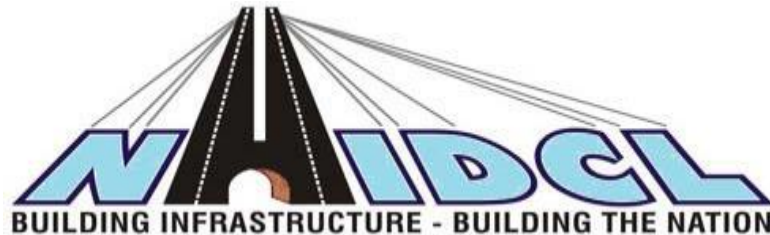


**National Highways & Infrastructure Development Corporation Limited**

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



**Construction and Upgradation of existing road to 2-lane with paved shoulder from Km 368.000 to Km. 399.000 of Lameri to Karaprayag (Excluding Km 379.100 to Km 380.275 of NH-07 under Chardham Pariyojna on EPC basis in the state of Uttarakhand. (Pkg-I)**

## **Detailed Project Report**

**January, 2018**

**NHIDCL, 3<sup>rd</sup> Floor, PTI Building, 4, Parliament Street, New Delhi – 110 001**



## Table of Contents

<b>CHAPTER 0. EXECUTIVE SUMMARY .....</b>	<b>1</b>
E.1 INTRODUCTION.....	1
E.2 PROJECT ROAD .....	1
E.3 PROJECT TERRAIN .....	3
E.4 LAND USE.....	3
E.5 RIGHT OF WAY .....	3
E.6 PAVEMENT .....	5
E.7 HORIZONTAL ALIGNMENT .....	5
E.8 VERTICAL ALIGNMENT .....	7
E.13 HORIZONTAL ALIGNMENT .....	8
E.14 VERTICAL ALIGNMENT .....	9
E.15 WIDENING SCHEME.....	9
E.16 IMPROVEMENT PROPOSAL .....	13
E.17 MATERIALS .....	13
E.18 PAVEMENT DESIGN .....	13
E.19 PROPOSAL FOR BRIDGES .....	13
E.20 CULVERTS .....	13
E.21 REALIGNMENT .....	14
E.22 ROAD APPURTENANCES .....	14
E.23 ENVIRONMENTAL AND SOCIAL ASPECTS: .....	14
E.24 SUMMARY OF COST ESTIMATES .....	15
<b>CHAPTER 1. PROJECT BACKGROUND.....</b>	<b>17</b>
1.1 GENERAL.....	17
1.2 PROJECT LOCATION .....	17
1.3 OBJECTIVE .....	19
1.4 SCOPE OF PROJECT SERVICES .....	19
1.5 CONTRACT PACKAGES .....	22
1.6 PROJECT ROAD DESCRIPTIONS.....	22
<b>CHAPTER 2. SOCIAL BACKGROUND AND DEMOGRAPHIC FEATURES.....</b>	<b>26</b>
2.1 PROJECT INFLUENCE AREA .....	26
2.2 ECONOMIC .....	26
2.3 INFRASTRUCTURE .....	29
2.4 TOURISM .....	30
<b>CHAPTER 3. ENGINEERING SURVEYS AND INVESTIGATIONS.....</b>	<b>32</b>
3.1 GENERAL.....	32
3.2 PRELIMINARY SURVEYS & INVESTIGATIONS.....	32
3.3 RECONNAISSANCE SURVEY .....	32
3.4 ROAD INVENTORY .....	32
3.5 ROAD AND PAVEMENT CONDITIONS SURVEY .....	36
3.6 MATERIAL INVESTIGATIONS AND SURVEYS .....	36
3.7 TOPOGRAPHICAL SURVEYS .....	37
3.8 PAVEMENT SURVEYS AND INVESTIGATIONS .....	38
3.9 HYDROLOGICAL INVESTIGATIONS .....	39
3.10 CONDITION SURVEY OF BRIDGES & STRUCTURES .....	39
3.11 TRAFFIC SURVEYS .....	40

<b>CHAPTER 4. ANALYSIS AND INTERPRETATION OF SURVEY &amp; INVESTIGATIONS .....</b>	<b>43</b>
4.1 GENERAL.....	43
4.2 IMPROVEMENT / CONSTRUCTION PROPOSALS .....	44
4.3 PAVEMENT.....	46
4.5 CULVERTS.....	47
4.6 ROAD SIDE DRAINAGE.....	48
4.7 RETAINING STRUCTURES AND SLOPE PROTECTION WORKS .....	48
4.8 TRAFFIC CONTROL AND SAFETY MEASURES .....	48
4.9 TRAFFIC MANAGEMENT .....	50
<b>CHAPTER 5. TRAFFIC SURVEY &amp; FORECAST .....</b>	<b>52</b>
5.1 APPRECIATION OF THE PROJECT CORRIDOR .....	52
5.2 TRAFFIC SURVEYS .....	54
5.3 TRAFFIC VOLUME CHARACTERISTICS .....	67
5.4 TRAFFIC VOLUME PROJECTIONS .....	72
<b>CHAPTER 6. DESIGN STANDARDS .....</b>	<b>74</b>
6.1 GENERAL .....	74
6.2 GEOMETRIC DESIGN.....	74
6.3 JUNCTIONS.....	83
6.4 PROPOSED TYPICAL CROSS SECTION .....	83
6.5 ROAD AESTHETICS AND LANDSCAPING .....	85
6.6 ROAD SIDE DRAINAGE.....	85
6.7 PAVEMENT DESIGN .....	85
6.8 DESIGN STANDARDS FOR BRIDGES AND OTHER STRUCTURES .....	86
6.9 ENVIRONMENTAL AND SOCIAL ASSESSMENT .....	86
6.10 SPECIFICATIONS.....	87
<b>CHAPTER 7. IMPROVEMENT PROPOSAL.....</b>	<b>88</b>
7.1 GENERAL.....	88
7.2 DESIGN STANDARDS AND METHODOLOGY FOR ROADS .....	88
7.3 PROPOSAL OF STRUCTURES .....	138
7.4 PROJECT FACILITIES .....	156
<b>CHAPTER 8. COST ESTIMATION .....</b>	<b>164</b>
8.1 GENERAL.....	164
8.2 ESTIMATION OF QUANTITIES.....	164
8.3 SITE CLEARANCE AND DISMANTLING .....	164
8.4 EARTHWORK.....	165
8.5 UNIT RATE.....	166
<b>CHAPTER 9. ENVIRONMENTAL ASPECTS .....</b>	<b>168</b>
9.1. ASSESSMENT OF ENVIRONMENTAL IMPACTS .....	168
9.2. MITIGATION MEASURES: .....	169
9.3. ENVIRONMENTAL MANAGEMENT PLAN (EMP).....	169
9.4. INSTITUTIONAL REQUIREMENT – CAPACITY BUILDING .....	171
9.5 TRAINING .....	171
9.6 DOCUMENTATION .....	171
9.7. DOCUMENTATION CONTROL.....	171
9.8. ENVIRONMENTAL COST .....	171
9.9. ENVIRONMENTAL CLEARANCE .....	171
<b>CHAPTER 10. ECONOMIC AND FINANCIAL ANALYSIS.....</b>	<b>173</b>

10.1 GENERAL.....	173
10.2 BASIC ASSUMPTIONS .....	173
10.3 PROJECT EPC COST .....	173
10.4 O&M COST.....	173
10.5 PROJECT RELATED ASSUMPTIONS .....	174
10.6 SCHEDULE OF USER FEE.....	174
10.7 BASE RATE FOR STRUCTURES .....	174
10.8 APPLICABLE TOLL RATES .....	175
10.9 FINANCIAL RESULTS .....	176
10.10 FINANCIAL FEASIBILITY FOR THE PROJECT .....	176
10.11 ECONOMIC ANALYSIS.....	176
10.12 METHODOLOGY FOR ECONOMIC ANALYSIS .....	176
10.13 ESTIMATION OF ECONOMIC PROJECT COST OF HIGHWAYS .....	178
10.14 ESTIMATION OF ECONOMIC COST OF OPERATION AND MAINTENANCE.....	178
10.15 VEHICLE OPERATING TIME .....	179
10.16 VEHICLE OPERATING COST .....	179
10.17 FUEL COST SAVINGS .....	180
10.18 SAVINGS DUE TO REDUCTION IN CARBON EMISSION .....	180
10.19 SAVINGS DUE TO REDUCTION IN O&M COST OF EXISTING ROAD .....	181
10.20 OUTCOME OF THE ECONOMIC VIABILITY .....	181
<b>CHAPTER 11. CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>182</b>
11.1 GENERAL.....	182
11.2 STATUS OF THE PROJECT ROAD .....	182
11.3 IMPROVEMENT PROPOSALS.....	182
11.4 PROJECT COST.....	182
11.5 RECOMMENDATIONS.....	182

## 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-I 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 139.604 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
5a	Km 489.350-Km 491.600	Km 471.400-Km 473.675	Shingdhar Bridge to Vishnuprayag bridge	Widening to 2-lane with Paved Shoulder	2.275

Pkg no.	Existing Chainage	Design Chainage	Section Description	Provision	Design Length (in km)
			including 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-I the Design length of the road in this package is 29.125 km i.e from km 368.00 to 398.300 of Lameri to Karanprayag(Excluding km 379.100 to km 380.275) NH-07 (Old NH-58) under chardham pariyojna 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:

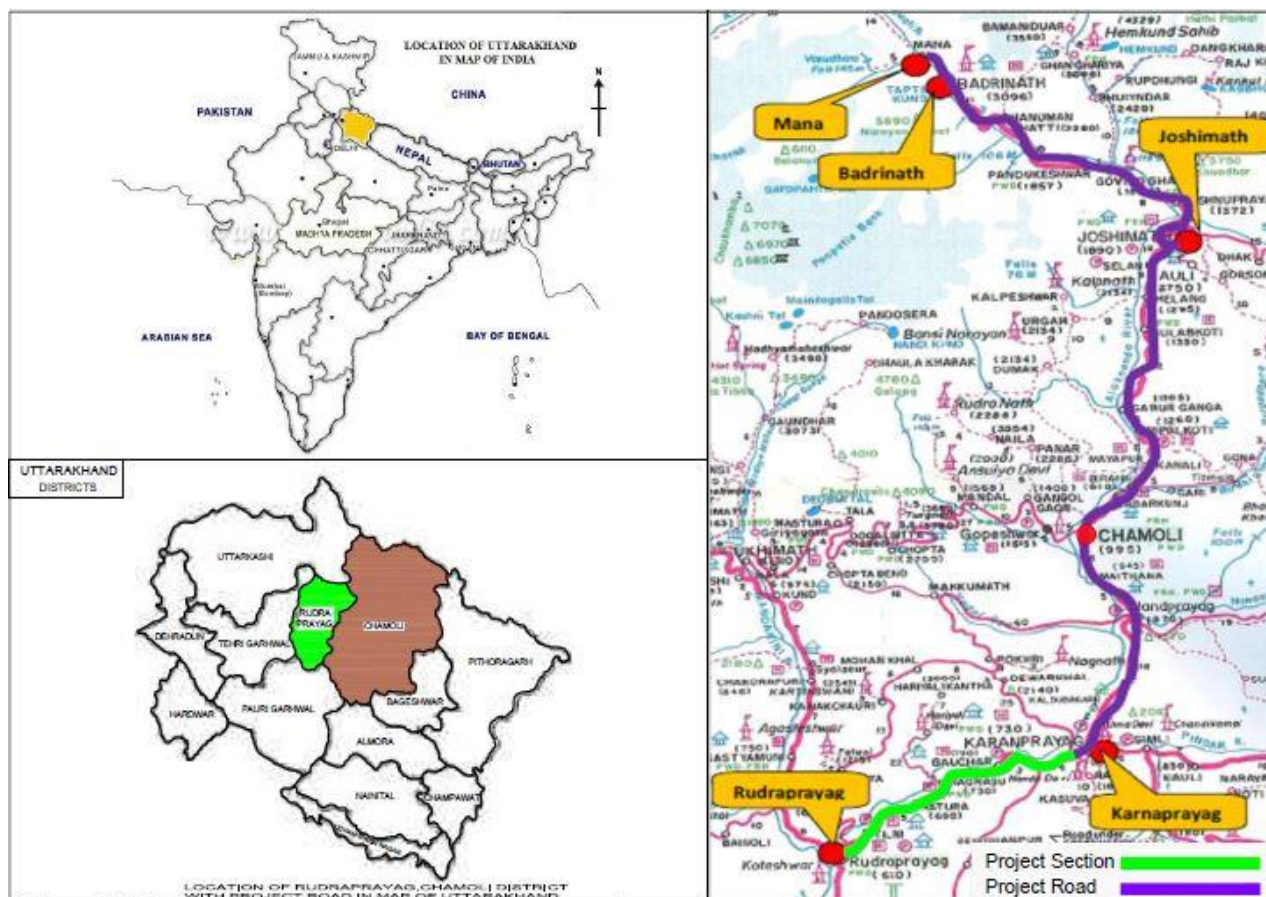


Fig. 1.1

### 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

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	Treated RAP/BSM	100
3	CT Sub Base	200
<b>Total</b>		<b>340</b>

## 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 and shown in Fig. 6.2 enclosed in the chapter-6 of this report.

**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	8 Hours	Karanprayag, Leads to Almora	398.600
		Karnprayag (Leads to Ranikhet)	399.000

Type of Survey	Duration	Location	Chainage (Km)
Survey		Nandprayag (Leads to Ghat)	418.800
		Chamoli (Leads to Gopeshwar – SH- 36)	430.800
		Joshimath (Leads to Auli)	478.800
Pedestrian Traffic Count	8 Hours	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 1.8:

**Table 1.8 Growth Rate**

Vehicle Type/Year	Trend Based			Econometric Method		
	2014-2019	2019-2024	2024-2029	2014-2019	2019-2024	2024-2029
<b>Car, Jeep, Vans etc</b>	1.940	2.136	2.351	6.94	7.63	8.39
<b>Motor cycle Scooters</b>	1.420	1.523	1.635	7.98	8.78	9.66
<b>LCV</b>	1.000	1.050	1.105	5.96	6.56	7.22
<b>Buses</b>	1.000	1.050	1.105	5.30	5.83	6.41
<b>2-Axle, Multi Axle Truck</b>	0.300	0.305	0.310	5.96	6.56	7.22
<b>Non-Motorised Vehicles</b>	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 Table 1.9 below:

**Table 1.9 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 6.1of Volume-I (Appendix Volume to Main Report) and presented in the table 1.10 below:

**Table 1.10 Projected Traffic per Year**

Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LC V	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	10627	262	593	516	1310	116	18773	20700
2040	5866	11519	281	632	554	1405	125	20382	22378
2041	6433	12486	302	673	594	1508	135	22131	24197
2042	7055	13534	324	717	637	1618	145	24030	26161
2043	7737	14670	348	763	683	1736	156	26093	28284
2044	8485	15901	374	812	733	1862	168	28335	30582

From Table 1.10 above it can be inferred that the project road requires 2laning 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/h for hilly/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.

