+750	412+775	TYPE-I	25
407	412+775	412+800	TYPE-I	25
408	412+800	412+825	TYPE-I	25
409	412+825	412+850	TYPE-I	25
410	412+850	412+875	TYPE-I	16
411	412+875	412+900	TYPE-I	25
412	412+900	412+925	TYPE-I	25
413	412+925	412+950	TYPE-I	14
414	412+950	412+975	TYPE-I	25
415	412+975	413+000	TYPE-III-B	25
416	413+000	413+025	TYPE-III-D	12
417	413+025	413+050	TYPE-III-D	25
418	413+050	413+075	TYPE-I	25
419	413+075	413+100	TYPE-I-A	25
420	413+100	413+125	TYPE-I-A	25
421	413+125	413+150	TYPE-I-A	25
422	413+150	413+175	TYPE-I-A	25
423	413+175	413+200	TYPE-I-A	25
424	413+200	413+225	TYPE-I-A	25
425	413+225	413+250	TYPE-I-A	25
426	413+250	413+275	TYPE-I-A	25
427	413+275	413+300	TYPE-I-A	12
428	413+300	413+325	TYPE-I-A	25
429	413+325	413+350	TYPE-I-B	25
430	413+350	413+375	TYPE-I-A	25
431	413+375	413+400	TYPE-I-A	25
432	413+400	413+425	TYPE-I-A	25
433	413+425	413+450	TYPE-I-A	25
434	413+450	413+475	TYPE-I-A	25
435	413+475	413+500	TYPE-II	14
436	413+500	413+525	TYPE-II	25
437	413+525	413+550	TYPE-II	25
438	413+550	413+575	TYPE-II	25
439	413+575	413+600	TYPE-II	25
440	413+600	413+625	TYPE-II	25
441	413+625	413+650	TYPE-III-B	25
442	413+650	413+675	TYPE-III-C	12

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
443	413+800	413+825	TYPE-I	25
444	413+825	413+850	TYPE-I	25
445	413+850	413+875	TYPE-I	14
446	413+875	413+900	TYPE-I	25
447	413+900	413+925	TYPE-I-C	25
448	413+925	413+950	TYPE-I-C	25
449	413+950	413+975	TYPE-I	25
450	413+975	414+000	TYPE-I-A	25
451	414+000	414+025	TYPE-I-A	25
452	414+025	414+050	TYPE-I	25
453	414+050	414+075	TYPE-I	25
454	414+075	414+100	TYPE-I	25
455	414+100	414+125	TYPE-I	25
456	414+125	414+150	TYPE-I	16
457	414+150	414+175	TYPE-I	25
458	414+175	414+200	TYPE-I	25
459	414+200	414+225	TYPE-I	25
460	414+225	414+250	TYPE-I	25
461	414+250	414+275	TYPE-I	25
462	414+275	414+300	TYPE-I	16
463	414+300	414+325	TYPE-I	25
464	414+325	414+350	TYPE-I	25
465	414+350	414+375	TYPE-I	25
466	414+375	414+400	TYPE-I	25
467	414+400	414+425	TYPE-I	25
468	414+425	414+450	TYPE-I	25
469	414+450	414+475	TYPE-I	25
470	414+475	414+500	TYPE-I	25
471	414+500	414+525	TYPE-I	25
472	414+525	414+550	TYPE-I	25
473	414+550	414+575	TYPE-I	25
474	414+575	414+600	TYPE-I	25
475	414+600	414+625	TYPE-I	25
476	414+625	414+650	TYPE-I	25
477	414+650	414+675	TYPE-I	14
478	414+675	414+700	TYPE-I	25
479	414+700	414+725	TYPE-I	25
480	414+725	414+750	TYPE-I	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
481	414+750	414+775	TYPE-I	25
482	414+775	414+800	TYPE-I	25
483	414+800	414+825	TYPE-I	25
484	414+825	414+850	TYPE-I	14
485	414+850	414+875	TYPE-I	25
486	414+875	414+900	TYPE-I	25
487	414+900	414+925	TYPE-I	25
488	414+925	414+950	TYPE-I	25
489	414+950	414+975	TYPE-I	25
490	414+975	415+000	TYPE-I	25
491	415+000	415+025	TYPE-I	16
492	415+025	415+050	TYPE-I	25
493	415+050	415+075	TYPE-I	25
494	415+075	415+100	TYPE-I	25
495	415+100	415+125	TYPE-I	25
496	415+125	415+150	TYPE-I	25
497	415+150	415+175	TYPE-I	25
498	415+175	415+200	TYPE-I	25
499	415+200	415+225	TYPE-I	25
500	415+225	415+250	TYPE-III-B	25
501	415+250	415+275	TYPE-III-B	14
502	415+275	415+300	TYPE-II	25
503	415+300	415+325	TYPE-II	25
504	415+325	415+350	TYPE-II	25
505	415+350	415+375	TYPE-IV-A	25
506	415+375	415+400	TYPE-IV-A	14
507	415+400	415+425	TYPE-IV-A	25
508	415+425	415+450	TYPE-IV	25
509	415+450	415+475	TYPE-IV	25
510	415+475	415+500	TYPE-IV	16
511	415+500	415+525	TYPE-IV	25
512	415+525	415+550	TYPE-IV-A	25
513	415+550	415+575	TYPE-II-B	25
514	415+575	415+600	TYPE-II-B	25
515	415+600	415+625	TYPE-II-B	25
516	415+625	415+650	TYPE-II-A	25
517	415+650	415+675	TYPE-II-A	25
518	415+675	415+700	TYPE-II-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
519	415+700	415+725	TYPE-II-A	25
520	415+725	415+750	TYPE-II-B	16
521	415+750	415+775	TYPE-II-B	25
522	415+775	415+800	TYPE-II	25
523	415+800	415+825	TYPE-I-C	16
524	415+825	415+850	TYPE-I-D	16
525	415+850	415+875	TYPE-I-C	25
526	415+875	415+900	TYPE-I	25
527	415+900	415+925	TYPE-II	25
528	415+925	415+950	TYPE-II	25
529	415+950	415+975	TYPE-II	25
530	415+975	416+000	TYPE-I	14
531	416+000	416+025	TYPE-III-A	25
532	416+025	416+050	TYPE-III-A	25
533	416+050	416+075	TYPE-III-A	25
534	416+075	416+100	TYPE-III-B	25
535	416+100	416+125	TYPE-III-B	14
536	416+125	416+150	TYPE-III-C	25
537	416+150	416+175	TYPE-III-A	16
538	416+175	416+200	TYPE-III-A	25
539	416+200	416+225	TYPE-I-A	25
540	416+225	416+250	TYPE-I-B	25
541	416+250	416+275	TYPE-II-B	25
542	416+275	416+300	TYPE-II	25
543	416+300	416+325	TYPE-II-B	25
544	416+325	416+350	TYPE-II-B	25
545	416+350	416+375	TYPE-II	25
546	416+375	416+400	TYPE-II	25
547	416+400	416+425	TYPE-II	25
548	416+425	416+450	TYPE-II-B	14
549	416+450	416+475	TYPE-II-B	25
550	416+475	416+500	TYPE-II-B	25
551	416+500	416+525	TYPE-II	25
552	416+525	416+550	TYPE-II	25
553	416+550	416+575	TYPE-II-B	25
554	416+575	416+600	TYPE-II	25
555	416+600	416+625	TYPE-II	25
556	416+625	416+650	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
557	416+650	416+675	TYPE-II	14
558	416+675	416+700	TYPE-II	25
559	416+700	416+725	TYPE-II	25
560	416+725	416+750	TYPE-II	25
561	416+750	416+775	TYPE-II	25
562	416+775	416+800	TYPE-II	25
563	416+800	416+825	TYPE-II	25
564	416+825	416+850	TYPE-II	25
565	416+850	416+875	TYPE-II	25
566	416+875	416+900	TYPE-II	25
567	416+900	416+925	TYPE-II	25
568	416+925	416+950	TYPE-II	25
569	416+950	416+975	TYPE-II	25
570	416+975	417+000	TYPE-II	25
571	417+000	417+025	TYPE-II	25
572	417+025	417+050	TYPE-II	16
573	417+050	417+075	TYPE-II	25
574	417+075	417+100	TYPE-II	16
575	417+100	417+125	TYPE-II	25
576	417+125	417+150	TYPE-II	25
577	417+150	417+175	TYPE-II	25
578	417+175	417+200	TYPE-II-B	25
579	417+200	417+225	TYPE-IV-A	25
580	417+225	417+250	TYPE-IV	25
581	417+250	417+275	TYPE-IV	25
582	417+350	417+375	TYPE-I-A	25
583	417+375	417+400	TYPE-I-A	25
584	417+400	417+425	TYPE-I-A	25
585	417+475	417+500	TYPE-I-D	25
586	417+500	417+525	TYPE-I-D	25
587	417+525	417+550	TYPE-I-D	25
588	417+550	417+575	TYPE-I-D	25
589	417+575	417+600	TYPE-I-D	25
590	418+250	418+275	TYPE-I-A	25
591	418+275	418+300	TYPE-I-A	25
592	418+300	418+325	TYPE-I-A	25
593	418+325	418+350	TYPE-I-B	16
594	418+350	418+375	TYPE-I-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
595	418+375	418+400	TYPE-I-A	25
596	418+400	418+425	TYPE-I-A	25
597	418+425	418+450	TYPE-I-A	25
598	418+650	418+675	TYPE-I-A	25
599	418+675	418+700	TYPE-I-A	25
600	418+700	418+725	TYPE-I-A	25
601	418+725	418+750	TYPE-I-A	25
602	418+750	418+775	TYPE-I-A	25
603	418+775	418+800	TYPE-I-A	25
604	418+800	418+825	TYPE-I-A	14
605	418+825	418+850	TYPE-I-A	25
606	418+850	418+875	TYPE-I-B	25
607	418+875	418+900	TYPE-I-B	25
608	418+900	418+925	TYPE-I-B	25
609	418+925	418+950	TYPE-I-A	25
610	418+950	418+975	TYPE-I-A	25
611	418+975	419+000	TYPE-I-A	25
612	419+000	419+025	TYPE-I-A	25
613	419+025	419+050	TYPE-I-C	25
614	419+050	419+075	TYPE-I-C	25
615	419+075	419+100	TYPE-II-A	25
616	419+100	419+125	TYPE-II-A	25
617	419+125	419+150	TYPE-I-A	25
618	419+150	419+175	TYPE-I-A	25
619	419+175	419+200	TYPE-I-A	25
620	419+200	419+225	TYPE-I-A	25
621	419+225	419+250	TYPE-I-A	16
622	419+250	419+275	TYPE-I-A	25
623	419+275	419+300	TYPE-I-B	25
624	419+300	419+325	TYPE-I-B	25
625	419+325	419+350	TYPE-I-B	25
626	419+350	419+375	TYPE-I-A	25
627	419+375	419+400	TYPE-I-A	14
628	419+400	419+425	TYPE-I-B	25
629	419+425	419+450	TYPE-I-B	25
630	419+450	419+475	TYPE-I-B	25
631	419+475	419+500	TYPE-I-A	25
632	419+500	419+525	TYPE-I-A	16

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
633	419+525	419+550	TYPE-I-B	25
634	419+550	419+575	TYPE-III-D	25
635	419+625	419+650	TYPE-II-B	25
636	419+650	419+675	TYPE-II	25
637	419+675	419+700	TYPE-II	25
638	419+700	419+725	TYPE-II	25
639	419+725	419+750	TYPE-II	16
640	419+750	419+775	TYPE-II-B	25
641	419+775	419+800	TYPE-II-B	25
642	419+800	419+825	TYPE-II	25
643	419+825	419+850	TYPE-II	25
644	419+850	419+875	TYPE-II	25
645	419+875	419+900	TYPE-II	25
646	419+900	419+925	TYPE-II	25
647	419+925	419+950	TYPE-II	25
648	419+950	419+975	TYPE-II	25
649	419+975	420+000	TYPE-II-B	25
650	420+000	420+025	TYPE-II-B	16
651	420+025	420+050	TYPE-II-B	25
652	420+050	420+075	TYPE-II	25
653	420+075	420+100	TYPE-II	25
654	420+100	420+125	TYPE-I-B	25
655	420+125	420+150	TYPE-I-C	12
656	420+150	420+175	TYPE-I-A	25
657	420+175	420+200	TYPE-I-B	25
658	420+200	420+225	TYPE-I-B	14
659	420+225	420+250	TYPE-I-A	25
660	420+250	420+275	TYPE-I-A	25
661	420+275	420+300	TYPE-I-A	25
662	420+300	420+325	TYPE-I-A	14
663	420+325	420+350	TYPE-I-A	25
664	420+350	420+375	TYPE-I-A	25
665	420+375	420+400	TYPE-I-B	25
666	420+400	420+425	TYPE-I-B	25
667	420+425	420+450	TYPE-I-B	25
668	420+450	420+475	TYPE-I-A	25
669	420+525	420+550	TYPE-I	25
670	420+550	420+575	TYPE-I-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
671	420+575	420+600	TYPE-I-B	25
672	420+600	420+625	TYPE-I-A	25
673	420+625	420+650	TYPE-I-A	25
674	420+650	420+675	TYPE-I-A	25
675	420+675	420+700	TYPE-I-A	25
676	420+700	420+725	TYPE-I-A	25
677	420+725	420+750	TYPE-I-A	14
678	420+750	420+775	TYPE-II	25
679	420+775	420+800	TYPE-II	25
680	420+800	420+825	TYPE-II	25
681	420+825	420+850	TYPE-II-A	25
682	420+850	420+875	TYPE-II-A	25
683	420+875	420+900	TYPE-I-A	25
684	420+900	420+925	TYPE-I-A	25
685	420+925	420+950	TYPE-I-A	25
686	420+950	420+975	TYPE-I-B	14
687	420+975	421+000	TYPE-I-B	25
688	421+000	421+025	TYPE-I-A	25
689	421+025	421+050	TYPE-I-A	25
690	421+050	421+075	TYPE-I	25
691	421+075	421+100	TYPE-I	16
692	421+100	421+125	TYPE-I-A	25
693	421+125	421+150	TYPE-I-A	25
694	421+150	421+175	TYPE-I	25
695	421+175	421+200	TYPE-I	25
696	421+200	421+225	TYPE-I-C	25
697	421+225	421+250	TYPE-I-D	25
698	421+250	421+275	TYPE-I-B	14
699	421+625	421+650	TYPE-I-C	25
700	421+650	421+675	TYPE-I-B	25
701	421+675	421+700	TYPE-I-B	16
702	421+700	421+725	TYPE-I-B	25
703	421+725	421+750	TYPE-I-B	25
704	421+750	421+775	TYPE-I-A	25
705	421+775	421+800	TYPE-I-A	14
706	421+800	421+825	TYPE-I-A	25
707	421+825	421+850	TYPE-I-A	25
708	421+850	421+875	TYPE-I-A	25



S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
709	421+875	421+900	TYPE-I-A	25
710	421+900	421+925	TYPE-I-A	25
711	421+925	421+950	TYPE-I-B	25
712	421+950	421+975	TYPE-I-A	25
713	421+975	422+000	TYPE-I-A	25
714	422+000	422+025	TYPE-I	14
715	422+450	422+475	TYPE-I-A	25
716	422+475	422+500	TYPE-I-A	25
717	422+500	422+525	TYPE-I-A	25
718	422+525	422+550	TYPE-I-A	25
719	422+550	422+575	TYPE-I-A	25
720	422+575	422+600	TYPE-I-A	14
721	422+600	422+625	TYPE-I-A	25
722	422+625	422+650	TYPE-I-A	25
723	422+650	422+675	TYPE-I-A	25
724	422+675	422+700	TYPE-I-A	25
725	422+700	422+725	TYPE-I-A	25
726	422+725	422+750	TYPE-I-A	25
727	422+750	422+775	TYPE-I-B	25
728	422+775	422+800	TYPE-I-A	25
729	422+800	422+825	TYPE-I-A	14
730	422+825	422+850	TYPE-I-A	16
731	422+850	422+875	TYPE-I-A	25
732	422+875	422+900	TYPE-I-A	25
733	422+900	422+925	TYPE-I-A	25
734	422+925	422+950	TYPE-I-A	25
735	422+950	422+975	TYPE-I-A	25
736	422+975	423+000	TYPE-I-A	25
737	423+000	423+025	TYPE-I-A	25
738	423+025	423+050	TYPE-I-A	25
739	423+050	423+075	TYPE-I-A	25
740	423+075	423+100	TYPE-I-A	16
741	423+100	423+125	TYPE-I-A	25
742	423+125	423+150	TYPE-I-A	25
743	423+150	423+175	TYPE-I-A	16
744	423+175	423+200	TYPE-I-A	25
745	423+200	423+225	TYPE-I-A	25
746	423+225	423+250	TYPE-I-A	25

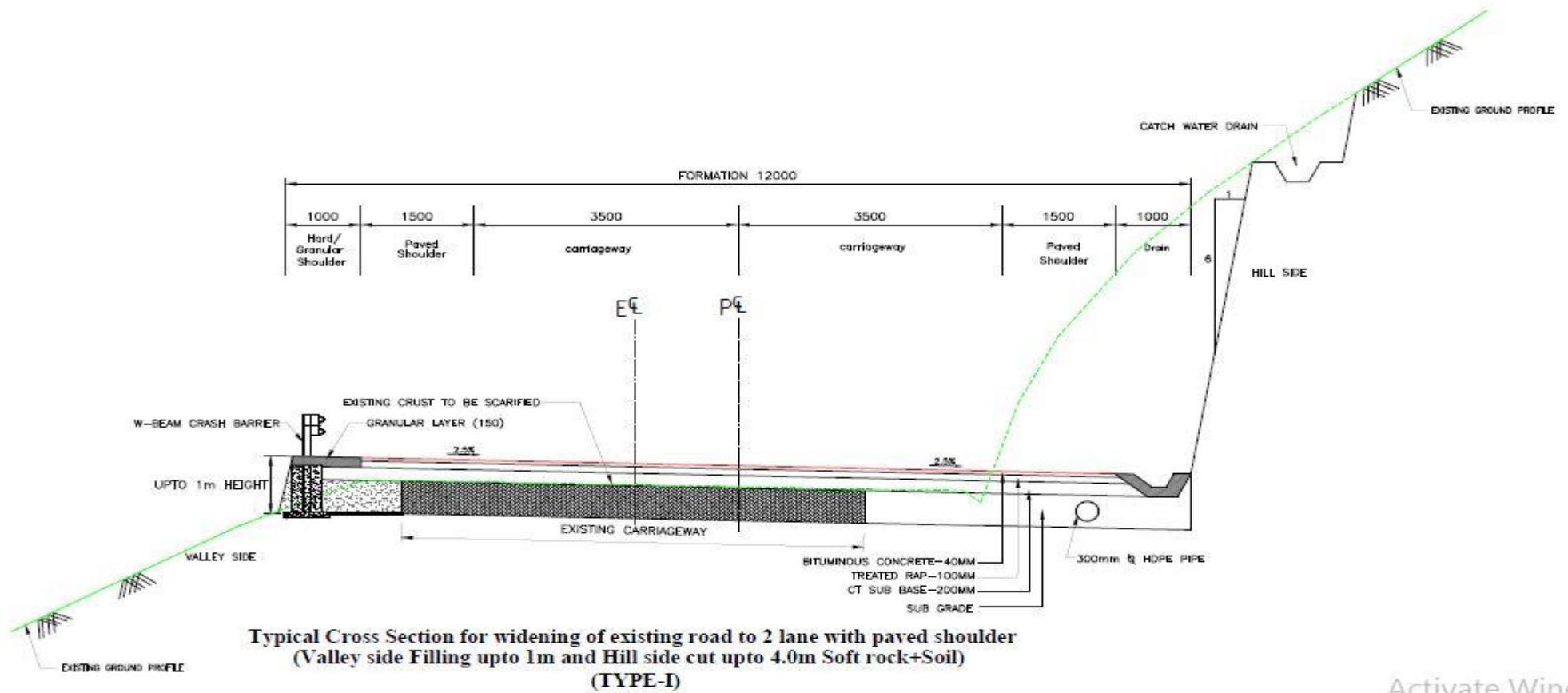
S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
747	423+250	423+275	TYPE-I-A	16
748	423+275	423+300	TYPE-II	25
749	423+300	423+325	TYPE-II	25
750	423+325	423+350	TYPE-II	25
751	423+350	423+375	TYPE-II	25
752	423+375	423+400	TYPE-II	14
753	423+400	423+425	TYPE-II	25
754	423+425	423+450	TYPE-II	25
755	423+450	423+475	TYPE-II	25
756	423+475	423+500	TYPE-II	25
757	423+500	423+525	TYPE-I-A	25
758	423+525	423+550	TYPE-I-A	25
759	423+550	423+575	TYPE-I-A	16
760	423+575	423+600	TYPE-I-B	25
761	423+600	423+625	TYPE-I-B	25
762	423+625	423+650	TYPE-I-A	25
763	423+650	423+675	TYPE-I-A	25
764	423+675	423+700	TYPE-I-A	14
765	423+700	423+725	TYPE-I-A	25
766	423+725	423+750	TYPE-I-A	25
767	423+750	423+775	TYPE-I-C	25
768	423+775	423+800	TYPE-I-D	25
769	423+800	423+825	TYPE-I-D	25
770	423+825	423+850	TYPE-I-B	25
771	423+850	423+875	TYPE-I-C	25
772	423+875	423+900	TYPE-I-C	14
773	423+900	423+925	TYPE-I-C	25
774	423+925	423+950	TYPE-I-C	14
775	423+950	423+975	TYPE-I-C	25
776	423+975	424+000	TYPE-I-C	25
777	424+000	424+025	TYPE-I	25
778	424+025	424+050	TYPE-I	25
779	424+050	424+075	TYPE-I-C	25
780	424+075	424+100	TYPE-I-C	16
781	424+100	424+125	TYPE-I-C	25
782	424+125	424+150	TYPE-I	25
783	424+150	424+175	TYPE-I-A	25
784	424+175	424+200	TYPE-I-A	14