#### 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. The standard so evolved is tabulated in table 1.5 given below:

**Table 1.11: 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	HillSide	Valley Side	HillSide	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)	Superelevation (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 superelevation</b>	m	1 in 60	
8	<b>Intersections</b>			
i)	<i>Minimum length of acceleration lane</i>	m	60m	
ii)	<i>Minimum length of deceleration lane</i>	m	70m	
iii)	<i>Minimum radius for left turn</i>	m	20m	
iv)	<i>Minimum radius for right turn</i>	m	15m	
v)	<i>Width of turning lane (inner radius of 30 m)</i>	m	4.5m	
vi)	<i>Rate of taper (min)</i>	m	1 in 15	
9	<b>Bus-shelters</b>			
i)	<i>Min. length of busbay</i>	m	15 m	
ii)	<i>Maximum length of pedestrian guard rail on either side of the busbay</i>	m	22 x 2 m	
10	<b>Truck Laybye</b>			
i)	<i>Min length of laybye</i>	m	100m	
ii)	<i>Min parking length for each vehicle</i>	m	15m	
iii)	<i>Min parking width for</i>	m	2.75m	

S. No.	Description	Unit	Proposed Standards	
			Mountainous	Steep
	<i>each vehicle</i>			
iv)	<i>Min. width of raised separator between laybye and carriageway</i>	m	1m	
v)	<i>Rate of taper (min)</i>	m	1 in 10	
<b>11</b>	<b>Safety barriers</b>			
i)	<i>Bridge approaches and high embankments</i>	m	3m and above	
<b>12</b>	<b>Clearance for Utility Lines</b>			
A)	Horizontal		As per IRC 32-1969	
i)	<i>Street lighting poles</i>	m	1.5m min from edge of carriageway	
ii)	<i>Overhead power and telecommunication lines</i>	m	10m min. from edge of roadway	
B)	Vertical		As per IRC 32-1969	
i)	<i>Ordinary wires/lines carrying voltage upto and including 110 volts and telecommunication lines</i>	m	5.5m minimum.	
ii)	<i>Electric power lines carrying voltage upto and including 650 volts</i>	m	6.0m minimum.	
iii)	<i>Electric power lines carrying voltage exceeding 650 volts</i>	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 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 1.12 given below:

**Table 1.12: 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



S No	Type	Description
		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 2 lane with paved shoulder in fill section Both Side upto 4.0m protection (Soft rock+Soil)
5	ID	Typical Cross Section for 2 lane with paved shoulder in fill section (Both Side upto 4.0m 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	III	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side cut upto 4m (Soft rock+ Soil)
10	IIIA	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side upto 4m protection (Soft rock+ Soil)
11	IIIB	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m cutting (Soft rock+ Soil)
12	IIIC	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
13	IV	Typical Cross Section for realignment and bypass Valley side Filling upto 1m and hill side cut hard rock)
14	IVA	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side cut in hard rock)
15	IVB	Typical Cross Section for realignment and bypass (Both sides protection in hard rock)
16	V	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (12.0m formation width)
17	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)
18	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)
19	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)
20	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)

### **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. For CBR 10% and MSA 20. Pavement composition for the proposed project road to design for rigid pavement. The details of proposed pavement composition of project road and their corresponding thickness is tabulated in table 1.13 given below:

**Table 1.13: Flexible Pavement Design (Main carriageway)**

<b>Pavement Composition</b>	<b>Pavement Thickness (in mm)</b>
Bituminous Concrete	40
Treated RAP (E=600Mpa)	100
CT Sub Base( E=600Mpa)	200
Total thickness of Pavement excluding subgrade	<b>340 mm</b>

### **E.19 Proposal for Bridges**

There are 07 No of minor Bridges proposed to be constructed on the project road.

### **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 1.14

**Table 1.14 :Summary of Proposed Box Culverts Structures**

S.NO	SIZE	NUMBER	REMARK
1	1 X 2 X 2	44	New Proposal / Reconstruction
2	1 X 4 X 4	87	New Proposal / Reconstruction
3	1 X 6 X 6	19	New Proposal / Reconstruction
	<b>TOTAL</b>	150	

### **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
- Km 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. Environmental clearance is not required as length of the road is only

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 1.15 given below

**Table 1.15: Cost Estimate**

<b>Bill No.</b>	<b>Description</b>	<b>Item Price (Cr.)</b>
1	SITE CLEARANCE	2.98
2	EARTH WORK AND DRAINAGE	10.40
3	CEMENT TREATED SUB BASE & BASE COURSE	15.99
4	SURFACE COURSES (BITUMEN)	32.99
5	TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES	24.20
6	DRAINAGE & PROTECTION WORKS	38.60
7	STRUCTURE	49.88
	<b>Total Civil Cost (A)</b>	<b>175.047</b>

Bill No.	Description	Item Price (Cr.)
	Maintenance during DLP (4 years) payable to contractor @5% of 'A'	8.75
	<b>Cost put to tender (A+B)</b>	<b>183.80</b>
	Add Contingencies over civil cost @2.80% of (A)	4.90
	Construction Supervision Charges @ 3% of (A)	5.25
	Administrative Charges @3% of (A)	5.25
	Quality Control @0.25% on 'A'	0.44
	Road Safety Cell Audit Charges @ 0.25% of 'A'	0.44
	Escalation @ 5% per annum for 1.5 years during construction payable to contractor of (A)	13.13
	Total cost of civil works including centage charges (C+D+E+F+G+H+I)	213.21
	Land Acquisition and Structure Cost	60.00
	Utility and Shifting	2.00
	<b>Total project cost (J+K+L)</b>	<b>275.21</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 III to Casta Engineering Pvt. Ltd. In J V 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 139.604 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
5a	Km 489.350-Km 491.600	Km 471.400-Km 473.675	Shingdhar Bridge to Vishnuprayag bridge	Widening to 2-lane with Paved Shoulder	2.275

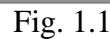
<b>Pkg no.</b>	<b>Existing Chainage</b>	<b>Design Chainage</b>	<b>Section Description</b>	<b>Provision</b>	<b>Design Length (in km)</b>
			including Hatipahar landslide		
5b	Km 491.600- Km 504.600	Km 473.675- Km 486.100	Vishnuprayag bridge to lambagadh	Widening to 2-lane+ Geometric Imp+R.S	12.425
-	Km 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-I the Design length of the road in this package is 29.125 km i.e from km 368.00 to 398.300 of Lameri to Karanprayag(Excluding km 379.100 to km 380.275) NH-07 (Old NH-58) under chardham pariyojna in the state of Uttarakhand.

## **1.2 PROJECT LOCATION**

The project road section (km 368.000 to km 399.300 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 below:





- 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 for 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 139.604 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**

<b>Pkg no.</b>	<b>Existing Chainage</b>	<b>Design Chainage</b>	<b>Section Description</b>	<b>Provision</b>	<b>Design Length (in km)</b>
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

<b>Pkg no.</b>	<b>Existing Chainage</b>	<b>Design Chainage</b>	<b>Section Description</b>	<b>Provision</b>	<b>Design Length (in km)</b>
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-I the Design length of the road in this package is 29.125 km i.e from km 368.00 to 398.300 of Lameri to Karanprayag(Excluding km 379.100 to km 380.275) NH-07 (Old NH-58) under chardham pariyojna 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:-

<b>S. No</b>	<b>Volume No.</b>	<b>Description</b>
1.	Volume-I	Main Report
2.	Volume-I/A	Appendix
3.	Volume-II	Design Report(Road)

S. No	Volume No.	Description
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
13.	Volume-XI	Project Clearances

Volume-I: Main Report will contain following chapters:

S. No.	Chapter No.	Description
	Chapter-0	Executive Summary
1	Chapter-1	Project Background
2	Chapter-2	Social Background and Demographic Features
3	Chapter-3	Engineering Surveys and Investigations
4	Chapter-4	Analysis and Interpretation of Survey & Investigations
5	Chapter-5	Traffic Survey & Forecast
6	Chapter-6	Traffic Survey and Analysis
7	Chapter-7	Improvement Proposal
8	Chapter-8	Cost Estimation
9	Chapter-9	Environmental Aspects
10	Chapter-10	Economic & Financial Analysis
11	Chapter-11	Conclusion and Recommendations

## 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-1 starting from Rudraprayag and ending at karanprayag Km 368.00 to km 399.300 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 29.125 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**

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

### **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 07 No of minor Bridges proposed to be constructed new on the Project road.

### **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. 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 1.3

**Table 1.3: Summary of Proposed Box Culverts Structures**

<b>S.NO</b>	<b>SIZE</b>	<b>NUMBER</b>	<b>REMARK</b>
1	1 X 2 X 2	44	New Proposal / Reconstruction
2	1 X 4 X 4	87	New Proposal / Reconstruction
3	1 X 6 X 6	19	New Proposal / Reconstruction
	<b>TOTAL</b>	150	

### 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 Table 1.4.

**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 are 1 major and 10 minor junctions along this road section.

#### Major Junctions

There is 01 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
1	397+950	At grade		✓			

#### Minor Junctions

There are 10 minor junctions along the project road. The list of minor junctions is presented in table 1.6:

**Table 1.6 : Minor Junction**

Sl. No.	Existing Chainage (km)	Type	
		Junction	Cross Road
1	369+450	Y	Village Road
2	375+200	Y	Village Road

SI. No.	Existing Chainage (km)	Type	
3	383+700	Y	Village Road
4	388+400	Y	Village Road
5	390+050	Y	Village Road
6	390+900	Y	Village Road
7	391+250	Y	Village Road
8	391+600	Y	Village Road
9	398+000	y	Village Road
10	398+500	T	Village Road

#### 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, Ramayana and Mahabharat that these Hindu scriptures are scripted in kedar-khand. It is believed that God Ganesha first script of vedas in Vayas gufa situated in the last village Mana only four km. from Badrinath. 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 Mahabharat in Vyas Gufa near Badrinath.

### 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 like apple, 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%
3	Agricultural sector's contribution in GSDP (FY 2009)	15.50 %

Sr. No.	Components	Growth/Ratio/Production
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 an 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.
Tourism	Focus on religious tourism, wildlife tourism, eco-tourism and adventure tourism

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
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 form 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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## **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 and secondary data, pertaining to project influence area, were collected and studied. All fieldwork involving topographic surveys and engineering investigations were primarily based on the information obtained from the reconnaissance survey.

### **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. The inventory data have been included in Appendix 3.1 of Volume-I(Appendix Volume of the Main Report).

### 3.4.1 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.

This report pertains to Sub-Package-I the Design length of the road in this package is 29.125 km i.e from km 368.00 to 398.300 of Lameri to Karanprayag(Excluding km 379.100 to km 380.275) NH-07 (Old NH-58) under chardham pariyojna 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 shown in table 3.1:

**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	Length (Km)	Snow affected area	Terrain
		(Km)			
1.	368+000	369+000	1.00	No	Steep
2.	369+000	379+000	10.00	No	Hilly
3.	379+000	381+000	2.00	No	Steep
4.	381+000	392+000	11.00	No	Hilly
5.	392+000	393+000	1.00	No	Steep
6.	393+000	394+000	1.00	No	Hilly
7.	394+000	398+000	4.00	No	Steep
8.	398+000	400+000	2.00	No	Hilly

### 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**

Sl. No.	Existing Chainage (km)		ROW (m)
	From	To	
1	368+000	369+000	6 to 8
2	369+000	370+000	6 to 9
3	370+000	371+000	6 to 8
4	371+000	372+000	6 to 8
5	372+000	373+000	6 to 8
6	373+000	374+000	6 to 8
7	374+000	375+000	6 to 8
8	375+000	376+000	6 to 10
9	376+000	377+000	6 to 10
10	377+000	378+000	6 to 10
11	378+000	379+000	6 to 8
12	379+000	380+000	6 to 8
13	380+000	381+000	6 to 8
14	381+000	382+000	6 to 8
15	382+000	383+000	6 to 8
16	383+000	384+000	6 to 12

Sl. No.	Existing Chainage (km)		ROW (m)
	From	To	
17	384+000	385+000	6 to 12
18	385+000	386+000	6 to 12
19	386+000	387+000	6 to 12
20	387+000	388+000	6 to 12
21	388+000	389+000	6 to 12
22	389+000	390+000	6 to 12
23	390+000	391+000	6 to 12
24	391+000	392+000	6 to 12
25	392+000	393+000	6 to 12
26	393+000	394+000	6 to 12
27	394+000	395+000	6 to 12
28	395+000	396+000	6 to 12
29	396+000	397+000	6 to 12
30	397+000	398+000	6 to 12
31	398+000	399+000	6 to 12

### 3.4.3.1 Settlements

There are 14<sup>th</sup> numbers of settlements along the project road out of which 03 number are urban habitation and 11 numbers are rural habitations shown in the table 3.4 to 3. 5

**Table 3.4: Urban Settlements**

S. No	Chainage (km)	Village Name	District
1	382+350	Nagrasu	Rudraprayag
2	387+000	Gouchar	Chamoli
3	399+000	Karanparyag	Chamoli



**Table 3.5 : Rural Settlements**

S. No	Chainage (km)	Village Name	District/Taluka
1	369+600	Lameri	Rudraprayag
2	369+850	Tilni	Rudraprayag
3	371+450	Sumerpur	Rudraprayag
4	373+900	Ratura	Rudraprayag
5	376+000	Kalnahodli	Rudraprayag
6	377+400	Sandh	Rudraprayag
7	378+250	Shivanandi	Rudraprayag
8	380+000	Gholteer	Rudraprayag
9	385+000	Kameda	Chamoli
10	391+700	Dhari nagar	Chamoli
11	392+850	Chatvapepal	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 is shown in table 3.6:

**Table 3.6: Deficient curve**

S.N	Location	Design chainage (km)		Length (m)	Width of Carriageway (m)	Ref. Typical cross section
		From	To			
1	Tilani	370+025	370+650	625	9	TYPE-V,V-A,V-B,V-C,V-D
2	Sumerpur	371+525	372+950	1425	9	TYPE-V,V-A,V-B,V-C,V-D
3	Ratura	373+750	374+750	1000	9	TYPE-V,V-A,V-B,V-C,V-D
4	Shivanandi	378+125	378+300	175	9	TYPE-V,V-A,V-B,V-C,V-D
5	Gholtir	380+075	382+600	2525	9	TYPE-V,V-A,V-B,V-C,V-D
6	Nagrasu	382+600	383+625	1025	9	TYPE-V,V-A,V-B,V-C,V-D
7	Gouchar	387+950	390+950	3000	9	TYPE-V,V-A,V-B,V-C,V-D
8	Karnprayag	397+325	398+275	950	9	TYPE-V,V-A,V-B,V-C,V-D

## 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 - 40 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.

**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

#### **3.6.1Borrowsoil**

The soil material excavated in the process of road construction is of sufficient quantity. Samples of these soils have been collected from pits and tested in the laboratory for their characteristics and strength. These materials conform to the MORTH specification clause 305.2 and can be used as embankment, subgrade, and miscellaneous backfills.

### **3.7 TOPOGRAPHICAL SURVEYS**

Topographic Survey covered the following:

- a) Establishing of Control Points
- b) Traverse Survey
- c) Cross-section Survey
- d) Establishing of Bench Marks

The Consultants have carried out the topographical survey by running the continuous open traverse along the existing road and realignments, alignment of new carriageway wherever required by fixing

the cardinal points such as Horizontal Intersection Points, centre points and transit points etc by properly referencing the same with a pair of reference pillars fixed on either side of the centreline. The topographic survey was carried to a corridor which extended from the hill side to the valley side covering about 8-10 m on valley side then extending still towards the hill side for the new carriageway. Thus a minimum of 60 m wide strip was surveyed. It extended suitably to cover up the viaducts and bridge sides.

Here the survey was done for 200 m up and 200m down side with cross sections at suitable intervals as per IRC SP -13, to capture the actual shape of stream cross sections. The survey corridor has been extended suitably at intersection locations. The longitudinal sections were taken @ 25 m interval, at the locations of curve points, small streams and the intersections were taken at 50 m interval. The spot levels for profile corrective courses were taken at very close intervals.

The topographical survey data was used to set-up a Digital Terrain Model (DTM) of the area up to the Proposed ROW boundary as necessary.

Reference pillars all along the project road including Bypasses have been established at site connecting GTS bench marks.

### **3.8 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.

#### **3.8.1 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.

### **3.9 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.*”

### **3.10 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:Existing 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	369+867	Open	RCC	PSC Girder	1 X 35.0	7.5
2	372+517	Open	RCC	RCC Girder	1 X 25.0	7.5
3	376+023	Open	RCC	PSC Girder	1 X 45.0	7.5
4	380+498	Open	RCC	PSC Girder	1 X 36.0	8.5
5	388+423	Open	RCC	PSC Girder	1 X 45.0	7.5
6	392+622	Open	RCC	PSC Girder	1 X 45.0	7.5

### 3.12 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:

#### PCU Factors Adopted for the Study:

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

Vehicle Type	PCU Equivalent	Vehicle Type	PCU Equivalent
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.

- 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

### Sub-packaging

The design length of project road is 139.604 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 as under.

**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



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

## 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 20-40 km/h for hilly/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 4.2

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

S.N	Location	Design chainage (km)		Length (m)	Width of Carriageway (m)	Ref. Typical cross section
		From	To			
1	Tilani	370+025	370+650	625	9	TYPE-V,V-A,V-B,V-C,V-D
2	Sumerpur	371+525	372+950	1425	9	TYPE-V,V-A,V-B,V-C,V-D
3	Ratura	373+750	374+750	1000	9	TYPE-V,V-A,V-B,V-C,V-D
4	Shivanandi	378+125	378+300	175	9	TYPE-V,V-A,V-B,V-C,V-D
5	Gholtir	380+075	382+600	2525	9	TYPE-V,V-A,V-B,V-C,V-D
6	Nagrasu	382+600	383+625	1025	9	TYPE-V,V-A,V-B,V-C,V-D
7	Gouchar	387+950	390+950	3000	9	TYPE-V,V-A,V-B,V-C,V-D
8	Karnprayag	397+325	398+275	950	9	TYPE-V,V-A,V-B,V-C,V-D

#### 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					Length of Element	Remarks/ Reason
	Start Chainage	Elevation (M)	End Chainage	Elevation (M)	Elevation Difference	Grade (%)	
1	395771.617	827.395	396428.97	774.807	52.588	-8	Continuous Steep Slope, Steep Terrain

## 4.2.2 Junctions

There are 1 major and 10 minor junctions along this road section.

### Major Junctions

There is 01 major junction along the project road in tabulated in table 4.4:

**Table 4.4 : Major Junction**

S.No	Existing Chainage (km)	At Grade	Grade Separated	Category of Cross Road+			
				NH	SH	MDR	Others
1	397+950	At grade		✓			

### Minor Junctions

There are 10 minor junctions along the project road. The list of minor junctions is presented in Table 4.5:

**Table 4.5 : Minor Junction**

SI. No.	Existing Chainage (km)	Type	
		Junction	Cross Road
1	369+450	Y	Village Road
2	375+200	Y	Village Road
3	383+700	Y	Village Road
4	388+400	Y	Village Road
5	390+050	Y	Village Road
6	390+900	Y	Village Road
7	391+250	Y	Village Road
8	391+600	Y	Village Road
9	398+000	y	Village Road
10	398+500	T	Village Road

## 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**

Pavement Composition	Pavement Thickness (in mm)
Bituminous Concrete	40
Treated RAP (E=600Mpa)	100
CT Sub Base( E=600Mpa)	200
Total thickness of Pavement excluding subgrade	<b>340 mm</b>

#### 4.3.1 Salient Features of Existing Bridges

There are total 7 bridges along the project road, out of which 01 is major and remaining 06 are minor.

**Table 4.7: Existing Major Bridges**

S. No.	Existing Chainage (km)	Type of Structure			No. of Spans with span length (m)	Width (m)
		Foundation	Sub-Structure	Super-Structure		
1	398+815	open	RCC	Steel Truss	1 x 90.0	7.5

**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	369+867	Open	RCC	PSC Girder	1 X 35.0	7.5
2	372+517	Open	RCC	RCC Girder	1 X 25.0	7.5
3	376+023	Open	RCC	PSC Girder	1 X 45.0	7.5
4	380+498	Open	RCC	PSC Girder	1 X 36.0	8.5
5	388+423	Open	RCC	PSC Girder	1 X 45.0	7.5
6	392+622	Open	RCC	PSC Girder	1 X 45.0	7.5

#### 4.5 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 4.9

**Table 4.89 Summary of Proposed Box Culverts Structures**

<b>S.NO</b>	<b>SIZE</b>	<b>NUMBER</b>	<b>REMARK</b>
1	1 X 2 X 2	44	New Proposal / Reconstruction
2	1 X 4 X 4	87	New Proposal / Reconstruction
3	1 X 6 X 6	19	New Proposal / Reconstruction
	<b>TOTAL</b>	150	

#### **4.6 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 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.

#### **4.7 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.

#### **4.8 TRAFFIC CONTROL AND SAFETY MEASURES**

##### **4.8.1 General**

The existing single/intermediate/2lane road is proposed for improvement to two-lane with paved shoulder:

- 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 such as clearly visible delineation and road markings and traffic signs.

#### **4.8.2 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.

#### **4.8.3 Width of carriageway**

Studies conducted on relationships between the width of carriageway/lanes and safety show that accident rates decrease with an increase in carriageway width. The project road has been proposed with 7.0m carriageway with 1.0m paved shoulder.

#### **4.8.4 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.

#### **4.8.5 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. The accidents on such alignment are caused mainly due to overtaking on curves, skidding, hazardous objects on bends, etc. The package road has been designed keeping in view all the above factors. Absolute minimum radius of 40m has been maintained in the project road sections. Similarly, steep grades result in higher accident rates especially for heavy vehicles on steep downgrades compared to near horizontal roads. The gradient for the project road alignment has been

designed to have less than 5.0% in general. However, both the vertical gradient & horizontal curvature have been coordinated in design so that the driver can have better perception of the alignment.

#### **4.8.6 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 for the project road. Headlight sight distance on the valley curves has also been taken into account in alignment design for safe driving during night travel.

#### **4.8.7 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.

### **4.9 TRAFFIC MANAGEMENT**

#### **4.9.1.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 Management Plan**

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 in accordance with IRC / MORT&H Standards and Specifications;
- The contractor would provide, erect, maintain, reposition, cover, uncover and remove traffic signs as required in respect of works on the project site;
- Adequate safety during night time would be signs at important locations finalized in consultation with the client, PD, NHAI.



## **CHAPTER-5. TRAFFIC SURVEY & FORECAST**

### **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**

<b>Homogeneous Section</b>	<b>Existing Chainage</b>	<b>Length (km)</b>	<b>Name Of Location</b>
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

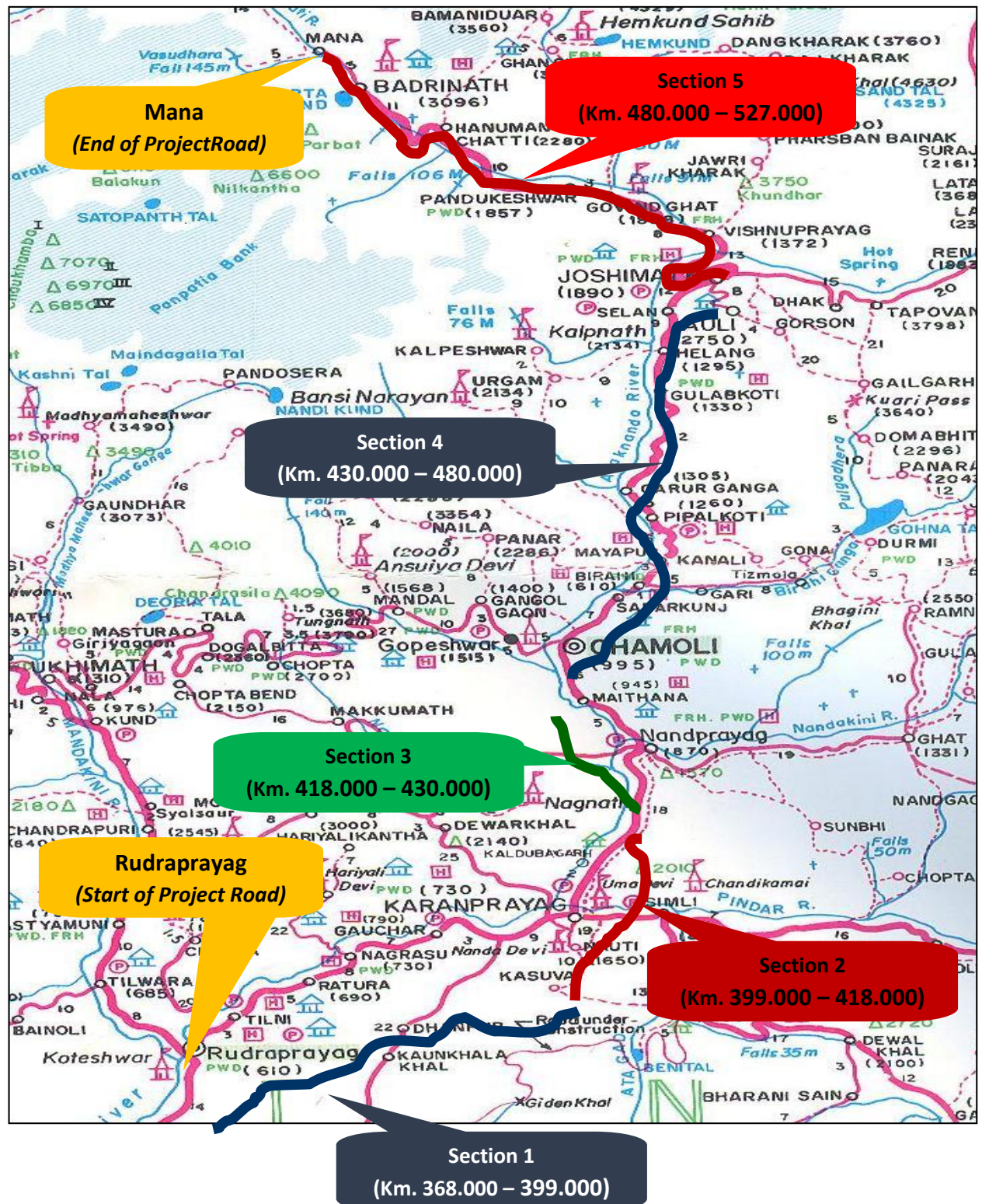


Fig 5.1: Homogeneous Sections for Traffic Survey

### 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:

#### PCU Factors Adopted for the Study:

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

Vehicle Type	PCU Equivalent	Vehicle Type	PCU Equivalent
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

### 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.

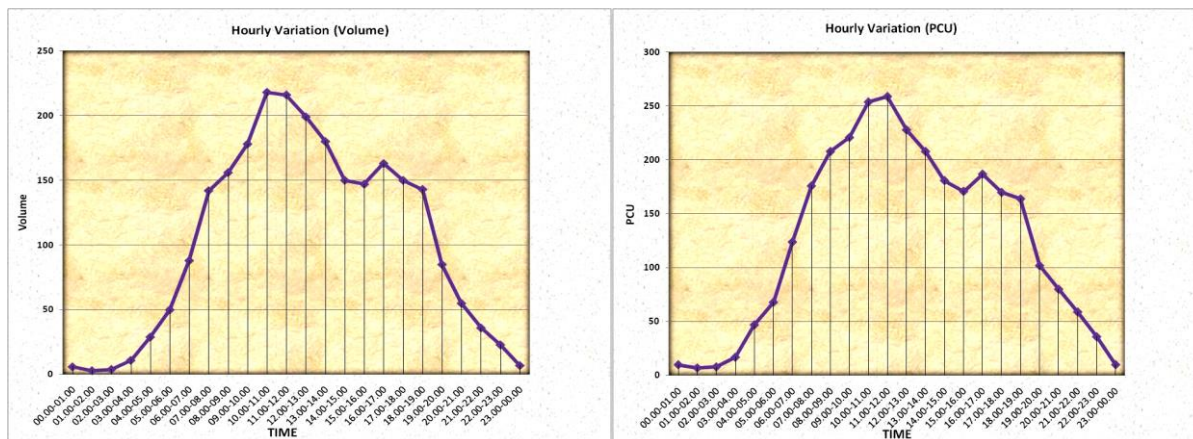
**Table 5.4 : Traffic Volume Count Survey Locations**