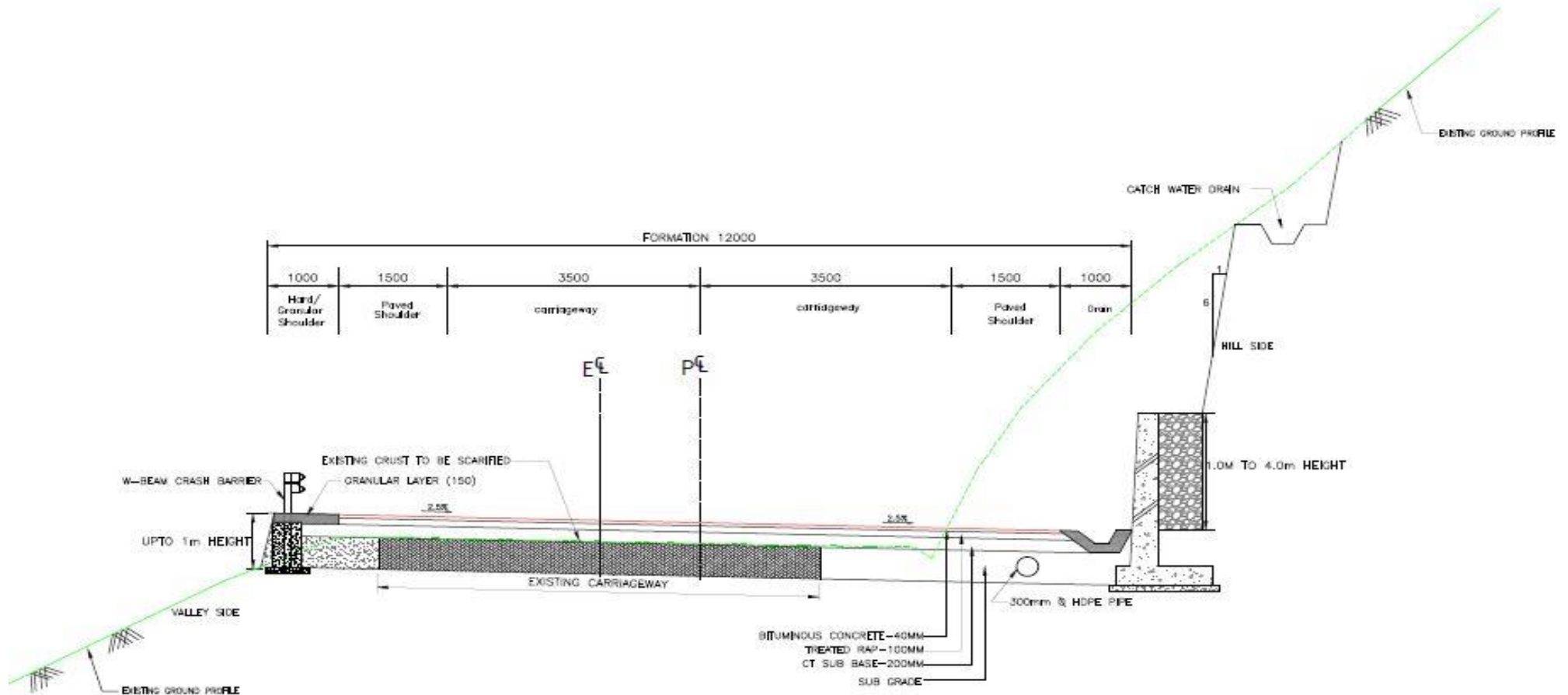
S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
785	424+200	424+225	TYPE-I-A	25
786	424+225	424+250	TYPE-I-A	25
787	424+250	424+275	TYPE-I	25
788	424+275	424+300	TYPE-I-C	14
789	424+300	424+325	TYPE-I-C	25
790	424+325	424+350	TYPE-I-C	25
791	424+350	424+375	TYPE-I-C	25
792	424+375	424+400	TYPE-I-C	12
793	424+400	424+425	TYPE-I-C	25
794	424+425	424+450	TYPE-I-C	25
795	424+450	424+475	TYPE-II-B	25
796	424+475	424+500	TYPE-II-B	25
797	424+500	424+525	TYPE-II-B	25
798	424+525	424+550	TYPE-II	25
799	424+550	424+575	TYPE-II	25
800	424+575	424+600	TYPE-I-B	12
801	424+600	424+625	TYPE-I-B	25
802	424+625	424+650	TYPE-I-A	25
803	424+650	424+675	TYPE-I-A	25
804	424+675	424+700	TYPE-I-B	25
805	424+700	424+725	TYPE-I-B	14
806	424+725	424+750	TYPE-I-B	25
807	424+750	424+775	TYPE-I-B	25
808	424+775	424+800	TYPE-I-A	25
809	424+800	424+825	TYPE-I-A	25
810	424+825	424+850	TYPE-I-A	25
811	424+850	424+875	TYPE-I-A	25
812	424+875	424+900	TYPE-I-A	14
813	424+900	424+925	TYPE-I	25
814	424+925	424+950	TYPE-I	25
815	424+950	424+975	TYPE-I-C	25
816	424+975	425+000	TYPE-I	25
817	425+000	425+025	TYPE-I	25
818	425+025	425+050	TYPE-I	25
819	425+050	425+075	TYPE-I-C	25
820	425+075	425+100	TYPE-I-C	25
821	425+100	425+125	TYPE-I-C	25
822	425+200	425+225	TYPE-III-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
823	425+225	425+250	TYPE-I	25
824	425+250	425+275	TYPE-I-C	16
825	425+275	425+300	TYPE-I-C	25
826	425+300	425+325	TYPE-I	25
827	425+325	425+350	TYPE-I-C	25
828	425+350	425+375	TYPE-I-C	25
829	425+375	425+400	TYPE-I	25
830	425+400	425+425	TYPE-I-C	14
831	425+425	425+450	TYPE-I-C	25
832	425+450	425+475	TYPE-I-C	25
833	425+475	425+500	TYPE-I-C	25
834	425+500	425+525	TYPE-I-C	25
835	425+525	425+550	TYPE-I-C	25
836	425+550	425+575	TYPE-I-B	25
837	425+625	425+650	TYPE-II-B	25
838	425+650	425+675	TYPE-II-B	25
839	425+675	425+700	TYPE-II-B	25
840	425+700	425+725	TYPE-II-B	25
841	425+725	425+750	TYPE-II-B	25
842	425+750	425+775	TYPE-II-C	25
843	425+775	425+800	TYPE-II-C	25
844	425+800	425+825	TYPE-II-C	25
845	425+825	425+850	TYPE-II-B	25
846	425+850	425+875	TYPE-II-B	25
847	425+875	425+900	TYPE-II-B	25
848	425+900	425+925	TYPE-II-B	25
849	425+925	425+950	TYPE-II	25
850	425+950	425+975	TYPE-II	25
851	425+975	426+000	TYPE-II	25
852	426+000	426+025	TYPE-IV-A	25
853	426+025	426+050	TYPE-IV-A	12
854	426+050	426+075	TYPE-III-B	25
855	426+075	426+100	TYPE-I-C	25
856	426+100	426+125	TYPE-I-C	25
857	426+125	426+150	TYPE-I	25
858	426+150	426+175	TYPE-I	25
859	426+175	426+200	TYPE-I	25
860	426+200	426+225	TYPE-I-C	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
861	426+225	426+250	TYPE-I-C	14
862	426+250	426+275	TYPE-I-C	25
863	426+275	426+300	TYPE-I-C	25
864	426+300	426+325	TYPE-II-B	25
865	426+325	426+350	TYPE-II	25
866	426+350	426+375	TYPE-I-A	25
867	426+375	426+400	TYPE-I-A	25
868	426+400	426+425	TYPE-I-A	25
869	426+425	426+450	TYPE-I-A	25
870	426+450	426+475	TYPE-I-A	14
871	426+475	426+500	TYPE-I-A	25
872	426+500	426+525	TYPE-I-A	25
873	426+525	426+550	TYPE-II-B	25
874	426+550	426+575	TYPE-II	25
875	426+575	426+600	TYPE-I-A	25
876	426+600	426+625	TYPE-I-A	14
877	426+625	426+650	TYPE-I-A	25
878	426+650	426+675	TYPE-I-A	25
879	426+675	426+700	TYPE-I-B	25
880	426+700	426+725	TYPE-I-B	25
881	426+725	426+750	TYPE-I-B	16
882	426+750	426+775	TYPE-I-A	25
883	426+775	426+800	TYPE-I-A	16
884	426+800	426+825	TYPE-I-A	25
885	426+825	426+850	TYPE-I-B	25
886	426+850	426+875	TYPE-I-B	25
887	426+875	426+900	TYPE-I-A	14
888	426+900	426+925	TYPE-I-B	25
889	426+925	426+950	TYPE-I-B	25
890	426+950	426+975	TYPE-I-B	25
891	426+975	427+000	TYPE-I-B	25
892	427+000	427+025	TYPE-I-B	16
893	427+025	427+050	TYPE-I-A	25
894	427+050	427+075	TYPE-I-A	25
895	427+075	427+100	TYPE-I-A	25
896	427+100	427+125	TYPE-I-B	25
897	427+125	427+150	TYPE-I-B	25
898	427+150	427+175	TYPE-I-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
899	427+175	427+200	TYPE-III-C	25
900	427+250	427+275	TYPE-II-B	25
901	427+275	427+300	TYPE-II	25
902	427+300	427+325	TYPE-II	25
903	427+325	427+350	TYPE-II	25
904	427+350	427+375	TYPE-II	25
905	427+375	427+400	TYPE-II-B	25
906	427+400	427+425	TYPE-II-B	25
907	427+425	427+450	TYPE-II-B	25
908	427+450	427+475	TYPE-II-B	25
909	427+475	427+500	TYPE-II-B	14
910	427+500	427+525	TYPE-II-B	25
911	427+525	427+550	TYPE-II-B	25
912	427+550	427+575	TYPE-II	25
913	427+575	427+600	TYPE-II	25
914	427+600	427+625	TYPE-II	25
915	427+625	427+650	TYPE-II	25

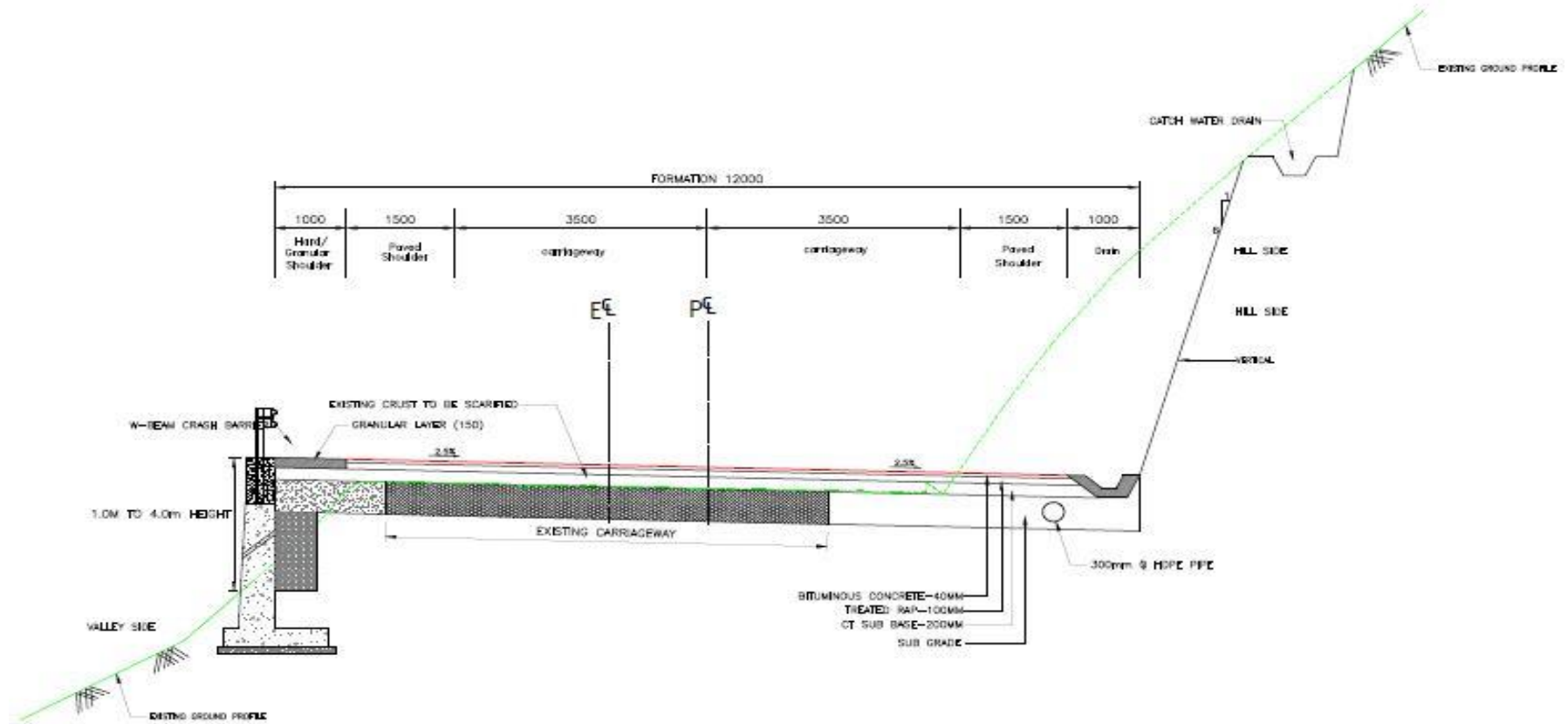




Typical Cross Section for widening of existing road to 2 lane with paved shoulder  
 (Valley side Filling upto 1m and Hill side upto 4.0m Protection Soft rock+Soil)  
 (TYPE-I-A)

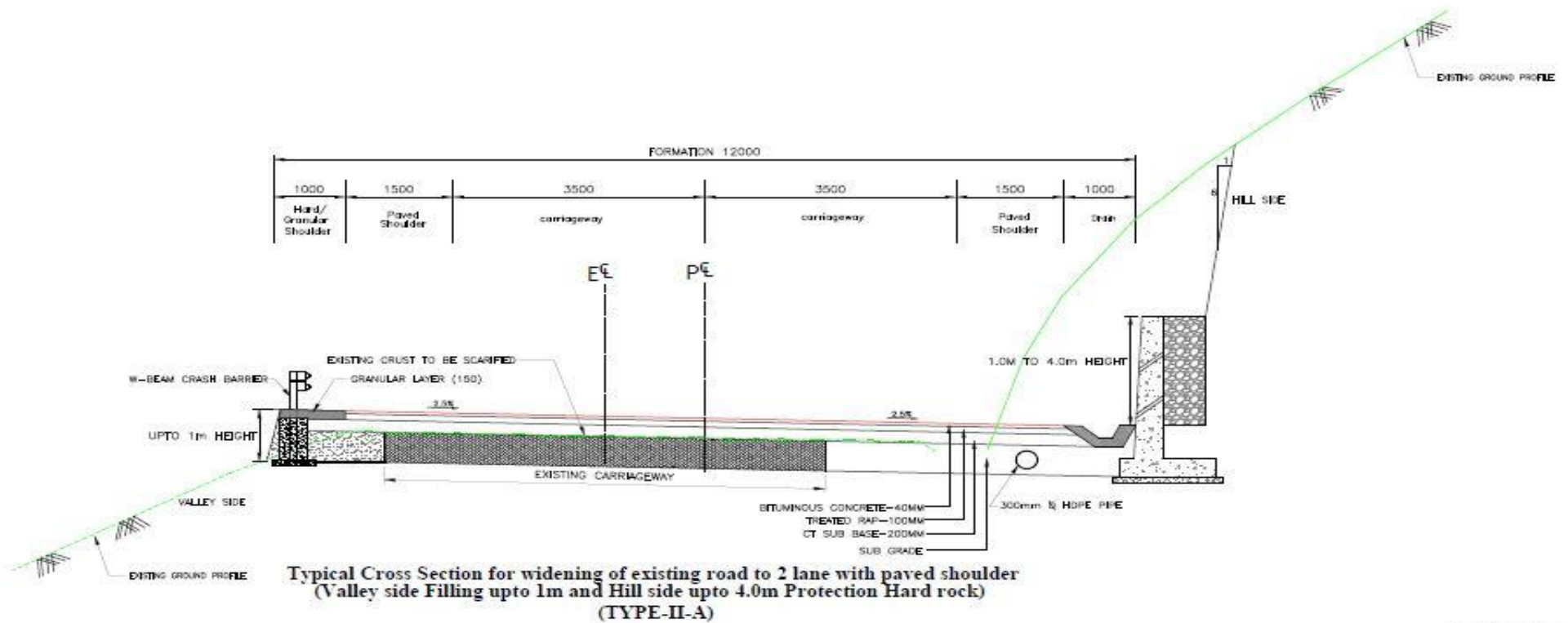


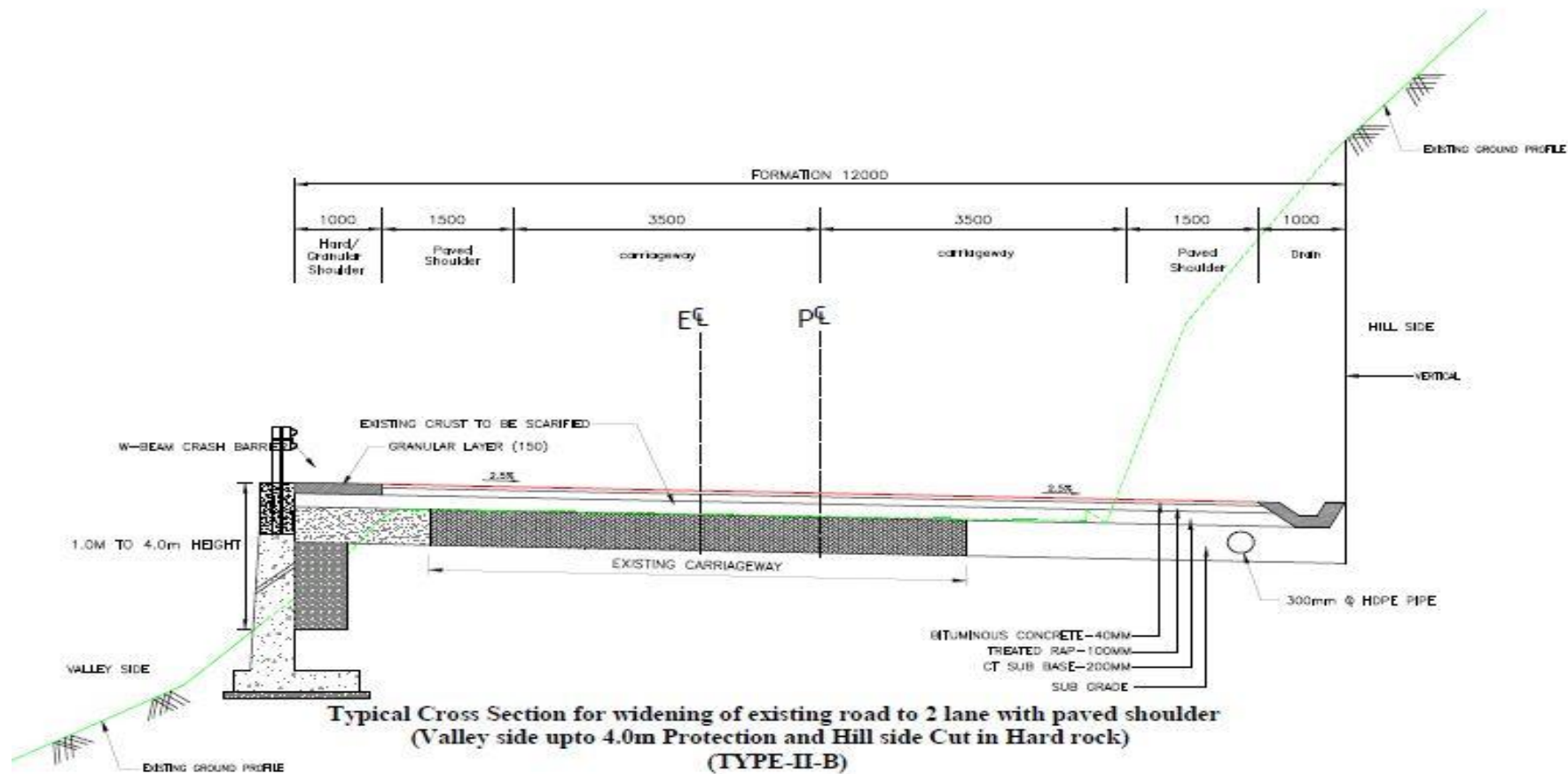


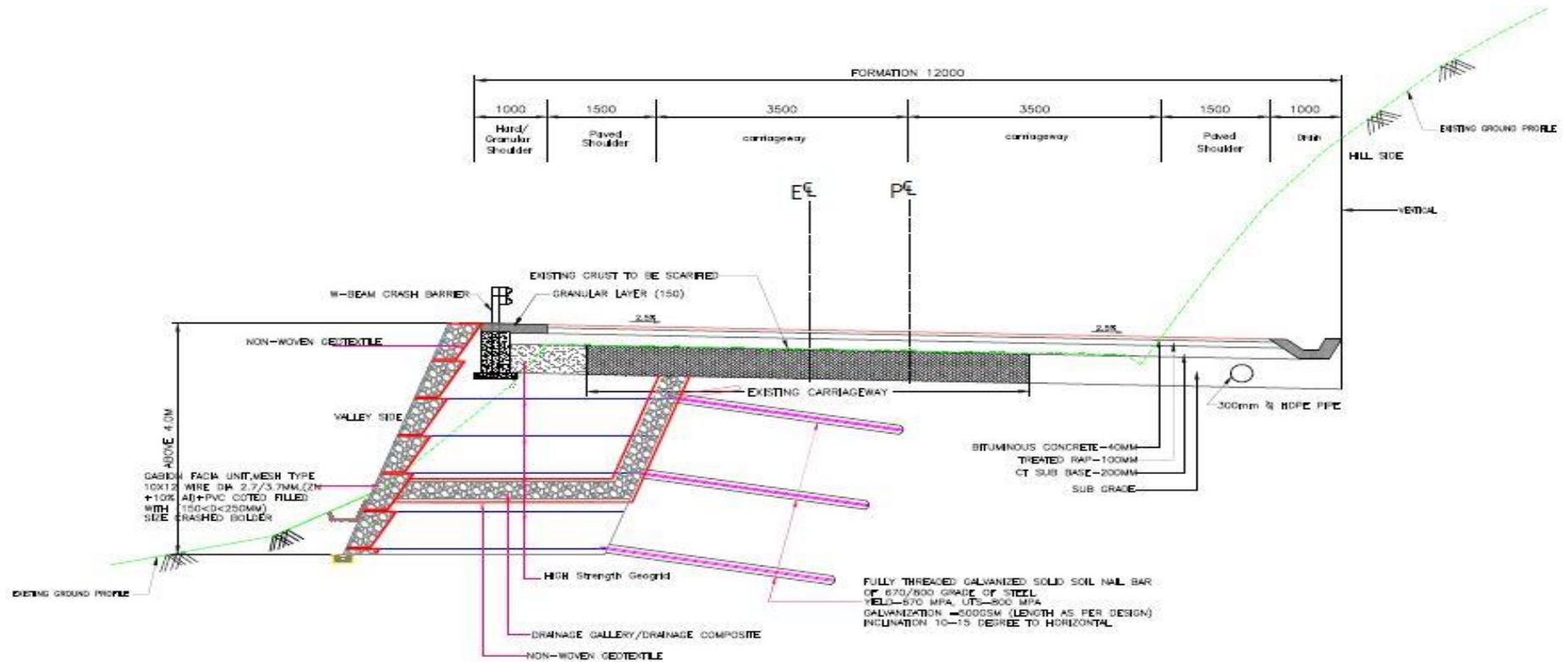


Typical Cross Section for widening of existing road to 2 lane with paved shoulder  
 (Valley side Filling upto 4m Protection Soft rock+Soil)  
 (TYPE-I-C)