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	-	16-05-2014	23-05-2014	7 Days

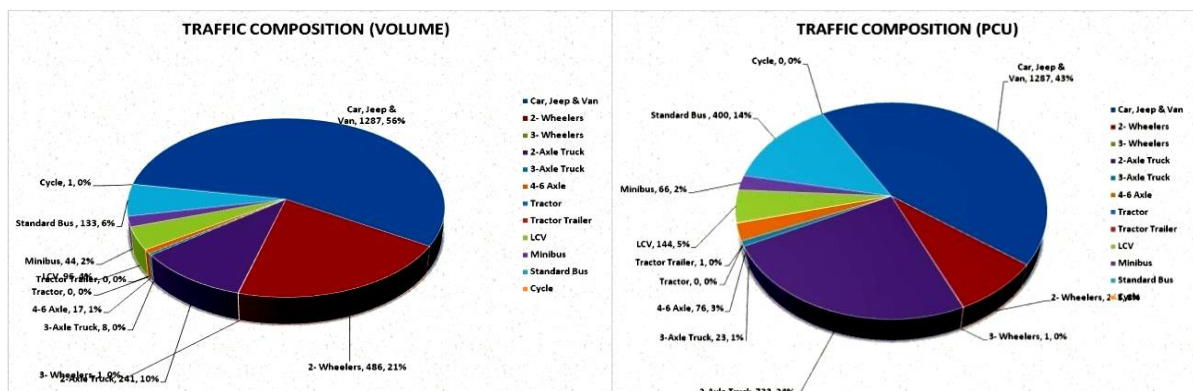
Location wise analysis of one-week counts is presented in the following section of the report.

#### 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.**



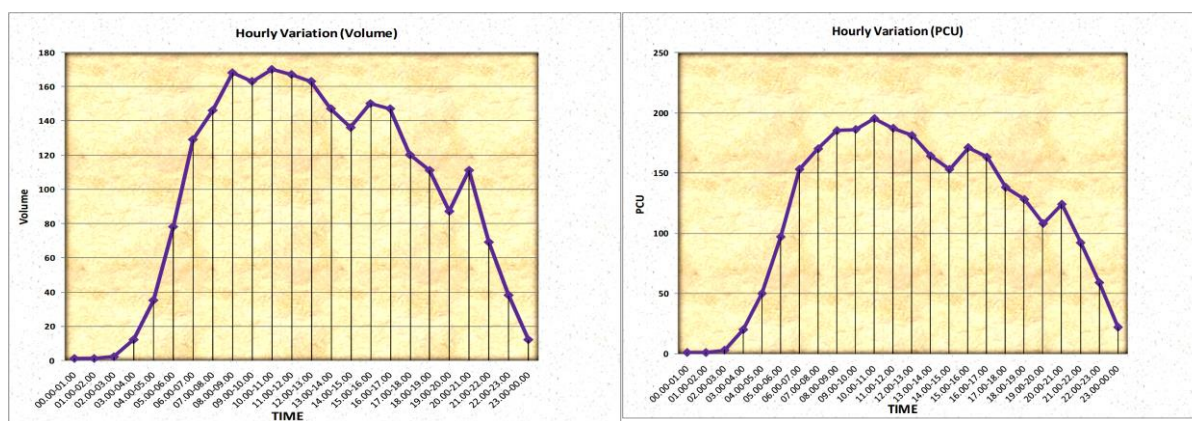
**Fig.5.2:Graphical representation of Hourly Variation (Volume and PCU wise) (374.000)**



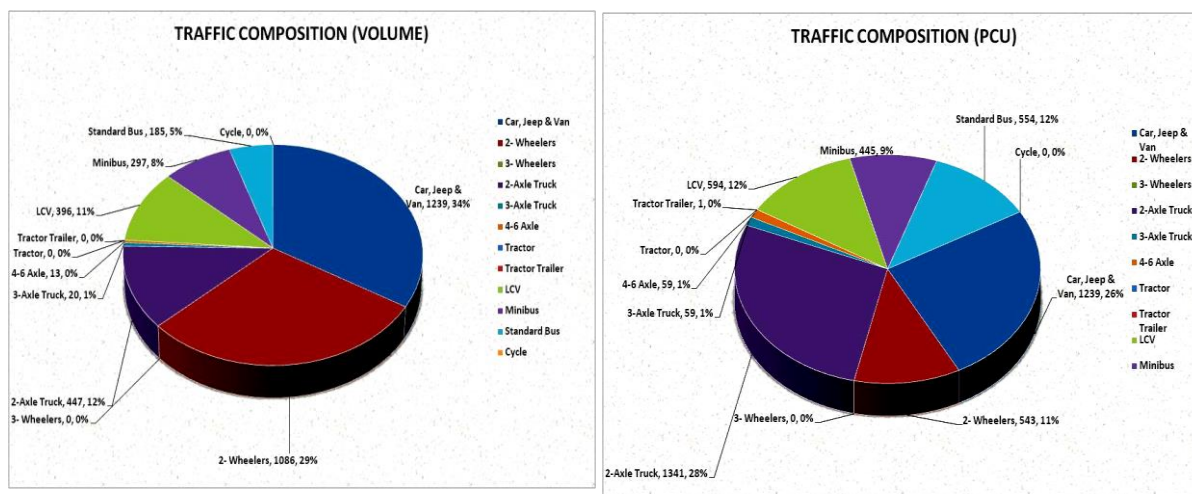
**Fig.5.3:Graphical representation of Traffic Composition (Volume and PCUwise) (374.000)**

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**.

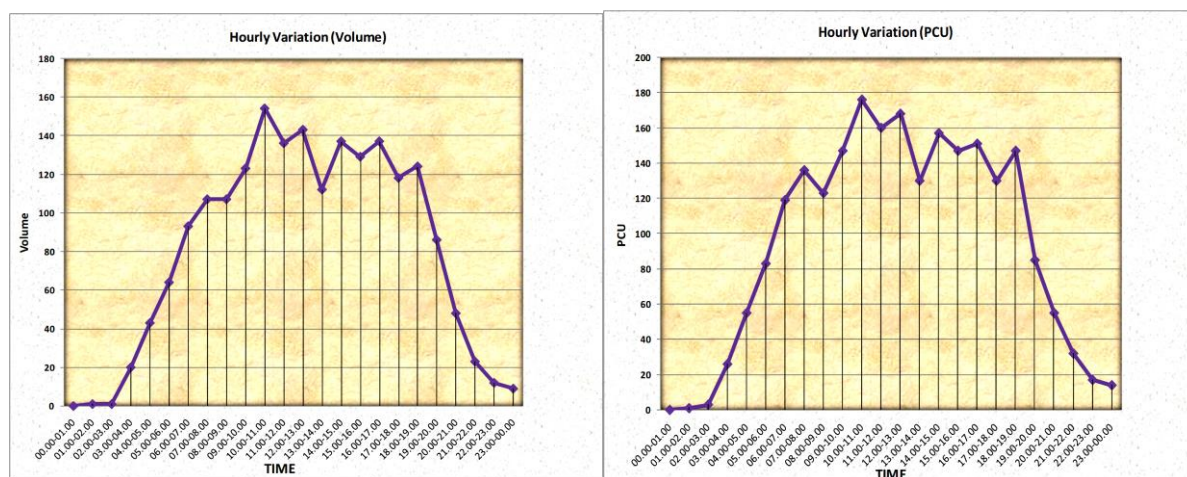


Fig.5.6:Graphical representation of Hourly Variation (Volume and PCUwise) (Km 425.000)

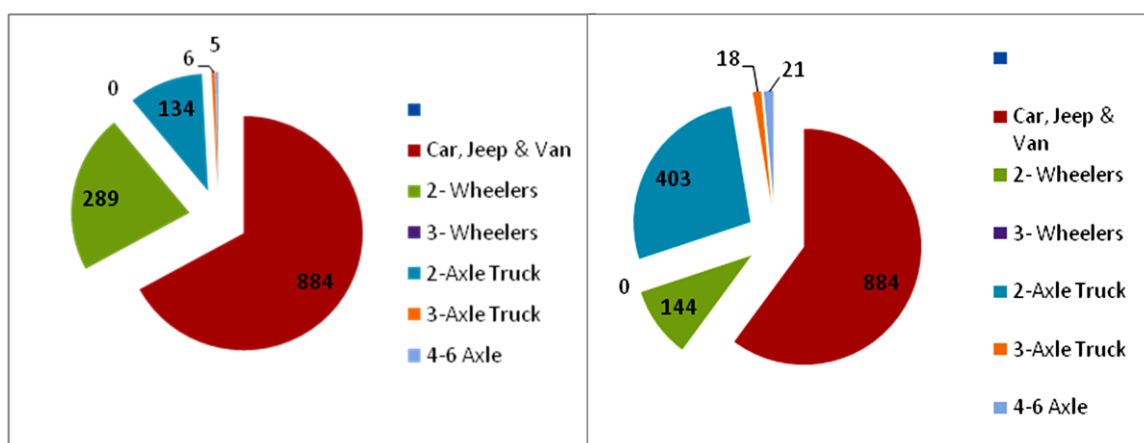


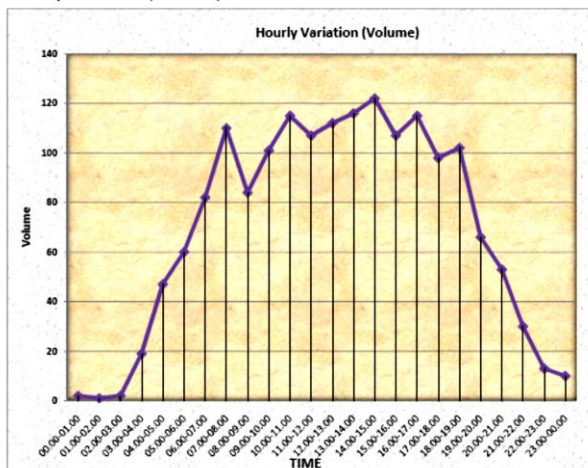
Fig.5.7:Graphical representation of Traffic Composition (Volume and PCU wise) (Km 425.000)

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

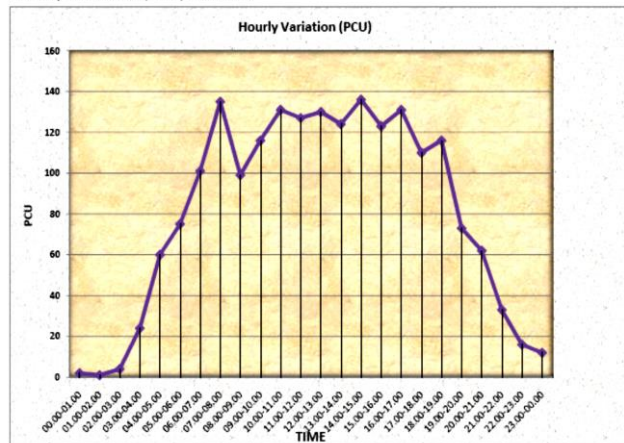


Fig.5.8:Graphical representation of Hourly Variation (Volume and PCUwise) (Km 444.000)

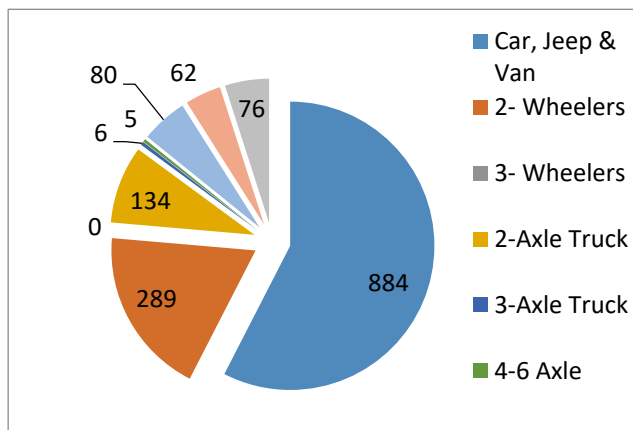
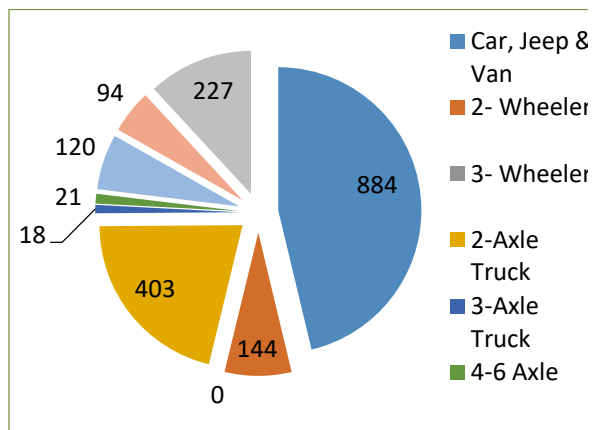


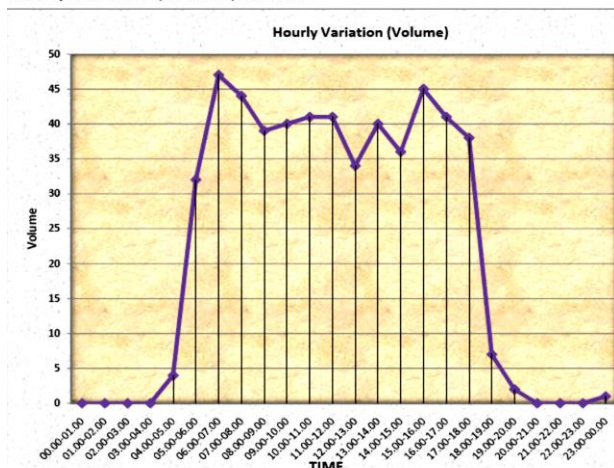
Fig.5.9:Graphical representation of Traffic Composition (Volume and PCUwise) (Km 444.000)

#### 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**.



Hourly Variation (Volume)CHART-3



Hourly Variation (PCU)CHART-4

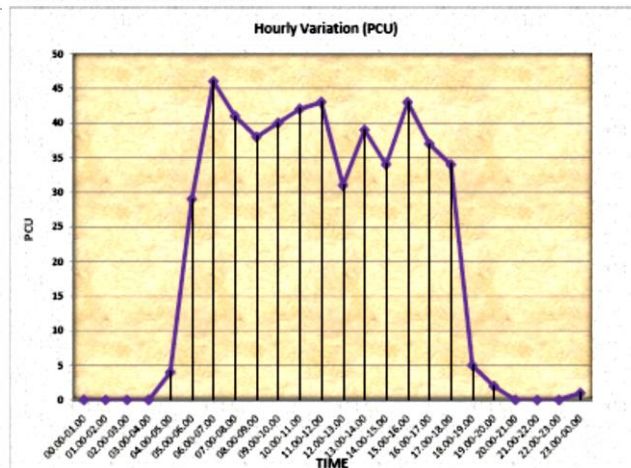


Fig.5.10:Graphical representation of Hourly Variation (Volume and PCUwise) (Km 501.000)

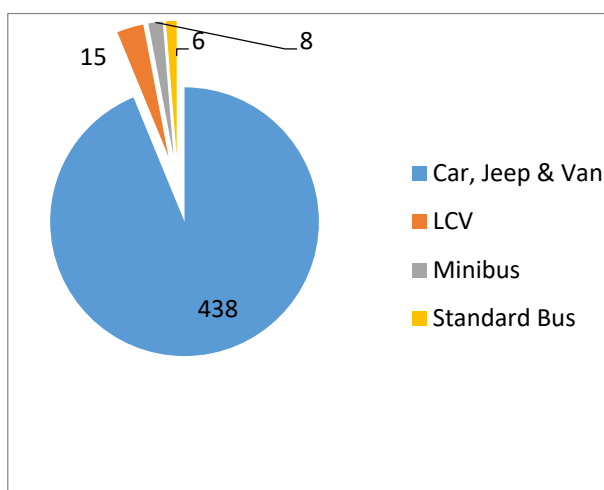
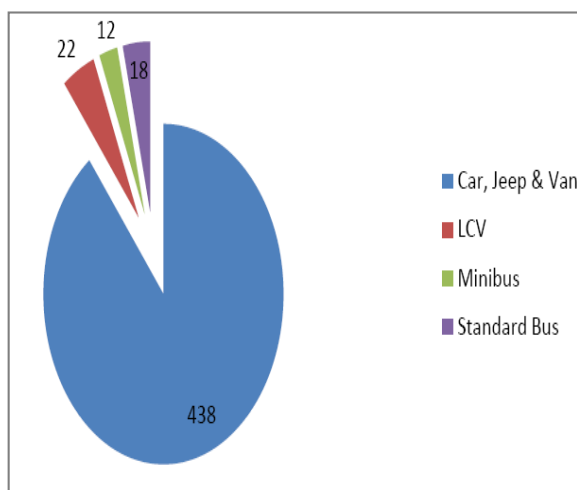


Fig.5.11:Graphical representation of Traffic Composition (Volume and PCU wise) (Km 501.000)

**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

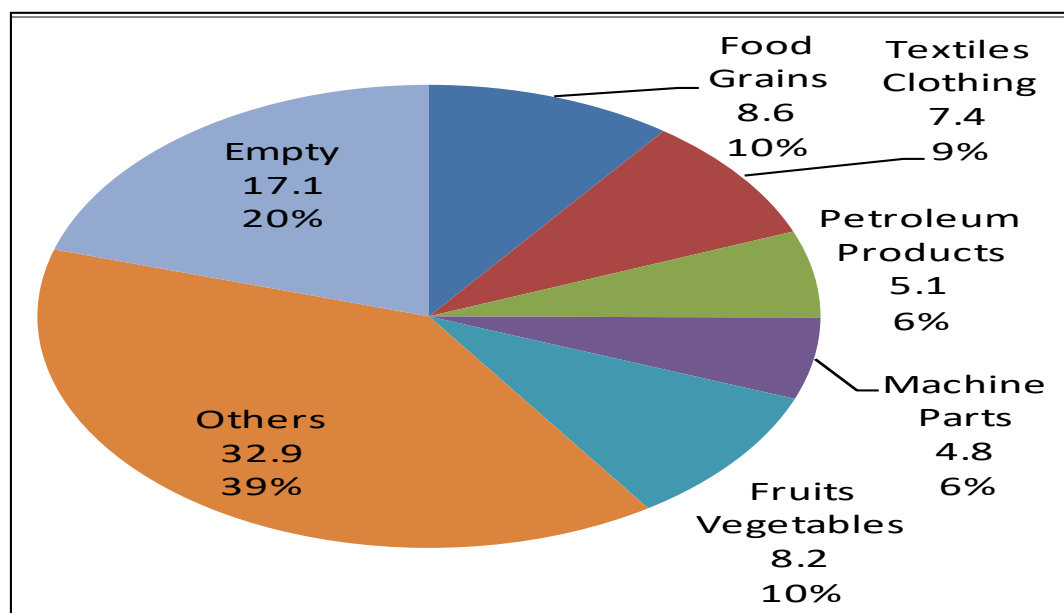
A traffic zoning system is essential for the appreciation of the travel pattern, which reflects direct and indirect impacts of the project. Keeping in view the impact of the project corridor, which falls in Rudraprayag and Chamoli district, the study area (India) is divided into a three-stage zoning 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

Distribution of Trips by Commodity Carried

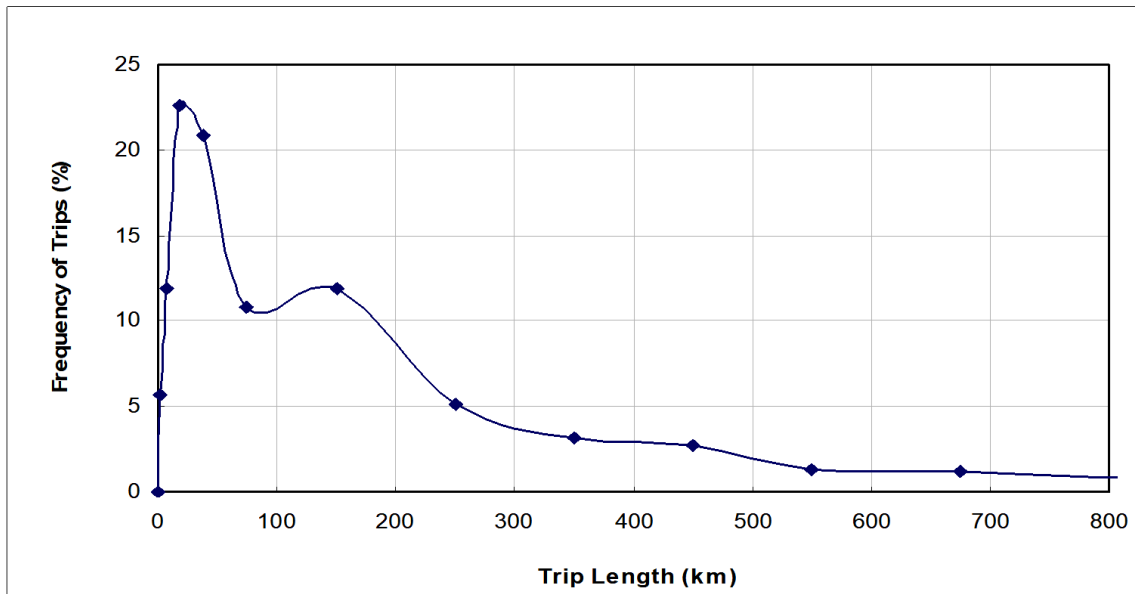


The corridor, being part of National Highway-58 from Rishikesh to Mana (Badrinath), caters to a variety of transported goods. Though being very tough to classify all varieties into categories, effort has been made to group the various types of goods into 7 categories to cover broad cross-section of the 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%).

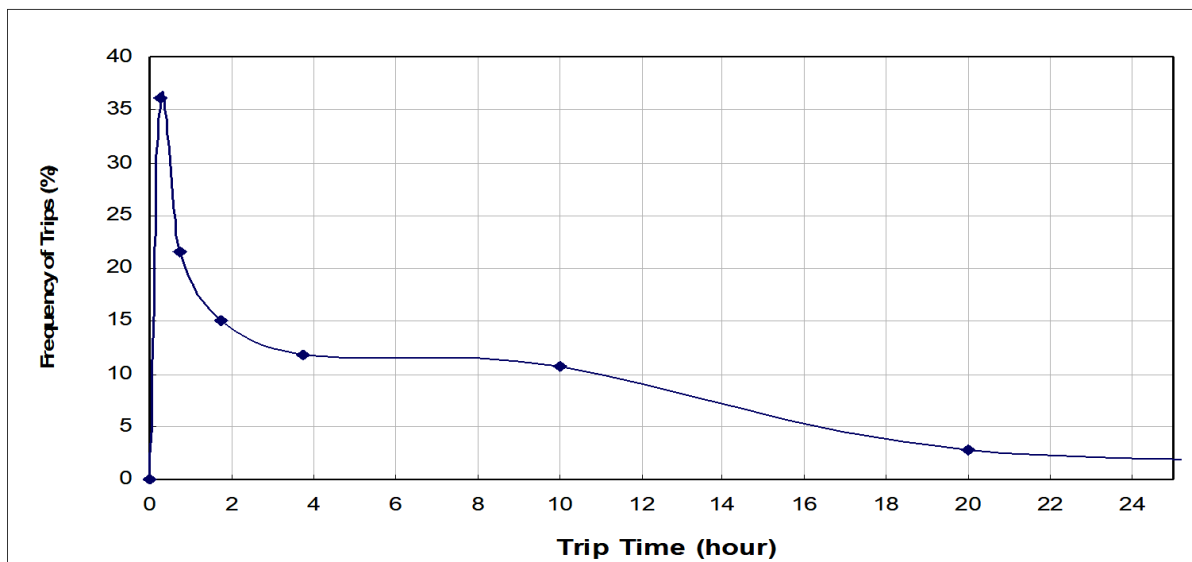
#### 5.2.4 Desire Pattern

##### Frequency Distribution of Trips:

Fig.5.25 and 5.26 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.6.27 and 6.28 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.

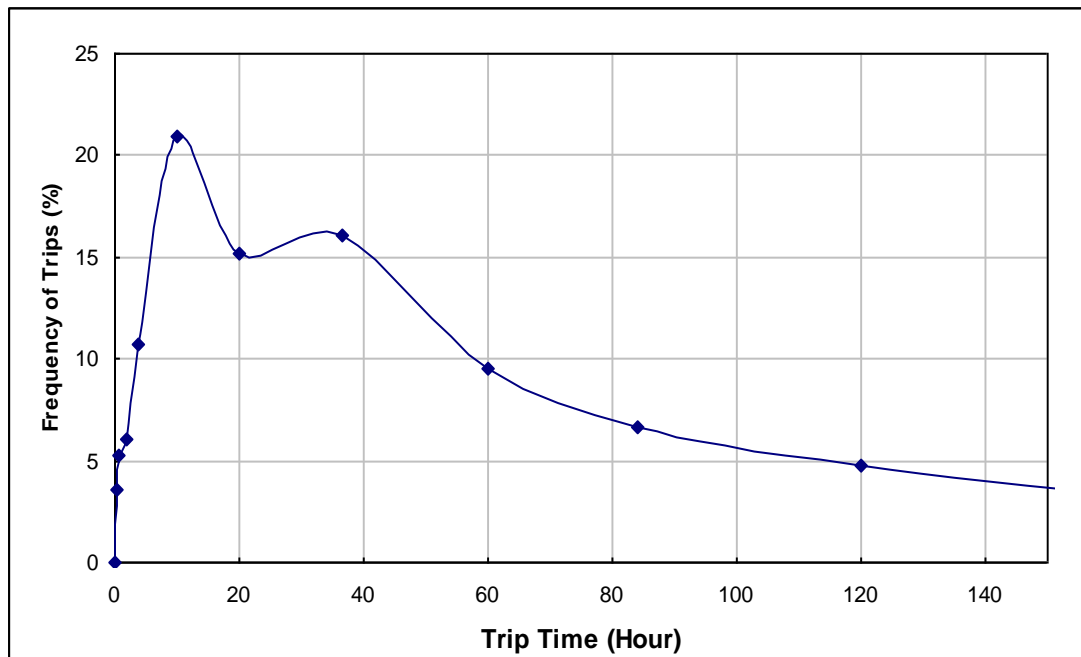
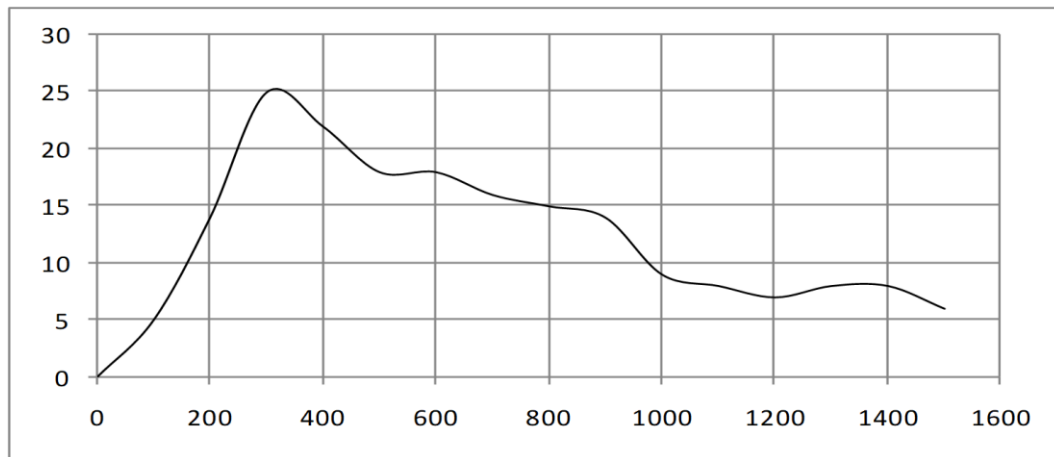


Fig.5.14: Trip Time Frequency Distribution Curve for Goods Vehicles

### 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.

**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 5.14.

From the table it can be observed that on the project corridor speeds are varying between 12to 48 kmph.