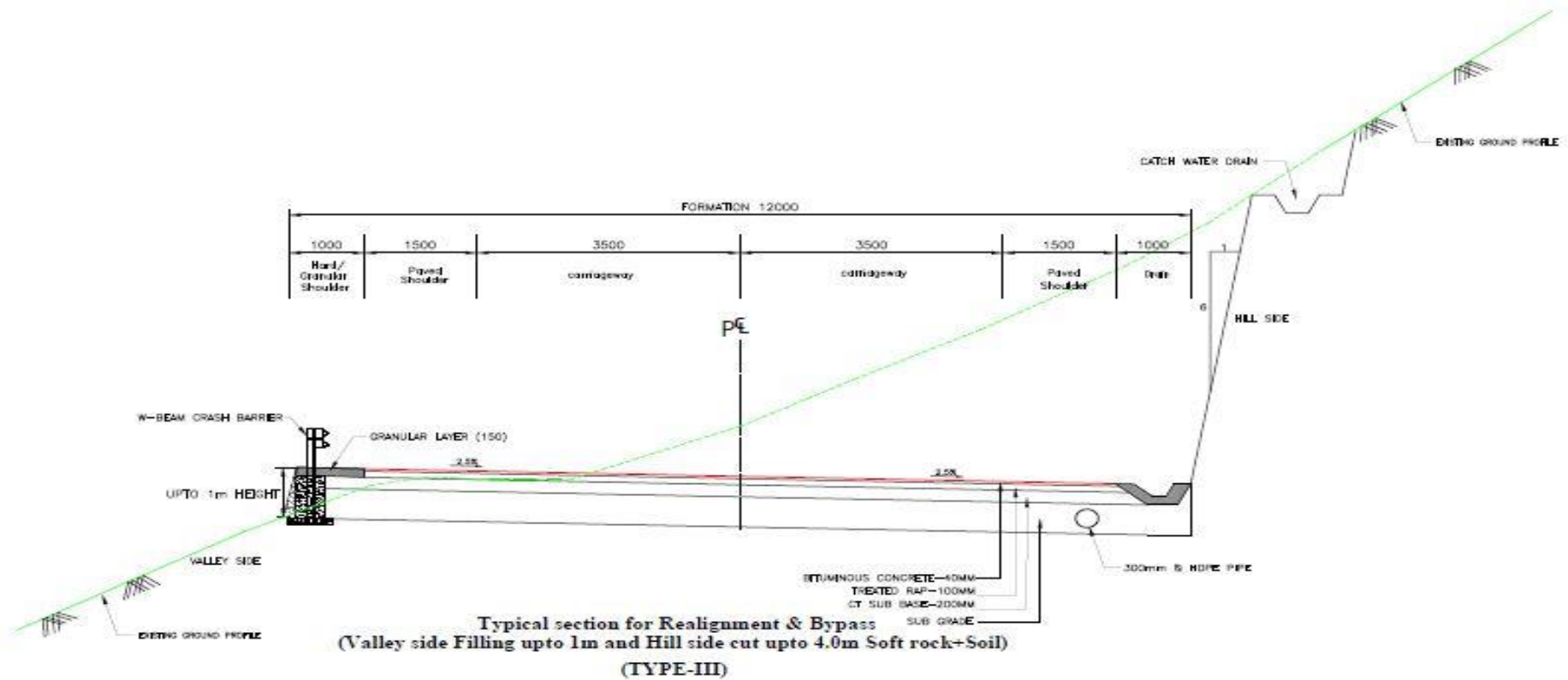




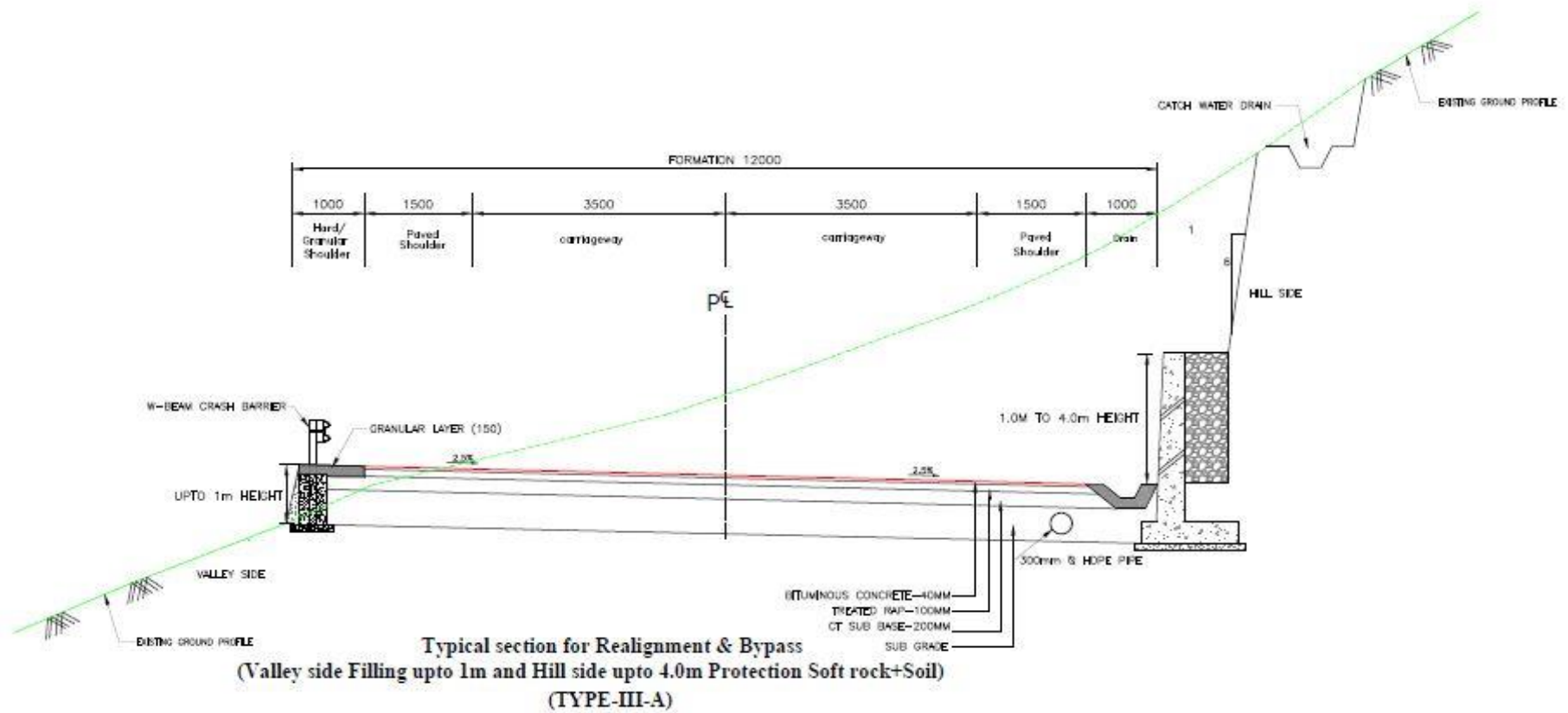




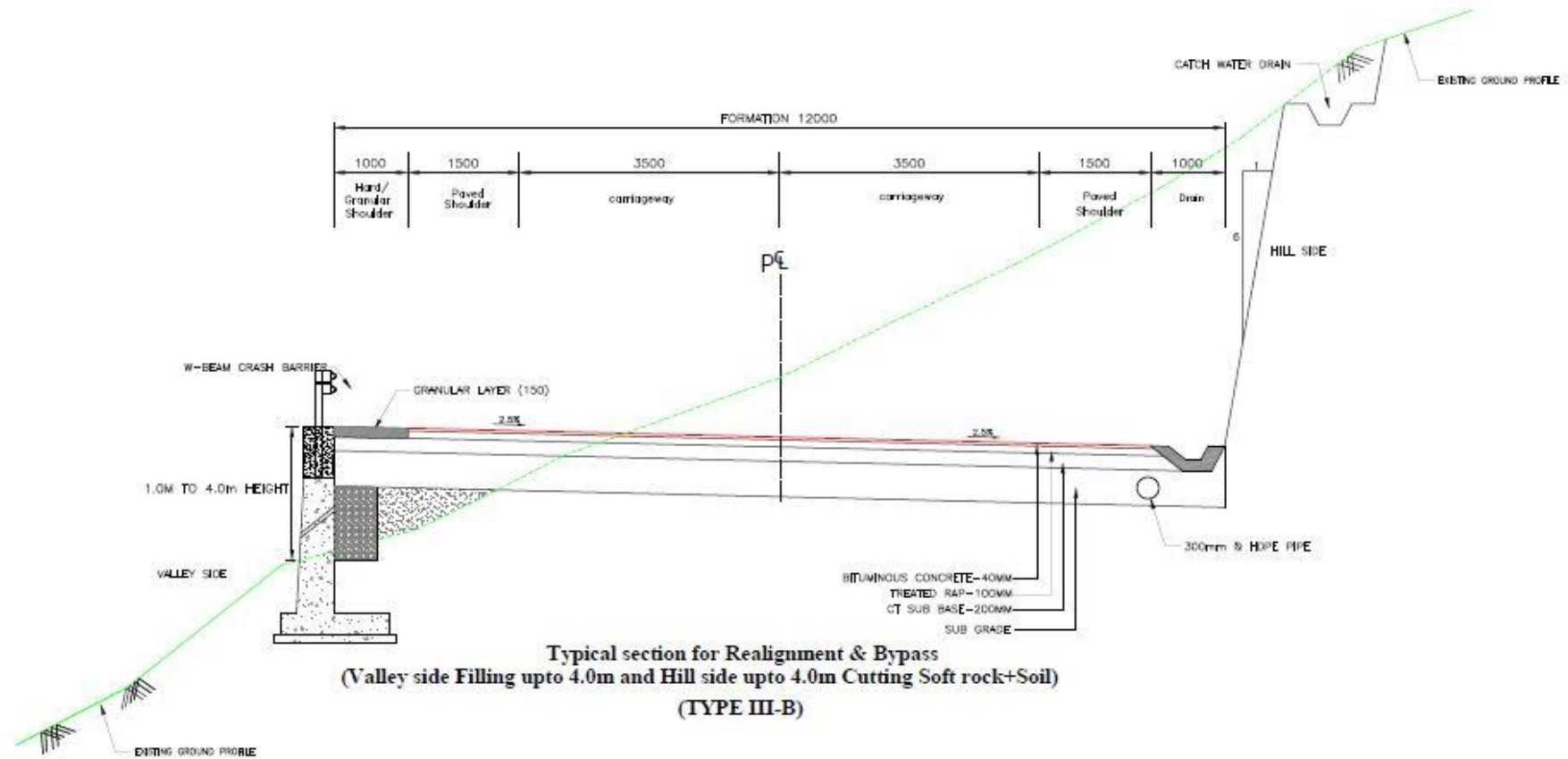
Typical Cross Section for widening of existing road to 2 lane with paved shoulder  
 (Valley side Filling >4.0m Protection in Hard rock)  
 (TYPE-II-C)

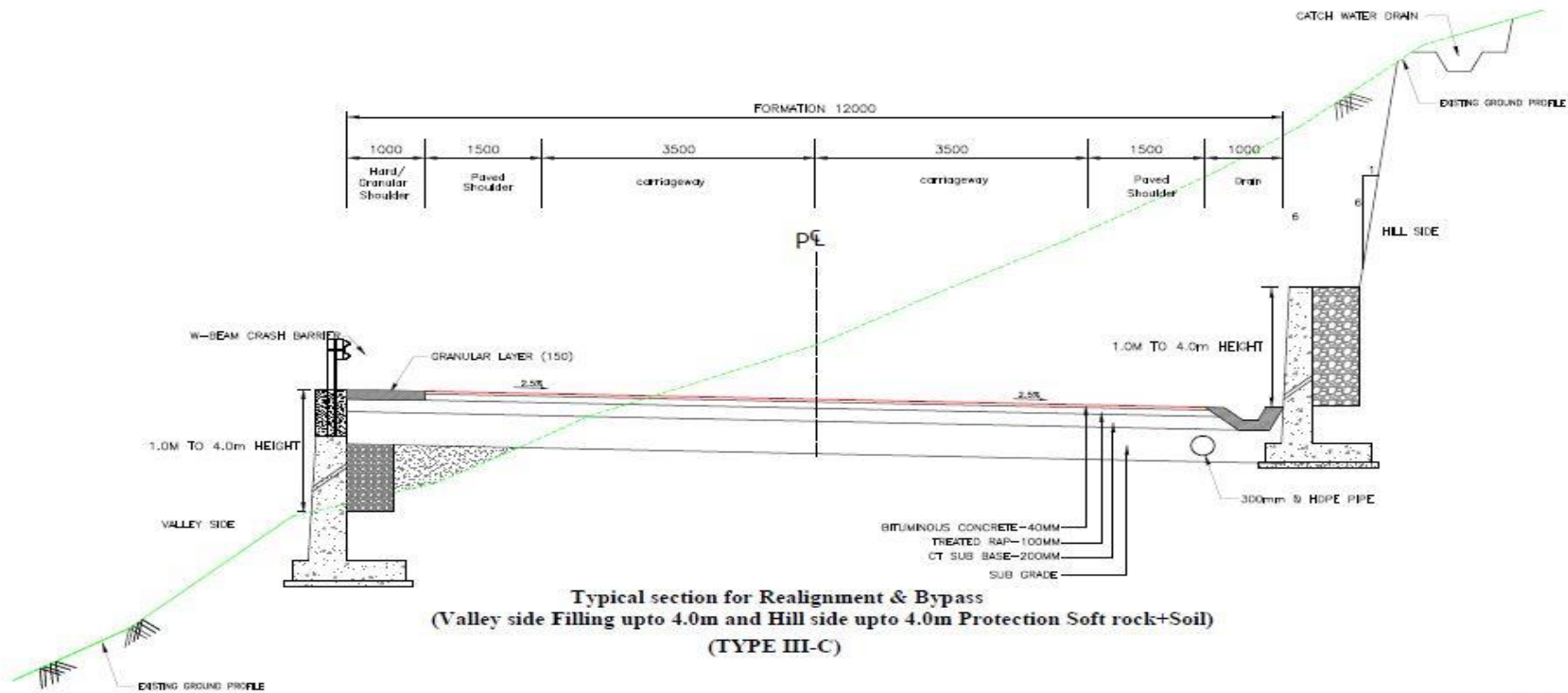


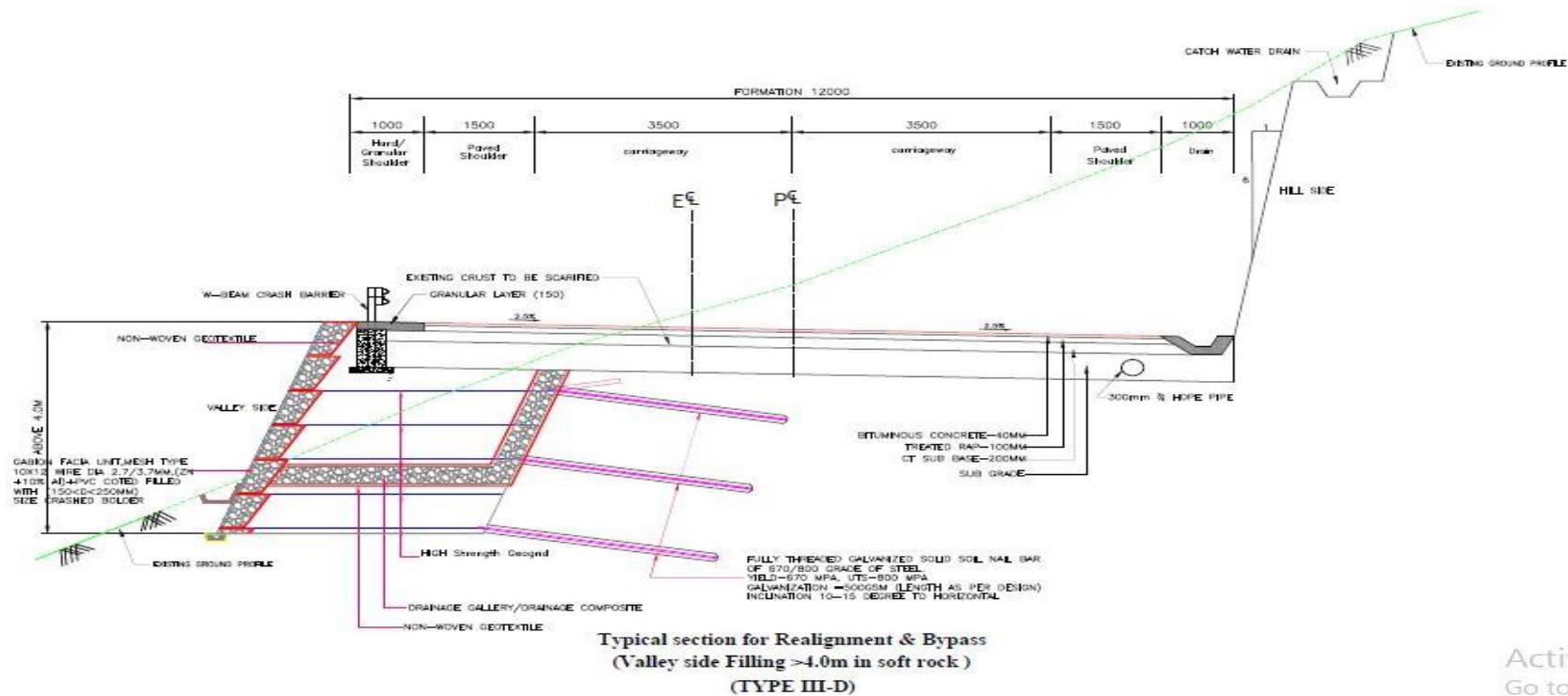


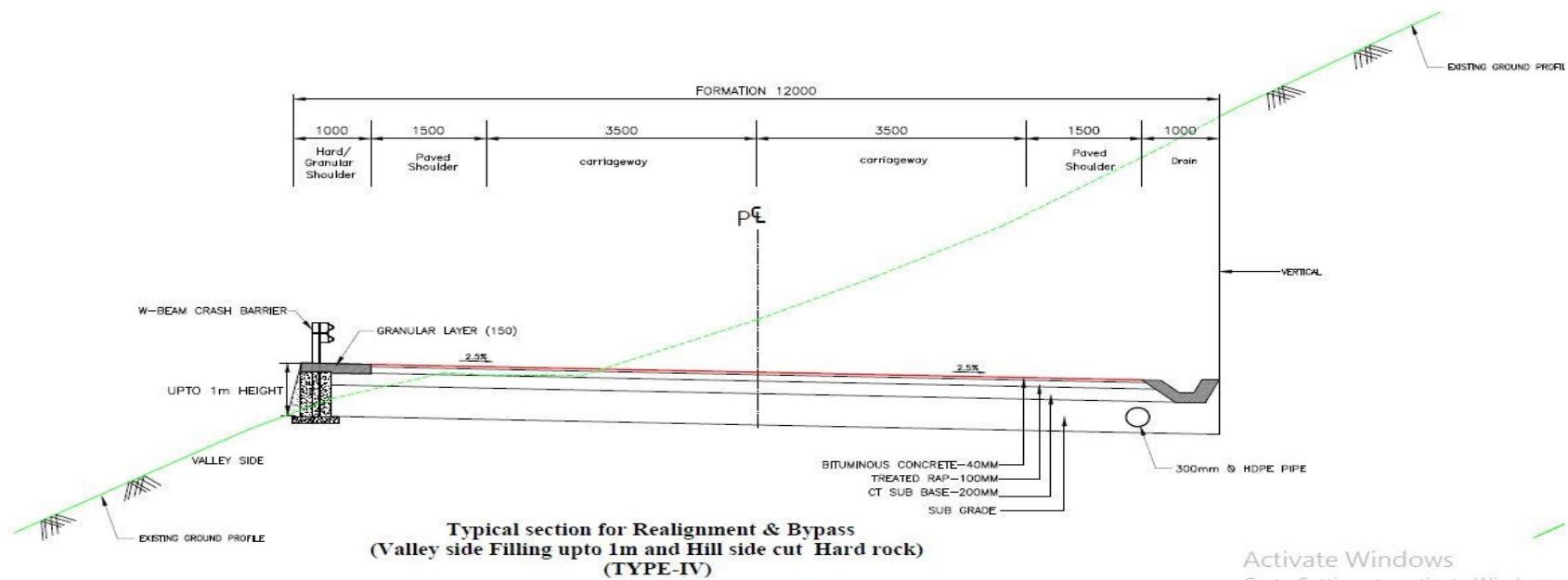


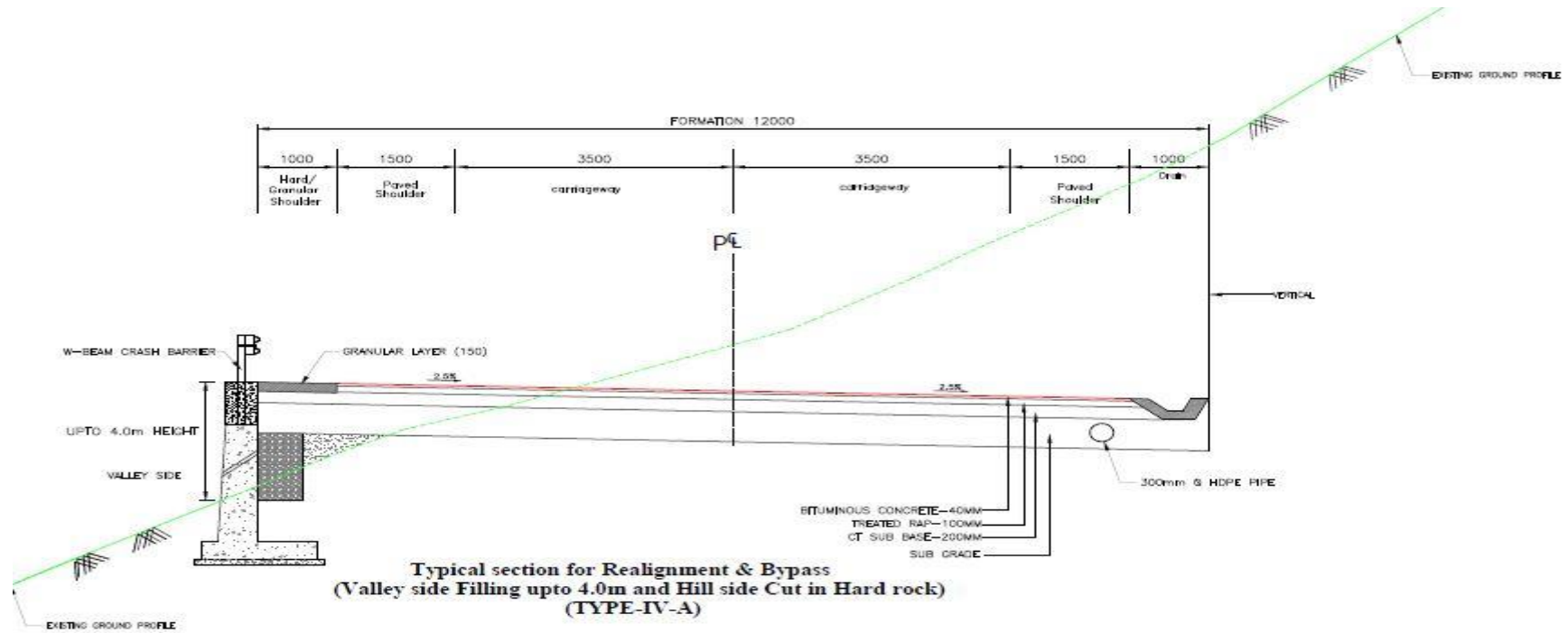


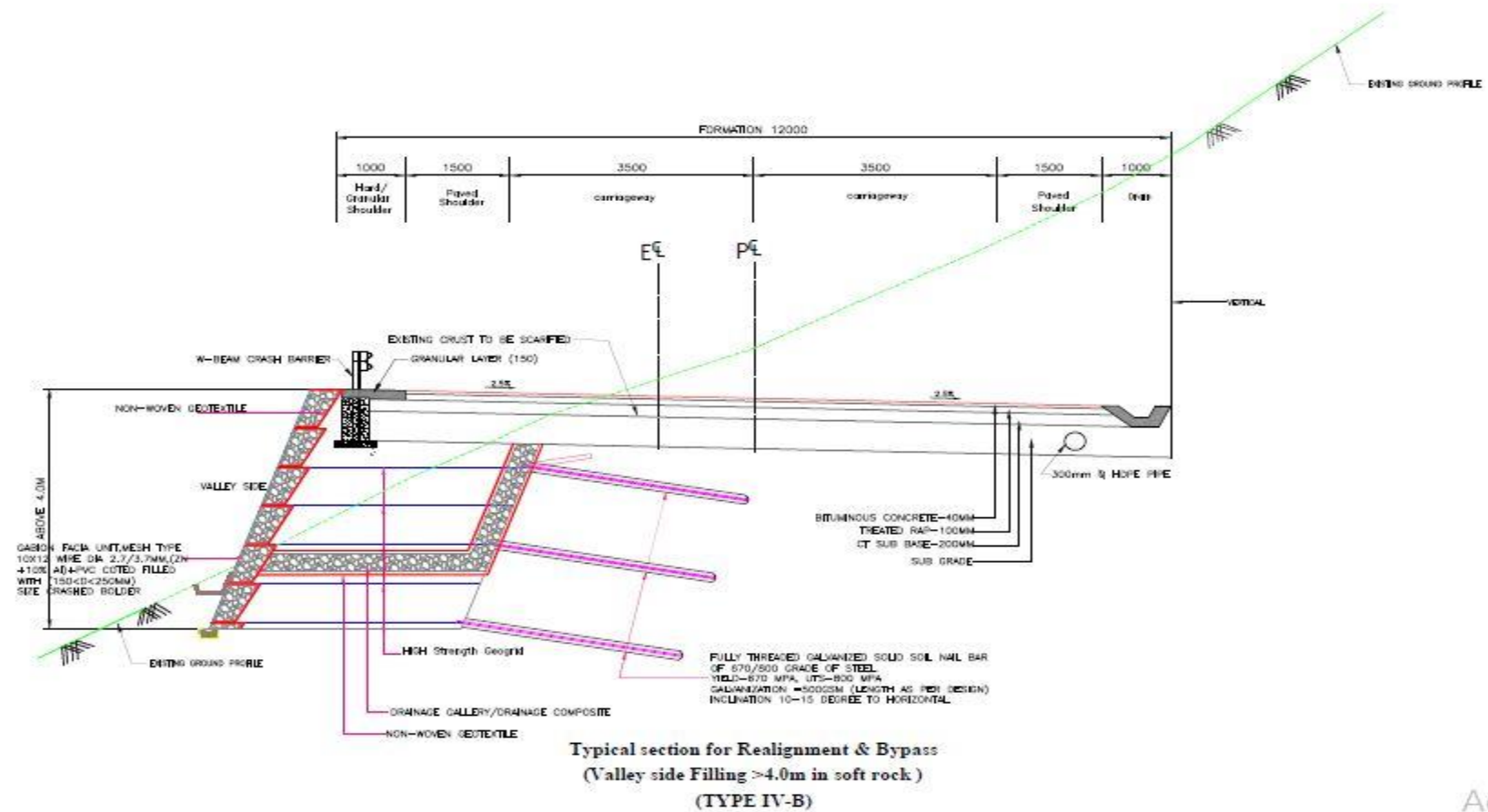


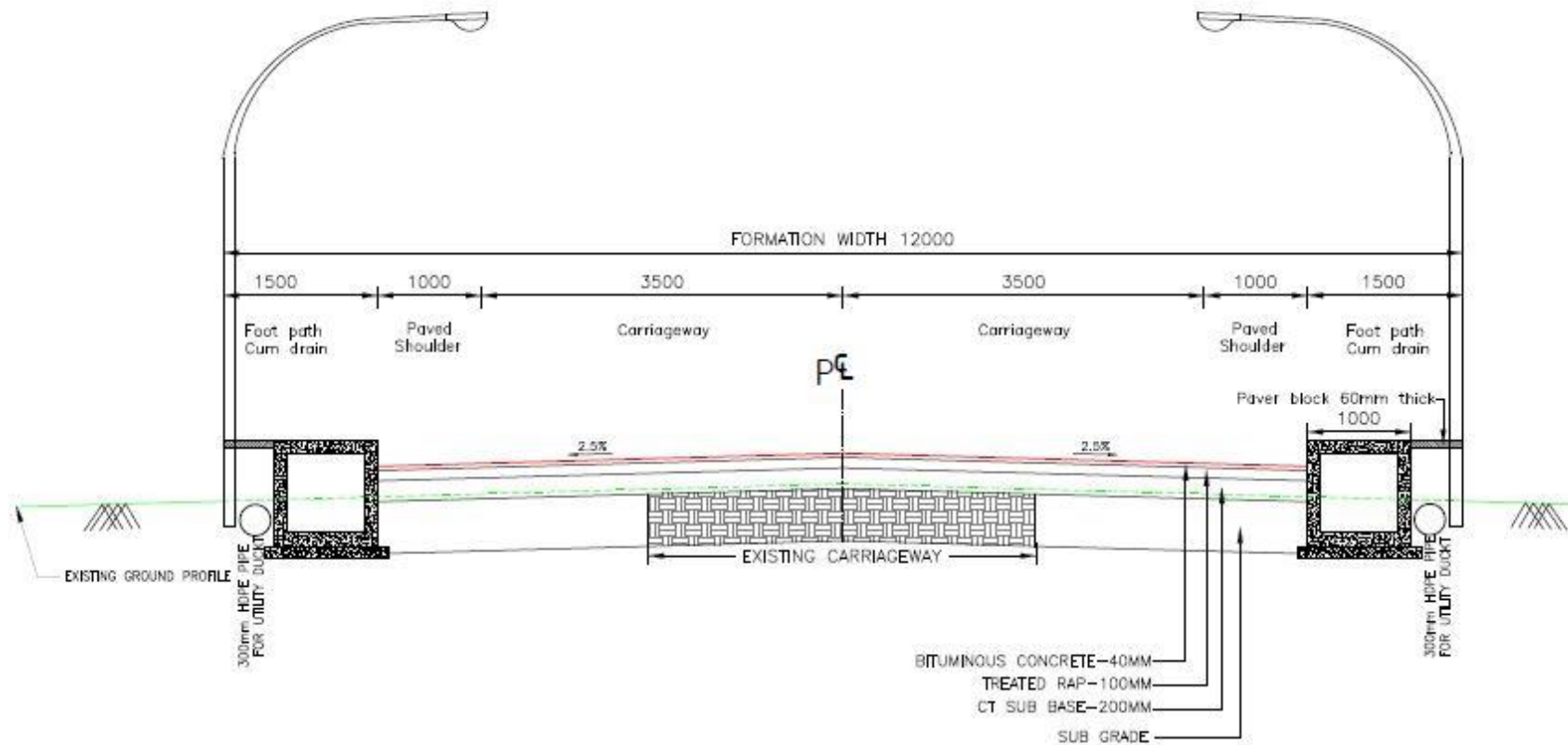






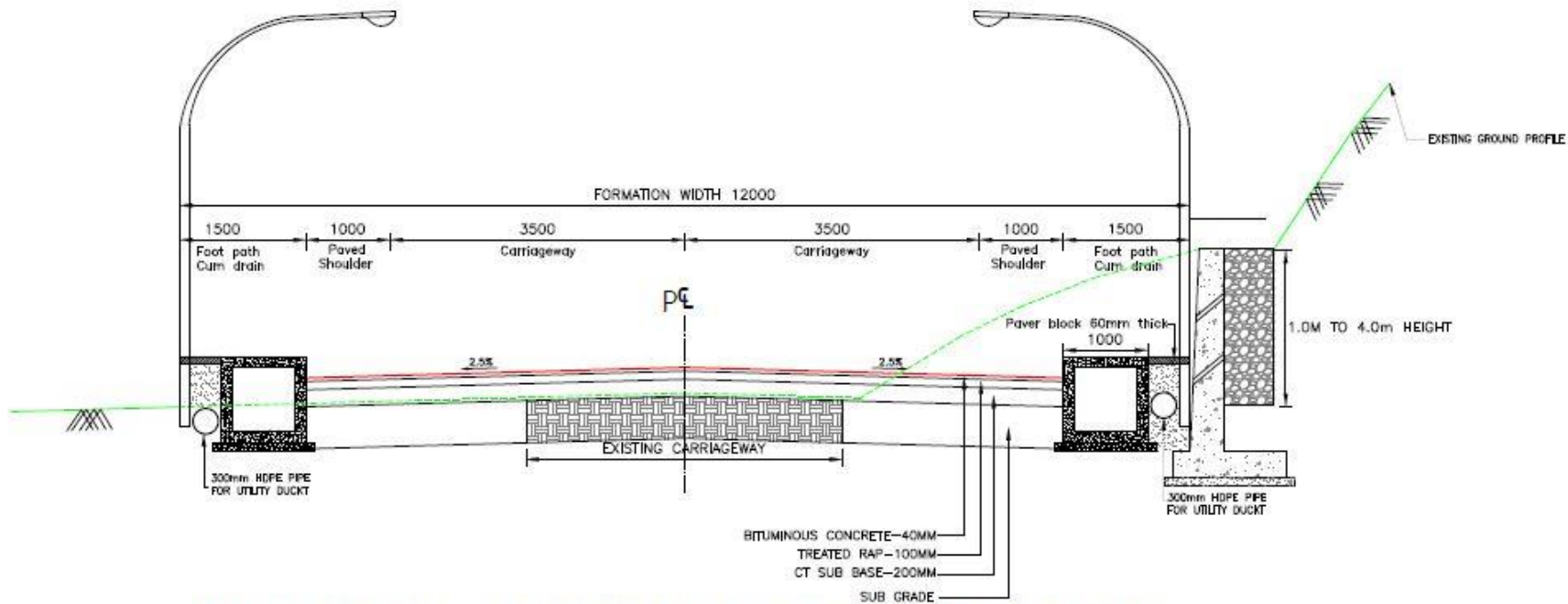






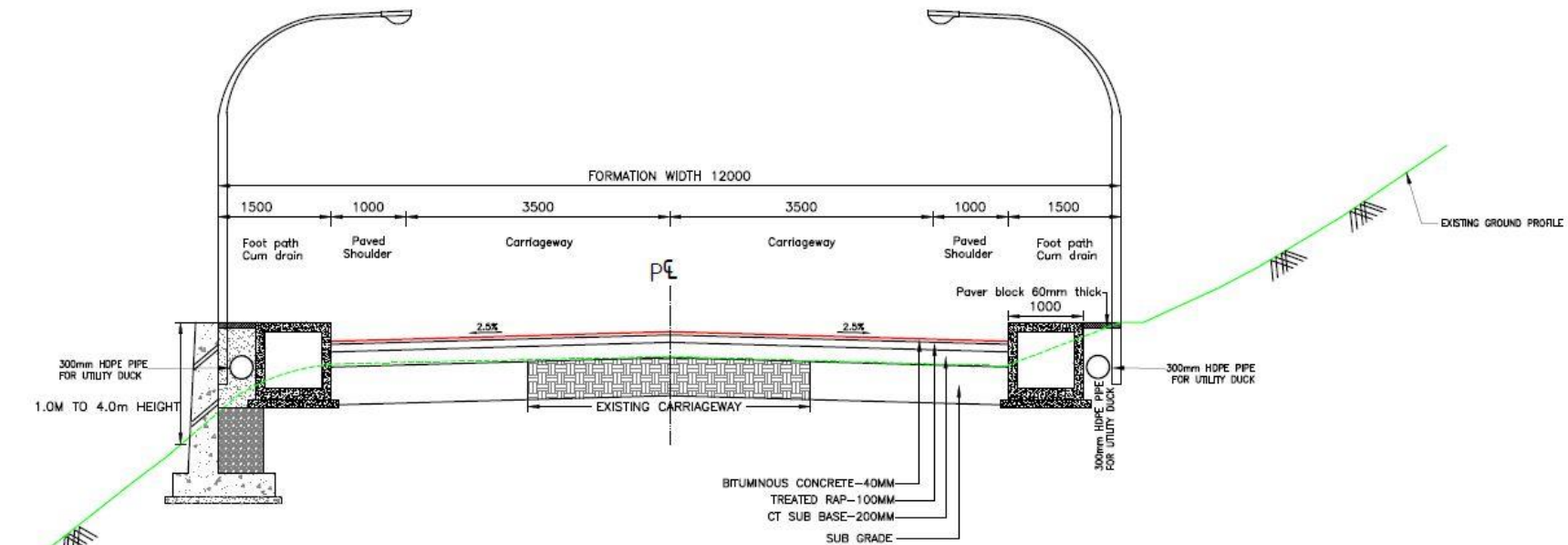
Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(12.0m formation width)  
(TYPE-V)





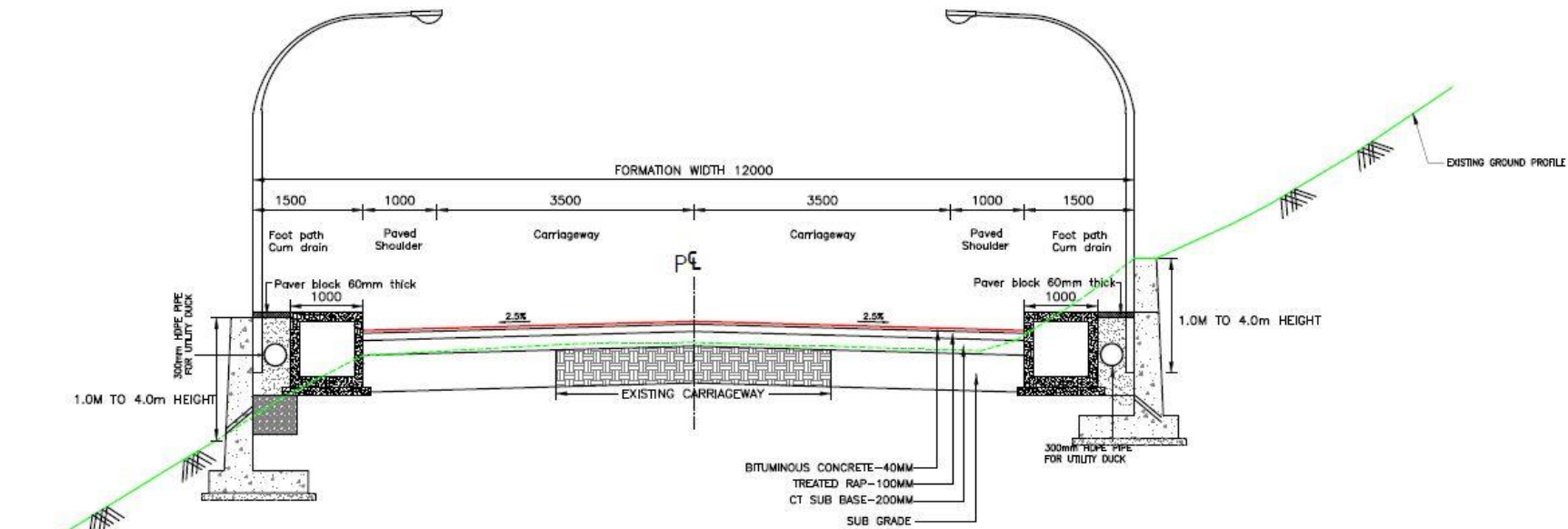
Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(Hill side Upto 4 m Protection ) (12.0m formation width)  
(TYPE-V-A)





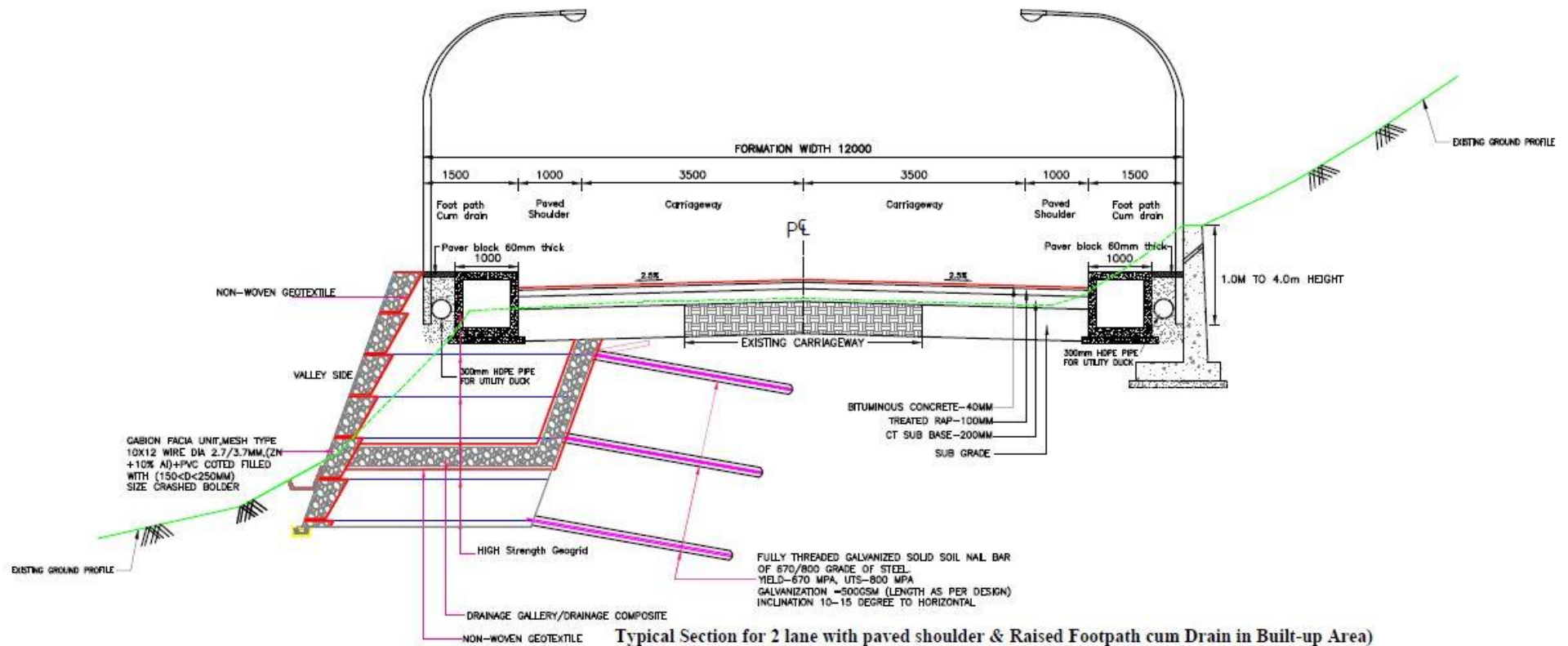
Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(Valley side Upto 4 m Protection and hill side no Protection ) (12.0m formation width)  
(TYPE-V-B)

Activate Windows  
Go to Settings to activate Wind



Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(Both side protection Upto 4.0 m ) (12.0m formation width)  
(TYPE-V-C)

Activate Windows



Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(Valley side Protection >4.0m) (12.0m formation width)  
(TYPE-V-D)

Activate Windows  
Go to Settings to activate Win

## 7.2.5 Pavement Design

### A. Methodology of Design

The pavement has been designed using the Indian Road Congress “IRC: 37-2012 “Guidelines for the Design of Flexible Pavements”. As this method has been developed in India to suit local conditions and the traffic composition, it is considered to be the most appropriate.