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

SI No	From	To	Distance (km)	JourneySpeed (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.

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

SI. 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

Sl. No.	Location	Chainage	Peak Flow(Pedestrians/hr.)	
			Rudraprayag - Badrinath side	Badrinath – Rudraprayag side
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.

### 5.2.8Axle 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 detailof 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:

**Table5.10: Axle Load Survey**

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

### 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

### 5.3.1Introduction

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.

**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

Village - Raitoli, Rudraprayag			Village –Sonla		
Month	Diesel	Petrol	Month	Diesel	Petrol
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
April	142,619	0.53	1.01	25,717	0.68	1.03
May	267,303	<b>1.00</b>	<b>0.54</b>	37,940	<b>1.00</b>	<b>0.70</b>
June	270,082	1.01	0.53	38,207	1.01	0.69
July	102,922	0.39	1.40	19,364	0.51	1.36
August	95,526	0.36	1.50	16,482	0.43	1.60
September	112,876	0.42	1.27	20,620	0.54	1.28
October	131,331	0.49	1.09	27,348	0.72	0.96
November	126,569	0.47	1.14	28,380	0.75	0.93
December	102,628	0.38	1.40	26,102	0.69	1.01
January	122,824	0.46	1.17	26,028	0.69	1.01
February	110,557	0.41	1.30	22,833	0.60	1.16
March	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**

Vehicle Type	Km 374	Km 410	Km 425	Km 444	Km 501
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>

Vehicle Type	Km 374	Km 410	Km 425	Km 444	Km 501
<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

Vehicle Type	Km 374.00 (near Ratura)	Induced traffic @ 50% of current traffic	AADT
Other vehicle (Plz Specify)	0	0	0
<b>Total Motorised Vehicles (Number)</b>	<b>1515</b>	-	<b>2773</b>
<b>Total Non Motorised Vehicles (Number)</b>	<b>0</b>	-	<b>0</b>
<b>Total Motorised Vehicles (PCU)</b>	<b>1827</b>	-	<b>2742</b>
<b>Total Non Motorised Vehicles (PCU)</b>	<b>0</b>	-	<b>0</b>
<b>Total Commercial Vehicle per day</b>	<b>291</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 following sections discuss traffic projections based on different considerations. 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.

**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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## **CHAPTER 6.DESIGN STANDARDS**

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### **6.1GENERAL**

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.

**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 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

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:

**Table 6.2 Projected Traffic per Year**

Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LC V	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



Year	2-Wheelers	Car / Jeep / Van	Mini Bus	Standard Bus	LC V	2-Axle, 3-Axle	MAV	Total Vehicle	Total PCU
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
2030	2330	5144	136	336	271	694	59	8970	10275

#### 6.2.4 Tabular Presentation of Major Design Parameters

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 6.1.

**Table 6.1: 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	20	20	20	20	20

length: (m)					
Ruling gradient (%)	5	5	5	5	5
Limiting gradient (%)	6	6	6	6	6
Exceptional gradient (%)	7	7	7	7	7
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 6.2: 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
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 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

The IRC standards recommend a ruling/minimum design speed of 20-40 kmph for mountainous/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, together with widening at curves, mitigate this requirement.

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 formula:

Grade Compensation (Percent) =  $\frac{30}{1 + R}$  Subject to a maximum of 75/R

where R = Radius of the curve in meters

Note: For grades flatter than 4 percent, no grade compensation is needed

## **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.

### **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 reflectorised tape, are recommended for installation on the inner walls of drain runs and bridge parapets on the valley side.

### 6.2.12 Bus bays and Laybye

The Consultant feels that since there are no large centres of population along the route, it is unnecessary to provide laybye. The bus service is also very scant, so providing bus stops and/or lay bye for the service may be a wastage of resources.

### 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. Twelve 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 6.3 given below:

**Table 6.3: 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))
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 2 lane with paved shoulder in fill section Both Side upto 4.0m protection (Soft rock+Soil)
5	ID	Typical Cross Section for 2 lane with paved shoulder in fill section (Both Side upto 4.0m 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	III	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side cut upto 4m (Soft rock+ Soil))
10	IIIA	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side upto 4m protection (Soft rock+ Soil))
11	IIIB	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m cutting (Soft rock+ Soil))
12	IIIC	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
13	IV	Typical Cross Section for realignment and bypass Valley side Filling upto 1m and hill side cut hard rock)



S No	Type	Description
14	IVA	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side cut in hard rock)
15	IVB	Typical Cross Section for realignment and bypass (Both sides protection in hard rock)
16	V	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (12.0m formation width)
17	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)
18	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)
19	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)
20	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 favorable 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.

### **6.7.2 Strengthening of existing pavement**

Strengthening of the existing pavement has been done in accordance with IRC: 81-1997. The strengthening layer shall comprise of DBM overlaid with BC surfacing with Modified Bitumen CRMB 60 grade.

Before laying the overlays, profile corrective courses shall be carried out with DBM/WMM/GSB as required.

### **6.7.3 Pavement drainage**

To ensure internal drainage of the pavement, the GSB layer shall be extended to full width across the shoulder on the sub grade to the side drain towards the hillside. The finished pavement profile shall be designed so that the bottom level of the sub-grade always remains above the high flood level by 1.0 meter.

## **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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## 7. IMPROVEMENT PROPOSAL

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### 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:

**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					

S. No.	Description	Unit	Proposed Standards	
			Hilly	Steep
(a)	Length (min)			
	Ruling Minimum	M	30	20
	Absolute Minimum	M	20	15
(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	

S. No.	Description	Unit	Proposed Standards	
			Hilly	Steep
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	
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 20-40 km/h for hilly/ 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.





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

S. No.	Design (km)		Design Radius	Existing Radius (m)	Grade In	Grade Out	Remarks
	From	To					
1	372+447	372+479	20	6	3.6%	0.0%	Bridge Approach, vertical hill, huge cutting involve
2	372+513	372+538	20	15	0.0%	-2.8%	
3	373+925	373+969	20	20	4.0%	4.0%	Hair Pin Bend
4	374+021	374+063	20	15	4.0%	5.4%	
5	380+420	380+460	20	20	0.0%	4.7%	Hair Pin Bend within Habitation
6	381+053	381+115	20	14	4%	4%	Hair Pin Bend
7	381+276	381+319	20	18	4.0%	4.0%	
8	388+383	388+429	20	14	4.0%	4.0%	Hair Pin Bend
9	398+122	398+130	20	20	2.3%	-1.0%	Approach of retained bridge in habitation of Karanparyag
10	398+275	398+282	20	20	-1.0%	5.6%	

### 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 below.

#### Vertical Alignment Deficient Curves

S. No.	Vertical Tangent Points					Gradient (%)	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

### 7.2.3.3 Widening Scheme

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

#### Reconstruction/Widening Scheme of Rural Section

S.N	Location	Design chainage (km)		Length (m)	Width of Carriageway (m)	Ref. Typical cross section
		From	To			
1	Tilani	370+025	370+650	625	9	TYPE-V,V-A,V-B,V-C,V-D
2	Sumerpur	371+525	372+950	1425	9	TYPE-V,V-A,V-B,V-C,V-D
3	Ratura	373+750	374+750	1000	9	TYPE-V,V-A,V-B,V-C,V-D
4	Shivanandi	378+125	378+300	175	9	TYPE-V,V-A,V-B,V-C,V-D
5	Gholtir	380+075	382+600	2525	9	TYPE-V,V-A,V-B,V-C,V-D
6	Nagrasu	382+600	383+625	1025	9	TYPE-V,V-A,V-B,V-C,V-D
7	Gouchar	387+950	390+950	3000	9	TYPE-V,V-A,V-B,V-C,V-D
8	Karnprayag	397+325	398+275	950	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, twelve typical cross-sections has been proposed and already discussed earlier for improvement of project road.

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.

### 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 2 lane with paved shoulder in fill section Both Side upto 4.0m protection (Soft rock+Soil)
5	ID	Typical Cross Section for 2 lane with paved shoulder in fill section (Both Side upto 4.0m 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	III	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side cut upto 4m (Soft rock+ Soil)
10	IIIA	Typical Cross Section for realignment and bypass (Valley side filling upto 1m and hill side upto 4m protection (Soft rock+ Soil)
11	IIIB	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side upto 4m cutting (Soft rock+ Soil)
12	IIIC	Typical Cross Section for realignment and bypass (Valley side filling >4m in soft rock)
13	IV	Typical Cross Section for realignment and bypass Valley side Filling upto 1m and hill side cut hard rock)
14	IVA	Typical Cross Section for realignment and bypass (Valley side filling upto 4m and hill side cut in hard rock)
15	IVB	Typical Cross Section for realignment and bypass (Both sides protection in hard rock)
16	V	Typical Cross Section for 2 lane with paved shoulder & Raised Footpath cum drain in built-up area) (12.0m formation width)
17	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)
18	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)
19	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)
20	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)

**Details of widening scheme according to typical cross section.**

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
1	368+000	368+025	TYPE-II-B	25
2	368+025	368+050	TYPE-II-B	25
3	368+050	368+075	TYPE-II	25
4	368+075	368+100	TYPE-IV	14
5	368+100	368+125	TYPE-IV	25
6	368+125	368+150	TYPE-II	25
7	368+150	368+175	TYPE-II	25
8	368+175	368+200	TYPE-II	25
9	368+200	368+225	TYPE-II	25
10	368+225	368+250	TYPE-II	25
11	368+250	368+275	TYPE-II	25
12	368+275	368+300	TYPE-II	25
13	368+300	368+325	TYPE-II	25
14	368+325	368+350	TYPE-II	25
15	368+375	368+400	TYPE-IV-A	0
16	368+400	368+425	TYPE-IV	25
17	368+425	368+450	TYPE-II	25
18	368+450	368+475	TYPE-II	25
19	368+475	368+500	TYPE-II	12
20	368+500	368+525	TYPE-II	25
21	368+525	368+550	TYPE-II	25
22	368+550	368+575	TYPE-II-B	25
23	368+575	368+600	TYPE-II	14
24	368+600	368+625	TYPE-II	25
25	368+625	368+650	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
26	368+650	368+675	TYPE-II	25
27	368+675	368+700	TYPE-II	25
28	368+700	368+725	TYPE-II	25
29	368+725	368+750	TYPE-II	25
30	368+750	368+775	TYPE-II-B	25
31	368+775	368+800	TYPE-II-B	25
32	368+800	368+825	TYPE-II	25
33	368+825	368+850	TYPE-I	25
34	368+850	368+875	TYPE-I	12
35	368+875	368+900	TYPE-I-A	25
36	368+900	368+925	TYPE-I-A	25
37	368+925	368+950	TYPE-I-A	25
38	368+950	368+975	TYPE-I-A	25
39	368+975	369+000	TYPE-I	25
40	369+000	369+025	TYPE-I	25
41	369+025	369+050	TYPE-I	25
42	369+050	369+075	TYPE-I-A	25
43	369+075	369+100	TYPE-I-A	16
44	369+100	369+125	TYPE-I	25
45	369+125	369+150	TYPE-I	25
46	369+150	369+175	TYPE-I	25
47	369+175	369+200	TYPE-I	25
48	369+200	369+225	TYPE-I	25
49	369+225	369+250	TYPE-I	25
50	369+250	369+275	TYPE-I	25
51	369+275	369+300	TYPE-I	14
52	369+300	369+325	TYPE-II	25
53	369+325	369+350	TYPE-II	25
54	369+350	369+375	TYPE-II	25
55	369+375	369+400	TYPE-II	25
56	369+400	369+425	TYPE-II	25
57	369+425	369+450	TYPE-II	25
58	369+450	369+475	TYPE-II-A	25
59	369+475	369+500	TYPE-II	25
60	369+500	369+525	TYPE-II	25
61	369+525	369+550	TYPE-II-B	25
62	369+550	369+575	TYPE-II-B	25
63	369+575	369+600	TYPE-II	25
64	369+600	369+625	TYPE-II	25
65	369+625	369+650	TYPE-II	25
66	369+650	369+675	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
67	369+675	369+700	TYPE-II	25
68	369+700	369+725	TYPE-II	25
69	369+725	369+750	TYPE-II	25
70	369+750	369+775	TYPE-I	25
71	369+775	369+800	TYPE-I	25
72	369+800	369+825	TYPE-I	25
73	369+825	369+850	TYPE-I	25
74	369+850	369+875	TYPE-I	25
75	369+900	369+925	TYPE-I	0
76	369+925	369+950	TYPE-III	25
77	369+950	369+975	TYPE-III	25
78	369+975	370+000	TYPE-III	25
79	370+000	370+025	TYPE-III	14
80	370+650	370+675	TYPE-I	25
81	370+675	370+700	TYPE-III-B	12
82	370+700	370+725	TYPE-III-B	25
83	370+725	370+750	TYPE-III	25
84	370+750	370+775	TYPE-I	25
85	370+775	370+800	TYPE-I	14
86	370+800	370+825	TYPE-I	25
87	370+825	370+850	TYPE-I	25
88	370+850	370+875	TYPE-I	14
89	370+875	370+900	TYPE-I	25
90	370+900	370+925	TYPE-I	14
91	370+925	370+950	TYPE-I	25
92	370+950	370+975	TYPE-I	25
93	370+975	371+000	TYPE-I	14
94	371+000	371+025	TYPE-I	25
95	371+025	371+050	TYPE-I	25
96	371+050	371+075	TYPE-I	25
97	371+075	371+100	TYPE-I	25
98	371+100	371+125	TYPE-I	25
99	371+125	371+150	TYPE-I	25
100	371+150	371+175	TYPE-II	25
101	371+175	371+200	TYPE-I	16
102	371+200	371+225	TYPE-I	25
103	371+225	371+250	TYPE-I	25
104	371+250	371+275	TYPE-I	25
105	371+275	371+300	TYPE-I	25
106	371+300	371+325	TYPE-I	25
107	371+325	371+350	TYPE-I	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
108	371+350	371+375	TYPE-I	25
109	371+375	371+400	TYPE-I-A	14
110	371+400	371+425	TYPE-I-A	25
111	371+425	371+450	TYPE-I-A	14
112	371+450	371+475	TYPE-I	25
113	371+475	371+500	TYPE-I	25
114	371+500	371+525	TYPE-I	25
115	372+950	372+975	TYPE-I-A	25
116	372+975	373+000	TYPE-I-A	16
117	373+000	373+025	TYPE-I-A	25
118	373+025	373+050	TYPE-I-A	25
119	373+050	373+075	TYPE-I-A	25
120	373+075	373+100	TYPE-II	25
121	373+100	373+125	TYPE-II	25
122	373+125	373+150	TYPE-II	25
123	373+150	373+175	TYPE-II	25
124	373+175	373+200	TYPE-II	25
125	373+200	373+225	TYPE-II-B	25
126	373+225	373+250	TYPE-II-B	12
127	373+250	373+275	TYPE-II-B	25
128	373+275	373+300	TYPE-II	25
129	373+300	373+325	TYPE-II	25
130	373+325	373+350	TYPE-II	25
131	373+350	373+375	TYPE-II	25
132	373+375	373+400	TYPE-II	25
133	373+400	373+425	TYPE-II	25
134	373+425	373+450	TYPE-II	25
135	373+450	373+475	TYPE-II-B	14
136	373+475	373+500	TYPE-II-B	25
137	373+500	373+525	TYPE-II	25
138	373+525	373+550	TYPE-II	25
139	373+550	373+575	TYPE-II	25
140	373+575	373+600	TYPE-II	25
141	373+600	373+625	TYPE-II	25
142	373+625	373+650	TYPE-II	14
143	373+650	373+675	TYPE-II-B	25
144	373+675	373+700	TYPE-II-B	25
145	373+700	373+725	TYPE-II-A	25
146	373+725	373+750	TYPE-II-A	25
147	374+250	374+275	TYPE-I	25
148	374+275	374+300	TYPE-I	25