### B. Construction and Maintenance Standards

The pavements will be constructed using the latest revision of the Ministry of Road Transport & Highways (MORTH) Specifications for Road and Bridge Works where appropriate.

### C. Design Traffic

In accordance with IRC: 37-2012, the design traffic loadings have been calculated in the terms of cumulative number of standard axles using the following formulae:

$$N_s = \sum_{i=1}^{DL} \times \sum_{i=1}^n \times \frac{365 \times ADT_i \times [(1 + r_i)^{DL} - 1] \times D \times F}{r}$$

where:

$N_s$	Is the cumulative number of standard axles to be catered for in the design in terms of MSA.
$ADT_i$	Is the average daily traffic for vehicle category “i” in the initial year
$r_i$	Is the growth rate for the vehicle category “i”
$DL$	Is the Design Life in years
$D$	Is the Lane Distribution Factor
$F$	Is the Vehicle Damage Factor

### D. Average Annual Daily Traffic

The average annual daily traffic based on the traffic volume counts of the classified traffic volume are shown in **Table 7.7** below:

**Table 7.7: Average Annual Daily Traffic (AADT)**

Commercial Vehicle Category	NH-58 (Rudraprayag-Mana) Km 368.00 to Km 528.00
Bus	108
Light Commercial Vehicle (LCV)	114
Two , Three Axle Truck (2AT) & MAV	215
<b>Total Commercial Vehicle</b>	<b>437</b>

### E. Growth Rates for Traffic

The percentage growth factors for each type of traffic derived from the traffic analysis are given in the Table below:

### Projected Traffic Growth Rates 2014 to 2044

Vehicle Type	2014-2019	2019-2024	2024-2029	2029-2044
Car, Jeep, Vans etc.	6.94	7.63	8.39	8.39
Motor cycle & Scooters	7.98	8.78	9.66	9.66
LCV	5.96	6.56	7.22	7.22
Buses	5.30	5.83	6.41	6.41
2-Axle, Multi Axle Truck	5.96	6.56	7.22	7.22
Non-Motorised Vehicles	2.00	2.00	1.00	1.00

#### F. Lane Distribution and Directional Distribution Factor

The values adopted for these factors are those that are suggested by IRC: 37-2012. The values used are given below:

- A directional distribution factor of 0.75 has been adopted.

#### G. Vehicle Damage Factor

The current traffic of the project does not represent the actual traffic scenario. However, axle load survey has been performed for assessing traffic load pattern. The summary of vehicle damage factor (VDF) analysed after axle load survey is presented in **Table 7.8** below:

**Table 7.8:** The summary of vehicle damage factor (VDF)

S.No	Type of Vehicle	VDF
1	Light commercial vehicle (LCV)	0.30
2	Standard two axle truck (2 Axle truck)	1.32
3	Three axle truck (3 Axle truck)	2.14
4	Standard Bus	0.92

Value for Vehicle damage factor (VDF) for design requirement is considered is 2.5 on higher side.

#### H. Calculation of Design Traffic Loadings

The above formula and assumptions were used to calculate the design traffic loadings for the following sections of the project corridor where the traffic loadings are uniform. The construction period of 2 financial years (2015-2016 & 2016-2017) is considered for design purpose.

**Table 7.9: Design Traffic Loadings**

Year	Design Million Standard Axles (MSA)
2017	0.37
2019	1.10
2024	2.95
2029	4.79
2034	6.63
2039	8.47
2044	10.31

The Parameter considered for design of new pavement is given in **Table 7.10** below:

**Table 7.10: Parameters for Design of New Pavement**

Parameters	Values considered for Design of New Pavement
Design Life (Years)	15 Years
Initial Traffic (Commercial Vehicles per day in 2014)	437
Traffic Loading in Million Standard Axles (MSA)	20 MSA
Lane Distribution Factor	0.75
Vehicle Damage Factor	2.5
CBR (%) of Subgrade Soil	10.0%

### Recommended Pavement Thicknesses

The pavement thickness (in accordance with IRC: 37-2012) is given in **Table 7.11** below:

**Table 7.11: Recommended Pavement Thickness**

S No	Pavement composition	Min. Thickness (mm)
1	Bituminous Concrete	40
2	Treated RAP/BSM	100
3	CT Sub Base	200
	<b>Total</b>	<b>340</b>

### 7.3 Proposal of Structures

In hilly region it is preferable that number of foundations shall minimum. This will necessitate the construction of large span bridges at most of the locations in hilly areas. Aesthetics of bridges in hilly terrain plays a very important role and therefore all efforts shall be made to match the structure with the environment.

It is not always possible to keep the bridges on the straight alignment in hilly terrains. This will necessitate providing of bridges on horizontal and vertical curves. Horizontally curved bridges will be most suitable for sharp turns and will help in reduction of hill cutting for the approaches.

Following type of super-structures will be most suitable for large span bridges-

- Structural steel girders/trusses
- Large span arch bridges
- Reinforced concrete pre-cast bridges
- Pre-cast Post tensioned concrete bridges

It may be a better solution to provide structural steel girders/truss type super-structure over deep gorges. Launching of truss or cantilever truss may be a better solution. Moreover since the project road is in heavy seismic zone, therefore all efforts shall be made to reduce the overall weight of the super-structure. Structural steel will be an ideal solution to reduce the overall weight of the super-structure for large span bridges over deep gorges.

Long bridges with large span can be constructed as balanced cantilever using cast-in-situ pre-stressed box girders. Props are not required for the construction of such type of bridges.

Piers shall be avoided in the mid-stream where velocity of water is more than 5.0m/second. It is generally seen that it is very difficult to construct sub-structure in such locations and there are possibility of bridge being washed away. Thus all efforts shall be made to provide large spans for the mid-stream in order to avoid any pier.

Circular/cellular circular/wall type piers shall be used after considering the aesthetics and economy. Solid wall type abutments/counter fort type abutments based on the height shall be selected. Counter fort type abutments are generally provided if height of the abutments is more than 10.0 meters.

#### 7.3.1 Formation Width of New Bridges and Culverts

The formation width of structure has been proposed as per MORT&H Circular No. RW/NH/33044/2/88-S&R(B) dated 21<sup>st</sup> October 2009. The width of bridge on two lane National Highway without and with footpath are given in **Table 7.12** below:

**Table 7.12:** The width of bridge on two lane National Highway without and with footpath

Description	Bridge without footpath (m)	Bridge with footpath (m)
Carriageway	7.00	7.00
Kerb Shyness	0.5 (2x0.25)	0.5 (2x0.25)

Description	Bridge without footpath (m)	Bridge with footpath (m)
Footpath	-	3 (2x1.5)
Safety Kerbs	1.60 (2x0.80)	-
Crash Barrier	0.90 (2x0.45)	0.90 (2x0.45)
Railing	-	0.60 (2 x 0.30)
<b>Overall Width</b>	<b>10.00</b>	<b>12.00</b>

It was decided in the meeting held on 24.03.2014 in PWD Campus, Dehradun that the total width of bridges to be considered for this project shall be 12.0m including footpath.



**Bridge Cross Section with Footpath**

### 7.3.2 Design Standard Consideration

#### A) Materials

##### Concrete Grade

Grade of concrete in various elements will be as under for moderate conditions of exposure:

- PSC Superstructure M-40
- RCC Superstructure M-35
- RCC Sub structure M-30/35
- RCC Solid slab M-30
- Composite Deck Slab M-35
- Bored Cast in Situ pile M-35
- Crash Barrier M-40
- RCC Retaining wall M-25
- PCC course M-15

##### Reinforcement Steel

High yield strength deformed bar shall be of grade Fe-500 conforming to IS: 1786

##### Structural Steel

High Strength Structural Steel shall be conforming to IS 2062 - 2011.

#### B) Pre-Stressing System

- a) System : 19T13 multipull strand system of



- |  |   |
|--|---|
|  | "Freyssinet" or "ISMALCCL" or equivalent  |
| b) Cables  | : 19T13 to 12T13 cables with strands of 12.7mm nominal dia.   |
| c) High Tensile Steel                            |   |
| - Strand   | : Nominal 12.7mm dia. 7 ply Uncoated Stress relieved Low relaxation strands conforming to IS: 14268 |
| - Area   | : 98.7 sqm per strand (nominal cross sectional area)  |
| - Ultimate load                                  | : 183.71 KN per strand  |
| - Modulus of Elasticity                          | : 1.95x105MPa   |
| d) Sheathing Duct                                | : 100mm OD corrugated HDPE sheathing for 19T13 And 12T13 cables.                                    |
| e) Friction Coefficient (k)                      | : 0.17/radian, Table 5, IRC 18:2000   |
| f) Wobble Coefficient                            | : 0.002/m, Table5, IRC 18:2000  |
| g) Anchorage Slip                                | : 6mm average   |
| h) Loss of force due to Relaxation after 1000 hr | : 3.8% at 0.765 UTS   |

#### C) Structural Steel

Composite construction consisting of structural steel girders with cast-in-situ deck slab may be proposed over deep valleys by keeping in view the seismic zone of the project roads. Superstructure weight shall be substantially reduced by using structural steel girders. Structural steel shall conform to IS: 2062-2011.

#### D) Bearings

Tar paper bearings will be proposed under simple supported RCC solid slab bridge. Reinforced elastomeric bearings will be proposed under RCC T-beam and slab type superstructure. The design of Elastomeric bearings will be as per the recommendation of IRC: 83 (Part II) and will conform to Cl. 2005 of MoRT&H Specifications for Road & Bridge Works (5th Revision).

POT-PTFE bearings (Fixed/ Guided/ Free) will be proposed under Steel Concrete Composite Superstructures. These bearings will be designed and tested as per IRC: 83 (Part III) and conforming to Cl. 2006 of MoRT&H Specifications for Road & Bridge Works (5th Revision).

#### E) Expansion Joints

The following types of expansion joints are proposed:

**Filler type expansion joints** are proposed for minor bridges with solid slab superstructures having span lengths not exceeding 10 meters. This type of joint will conform to Cl. 2605 of MOST's Specifications for Road & Bridge Works (5th Revision).

**Single Strip seal expansion joints** shall be proposed for superstructures having movements up 80mm. (± 40mm). The strip seal joints will conform to Cl. 2607 of MOST's Specification for Road and ~Bridges works (5th Revision).

#### Concrete Clear Covers:

For all reinforcement	-	As per Cl. 304.3 of IRC: 21-2000
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For other covers and inter duct spacing - As per Cl 16 of IRC: 18-2000  
**F) Loads and Load Combinations**

**a. Dead Loads**

Following unit weights will be assumed in the design as per IRC Codes.

- |                             |   |             |
|-----------------------------|---|-------------|
| • Pre-stressed Concrete     | - | 2.5 t/cu.m  |
| • Reinforced Concrete       | - | 2.5 t/cu.m  |
| • Plain Cement Concrete     | - | 2.5 t/cu.m  |
| • Structural steel          | - | 7.85 t/cu.m |
| • Dry Density of Soil       | - | 1.8 t/cu.m  |
| • Saturated Density of Soil | - | 2.07 t/cu.m |

**b. Superimposed Dead Loads**

- |                  |  |
|------------------|--|
| - Wearing Coat   | : 40mm thick bituminous concrete wearing course with 25mm thick mastic asphalt for major bridge,<br>: 40mm thick bituminous concrete wearing course for minor bridge,<br>: considering allowances for future overlay of 25mm for design purpose. |
| - Crash barriers | : For design purpose 0.8t/m per side is considered.  |

**c. Live Loads**

- Three lane of IRC Class A.
- One lane of IRC Class 70R (wheeled/ tracked)
- One lane of 70R & one lane Class A
- Whichever produces worst effects.

For design of 2-lane Bridge the combination of above live load will be as per IRC: 6-2014.

Impact factor will be as IRC: 6-2014 for the relevant load combinations.

**d. Longitudinal Forces**

The following effects will be considered for calculating the longitudinal forces in the design-  
Braking forces as per the provision of IRC: 6:2014.

Frictional resistance offered to the movement of free bearings due to change of temperature.  
Distribution of longitudinal forces due to horizontal deformation of bearings/frictional resistance shall be carried out as per IRC: 6:2014 by assuming stiff supports.

**e. Centrifugal Forces**

Bridges on a horizontal curve shall be designed for centrifugal forces based on the following equation-

$$C = W \cdot V^2 / 127R,$$

Where C = Centrifugal force acting normal to the traffic.

W = Carriageway Live Load

V = Design speed of the Vehicles using the bridge in km per hour.

R = Radius of curvature in meters.

The centrifugal force shall be considered as per IRC 6-2014.

**f. Water Current Forces**

The effect of water current forces shall be calculated in accordance with IRC: 6-2014 on sub structure and foundations. High flood level and Velocity shall be calculated based on the details received from relevant Government departments or Local inquiries.

**g. Impact Forces**

All the sub- structure and foundations in the river shall be designed for the impact due to striking of rolling boulders on the sub-structure in mountainous terrain. The magnitude of force shall be decided based on field studies and in consultation with client.

**h. Earth Pressure Forces**

Earth pressure forces will be calculated as per the provisions of IRC: 6-2014 assuming the following soil properties:

*Type of soil assumed*

For backfilling	:	As per Appendix 6 of IRC:78-2014 with dry density of 1.8 t/cum and saturated density of 2.07 t/cum
Angle of Internal Friction	:	$\phi = 30^\circ$
Angle of Wall Friction	:	$\delta = 20^\circ$
Coefficient of Friction ' $\mu$ ' at base	:	$\tan (2/3 \phi)$ , while $\phi$ is the Angle of internal friction of substrata Immediately under the foundations.

Live load surcharge will be considered as per the provisions of IRC:78-2014 i.e. equivalent of 1.2m height of fill.

**i. Wind Effect**

Structures will be designed for wind effects as stipulated as per IRC: 6-2014.

**j. Seismic Effect**

Suitable consideration should be made in detailed design as per provision of IRC: 6-2014.

The project road falls under seismic zone-V. Horizontal seismic force shall be calculated using the following formula-

$$F_{eq} = A_h \times (\text{Dead Load} + \text{Appropriate Live Load})$$

Where,

$$A_h = \text{Horizontal seismic co-efficient} = (Z/2) \times (S_a/g)/(R/I)$$

$$Z = \text{Zone factor}$$

$$I = \text{Important factor and is taken as 1.5 for important Bridges.}$$

$$R = \text{Response reduction factor and is equal to 2.5}$$

$$S_a/g = \text{Average response acceleration coefficient depending upon fundamental period of vibration } T$$

$T$  = Fundamental period of Bridge in seconds in horizontal vibrations.

The vertical seismic coefficient shall be considered in the case of structures built in seismic zone-V. The vertical seismic coefficient shall be considered as half of the horizontal seismic force. Both horizontal and vertical seismic forces shall be assumed to act simultaneously for the design of bridge components.

**k. Temperature Range**

The bridge structure/components i.e. bearings and expansion joints, will be designed for a temperature variation of considering extreme climate as per IRC 6-2014.

The superstructures will also be designed for effects of distribution of temperature across the deck depth as applicable.

**l. Differential Settlement Effects**

Differential Settlement effects for continuous superstructure units will be appropriately assessed for each structure. However in any case of differential settlement shall be accounted for in the design as per IS 1904-1986.

**m. Differential Shrinkage Effects**

A minimum reinforcement of 0.2% of cross sectional area in the longitudinal direction of the cast-in-situ slab shall be provided to cater for differential shrinkage stresses in superstructures with in-situ slab over pre-cast girders as per IRC: 122-2011.

However, effects due to different shrinkage and/or different creep shall be duly accounted for in the design.

**n. Buoyancy**

100% buoyancy shall be considered while checking stability of foundations irrespective of their resting on soil/weathered rock/or hard rock. However, the maximum base pressures will also be checked under an additional condition with 50% buoyancy in cases where foundations are embedded into hard rock. Pore pressure uplift limited to 15% shall be considered while checking stresses of the substructure elements.

In the design of abutment, the effects of buoyancy shall be considered assuming the fill behind abutment has been removed by scour

**o. Load Combination**

All members will be designed to sustain safely the MORTH critical combination of various loads and forces that can coexist. Various load combinations as relevant with increase in permissible stresses considered in the design shall be as per IRC: 6-2014 and IRC: 78-2014.

In addition, the stability of bridge supporting resting on neoprene/POT-PTFE bearings will be checked under one span dislodged condition. The load case will be checked with seismic/wind load combinations.

### **Exposure Condition**

Moderate exposure conditions will be considered while designing various components of the bridge.

### **7.3.3 Design Methodology**

#### **A) Superstructure**

##### **a) General**

The superstructure is designed for various combination of Class A load and 70Rload, severest of these load combination are chosen for design. The method of analysis and design of superstructure depends on type of superstructure. Grillage analysis or any other suitable analysis is adopted for T Girder, I Girder, solid slabs, voided slabs, live load analysis for box girder a single line beam is idealized for longitudinal live load analysis. The superstructure is analyzed in the longitudinal direction for bending moment and shear, corresponding reinforcement or pre-stressing is provided for it. In the transverse direction deck slab is analyzed as continuous over girders and effect of differential bending of girders is also considered for deck slab design. The superstructure is also designed for temperature stresses, resulting from maximum and minimum temperature variations. The superstructure shall be RCC solid slab for spans up to 10.0 m. For spans ranging from 10.0 m to 25 m RCC T-girder and slab shall be provided. For spans from 20.0 m to 30.0 m pre-stressed concrete I-girders or pre-stressed concrete voided slabs shall be provided. For spans over 30.0 m PSC single cell or multi cell box girder shall be provided.

##### **b) RC Slab/RCC T- Beam & Slab Type Superstructure.**

Based on the loads mentioned earlier, the bending moments and shear forces are worked out at the selected sections. Distributions of live load on longitudinal beams are worked out (in case of T-beam and slab type of superstructure). The sections are then designed as reinforced concrete sections subjected to the applied moments and shear forces. The design moments, shear forces and joint displacements can be worked out using Grillage method of analysis in STAAD-Pro, program, based on which structural design of various elements and checking of adequacy of different section can be done.

The RC Solid slab superstructures shall be analyzed using Grillage analogy method to obtain internal moments and forces based on which structural design shall be carried out.

##### **c) Modelling & analysis of Superstructure**

Modelling is substituting the actual structure to an equivalent mathematical structure, which is amenable to computer analysis. In modelling, the properties of the prototype are required to be correctly assessed and assigned to corresponding components of the model. Similarly support conditions are based on deformations permitted at the supports. Grillage modeling offers a good choice for a large variety of super structure forms.

The analysis is accurate only if the prototype is modelled accurately. We will pay special attention to the modelling / idealization aspect and if necessary will revise our model for greater accuracy.

We have suitable software for the analysis of bridges of all types for various IRC live loading, permanent dead loading and construction stage loading. These will be used in the analysis.

**d) Design of Elements above Deck Level**

The miscellaneous elements such as kerbs and parapets/railing are designed as reinforced concrete section for the loads and forces as per Cl. 209 of IRC: 6 - 2014.

**e) Design of Bearing**

The loads transferred from the superstructure to the bearings shall be taken from the earlier analysis of superstructure. Short and long term deformations shall be computed for the temperature, shrinkage and creep of concrete.

Elastomeric bearings shall be designed as per IRC: 83-2015 (Part II) for these effects as reinforced multi-layer neoprene bearings. However, design loads and movements are to be supplied to the manufacturer to enable him to manufacture these bearings. The manufacturer's details & design have to be got checked to ensure compliance with the design requirements.

**B) Substructure and Foundation**

**a) Piers**

Pier will be wall/circular type with cantilever fixed at base, which is taken as top of foundation. The sections at various levels will be checked as sections subjected to axial thrust and bi-axial bending. In addition to dead load and live loads from superstructure, the pier substructure and its foundation will be designed for the loads due to seismic/wind and water current forces as appropriate.

**b) Abutment**

Abutments will be of non-spill through type. These shall be designed resting on open foundations, pile foundations or well foundations as per requirement and may have cantilever returns at top. In case the cantilever returns become too long independent RCC retaining walls shall be provided. For height of abutments greater than 8.0m counter forts shall be provided.

Open foundation for piers and abutments shall be designed in reinforced concrete. The stability checks shall be carried out as per relevant IRC Codes.

**c) Foundation**

Foundation of bridge / ROB is to be conceptualized after evaluation of subsoil data such as type of soil and its safe bearing capacity at foundation level for abutment/pier/return-wall and footings. Thereafter suitable type of foundations is to be provided with respect to soil and type of superstructure. Adequacy of the size and depth of foundation will be ensured for the satisfactory performance of the structure. The structural design of the foundation is to be designed as per the latest computerized modeling. Particular attention is paid to stability checks and corresponding safety factors.

**d) Open Foundation**

Design of isolated open foundation shall be based on complete sub soil investigations. The allowable bearing pressure shall satisfy the provisions contained in the clause 708 and the minimum foundation depth shall not be less than that specified in Clause 705 of IRC: 78-2014 (Second Revision).

The selection of the appropriate type of open foundation (counter fort type or cantilever type) depends on the magnitude and disposition of structural loads, allowable bearing capacity etc. However, if rock strata are encountered at shallow depth, it will be preferable to adopt open foundation to pile foundation.

**e) Deep Foundations**

In case of large scour depths and unavailability of rock at shallow depth deep foundation shall be provided. This may be pile foundation or well foundation depending on vertical load, horizontal load, bending moment and soil strata. Cast in situ Pile foundation up to 1.2m dia can be constructed fast and are more suitable if the total length of pile is up to 25.0m, pile can also be seated on hard rock, and guidance can be taken from appendix-5 of IRC-78-2014 (Second Revision). Beyond 30.0m depth of foundation, well foundation shall be adopted as they can carry large horizontal loads and bending moments compared to pile foundations. Choice of foundation between pile and well shall depend on their relative merits and demerits with respect to loads and soil strata.

**f) Load & Stresses**

In meeting the broad scope of the assignment as outlined, our methodology is as under.

Independent assessment of the loading will be made on each component of structure and possible combination of these loading in line with IRC: 6-2014 will be made for designing the various components of the bridge – structure at various stages of construction. These loading and loading combinations will be compared with other IRC code provisions also wherever applicable.

Permissible stresses under various combinations of loading are different. These permissible stresses are given in IRC 6 and these will be followed. It will be ensured that these are never exceeded. If a particular component is appreciably under stressed then relevant sections will be revised and reduced in the interest of the economy.

**C) Seismic Design**

The Project Corridor falls under the seismic Zone-II. Seismic Analysis shall be carried out in 2 Steps:

- Carrying out single mode of analysis to obtain the fundamental vibration period of the structure in two orthogonal directions (i.e. Longitudinal & Transverse direction).
- Estimation of seismic forces using the spectrum response, as per IRC: 6-2014.

The calculation for fundamental period shall be done either by using the simplified expression given in Appendix- D of IRC:6-2014 or else by modeling the structure in STAAD/Pro and carrying out dynamic analysis.

Vertical seismic coefficient shall be taken as "two third" of the horizontal seismic coefficient. The vertical seismic shall be combined with the horizontal seismic in any one direction. The seismic combination to be considered is as follows:

- $+S_X + 0.3S_Y + 0.3S_Z$
- $+S_Y + 0.3S_X + 0.3S_Z$

$$\circ +SZ+0.3SX+0.3SY$$

Where SX & SZ are seismic forces in longitudinal & transverse direction respectively, while SY is the seismic force in vertical direction.

#### **D) Reinforcement Detailing**

- The bar sizes and distance between bars and pre-stressing cable ducts/tendons shall be in accordance with section 15 of IRC: 112-2011.
- Curtailment of bars shall be as per clause 16.5.1.3 of IRC: 112-2011,
- Minimum Reinforcement and Distribution reinforcement in slabs shall be as per IRC: 112-2011
- Minimum shear reinforcement shall be as per IRC: 112-2011.
- Minimum diameter of any reinforcement shall not be less than 10 mm for open foundation, transverse ties, stirrups and all secondary reinforcement for girder and slab.
- Minimum diameter of any reinforcement shall not be less than 12 mm for pier vertical bar, pier cap main bar, and longitudinal bar in girder.
- Ductile detailing shall be done as per chapter 17 of IRC: 112-2011
- Box culverts shall be constructed with individual precast inverted U-shaped sections connected by in-situ base and stitch concrete at deck.

#### **E) Permissible Stresses**

The Permissible Stresses in the RCC & PSC members shall be as per IRC: 112-2011. The Permissible Stresses in the Composite members & Steel structures considered in design shall be as per IRC: 22-2015 & IRC: 24-2010, respectively.

Increase in Permissible Stress in steel and concrete due to various load combinations shall be as per IRC: 6-2014.

#### **F) Software for Analysis and Design**

- In house developed programs and spread sheets for checking stresses and capacity of structural element.
- Structural Analysis: STAAD.pro

#### **G) Hydrology and Hydrological Study**

##### **a) General**

Main objective of hydrology is to determine anticipated flood and other parameters such as Design Discharge, Flow Velocity, HFL, and Scour Depth. Bridge structure shall be designed so as to cater for the anticipated floods without endangering the structure. The hydrological and hydraulic studies shall be carried out in accordance with IRC:SP: 13-2004 ("Guidelines for the Design of Small Bridges and Culverts") and IRC:5-2015("Standard Specifications & Code of Practice for Road Bridges, Section-I ("General Feature of Design") and specific Flood Estimation Report for particular Sub-Zone published by the Directorate of Hydrology (Small Catchment) Central Water Commission, New-Delhi, Government of India. As per these CWC report, the project lies in Zone 1(b). Detailed Hydrological Investigations for all Structures shall be done in Hydrology report.

##### **b) Data Collection**



The various essential data shall be collected for hydrological investigation. Catchment area will be calculated from the Top sheets available on a scale of 1:50000 for small catchments and 1:250000 for large catchments. Highest flood level will be observed and measured during site visit supplemented by local enquiry. Attempts shall be made to collect the data of existing bridge and their performance during past floods from the Governing Departments.

**c) Estimation of Flood Discharge**

The most common methods to estimate the flood discharge are as under:

- |                      |                          |
|----------------------|--------------------------|
| i) Empirical Method  | ii) Rational Method      |
| iii) Unit Hydrograph | iv) Area Velocity Method |

**i) Empirical Method:**

Dickens's Formula can be used for the project area, as per IRC SP-13-2004

$$Q = C M^{3/4}$$

Where,

Q = Peak run-off in m<sup>3</sup>/sec

M = Catchment area in SqKm.

C = Coefficient of run-off, depends upon annual rainfall

The catchment area M is determined from the Topo sheet, Coefficient of run-off 'C' is determined from IRC SP-13 depending upon the intensity of rainfall. This formula gives a simplified approach and results are approximate. Comparisons are made with alternative methods for important structures.

**ii) Flood assessment based on rational approach:**

The rational formula for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances, and time of concentration and critical intensity of rainfall. Basic formulae are as under:

One hour rainfall (I<sub>o</sub>), I<sub>o</sub> = (FIT)\*(T+1) I (1+1) Critical rainfall intensity,

$$I_c = I_o * (2 I (1+tc)) \text{ Discharge,}$$

$$Q = 0.028 * P * f * A * I_c$$

$$\text{Time of concentration, } t_c = (0.87 * L^3 I H)^{0.385}$$

Where,

t<sub>c</sub> = Time of concentration i.e. time taken by runoff from periphery of catchment (hrs)

I<sub>o</sub> = One hour rainfall in cm

I<sub>c</sub> = Critical intensity of rainfall in cm per hour

P = Coefficient of runoff for the catchment characteristics (Ref: Table - 4.1, P-13 and IRC SP: 13-2004)

A = Catchment area in hectare

Q = Maximum discharge in cumecs

L = Distance from the critical point to the structure (Length of path in Km) H = The difference in level from the critical point to the structure in meter F= Maximum rain fall in mm

T = Duration of storm in hours

f = fraction of maximum point intensity at the center of the storm and related with the catchment area (Determined from Fig.4.2, Page-14, and IRC: SP: 13-2004.)

In the present study, storm rainfall and storm duration data of 100 Years return period shall be utilized from design flood hydrograph of nearby project sites, developed on the basis of Hydro-meteorological studies as per relevant Flood estimation reports of the particular regional area.

### **iii) Unit Hydrograph Approach for Assessment of Design Flood Discharge:**

The unit hydrograph (UG) of a drainage basin is defined as the direct runoff (outflow) hydrograph resulting from one unit of effective rainfall which is uniformly distributed over the basin at a uniform rate during the specified period of time known as unit time or unit duration.

This method is applicable for Catchment area varying between 20-25 Sq. Km to 2500-5000 Sq Km. In present study, the design discharge calculations shall be done for 100Years return period.

### **iv) Area Velocity Method**

The area velocity method uses Manning's formula (as per IRC SP: 13-2004 manually or using HEC-RAS Software) for calculating flow velocity as under.

$$Q = A \cdot V; \quad V = (1/n) R^{2/3} S^{1/2}$$

Where,

Q = Peak run-off in m<sup>3</sup>/sec

A = Cross sectional area of flow

V = Velocity of flow

n = Rigidity coefficient

R = Hydraulic mean radius = A / P; P= Wetted perimeter

S = Energy slope which may be taken equal to bed slope

Cross sections of the streams are taken both upstream and downstream at a distance as specified in IRC SP -13 by Topo survey in the field. Longitudinal slope of the bed is also calculated by taking long section over a reasonably long reach of the stream. HFL can be observed in the field by flood marks and local enquiry. This formula gives fairly reasonable estimation of flood discharge.

### **d) Design Discharge**

Design discharge is fixed as per provisions of Clause 6.2 of IRC SP-13-2004. The values of peak discharge calculated by above methods are compared. The highest of these values is adopted as design discharge, provided it does not exceed the next highest discharge by more than 50 percent. If it does, restrict it to that limit.

#### e) Scour Depth

Determination of scour depth is important factor for deciding depth of foundation and shall be derived as per Cl. 703.2 of IRC: 78 - 2014 according to which:

$$dsm = 1.34 * (Db I Ksf)^{1/3}$$

Where, dsm = Mean depth of scour

Db = Design discharge per meter width of effective waterway

Ksf = Silt factor of bed material,

The maximum depth of scour below the highest flood Level (HFL) for the design of piers and abutments located in a straight reach and having individual foundations without any floor protection works is taken as under.

In the vicinity of piers = 2.0 dsm;

Near abutments= 1.27 dsm

#### f) Vertical Clearance

Provision of Vertical clearance in bridges above HFL shall be kept as per IRC SP-13, Clause 12.3 given in **Table 7.13** below:

**Table 7.13:** Provision of Vertical clearance in bridges above HFL

Discharge in m <sup>3</sup> /s	Minimum Vertical Clearance in m
Up to 0.30	0.15
Above 0.3 and up to 3.0	0.45
Above 3 and above 30	0.6
Above 30 and up to 300	0.9
Above 300 and up to 3000	1.2
Above 3000	1.5

However, for clarity, it is emphasized that no changes are envisaged in existing structures unless reconstruction is involved.

#### H) Geotechnical Investigation and Study

To evaluate the subsoil properties needed for the design of foundations, detailed geo- technical investigations need to be conducted at all bridges, flyovers, underpasses, ROBs, embankment locations along the project road. The minimum scope followed for geo-technical investigations for bridges & other structures is given in **Table 7.14** below:

**Table 7.14:** Minimum scope followed for geo-technical investigations for bridges & other structures

S. No.	Description	Location of Boring
1	Overall Length = 6 to 30m	One abutment location
2	Overall Length = 30 to 60 m	One abutment location & at least one intermediate location between abutments for structures having more than one span.

S. No.	Description	Location of Boring
3	Overall Length >60 m	Each abutment and each pier locations

The depth of boring shall be conducted as per provision in IRC: 78-2014, MORTH specification.

The Depth of bore-Logs is based on expected type of foundation. As per the preliminary survey it seems open foundation shall be suitable. In case of open foundation, the bore hole shall be done as per IRC: 78 i.e. 1.5 times the width of the foundation below the proposed foundation level. The depth of drilling/ boring shall be 5.0m in soft rock & 3.0m in hard rock.

#### I) Type of Superstructure

When the length of the new bridges is less than 60m, the alignment of bridges is governed by alignment of the road. Considering small spans ranging from 10.0m to 25.0m (centre to centre of expansion gap) RCC T-beam and Slab type superstructure has been adopted here for overall economy, and easy and rapid construction. The following types of superstructures have been considered though in some cases RC Solid Slab type superstructure has been considered at end span to adjust total bridge length and linear waterway as given in **Table 7.15** below:

**Table 7.15: Type of Superstructures**

Sr. No.	Type of Superstructure	Span Length(c/c exp. Gap)
i)	RCC Solid Slab	Up to 10.0 m
ii)	RCC T-Beam & Slab	10.0 to 26.0 m
iii)	PSC I-girder/Steel composite plate girders	20.0 to 40.0 m
iv)	Box Girder/Steel composite plate girders	30.0 to 60.0 m
v)	Steel Truss/ Arches	Above 60m

The depth of superstructures has been decided based on structural considerations. Keeping in view the minimum vertical clearances above HFL, the road formation levels have been achieved.

### 7.3.4Improvement Proposals

#### 7.3.4.1 Bridges

There are 11 No of Bridges proposed for new construction which is given in **table 7.17** below:

**Table 7.16: Proposal for Reconstruction of Bridges**

Sr. No.	Design Chainage (km)	Name of Bridge	Existing Span Arrangement	Reason of proposal	Proposed span	Proposed type
1	425+600	Bajipur Bridge	1 x 12.0	Inadequate cross drainage structure & curve improvement	20	RCC T

**Table 7.17: Proposal of Additional New Bridges**

S. No.	Design Chainage (km)	Proposed span	Type of Bridge
1	401+975	1X10	Solid Slab
2	402+640	1X10	Solid Slab
3	404+660	1X30	PSC
4	406+100	1x 30	PSC
5	407+060	1X30	PSC
6	409+125	1x 20	RCC T Beam
7	410+390	1X30	PSC
8	418+220	1x 30	PSC

**Project: 2-laning of NH-58 from Rudraprayag to Mana**  
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S. No.	Design Chainage (km)	Proposed span	Type of Bridge
9	419+600	1X30	PSC
10	425+175	1X30	PSC
11	427+220	1x 30	PSC

### 7.3.4.2 Culverts

There are 85 numbers of culverts along the project road which is proposed for reconstruction given in **Table 7.18** below:

**7.18: Proposed reconstructed culverts**

S. No.	Design Chainage (km)	Culvert No.	Proposal	Span Arrangement (m)	Type of Culvert
1	398+500	400/1	Reconstruction	4	Box
2	398+700	400/2	Reconstruction	4	Box
3	399+390	401/1	Reconstruction	4	Box
4	399+940	401/2	Reconstruction	4	Box
5	400+050	401/3	Reconstruction	4	Box
6	400+165	401/4	Reconstruction	4	Box
7	400+265	401/5	Reconstruction	4	Box
8	400+345	402/1	Reconstruction	4	Box
9	400+610	402/2	Reconstruction	4	Box
10	402+265	404/1	Reconstruction	4	Box
11	402+355	404/2	Reconstruction	4	Box
12	402+965	404/3	Reconstruction	4	Box
13	403+315	405/1	Reconstruction	4	Box
14	403+475	405/2	Reconstruction	4	Box
15	403+695	405/3	Reconstruction	4	Box
16	404+205	406/1	Reconstruction	4	Box
17	405+475	407/1	Reconstruction	4	Box
18	405+700	407/2	Reconstruction	4	Box
19	406+410	408/2	Reconstruction	4	Box
20	407+160	409/1	Reconstruction	2	Box
21	407+255	409/2	Reconstruction	2	Box
22	407+290	409/3	Reconstruction	2	Box
23	407+460	409/4	Reconstruction	2	Box
24	407+940	410/1	Reconstruction	4	Box

S. No.	Design Chainage (km)	Culvert No.	Proposal	Span Arrangement (m)	Type of Culvert
25	408+005	410/3	Reconstruction	6	Box
26	408+070	410/4	Reconstruction	4	Box
27	408+470	410/5	Reconstruction	4	Box
28	408+665	410/6	Reconstruction	4	Box
29	408+705	410/7	Reconstruction	4	Box
30	409+625	411/2	Reconstruction	2	Box
31	409+675	411/3	Reconstruction	2	Box
32	409+925	412/1	Reconstruction	2	Box
33	410+435	412/2	Reconstruction	2	Box
34	410+680	413/1	Reconstruction	2	Box
35	411+135	413/2	Reconstruction	4	Box
36	412+425	414/1	Reconstruction	2	Box
37	412+560	414/2	Reconstruction	2	Box
38	412+705	415/1	Reconstruction	2	Box
39	412+750	415/2	Reconstruction	2	Box
40	412+860	415/3	Reconstruction	2	Box
41	412+945	415/4	Reconstruction	4	Box
42	413+020	415/5	Reconstruction	6	Box
43	413+660	416/1	Reconstruction	6	Box
44	413+855	416/2	Reconstruction	4	Box
45	414+145	416/3	Reconstruction	2	Box
46	414+280	416/4	Reconstruction	2	Box
47	415+005	417/1	Reconstruction	2	Box
48	415+260	417/2	Reconstruction	4	Box
49	415+485	418/1	Reconstruction	2	Box
50	415+805	418/2	Reconstruction	2	Box
51	415+990	418/3	Reconstruction	4	Box
52	416+175	418/4	Reconstruction	2	Box



S. No.	Design Chainage (km)	Culvert No.	Proposal	Span Arrangement (m)	Type of Culvert
53	416+430	419/1	Reconstruction	4	Box
54	417+050	419/2	Reconstruction	2	Box
55	417+090	419/3	Reconstruction	2	Box
56	417+845	420/1	Reconstruction	2	Box
57	419+229	422/1	Reconstruction	2	Box
58	419+523	422/2	Reconstruction	2	Box
59	420+005	422/3	Reconstruction	2	Box
60	420+130	423/1	Reconstruction	6	Box
61	420+219	423/2	Reconstruction	4	Box
62	420+975	423/3	Reconstruction	4	Box
63	421+252	424/1	Reconstruction	4	Box
64	422+022	425/1	Reconstruction	4	Box
65	422+342	425/2	Reconstruction	2	Box
66	422+805	425/3	Reconstruction	4	Box
67	422+840	425/4	Reconstruction	2	Box
68	423+096	426/1	Reconstruction	2	Box
69	423+160	426/2	Reconstruction	2	Box
70	423+260	426/3	Reconstruction	2	Box
71	423+573	426/4	Reconstruction	2	Box
72	423+700	426/5	Reconstruction	4	Box
73	423+890	426/6	Reconstruction	4	Box
74	423+925	426/7	Reconstruction	4	Box
75	424+095	427/1	Reconstruction	2	Box
76	424+290	427/2	Reconstruction	4	Box
77	424+390	427/4	Reconstruction	6	Box
78	424+895	427/5	Reconstruction	4	Box
79	425+258	428/1	Reconstruction	2	Box
80	426+035	429/1	Reconstruction	6	Box

S. No.	Design Chainage (km)	Culvert No.	Proposal	Span Arrangement (m)	Type of Culvert
81	426+615	429/2	Reconstruction	4	Box
82	426+745	430/1	Reconstruction	2	Box
83	426+795	430/2	Reconstruction	2	Box
84	426+890	430/3	Reconstruction	4	Box
85	427+005	430/4	Reconstruction	2	Box

**Table 7.19:Proposed New Culvert**

S. No.	Design Chainage (km)	Span (m)	Arrangement	Width (m)	Type of Culvert
1	399+170	4		12	Box
2	400+545	4		12	Box
3	400+865	4		12	Box
4	401+105	4		12	Box
5	401+525	4		12	Box
6	401+750	4		12	Box
7	402+500	2		12	Box
8	403+850	4		12	Box
9	404+450	4		12	Box
10	404+800	4		12	Box
11	405+050	4		12	Box
12	405+325	4		12	Box
13	405+545	4		12	Box
14	405+615	4		12	Box
15	405+800	4		12	Box
16	406+520	4		12	Box
17	406+590	4		12	Box
18	407+700	4		12	Box

S. No.	Design Chainage (km)	Span (m)	Arrangement	Width (m)	Type of Culvert
19	408+165	4		12	Box
20	408+300	4		12	Box
21	408+800	4		12	Box
22	409+000	4		12	Box
23	409+480	4		12	Box
24	410+165	2		12	Box
25	410+850	2		12	Box
26	411+000	2		12	Box
27	411+550	4		12	Box
28	411+750	2		12	Box
29	411+975	2		12	Box
30	412+225	4		12	Box
31	412+505	2		12	Box
32	413+295	6		12	Box
33	413+500	4		12	Box
34	414+655	4		12	Box
35	414+850	4		12	Box
36	415+390	4		12	Box
37	415+740	2		12	Box
38	415+850	2		12	Box
39	416+115	4		12	Box
40	416+675	4		12	Box
41	417+655	2		12	Box
42	418+345	2		12	Box
43	418+815	4		12	Box
44	419+400	4		12	Box
45	419+750	2		12	Box
46	420+320	4		12	Box

S. No.	Design Chainage (km)	Span (m)	Arrangement	Width (m)	Type of Culvert
47	420+750	4		12	Box
48	421+100	2		12	Box
49	421+685	2		12	Box
50	421+800	4		12	Box
51	422+075	4		12	Box
52	422+170	4		12	Box
53	422+600	4		12	Box
54	423+400	4		12	Box
55	424+195	4		12	Box
56	424+590	6		12	Box
57	424+725	4		12	Box
58	425+425	4		12	Box
59	426+250	4		12	Box
60	426+475	4		12	Box
61	427+500	4		12	Box

## 7.4 Project Facilities

### 7.4.1 Bus Shelters

In hilly areas, there are several locations, where buses make short stops over for a lighting / getting down passengers. These locations are provided with a suitable shed for waiting passengers. The bus stop/shelter is normally located, where the road is straight on both sides, the gradient is level or as flat as possible and the visibility is reasonable (not less than 50 m). Suitable signs are provided at and in advance of such locations. The typical locations of bus shelter suggested as per site requirement is presented below

**Table 7.20: Bus Shelters**

S. No.	Design Chainage (km)	Village	Side
1	400+300	Rajnagar	Both Side
2	402+950	Humatha	Both Side
3	403+200	Kalpeshwar	Both Side

S. No.	Design Chainage (km)	Village	Side
4	405+300	Jaikandigad	Both Side
5	407+000	Langasu	Both Side
6	409+450	Baidanu	Both Side
7	410+700	Bakuda	Both Side
8	411+550	Virajgang	Both Side
9	413+000	Devli	Both Side
10	414+000	Sonla	Both Side
11	417+000	Nandprayag	Both Side
12	421+000	Pursadi	Both Side
13	424+000	Mathana	Both Side
14	426+000	Bazbara	Both Side
15	427+000	Kuher	Both Side
16	428+000	Bachpur	Both Side
17	429+000	Chamoli	Both Side

#### 7.4.2 Truck Lay bye

**Table 7.21: Truck lay bye**

S.No	Existing Chainage	Location
NIL		

#### 7.4.3 Parking with Rest areas

**Table 7.22: Parking with Rest areas**

S.No.	Existing Chainage	Location
NIL		

## **7.4.6 Traffic Signs**

### **7.4.6.1 Road Signage**

The functions of traffic signs are timely warning of hazardous situations when they are not self-evident. Regulation of traffic imparting messages to drivers about the need to stop, give way and limit their speed and also inform them about the directions & points of intersections.