S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
149	374+300	374+325	TYPE-I	25
150	374+325	374+350	TYPE-I	25
151	374+350	374+375	TYPE-I	25
152	374+375	374+400	TYPE-I	25
153	374+400	374+425	TYPE-I	12
154	374+425	374+450	TYPE-I	25
155	374+450	374+475	TYPE-I	25
156	374+475	374+500	TYPE-I	25
157	374+500	374+525	TYPE-I	25
158	374+525	374+550	TYPE-I	25
159	374+550	374+575	TYPE-I	25
160	374+575	374+600	TYPE-I	25
161	374+600	374+625	TYPE-I	25
162	374+750	374+775	TYPE-I	25
163	374+775	374+800	TYPE-I	25
164	374+800	374+825	TYPE-I	25
165	374+825	374+850	TYPE-I	25
166	374+850	374+875	TYPE-I	25
167	374+875	374+900	TYPE-I	14
168	374+900	374+925	TYPE-I	25
169	374+925	374+950	TYPE-I	25
170	374+950	374+975	TYPE-I	25
171	374+975	375+000	TYPE-I	25
172	375+000	375+025	TYPE-I	25
173	375+025	375+050	TYPE-I	25
174	375+050	375+075	TYPE-I	14
175	375+075	375+100	TYPE-II	25
176	375+100	375+125	TYPE-II	25
177	375+125	375+150	TYPE-II-B	25
178	375+150	375+175	TYPE-II-B	16
179	375+175	375+200	TYPE-II-B	25
180	375+200	375+225	TYPE-II	25
181	375+225	375+250	TYPE-II	25
182	375+250	375+275	TYPE-II	25
183	375+275	375+300	TYPE-II	25
184	375+300	375+325	TYPE-II	25
185	375+325	375+350	TYPE-II	25
186	375+350	375+375	TYPE-II	25
187	375+375	375+400	TYPE-II	25
188	375+400	375+425	TYPE-II	14
189	375+425	375+450	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
190	375+450	375+475	TYPE-II	25
191	375+475	375+500	TYPE-II-B	25
192	375+500	375+525	TYPE-II-B	25
193	375+525	375+550	TYPE-II	25
194	375+550	375+575	TYPE-II-B	25
195	375+575	375+600	TYPE-II-B	25
196	375+600	375+625	TYPE-II	25
197	375+625	375+650	TYPE-II	25
198	375+650	375+675	TYPE-II	14
199	375+675	375+700	TYPE-II	25
200	375+700	375+725	TYPE-II	25
201	375+725	375+750	TYPE-II	25
202	375+750	375+775	TYPE-II	25
203	375+775	375+800	TYPE-II-B	25
204	375+800	375+825	TYPE-IV	16
205	375+825	375+850	TYPE-IV	25
206	375+850	375+875	TYPE-II	25
207	375+900	375+925	TYPE-I	0
208	375+925	375+950	TYPE-III	0
209	375+950	375+975	TYPE-III	25
210	375+975	376+000	TYPE-III	25
211	376+000	376+025	TYPE-III	25
212	376+025	376+050	TYPE-I	25
213	376+050	376+075	TYPE-I	14
214	376+075	376+100	TYPE-I	25
215	376+100	376+125	TYPE-I	25
216	376+125	376+150	TYPE-I	25
217	376+150	376+175	TYPE-I	25
218	376+175	376+200	TYPE-I	25
219	376+200	376+225	TYPE-I	25
220	376+225	376+250	TYPE-III	25
221	376+250	376+275	TYPE-III	25
222	376+275	376+300	TYPE-I	25
223	376+300	376+325	TYPE-I	14
224	376+325	376+350	TYPE-I	25
225	376+350	376+375	TYPE-I	25
226	376+375	376+400	TYPE-I	25
227	376+400	376+425	TYPE-II-B	25
228	376+425	376+450	TYPE-II-B	25
229	376+450	376+475	TYPE-II	25
230	376+475	376+500	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
231	376+500	376+525	TYPE-I	14
232	376+525	376+550	TYPE-I-A	25
233	376+550	376+575	TYPE-I-A	25
234	376+575	376+600	TYPE-I-A	25
235	376+600	376+625	TYPE-I-A	25
236	376+625	376+650	TYPE-I-A	16
237	376+650	376+675	TYPE-III-A	25
238	376+675	376+700	TYPE-III-A	25
239	376+700	376+725	TYPE-III-A	25
240	376+725	376+750	TYPE-I-A	25
241	376+750	376+775	TYPE-I	25
242	376+775	376+800	TYPE-I	25
243	376+800	376+825	TYPE-I	25
244	376+825	376+850	TYPE-I	25
245	376+850	376+875	TYPE-II	25
246	376+875	376+900	TYPE-II	16
247	376+900	376+925	TYPE-I	25
248	376+925	376+950	TYPE-I	25
249	376+950	376+975	TYPE-I	16
250	376+975	377+000	TYPE-I	25
251	377+000	377+025	TYPE-I	25
252	377+025	377+050	TYPE-I	25
253	377+050	377+075	TYPE-I	25
254	377+075	377+100	TYPE-I	25
255	377+100	377+125	TYPE-I	25
256	377+125	377+150	TYPE-I	25
257	377+150	377+175	TYPE-I	25
258	377+175	377+200	TYPE-III-B	25
259	377+200	377+225	TYPE-III-B	25
260	377+225	377+250	TYPE-III	25
261	377+250	377+275	TYPE-III	25
262	377+275	377+300	TYPE-III	25
263	377+300	377+325	TYPE-III	25
264	377+325	377+350	TYPE-I	25
265	377+350	377+375	TYPE-I	25
266	377+375	377+400	TYPE-I	25
267	377+400	377+425	TYPE-I	25
268	377+425	377+450	TYPE-I	16
269	377+450	377+475	TYPE-I	25
270	377+475	377+500	TYPE-I	25
271	377+500	377+525	TYPE-I	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
272	377+525	377+550	TYPE-I	25
273	377+550	377+575	TYPE-I	25
274	377+575	377+600	TYPE-I	16
275	377+600	377+625	TYPE-I	25
276	377+625	377+650	TYPE-I	25
277	377+650	377+675	TYPE-I	25
278	377+675	377+700	TYPE-I	25
279	377+700	377+725	TYPE-I	25
280	377+725	377+750	TYPE-II	12
281	377+750	377+775	TYPE-II	25
282	377+775	377+800	TYPE-IV	25
283	377+800	377+825	TYPE-IV	25
284	377+825	377+850	TYPE-II	25
285	377+850	377+875	TYPE-II	25
286	377+875	377+900	TYPE-II	16
287	377+900	377+925	TYPE-II	25
288	377+925	377+950	TYPE-II	25
289	377+950	377+975	TYPE-II	25
290	377+975	378+000	TYPE-II	25
291	378+000	378+025	TYPE-II	25
292	378+025	378+050	TYPE-II	25
293	378+050	378+075	TYPE-II	12
294	378+075	378+100	TYPE-II	25
295	378+100	378+125	TYPE-II	25
296	378+325	378+350	TYPE-I	25
297	378+350	378+375	TYPE-I	25
298	378+375	378+400	TYPE-I	25
299	378+400	378+425	TYPE-I	25
300	378+425	378+450	TYPE-I	25
301	378+450	378+475	TYPE-I	25
302	378+475	378+500	TYPE-I	25
303	378+500	378+525	TYPE-I	25
304	378+525	378+550	TYPE-I	25
305	378+550	378+575	TYPE-III	25
306	378+575	378+600	TYPE-III	25
307	378+600	378+625	TYPE-III	12
308	378+625	378+650	TYPE-I	25
309	378+650	378+675	TYPE-I	25
310	378+675	378+700	TYPE-I	25
311	378+700	378+725	TYPE-I	25
312	378+725	378+750	TYPE-I	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
313	378+750	378+775	TYPE-III	25
314	378+775	378+800	TYPE-III	12
315	378+800	378+825	TYPE-I	25
316	378+825	378+850	TYPE-I	25
317	378+850	378+875	TYPE-I	25
318	378+875	378+900	TYPE-I	25
319	383+625	383+650	TYPE-I-A	25
320	383+650	383+675	TYPE-II	16
321	383+675	383+700	TYPE-II	25
322	383+700	383+725	TYPE-II	25
323	383+725	383+750	TYPE-II-A	25
324	383+750	383+775	TYPE-II-A	25
325	383+775	383+800	TYPE-II-A	25
326	383+800	383+825	TYPE-II-B	25
327	383+825	383+850	TYPE-II-B	25
328	383+850	383+875	TYPE-II	25
329	383+875	383+900	TYPE-II	25
330	383+900	383+925	TYPE-II	16
331	383+925	383+950	TYPE-II	25
332	383+950	383+975	TYPE-II	25
333	383+975	384+000	TYPE-II	25
334	384+000	384+025	TYPE-II	25
335	384+025	384+050	TYPE-II	25
336	384+050	384+075	TYPE-II	25
337	384+075	384+100	TYPE-II	25
338	384+100	384+125	TYPE-II-B	25
339	384+125	384+150	TYPE-II	25
340	384+150	384+175	TYPE-II	14
341	384+175	384+200	TYPE-II-B	25
342	384+200	384+225	TYPE-II-B	25
343	384+225	384+250	TYPE-II-B	25
344	384+250	384+275	TYPE-II-B	25
345	384+275	384+300	TYPE-II	25
346	384+300	384+325	TYPE-II	25
347	384+325	384+350	TYPE-II	16
348	384+350	384+375	TYPE-II	25
349	384+375	384+400	TYPE-II	25
350	384+400	384+425	TYPE-II	25
351	384+425	384+450	TYPE-II	25
352	384+450	384+475	TYPE-II	25
353	384+475	384+500	TYPE-II-B	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
354	384+500	384+525	TYPE-II-B	12
355	384+525	384+550	TYPE-II-B	25
356	384+550	384+575	TYPE-II	25
357	384+575	384+600	TYPE-II-B	25
358	384+600	384+625	TYPE-II-B	25
359	384+625	384+650	TYPE-II-B	25
360	384+650	384+675	TYPE-II	25
361	384+700	384+725	TYPE-IV	0
362	384+725	384+750	TYPE-I	0
363	384+750	384+775	TYPE-I	25
364	384+775	384+800	TYPE-I	25
365	384+800	384+825	TYPE-I-A	25
366	384+825	384+850	TYPE-I-A	25
367	384+850	384+875	TYPE-I-A	25
368	384+875	384+900	TYPE-I	25
369	384+900	384+925	TYPE-I	25
370	384+925	384+950	TYPE-I	25
371	384+950	384+975	TYPE-I	25
372	384+975	385+000	TYPE-I	14
373	385+000	385+025	TYPE-I	25
374	385+025	385+050	TYPE-I	25
375	385+050	385+075	TYPE-I	25
376	385+075	385+100	TYPE-I	25
377	385+100	385+125	TYPE-I	25
378	385+125	385+150	TYPE-I	14
379	385+150	385+175	TYPE-III	25
380	385+175	385+200	TYPE-III-C	25
381	385+200	385+225	TYPE-III-C	12
382	385+225	385+250	TYPE-I	25
383	385+250	385+275	TYPE-III	25
384	385+275	385+300	TYPE-III-C	25
385	385+325	385+350	TYPE-I	25
386	385+350	385+375	TYPE-I	25
387	385+375	385+400	TYPE-I	25
388	385+400	385+425	TYPE-I	25
389	385+425	385+450	TYPE-I	25
390	385+450	385+475	TYPE-I	25
391	385+475	385+500	TYPE-I	25
392	385+500	385+525	TYPE-I-A	12
393	385+525	385+550	TYPE-III-A	25
394	385+550	385+575	TYPE-III-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
395	385+600	385+625	TYPE-I	0
396	385+625	385+650	TYPE-I-C	25
397	385+700	385+725	TYPE-I-A	25
398	385+725	385+750	TYPE-I-A	25
399	385+750	385+775	TYPE-I-A	25
400	385+775	385+800	TYPE-I-A	25
401	385+800	385+825	TYPE-I	25
402	385+825	385+850	TYPE-I	14
403	385+850	385+875	TYPE-I	25
404	385+875	385+900	TYPE-I	25
405	385+900	385+925	TYPE-I	25
406	385+925	385+950	TYPE-I	25
407	385+950	385+975	TYPE-I-B	25
408	385+975	386+000	TYPE-I-B	25
409	386+000	386+025	TYPE-I-B	25
410	386+050	386+075	TYPE-I-A	25
411	386+075	386+100	TYPE-I-A	14
412	386+100	386+125	TYPE-I-A	25
413	386+125	386+150	TYPE-I-A	25
414	386+150	386+175	TYPE-I-A	25
415	386+175	386+200	TYPE-I-A	25
416	386+200	386+225	TYPE-I-A	25
417	386+225	386+250	TYPE-I	25
418	386+250	386+275	TYPE-I	25
419	386+275	386+300	TYPE-I	25
420	386+325	386+350	TYPE-I	0
421	386+350	386+375	TYPE-I	14
422	386+375	386+400	TYPE-I	25
423	386+400	386+425	TYPE-I	25
424	386+425	386+450	TYPE-I	16
425	386+450	386+475	TYPE-I-B	25
426	386+475	386+500	TYPE-I-A	25
427	386+500	386+525	TYPE-I-A	25
428	386+525	386+550	TYPE-I	12
429	386+550	386+575	TYPE-I	25
430	386+575	386+600	TYPE-I-A	25
431	386+600	386+625	TYPE-I-A	25
432	386+625	386+650	TYPE-I-A	25
433	386+650	386+675	TYPE-II	25
434	386+675	386+700	TYPE-II	25
435	386+700	386+725	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
436	386+725	386+750	TYPE-II	25
437	386+750	386+775	TYPE-II	25
438	386+775	386+800	TYPE-II	25
439	386+800	386+825	TYPE-II	25
440	386+825	386+850	TYPE-II	25
441	386+850	386+875	TYPE-II	14
442	386+875	386+900	TYPE-II	25
443	386+900	386+925	TYPE-II	25
444	386+925	386+950	TYPE-II	25
445	386+950	386+975	TYPE-II	25
446	386+975	387+000	TYPE-II	25
447	387+000	387+025	TYPE-II	25
448	387+025	387+050	TYPE-II	25
449	387+050	387+075	TYPE-II	25
450	387+075	387+100	TYPE-II	14
451	387+100	387+125	TYPE-II	25
452	387+125	387+150	TYPE-II	25
453	387+150	387+175	TYPE-II	25
454	387+175	387+200	TYPE-II	25
455	387+200	387+225	TYPE-II	25
456	387+225	387+250	TYPE-II	25
457	387+250	387+275	TYPE-II	25
458	387+275	387+300	TYPE-II	25
459	387+300	387+325	TYPE-II	25
460	387+325	387+350	TYPE-II	16
461	387+350	387+375	TYPE-I	25
462	387+375	387+400	TYPE-I	25
463	387+400	387+425	TYPE-I	25
464	387+425	387+450	TYPE-I	25
465	387+450	387+475	TYPE-I	25
466	387+475	387+500	TYPE-I	16
467	387+500	387+525	TYPE-I	25
468	387+525	387+550	TYPE-I	25
469	387+550	387+575	TYPE-I	25
470	387+575	387+600	TYPE-I	25
471	387+600	387+625	TYPE-I	25
472	387+625	387+650	TYPE-I	25
473	387+650	387+675	TYPE-I	25
474	387+675	387+700	TYPE-I	25
475	387+700	387+725	TYPE-I-A	25
476	387+725	387+750	TYPE-I-A	25