According to Motor Vehicles Act of India 1988 the state governments are required to erect traffic signs, which have been prescribed in the act. IRC standards have been evolved keeping in consideration the above act. General principles of traffic signing in brief are:

- 1) Excessive signs should not be resorted to and unofficial signs should not be permitted. The signs should be legible to those using that and should be understood in time to have a proper response and it should be designed for the foreseeable traffic conditions and speeds on the highways
- 2) Besides this it should have high visibility both during day and at night. The letter or the symbol should be of adequate size for being read from far away by a speeding driver.
- 3) It should be simple and uniform in design, position and application.
- 4) It should have two sizes for each type of sign. A standard size for main highway and a reduced size for less important roads.

### **7.4.6.2 Traffic signs are of the following type**

- a) Dangerous signs also known as warning or cautionary signs.
- b) Signs having definite instructions also known as Regulatory signs as per Motor Vehicles Act of India 1988. It is further divided into 2 types
  - i) Prohibitory signs
  - ii) Mandatory signs
- c) Information signs, further subdivided into
  - i) Indication signs
  - ii) Advanced Direction and Direction signs
  - iii) Place & Route identification signs

The IRC standards confirms to the above classifications.

The type of sign and there locations has been illustrated in the road safety audit chapter.

### **7.4.6.3 Dangerous Signs (Warning or Cautionary signs)**

They are used when it is necessary to warn the traffic of hazardous conditions on or adjacent to the highway. The UN protocol as well as IRC recommends the equilateral triangle side with one point upwards. The standard is 900 mm & reduced size is 600 mm. The signs have a red border and symbols indicated therein are black color against a white pattern. The warning signs as per IRC are illustrated. These may be kindly be referred to in drawing vol.

### **7.4.6.4 Regulatory signs**

These signs are a part of regulatory signs, which are intended to inform the traffic users of traffic laws and regulations.

#### **7.4.6.5 Prohibitory signs**

These give definite negative instructions prohibiting the motorist from making particular maneuvers and they may be

- i) movement restrictions
- ii) waiting restrictions
- iii) restrictions on dimensions

According to IRC standards, these are of a standard size of 600 mm and 400mm for reduced size. The signs have a red border, the color of the background is white for speed control. Blue for waiting and parking restrictions and direction controls. The signs are illustrated drawing volume.

#### **7.4.6.6 Mandatory Signs**

These are a part of regulatory signs and are intended to convey definite positive instructions when it is desired to take positive actions. The two important Mandatory signs are STOP signs and GIVEWAY or YIELD

##### **1) STOP signs:**

The stop signs require all the vehicles to come to a stop before the stop line. The general principles of use of stop signs are the following

- i) Intersection of less important roads with main highway where the application of normal right of way is unduly hazardous. A stretch intending a through highway unsignalised intersection in signalized area.
- ii) Other intersections where a combination of high-speed restrictions, severe accident record need a control by stop sign.

The stop signs should not be used on through highway for a speed control at signalized intersections. There are different practices such as American, English & IRC for the size and shape of stop signs. IRC standards have been used in this highway as per octagon with white border and red back background, with the side of the octagon 900 mm, 600mm for a smaller size has been used. It shall be used in combination with a definition plate carrying a message 'stop'.

##### **2) YIELD or GIVEWAY Sign:**

The yield or give way sign is used to assign right of way on traffic at approaches to intersections. Vehicles controlled by yield sign need a stop when necessary only to avoid infiltration i.e., give right of way. It controls the traffic at major intersections.

At places where stop sign is on the thorough highway, the yield sign has an equilateral triangle with one point downwards having a red border & white background of 900 mm size and 600mm for a smaller size. It shall be used in combination with a plate-carrying message Giveway.

#### **7.4.6.7 Informatory signs**

These are intended to guide the motorist along highway. Information of intersections, routes to direct him to the cities, towns, villages and other important destinations and to identify nearby rivers and streams, parks, forests and historical sites giving general information which will help him along the carriageway in most simple and direct manner as far as possible. Informatory

signs do not lose their effectiveness and it is desirable to erect them as frequently as is necessary and in any case at locations where motorists is in doubt.

In Indian practice only the upper case letters are used. Informatory signs generally used in Indian state highways are enclosed in drawing volume IX.

#### **7.4.6.8 Indication signs**

Indication signs are a subclass of informatory signs. They generally provide the information of facilities such as filling station, telephone, eating home, first aid course etc. IRC standards provide a size of 600mmx450mm with a black symbol against a white rectangle and blue background.

#### **7.4.6.9 Direction signs, advanced destination signs and place identification signs**

Direction signs, advanced directions signs and place identification signs indicate the name of place and are rectangular in shape terminating in the form of an arrow. Advanced destination signs are necessary at the intersection of roads. They are also rectangular in shape. Advanced destination signs indicate the name of the place and the distance. A place destination sign is rectangular in shape with name of place written in specified size of letter. A destination signs reassures the traveler about the places ahead and the distances. All the above signs shall be of IRC standards.

#### **7.4.6.10 Overhead signs**

These are provided at locations such as where the traffic volume at or near the capacity, complex interchanges, closely spaced interchanges where multiple lane roads exist in sufficient space for the round mounted signs. These are also located at Toll plaza and junctions of an interstate road with another freeway.

#### **7.4.6.11 Route marker signs**

It is standardized by IRC: 2-1968. It consists of a shield painted on a rectangular plate 400mm x 600mm. The sign has a yellow background and lettering & bordering are black.

All the signs of different category shall be placed at suitable location and height as per requirement.

#### **7.4.6.12 Location and height**

As per IRC standards the signs should be erected not less than 60cm away from the edge of the kerb, in case of road and at a distance of 2-3m from the carriageway edge in case of unkerbed roads.

The mounting height shall be at least 1.5m (measured from the bottom to the pavement). In business and commercial areas where parking and pedestrian movement is to occur the height is at least 2.1m. The IRC standards prescribe a height of 1.5m for unkerbed and 2m for the kerbed roads. IRC standards have been followed. A stop sign is to be located at the point where the vehicle is to stop or as near as possible say 1.5m where there is pedestrian crossing. The stop sign shall be erected in 1.2m in advance before the stop line. Warning sign for a National Highway shall be located at definite intervals wherever necessary of the hazard warned against.



#### **7.4.6.13 Road markings**

Road markings are basically of 2 types' carriage marking and object marking. As the name implies the former type of markings are those that are applied to the road itself, the latter type covers marking on the objects such as abutments, piers, kerbs, traffic islands, culvert head walls etc.

The carriageway marking are of following category

- 1) Centre line
  - 2) Traffic lane lines
  - 3) No overtaking zone markings
  - 4) Pavement edge lines
  - 5) Carriageway width reduction transition marking
  - 6) Obstruction approach marking
  - 7) Pedestrian marking
  - 8) Stop lines
  - 9) Cyclist crossings
  - 10) Route direction arrows etc.
  - 11) Markings at approaches to intersections
  - 12) Word messages
  - 13) Parking space limits
  - 14) Bus stops
- Object markings are of the following categories
- 1) Objects within the carriageway
  - 2) Kerb marking for parking restrictions
  - 3) Objects adjacent to carriageway

#### **7.4.6.14 General Principles of Longitudinal Pavement**

Solid lines are restrictive in nature and it is an offence to cross the line, broken lines are also restrictive in nature but vehicles can cross these lines provided safety measures are taken. Double lines indicate maximum restriction.

#### **7.4.6.15 Material & Color**

##### **Material**

Thermoplastic paints applied hot shall be used as per MOST specifications. Improved night visibility shall be obtained by the use of minute glass pieces incorporated in the markings to the produce a retro reflective surface

##### **Colour**

The commonly used color for road markings is white and yellow. As per Indian practice the color of road marking is as below.

<b>Colour</b>	<b>Uses</b>
White	All Carriageway marking except those intended for parking restrictions
Yellow	i) Marking intended for parking restrictions ii) Continuous centre and barrier line markings

The different markings such as centre line, traffic lane lines, no overtaking zone marking, pavement edge lines carriageway reduction transition marking, Obstruction approach marking Pedestrian marking, stop lines, route direction arrows, markings at approaches to intersections, parking space limits etc. shall be as per IRC:35-1970 revised, specifications for road marking for paints shall be as per IS-164-1981 revised, BIS-1986. A specification for Road and Bridge works published by IRC revised upto date shall be followed.

#### **7.4.6.16 Roadway delineators**

These are intended to provide visual aide connecting the roadway alignment at night times. They are effective in locations where the horizontal and vertical geometric changes and in severe weather conditions. Generally delineators are reflectorized for better illumination. Road delineators are generally in the form of guide post of metal concrete. These shall be provided as per IRC 67-1981. The side facing the traffic should have dimension not less than 80-100cm in length. The use of road delineators in rural highway section under the following situations:

##### **i. Curve sections**

In the horizontal curve section having radius 1000m or less, and vertical curves with adequate visibility.

##### **ii. Straight sections**

In the section of roadway where there is heavy rainfall, mist, fog etc., at the side of temporary road diversion height exceeding 3m approaching to intersections.

##### **iii. Spacing**

The spacing shall be 50cm in straight sections on either side of carriageway. In curves the spacing may be reduced to 50m for a curve of 1000m radius and for a radius of 300-400m it should be 30m.

#### **7.4.6.17 Road appurtenances**

Road Appurtenances have been proposed on the project comprising of:

- (i) Hectometer stone
- (ii) Kilometer Stone
- (iii) 5<sup>th</sup> Kilometer Stone
- (iv) Boundary pillars

Although a very few of the above appurtenances still exist along the road, but many are missing. The existing ones are old, broken, and not of the standard size and shape. It is proposed to fix new hectometer, kilometer and 5th Kilometer stones along both sides of the carriageway. New boundary pillars are proposed to delineate the right-of-way. 200 meter stones shall be installed between kilometer stones for ease of maintenance planning.

Kilometer stones and 200 meter stones shall be in accordance with type, size and design as per IRC-8 and IRC-26. Boundary pillars shall be as per design and specifications given in IR

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## **CHAPTER 8: COST ESTIMATION**

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### **8.0 GENERAL**

The cost estimate for the project is extremely important as its entire viability and implementation depends on the project cost. Therefore, cost estimates and rate analysis of the items have been carried out with due care. The project cost estimates have been prepared considering various items of works associated with the identified improvements and based on the rates calculated as per standard Data Book for analysis of rates (MORTH) and assessed from current market rates and also the consultant's experience on similar works.

### **8.1 ESTIMATION**

The quantities of all the items of work for the Project road have been estimated on the basis of Pavement designs, geometric design and structural designs presented in drawings folder of Preliminary Project Report. The quantities have been calculated bill wise as detailed below:

### **8.2 SITE CLEARANCE AND DISMANTLING**

Site clearance quantity is estimated, as overall area requires clearance for construction of road. It includes necessary clearing, grubbing, dismantling and clearing of such material.

### **8.3 EARTHWORK**

Cut and fill volumes obtained with this Software are calculated between two surfaces, or Digital Terrain Models (DTMs), by projecting the triangles from the Original Surface onto the Design Surface. Volumes where the Design Surface is below the Original Surface are cut columns. Fill volumes exist where the Design Surface is above the Original Surface. The volume calculated is the exact mathematical Calculation between the two selected surfaces. Pavement Quantity: Pavement quantities have been worked out on the basis of Typical Cross sections of the road adopted along the alignment of the proposed road.

#### **8.3.1 PAVEMENT MATERIAL (FLEXIBLE)**

Pavement materials comprise of Sub base, Base courses and bituminous courses. Pavement work includes construction of new proposed two lane carriageway. The flexible pavement includes Bituminous Concrete (BC), Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM), Granular Sub base (GSB) and other related items like prime coat and tack coat etc. Overall quantities include road pavement regulations and scarifying quantities.

#### **8.3.2 Culverts**

The existing culverts which are mostly RCC Slab culverts and some are stone masonry arch culverts are old and damaged. They are proposed to be replaced with new box culverts and run through both the carriageways of standard sizes as per MORT&H.

### **8.3.3 Bridges**

There are 12 numbers of existing bridges between km 399 to km 430.

### **8.3.4 Drainage work**

Lined uncovered drain is provided in rural stretches as per requirement and quantity is calculated as per design and drawings.

### **8.3.5 Traffic Signs, Marking and Road Appurtenances**

The provisions of following road fixtures have been considered in this package:

#### **Type of structure**

- Km Stone
- Hectometre Stone
- Guard Stone
- Boundary Stone
- Information Sign Board / Direction / Destination Board
- Mandatory Signs
- Cautionary Signs
- Over Head Gantry

### **8.3.6 Land Acquisition**

Land acquisition includes provision for the additional land required to make up the proposed Right of Way (ROW). Land acquisition requirements also cover the provision of extra for widening on curves and construction of junctions and U-Turns required to accommodate the proposed 2-lane carriageway facility. Based on alignment design, land and structure acquisition cost including rehabilitation and Resettlement costs have been assessed and provided for in the cost estimate

### **8.3.7 Environmental Improvement Works**

The cost of environmental improvement works including the cost of tree cutting, re plantation, monitoring during construction including all civil and non-civil works have been included in the project cost estimate.

## **8.4 UNIT RATE**

The Analysis of Rate for the project is based on SOR, Government of Uttarakhand for block 11 Karanprayag which is Effective from 15 Sep 2018

### **8.4.1 Material Rates**

The material rates adopted are based on the rates given in Schedule of rates of Uttarakhand PWD Schedule of Rates 2004. The rates of materials, which are not given in the above noted schedule of Rates, are the market rates.

#### 8.4.2 Material Lead Charges

The average lead for different construction materials are worked out based on the sources of the materials. The lead rates (transportation) are based on the schedule of rates of Uttarakhand PWD Schedule of Rates 2004.

#### 8.5 PROJECT TOTAL COST

Grand total Project cost of construction for package No 2 is 404.77 Cr.

The summary of the project cost bill wise and the bill of quantities and their cost for the package is given in **table 8.1** below:

**Table 8.1: Summary of Cost**

Bill No.	Description	Item Price (Cr.)
1	SITE CLEARANCE	3.96
2	EARTH WORK AND DRAINAGE	30.89
3	CEMENT TREATED SUB BASE & BASE COURSE	17.48
4	SURFACE COURSES (BITUMEN)	43.04
5	TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES	18.91
6	DRAINAGE & PROTECTION WORKS	105.22
7	STRUCTURE	61.93
	<b>Total Civil Cost (A)</b>	<b>281.423</b>
	Maintenance during DLP (4 years) payable to contractor @5% of 'A'	14.07
	<b>Cost put to tender (A+B)</b>	<b>295.49</b>
	Add Contingencies over civil cost @2.80% of (A)	7.88
	Construction Supervision Charges @ 3% of (A)	8.44
	Administrative Charges @3% of (A)	8.44
	Quality Control @0.25% on 'A'	0.7
	Road Safety Cell Audit Charges @ 0.25% of 'A'	0.7
	Escalation @ 5% per annum for 1.5 years during construction payable to contractor of (A)	21.11
	Total cost of civil works including centage charges (C+D+E+F+G+H+I)	342.11
	Land Acquisition and Structure Cost	59.00
	Utility and Shifting	1.00
	<b>Total project cost (J+K+L)</b>	<b>404.77</b>

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## CHAPTER 9: ENVIRONMENTAL ASPECTS

### 9.1. ASSESSMENT OF ENVIRONMENTAL IMPACTS

While Planning and Design, Construction and Operation Stages of the project, various components of the environment has been evaluated and the road alignment has been studied thoroughly with respect to the provisions of realignment, side of widening, along the existing road alignment, requirement of bypasses, construction details, materials of construction etc., which ultimately decides the impacts during later phases. Most of the impacts are during construction and operation phases and out of all the impacts, very few are long term. Important criterion for identification of impacts is the identification of the impact zone. For present studies, a 'Corridor of Impact (COI)' based upon the GIS based model extending from one ridge line to the other ridge line of the valley and through which the road passes has been considered.

Physical environment includes; Weather Quality, Water Resources, Water Quality, Air Quality, Noise and Land Environment. The Biological Environment includes; Forest Cover, Plantation, Horticulture, Sericulture and Agricultural Environment, Wild life in all forms, their habitat and migration and associated relations with Flora and Fauna and Issues related with the Animals. Social Environment includes Rehabilitation, Employment, Agriculture, Housing, Culture etc. Reviewing the project activities and baseline conditions, the design was improved to consider environmental aspects. The impacts can be assessed both qualitatively and quantitatively. Project impacts on different environmental components are generally identified in a checklist matrix (known as Leopold Matrix also) method, which is a qualitative approach. The present trend is to quantify the impact using a common unit of measurement. This methodology called weighing scaling checklist method has been developed by a number of groups. The approach assigns some environmental components also called valued environmental components (VEC). Then it assigns importance weights to impact scales for each alternative activity relative to each environmental component. The basic concept can be expressed as:

based on the impacts on these components. Environmental components considered for assessment of impacts for this project are given in **Table – 9.1** below:

**Table – 9.1: Valued Environmental Components**

Environmental Components	Detail of Components
Physical Environment	Climate and Weather
	Air Quality
	Land Resources
	Soil Resources
	Water Resources
	Noise



Environmental Components	Detail of Components
Ecological Environment	Roadside Plantation
	Forest Cover
	Non-forest Flora
	Wildlife (Fauna)
Social Environment	Land Acquisition
	Rehabilitation
	Employment
	Housing
	Agriculture
	Culture

## 9.2. MITIGATION MEASURES:

Mitigation measures have been suggested based on environment and social criteria and also relying on best engineering practices. Besides the mitigation measures, environmental enhancement programmes have also been coincided.

## 9.3EMP

In order to mitigate the adverse effects of the proposed construction a through 'Environmental Management Plan (EMP)' has been prepared and being presented as an key to ensure that the environmental quality of the project influence area, which is subjected under impact, so that it does not deteriorate beyond the expected level due to the construction and operation of the project. The details of the operation phase have also been considered in quite a length with a number of recommendations for 'Environmental Enhancement'. The road design, construction at various levels of environmental impacts, they have been estimated in qualitative and quantitative terms and the 'Environmental Management Plan (EMP)' has been drafted in consideration of every aspect of the Design/ Pre-construction, construction and operational phases related to the environment and the environmental enhancement issues. The recommendations in the 'Environment Management Plan (EMP)' are expected to be implemented right from the conception till the commissioning and in operational phases. For the sake of implementation the plan has been divided into three phases- (a) Design Phase, (b) Construction Phase and (c) Operation Phase. An additional section on environmental enhancement has also been considered as a part of the mitigation measures.

#### **9.4. INSTITUTIONAL REQUIREMENT**

A separate environmental management group will be established to implement the management plan. The group shall be headed by an Executive Engineer and it shall ensure the suitability, adequacy and effectiveness of the Environment Management Programme. The management review process will ensure that the necessary information is collected to allow management to carry out its evaluation. This review will be documented. Besides proper implementation of EMP.

#### **9.5 TRAINING**

Training is of much importance in the environmental management. Environmental management is a developing subject and the people implementing environmental strategies should remain update with the environmental control processes. Besides in absence of environmental awareness, the implementing engineers and workers will not be able to implement the mitigation measures properly. This group will arrange environmental engineers to train the construction engineers and supervising engineers on implementation of environmental measures. Contractors' personnel should also be given training.

#### **9.6 DOCUMENTATION**

Documentation of the environmental activities is one of the important steps in Environment Management Plan. All monitoring activities details, results, standards, statutory requirements documents, plantation details, equipment performance, road activities related to environment etc. will be documented in a proper manner so that the relevant information are quickly available as required.

The documentation will include:

- Major technical information in road construction and operation (Similar to the process information for a manufacturing unit)
- Organizational Charts
- Environmental Monitoring Standards
- Environmental and related legislation
- Operational Procedure
- Monitoring Records
- Complaint Records
- Training Records
- Incident Records
- Quality Assurance Plan for Monitoring
- Emergency Plans

## **9.7. DOCUMENTATION CONTROL**

Documentation Control is very important and it reviews of the management programme. Main elements of document control are;

- Accessibility: They must be assessable and can be easily located. General Manager (Environment) of National Highway Authority of India (NHAI) will decide the locations for each document. Some of the documents will be at a number of places at a time but those locations will be mentioned. Environmental Monitoring standards and 'Quality Assurance Plan' should be available at project site officers as well as at the headquarter.
- They will be periodically reviewed, revised as necessary and approved for adequacy by authorised personal.
- Current versions of relevant documents are available at all the locations where operations essential to the effective functioning of the system are performed.
- Obsolete documents will be promptly removed of all points of issues and points of use or otherwise will be assured against unintended use.

## **9.8. ENVIRONMENTAL COST**

A budgetary cost estimated for the environmental management activities is presented in Summary of cost. Environmental mitigation measures which are part of engineering activities such as slope stabilization, road construction in bypasses or implementation of air pollution control I crusher etc. are not included in this estimate.

## **9.9. ENVIRONMENTAL CLEARANCE**

In accordance to the Environmental Impact Assessment Notification, 1994 under Environment (Protection) Act, 1986 the 'Environmental Clearance' for the project is issued, for which the project proponent is required to make an application through the Specified Performa, accompanying the 'Environmental Impact Assessment (EIA) Report/Environmental Management Plan' prepared in accordance with the guidelines issued by Ministry of Environment and Forest The notification in Schedule-I of the Environmental Impact Assessment Notification, 1994 lists 30 categories of projects which require preparation of the 'Environmental Impact Assessment Report (EIA) and Environmental Management Plan Report', for the clearance from MoEF if the investment is more than Rs. 1000 million for the project. The EIA application also requires 'No Objection Certificate (NOC)' from respective 'State Pollution Control Board', Public Hearing at district level is also requited and these are conducted by respective 'State Pollution Control Board'. There is no specific environmental act or law exclusively governing road and highway projects. However the item no.21 of 'Schedule-I' of the 'EIA Notification' specifies that any highway project needs environmental clearance from the central government in the form of an approved EIA. In April 1997, a notification was issued by MoEF amending Schedule-I of the EIA Notification, 1994 which lists projects requiring Environmental Clearance. The April, 1997 notification amended Item 21 of the Schedule and stated;

“Environmental clearance by MoEF is not required for highway projects relating to improvement work including widening and strengthening of roads with marginal land acquisition along the existing alignments provided and which do not pass through ecologically sensitive area such as National Parks, Wildlife Sanctuaries, Reserve Forest and Project Tiger Sites.

Since in the present case the land acquisition is not marginal the project will require environmental clearance from MoEF, GoI. According to the latest notification of MoEF on June 13, 2002, “the public hearing shall be conducted in each district through which the highway passes”.

In the present project following clearance will be required for environmental clearance;

1. Forest clearance from Ministry of Environment and Forest, Uttarakhand
2. Public Hearing Reports Conducted by Uttarakhand Pollution Control Board
3. No Objection Certificate from Uttarakhand Pollution Control Board
4. No Objection/ Document Listing the Concerns of Wildlife in relation to the project.
5. Environmental Clearance from Ministry of Environment and Forest, Government of India.

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## CHAPTER 10: ECONOMIC AND FINANCIAL ANALYSIS

### 10.1 General

The financial analysis has been carried out based on Consultant's knowledge of the subject and considering most realistic values. The assumptions made for the financial analysis of the project and the key project financials are summarized in the subsequent sections.

### 10.2 Basic Assumptions

#### 10.2.1 Construction Phasing

It has been considered that the project can be completed in two and half year time and the annual completion schedule is as follows:

**Table 10.1: Annual completion schedule**

Project Cost (in INR Lakhs)	2014-15	2015-16	2016-17
Phasing	20%	40%	40%

### 10.3 Project EPC Cost

For the purpose of this analysis, four scenarios have been considered for project cost which includes different EPC cost of the project. The scenarios are discussed in **Table 10.2** below:

**Table 10.2: Scenarios for project cost**

Project Cost (in INR Lakhs)	2014-15	2015-16	2016-17	Total
Phasing	20%	40%	40%	100%
Improvement on existing alignment	26,701.40	53,402.80	53,402.80	133,507.00

For the purpose of this study, the analysis has been carried out for three above options for improvement of project road.

### 10.4 O&M Cost

The operations and maintenance cost which has been assumed for the project is presented in the **Table 10.3** below:

**Table 10.3: Operations and maintenance cost**

O&M Cost (in INR Lakhs) in Year 2014-15	All Options
Actual O&M Cost (per km)	
Routine Annual Maintenance	4
Periodic Maintenance	30

## 10.5 Project Related Assumptions

The assumptions for performing the financial analysis are summarized in the **table 10.4** below:

**Table 10.4: Assumptions for performing the financial analysis**

<b>Concession Period (years)</b>	<b>30</b>
Project Construction period	2.5 years
Project Operations date	1 March 2018
Road Length (km)	28.8

## 10.6 Schedule of user fee

As per Schedule of user fee, the fee per km of highway as applicable as per The Gazette of India (Extraordinary) published on 12<sup>th</sup> January 2011 by MORT&H and is given in Table below. The revisions are done using the prescribed method using wholesale price index (WPI). The toll shall be rounded off to the nearest Rs 5. As per notification, the rate of fee for use of section of Highway is provided in table presented in **table 10.5** below:

**Table 10.5: Rate of fee for use of section of Highway**

<b>Type of Vehicles</b>	<b>Base rate of fee in 2010-11</b>
	<b>(in Rs per Km)</b>
Car, Jeep, Van, Light Motor Vehicle, Three Wheeler, or Tractor with trolley carrying non-agricultural, produce	0.65
Light Commercial Vehicle, Light Goods Vehicle or Mini Bus	1.05
Bus or truck	2.2
Heavy Construction Machinery (HCM) or Earth Moving equipment (EME) or Multi Axle Vehicle, (MAV), three to six axles	3.45
Oversized Vehicles (seven or more axles)	4.2

The rates specified in the table above are to be annually increased by 3% with additional increase of 40% of the increase in the WPI for the duration. The first revision has to be done on 1 April 2011 and at the same date every consecutive year. The increased rate after adjustment as per the WPI shall be deemed to be the base rate for the subsequent years, from 2011.

## 10.7 Base Rate for Structures

As per the notification, the arrived rate of fee for use of structures forming the part of Highway shall be as follows.

**Table 10.6: Base Toll Rate for Structures (rupees per vehicle per trip) - 2010-11**

	Car, Jeep, Van, Three Wheeler or Light Motor Vehicle	Light Commercial Vehicle Light Goods Vehicle or Mini bus	Truck or Bus	HCM, EME, or MAV	Oversized Vehicle
10 to 15	5	7.5	15	22	30
For every additional rupees five Crore or part thereof, exceeding rupees seven point five Crore and up to rupees on hundred Crore.	1	1.5	3	4.5	6
For every additional rupees five Crore or part thereof, exceeding rupees hundred Crore and up to rupees two hundred Crore.	0.75	1.15	2.25	3.4	4.5
For every additional rupees five crore or part thereof, exceeding rupees two hundred Crore.	0.5	0.75	1.5	2.25	3

Further, it has been provided in the notification that if the structure forms part of a highway where toll is being collected for the use of the highway, the base rate for the structures has also been escalated through the same methodology as was used for the highway toll rate.

### 10.8 Applicable Toll Rates

The toll rates arrived for the year 2017-18 for Option 1 and Option 2 is provided in the **table 10.7** below:

**Table 10.7: Toll rates for the year 2017-18 for Option 1 and Option 2**

Mode	Toll Rate
Car	160.00
Mini Bus	255.00
Bus	535.00
LGV	255.00
2T	535.00
3T	830.00
MAV	830.00
Heavy Comm Veh	1030.00
ML	240.00



The toll rates arrived for the year 2017-18 for Option 3is provided in the **table 10.8** below:

**Table 10.8: Toll rates arrived for the year 2017-18 for Option 3**

Mode	Toll Rate
Car	195.00
Mini Bus	310.00
Bus	640.00
LGV	310.00
2T	640.00
3T	990.00
MAV	990.00
Heavy Commercial Vehicle	1240.00
ML	275.00

## 10.9 Financial Results

Based on the assumptions regarding the financial analysis elaborated above as well as the toll rates arrived at from the Gazette, the results of the financial analysis is presented in the **table 10.9** below:

**Table 10.9: Results of the financial analysis**

Urban Areas	FIRR	Hurdle Rate	Viability
Recommended alignment	2.22%	14%	Financially Non-Viable

## 10.10 Financial Feasibility for the project

As elaborated above, the results of the projects are not attractive to explore the possibility of performing the project on PPP model. The guidelines issued by Government of India specify that a return of 14% is needed for taking up a project on PPP basis.

## 10.11 Economic Analysis

The Economic analysis of the various options have been undertaken with an objective to evaluate the contribution of proposed highway to social objectives and to the economy. In order to assess economic viability, economic benefits and costs associated with the project have been identified to the extent possible. The “With Project” scenario is compared with the option of “Without project scenario” to determine the economic benefits.

## 10.12 Methodology for Economic Analysis

As a first stage of the methodology adopted for performing the economic and social benefits of the proposed up-gradation of the NH, a long list of benefits of the project has been prepared and then later classified as “Quantifiable Benefits” and “Non Quantifiable Benefits”. The summary of the benefits and their further classification is presented in the **table 10.10** below:

**Table 10.10: Summary of the benefits and their further classification**

Benefits	Quantifiable Benefits	Non Quantifiable Benefits
<b>Savings in VOT</b>	√	
<b>Savings in VOC</b>	√	
<b>Savings due to pollution reduction</b>	√	
<b>Savings due to accidents reductions</b>	√	
<b>Economic Impetus to micro region</b>		√
<b>Overall increased mobility</b>		√
<b>Better urban planning</b>		√
<b>Benefits to City Image</b>		√
<b>Better access to workplace</b>		√
<b>Indirect health benefits of Reduce Pollution to Population living adjacent to highway</b>		√

The total economic cost is subtracted from the total benefits to estimate the net benefit of the project. Discounted Cash Flow (DCF) technique has been used to determine the economic viability of the project. Detailed methodology and approach are described in subsequent sections. Final section discusses the economic viability of the project under the different sensitivity tests.

The economic viability of the project has been carried out using the social cost benefit analysis approach and Discounted Cash Flow (DCF) technique. The financial project cost has been determined using the market prices. The economic project cost has been computed by applying appropriate conversion factor to the financial project cost. This has been done to remove distortion due to externalities and anomalies in market pricing system so as to arrive at true cost to economy. The detailed discussion pertaining to economic project cost is specified in economic cost section. The project benefits have been computed through comparison of costs arising out of “With project” and “Without Project” scenario. For instance, in without project scenario, the economic costs incurred by the economy due to queuing of vehicles, wastage of fuel, emission of the pollutants to the environment, loss in time due to stoppage etc. Therefore, the economic benefits would arise due to savings in cost that would accrue to the economy by moving the project traffic to the highway. These savings in social costs have also been considered to the extent that they are quantifiable. These social benefits have been computed based on economic prices instead of market prices. Shadow prices have been used to arrive at the economic costs/benefits.

The annual streams of economic costs and benefits have been computed for analysis period of 30 years. Economic viability has been undertaken using the Discounted Cash Flow (DCF) technique to obtain the economic internal rate of return (EIRR) and Net Present Economic Benefits (NPEB) for the proposed project. This is followed by a ‘sensitivity analysis’ by increasing or decreasing the critical factors affecting the cost and benefit streams of the proposed project, in order to ascertain their effect on the economic feasibility indicators i.e. EIRR, NPEB.

### 10.13 Estimation of Economic Project Cost of highways

The Economic Project Cost of the project is calculated from the financial project cost on the following basis:

1. On capital cost sides, subsidies and market distortion including foreign exchange distortions are difficult to evaluate. Therefore, the practice is to apply an overall Conversion Factor (CF) to cost figures to eliminate all possible distortions including foreign exchange distortions if applicable. ADB projects in the past have used in India a conversion factor (CF) equal to 0.90. Hence to eliminate all possible distortion owing to subsidies, wages of labourers and foreign exchange distortion, conversion factor equal to 0.9 have been used to arrive at Economic project cost.
2. Tax components are excluded from the financial project cost as it represents transfer payments.
3. Interest during Construction (IDC) has been excluded from the financial cost.

The development of highway project has been proposed in two and half years. The proposed phasing of construction is explained in the **Table 10.11** below:

**Table 10.11: OPTION 1**

Project Cost (in INR Lakhs)	2014-15	2015-16	2015-16	Total
Phasing	20%	40%	40%	100%
Total Project Cost including Contingencies	8,848.20	17,696.40	17,696.40	44,241.00
Total Project Cost including Escalation Charges	8,404.60	16,809.20	16,809.20	42,023.00
Total Economic Cost of Project (@90%)	9,210.40	18,420.80	18,420.80	46,052.00

A factor of 0.9 has been applied for arriving at economic project cost of the project.

### 10.14 Estimation of Economic cost of Operation and Maintenance

The conversion factor equal to 0.9 is applied to arrive at economic O&M estimates. This owes to adjust the market prices for transfer payments Economic cost of Operation and Maintenance of highway are summarized in **table 10.12** below:

**Table 10.12: Market prices for transfer payments Economic cost of Operation and Maintenance of highway**

O&M Cost (in INR Lakhs) in Year 2014-15	
<b>Actual O&amp;M Cost</b>	
<b>Routine Annual Maintenance</b>	5.00
<b>Periodic Maintenance</b>	30.00
<b>Economic O&amp;M Cost (@ 90%)</b>	
<b>Routine Annual Maintenance</b>	4.50
<b>Periodic Maintenance</b>	27.00

The per km cost of routine operation and maintenance and periodic maintenance has been assumed at INR 5 lakh per km per annum and INR 30 lakh per km per annum across all the proposed highway.

### 10.15 Vehicle Operating Time

The highway will provide a clear access to road vehicle which are presently using a dilapidated and narrow road stretches. This will lead to considerable saving in time of passenger travelling on this road. The savings of travel time of passenger is calculated as follows:

$$\text{Passenger Time Savings} = (\text{Time taken by Passenger on existing road} - \text{Time taken by passenger on improved highway}) \times \text{Value of Passenger time}$$

With the construction of the highway, the time savings can be categorized into two:

1. There is a considerable increase in the running speed and the journey speed of the vehicle.
2. With the construction of the bypasses and viaduct sections along the stretch, the delays which were happening at various difficult terrains and urban areas can be completely removed and this can result in the saving time of the road users.

The table below provides the time saving which can be achieved post construction of the highway:

Reduction in Travel Time (in Minutes)	Option 1
Reduction in Travel Time due to increased speed	120
Increase in Travel Time due to increase length	0

The anticipated savings which can be achieved post construction of the highway for different categories of the vehicle is presented in the **table 10.13** below:

**Table 10.13: Anticipated savings for different categories of the vehicle**

IRC SP 30 – July 2007	Two Wheelers	LCV/3W	Cars	Buses/ Trucks
Value of Time (VOT) Rs/hr	35.00	40.00	60.00	20.00
<b>At 2014 Prices with escalation @ 5% per annum</b>				
Value of Time (VOT) Rs/hr	49.25	56.28	84.43	28.14

As shown in the table above, a saving of INR 49.25, INR 56.28, INR 84.43 and INR 28.14 can be achieved for two wheelers, three wheelers, cars and buses/trucks respectively can be achieved.

### 10.16 Vehicle Operating Cost

The Special Publication of IRC SP 30 suggest that there is a saving in the Vehicle Operating Cost (VOC) which includes savings in the operations and maintenance of the vehicles, cost of Tyres, cost of accessories, replacement of spare parts etc. the suggestions made by IRC for the VOC is presented in the **table 10.14** below:

**Table 10.14: Suggestions made by IRC for the VOC**

IRC SP 30 - July 2007	Two Wheelers	Three Wheelers	Cars	Buses/ Trucks
Vehicle Operating Cost (VOC) Rs/km	1.35	1.75	2.25	11
Speed Assumed for the vehicles	35	40	60	20

At 2014 Prices assuming an escalation of 5% per annum				
Vehicle Operating Cost (VOC) Rs/hour	56.99	61.56	110.81	386.95

The IRC provides for the VOC per running kilometers of the vehicle. An average speed of 35 kmph, 40 kmph, 60 kmph and 20 kmph has been assumed for Two Wheelers, Three Wheelers/LCV, Cars, Buses/Trucks to convert the per kilometer VOC to per hour VOC. A VOC of INR 56.99 per hour and INR 61.56 per hour have been calculated for Two Wheelers and Three Wheelers/LCV respectively. A VOC of INR 110.81 per hour and INR 386.95 per hour have been calculated for Cars and Buses/Trucks respectively.

### 10.17 Fuel Cost Savings

The third impact of the reduction in the journey time as well as the waiting time of the vehicles is on the reduction in the fuel cost. The time savings is presented in a table in the previous section. The assumptions made regarding the cost of the fuel is presented in the **table 10.15** below:

**Table 10.15: Assumptions made regarding the cost of the fuel**

Cost of Fuel	Petrol	Diesel
2013	77	62

The cost of petrol is about INR 77 as per the prevailing rates in Panipat, Haryana and the cost of diesel has been assumed as INR 62 in year 2014. The escalation of the fuel prices has been done at the rate of 5% per annum to arrive at the rates in the future years.

### 10.18 Savings due to Reduction in Carbon Emission

With the reduction in the journey time of the vehicles on the project section, another economic saving is in the reduction of the carbon emitted due to fuel combustion. The vehicles idling at the urban areas in the queue as well as the reduction in the overall journey time, both result in the reduction of fuel cost.

Considering the above potential, United Nations Framework Convention for Climate Change (UNFCCC) approved methodology has been used to estimate the possible carbon emission reduction. This methodology has been stipulated by UNFCCC under the possible financing through Clean Development Mechanism (CDM). Based on above Methodology, Carbon finance i.e. Monetization of emission reduction is calculated as follows:

**Carbon Finance** = Emission Reduction from highway Project x Price of per tonnes of CO<sub>2</sub>  
**Emission Reduction from Project:** Baseline Emission (In without project, BAU) - Project Emission (Direct Project Emission + Indirect Project Emission)

The price of per tonnes of CO<sub>2</sub> is considered as Rs 1,000, which was is an average carbon trading price in spot market in European Energy Exchange. In order to estimate baseline emission, emission per kilometer run of each vehicle category has been estimated. Default vehicle technology improvement factor of 0.99 as stipulated under the UNFCCC methodology has been used to arrive at year wise emission factor of each vehicle category. Following **table 10.16** present the estimate of the CO<sub>2</sub> emission due to combustion of petrol and diesel:

**Table 10.16: Estimate of the CO<sub>2</sub> emission due to combustion of petrol and diesel**

	Petrol	Diesel
Carbon Emission (Tonnes per litre of fuel combustion)	0.0023	0.0027
Cost per ton of CO <sub>2</sub> (in Rs per tonnes)	1,000	

#### 10.19 Savings due to Reduction in O&M cost of existing Road

With the construction of the highway, the O&M cost required to be incurred on the existing road is not required to be made. Thus there will be a saving in O&M cost of the existing road. The O&M cost which will be required for the old road stretch is assumed as INR 1 Lakh per annum.

#### 10.20 Outcome of the Economic Viability

As discussed in previous sections, the cost and benefits streams for the thirty year period in economic prices have been estimated. Further, the Discounted Cash Flow (DCF) technique has been used to obtain the economic internal rate of return (EIRR) and Net Present Economic Benefits (NPEB). The present values of the savings which has been calculated for the four options are presented in the **table 10.17** below:

**Table 10.17: The present values of the savings which has been calculated for the four options**

(in INR Lakh)	Option 1
Value of Time	40017.76
Vehicle Operating Cost	63093.45
Fuel Cost Savings	37367.90
Emission Reduction Savings	569.22
Maintenance of Old Road	1,484.67

The economic viability of the highway is presented in the **table 10.18** below:

**Table 10.18: Economic viability of the highway**

Urban Areas	EIRR	Hurdle Rate	Viability
Option 1	14.06%	12%	Economically Viable

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## CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

### 11.1 GENERAL

The preceding Chapters of this report dwell on the various aspects of the study carried out by the Consultants for the two laning with Paved. The status of the project road, the surveys carried out, the proposals, findings of the technical evaluation of widening proposals and the recommendations are summarized in this chapter.

### 11.2 PROJECT ROAD.

The road pavement condition has been surveyed and investigated. The pavement condition in carriageway portion is generally fair. The shoulders are damaged at many places. It has been observed that the condition of the pavement is unable to cope up with the current traffic loading. The geometric of the project road is poor. The terrain along the highway is generally mountainous /steep. There are 12 minor bridges and 85 culverts exist in the package road. The conditions of the culverts are poor.

### 11.3 IMPROVEMENT PROPOSALS

The road upgrading proposals are based on the findings of the detailed field studies, investigation and testing. Various engineering alternatives were considered. The proposals cover strengthening of existing pavement and construction of additional two lanes, side and cross drainage structures. The design standards have been formulated for design speed of 20-30 km/h, in general. A carriageway of 7.0 m with 1.0m paved shoulder on either side of the median is proposed. Most of the existing culverts are damaged and therefore reconstruction is proposed. For strengthening the existing carriageway, minimum 250 mm WMM has been proposed, prior to DBM and BC overlays.

### 11.4 PROJECT COST

The cost of widening to four lanes including strengthening of existing two lanes, and cross drainage works, social settlement, and shifting of utilities costs, etc. have been worked out at current rates. The total cost of this stretch works out to Rs. 404.77 Cr

### 11.5 RECOMMENDATIONS

Based on the assumptions regarding the financial analysis elaborated in the relevant chapters as well as the toll rates arrived at from the Gazette, the results of the financial analysis is presented in the **table 11.1** below:

**Table 11.1: Financial Analysis**

Urban Areas	FIRR	Hurdle Rate	Viability
Recommended alignment	2.22%	14%	Financially Non-Viable

As elaborated above, the results of the projects are not attractive to explore the possibility of performing the project on PPP model. The guidelines issued by Government of India specify that a return of 14% is needed for taking up a project on PPP basis.

The economic viability of the highway is presented in the **table 11.2** below:



**Table 11.2: Economic Analysis**

<b>Urban Areas</b>	<b>EIRR</b>	<b>Hurdle Rate</b>	<b>Viability</b>
Option 1	14.06%	12%	Economically Viable

From the above result it can be seen that the project EIRR is worked out 14.06% which shows that project is economically viable and it is proposed to be taken in EPC mode.