S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
477	387+750	387+775	TYPE-I-A	25
478	387+775	387+800	TYPE-I-A	25
479	387+800	387+825	TYPE-I-A	25
480	387+825	387+850	TYPE-I-A	16
481	387+850	387+875	TYPE-I-A	25
482	387+875	387+900	TYPE-I	25
483	387+900	387+925	TYPE-I	25
484	387+925	387+950	TYPE-I	25
485	390+625	390+650	TYPE-I	16
486	390+650	390+675	TYPE-III	25
487	390+675	390+700	TYPE-III-B	25
488	390+950	390+975	TYPE-II-B	25
489	390+975	391+000	TYPE-II	14
490	391+000	391+025	TYPE-II	25
491	391+025	391+050	TYPE-II	25
492	391+050	391+075	TYPE-II	25
493	391+075	391+100	TYPE-II	25
494	391+100	391+125	TYPE-II	25
495	391+125	391+150	TYPE-II	25
496	391+150	391+175	TYPE-II	25
497	391+175	391+200	TYPE-II-A	14
498	391+200	391+225	TYPE-II	25
499	391+225	391+250	TYPE-II	25
500	391+250	391+275	TYPE-II	25
501	391+275	391+300	TYPE-I-A	25
502	391+300	391+325	TYPE-I-A	25
503	391+325	391+350	TYPE-I-A	25
504	391+350	391+375	TYPE-I-A	25
505	391+375	391+400	TYPE-I-B	25
506	391+400	391+425	TYPE-III-B	14
507	391+425	391+450	TYPE-III-A	25
508	391+450	391+475	TYPE-III-A	25
509	391+475	391+500	TYPE-III-A	25
510	391+500	391+525	TYPE-I	25
511	391+525	391+550	TYPE-I-A	14
512	391+550	391+575	TYPE-I-A	25
513	391+575	391+600	TYPE-I-A	25
514	391+600	391+625	TYPE-I-A	25
515	391+625	391+650	TYPE-I-B	25
516	391+650	391+675	TYPE-I-B	25
517	391+675	391+700	TYPE-I	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
518	391+700	391+725	TYPE-I	16
519	391+725	391+750	TYPE-III	25
520	391+750	391+775	TYPE-III	25
521	391+775	391+800	TYPE-III	25
522	391+800	391+825	TYPE-III-A	25
523	391+825	391+850	TYPE-I-A	25
524	391+850	391+875	TYPE-I	25
525	391+875	391+900	TYPE-I	25
526	391+900	391+925	TYPE-II	14
527	391+925	391+950	TYPE-II	25
528	391+950	391+975	TYPE-II	25
529	391+975	392+000	TYPE-II	25
530	392+000	392+025	TYPE-II	25
531	392+025	392+050	TYPE-II	14
532	392+050	392+075	TYPE-II	25
533	392+075	392+100	TYPE-IV	25
534	392+100	392+125	TYPE-IV	25
535	392+125	392+150	TYPE-IV	25
536	392+150	392+175	TYPE-IV	14
537	392+200	392+225	TYPE-I	0
538	392+225	392+250	TYPE-I	0
539	392+250	392+275	TYPE-I-A	25
540	392+275	392+300	TYPE-I-A	25
541	392+300	392+325	TYPE-I-A	25
542	392+325	392+350	TYPE-I-A	25
543	392+350	392+375	TYPE-I-A	25
544	392+375	392+400	TYPE-I-A	14
545	392+400	392+425	TYPE-I-A	25
546	392+425	392+450	TYPE-I-A	25
547	392+450	392+475	TYPE-I-A	25
548	392+475	392+500	TYPE-I-A	25
549	392+500	392+525	TYPE-II	25
550	392+525	392+550	TYPE-II	16
551	392+550	392+575	TYPE-I	25
552	392+575	392+600	TYPE-I	25
553	392+600	392+625	TYPE-I	25
554	392+625	392+650	TYPE-I	25
555	392+650	392+675	TYPE-I	25
556	392+675	392+700	TYPE-I-A	25
557	392+700	392+725	TYPE-I-A	14
558	392+725	392+750	TYPE-I-A	25

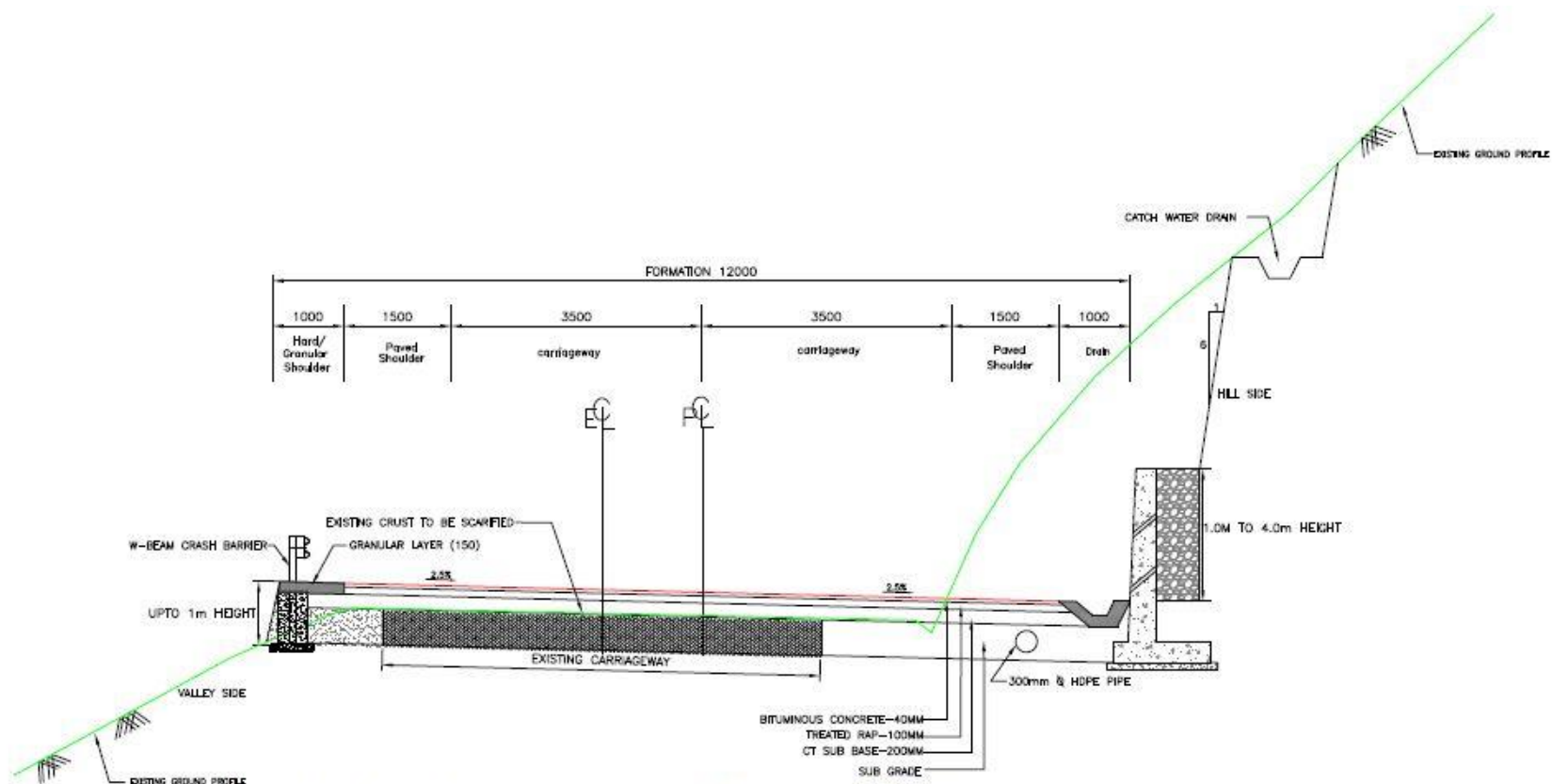
S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
559	392+750	392+775	TYPE-I-A	25
560	392+775	392+800	TYPE-I-A	25
561	392+800	392+825	TYPE-I-A	25
562	392+825	392+850	TYPE-I-A	25
563	392+850	392+875	TYPE-I-A	25
564	392+875	392+900	TYPE-I-A	25
565	392+900	392+925	TYPE-I-A	14
566	392+925	392+950	TYPE-I-A	25
567	392+950	392+975	TYPE-I-A	25
568	392+975	393+000	TYPE-I-A	25
569	393+000	393+025	TYPE-I-A	25
570	393+025	393+050	TYPE-I-A	25
571	393+050	393+075	TYPE-II-B	14
572	393+075	393+100	TYPE-II-B	25
573	393+100	393+125	TYPE-II-B	25
574	393+125	393+150	TYPE-II-A	25
575	393+150	393+175	TYPE-II-A	25
576	393+175	393+200	TYPE-II	25
577	393+200	393+225	TYPE-II	25
578	393+225	393+250	TYPE-II	14
579	393+250	393+275	TYPE-II	25
580	393+275	393+300	TYPE-II	25
581	393+300	393+325	TYPE-II	25
582	393+325	393+350	TYPE-II	25
583	393+350	393+375	TYPE-II	14
584	393+375	393+400	TYPE-II	25
585	393+400	393+425	TYPE-II	25
586	393+425	393+450	TYPE-II	25
587	393+450	393+475	TYPE-II	25
588	393+475	393+500	TYPE-II	14
589	393+500	393+525	TYPE-II	25
590	393+525	393+550	TYPE-II	25
591	393+550	393+575	TYPE-II	14
592	393+575	393+600	TYPE-II	25
593	393+600	393+625	TYPE-II	25
594	393+625	393+650	TYPE-II	25
595	393+650	393+675	TYPE-II	25
596	393+675	393+700	TYPE-II	25
597	393+700	393+725	TYPE-II	14
598	393+725	393+750	TYPE-II	25
599	393+750	393+775	TYPE-II	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
600	393+775	393+800	TYPE-II	25
601	393+800	393+825	TYPE-II	25
602	393+825	393+850	TYPE-II	25
603	393+850	393+875	TYPE-II	25
604	393+875	393+900	TYPE-II	14
605	393+900	393+925	TYPE-II	25
606	393+925	393+950	TYPE-II	25
607	393+950	393+975	TYPE-II	14
608	393+975	394+000	TYPE-II	25
609	394+000	394+025	TYPE-II	25
610	394+025	394+050	TYPE-II	14
611	394+050	394+075	TYPE-II	25
612	394+075	394+100	TYPE-II	25
613	394+100	394+125	TYPE-II	25
614	394+125	394+150	TYPE-II	25
615	394+150	394+175	TYPE-II	25
616	394+175	394+200	TYPE-II	25
617	394+200	394+225	TYPE-II	25
618	394+225	394+250	TYPE-II	14
619	394+250	394+275	TYPE-II	25
620	394+275	394+300	TYPE-II	25
621	394+300	394+325	TYPE-II	25
622	394+325	394+350	TYPE-II	25
623	394+350	394+375	TYPE-II	25
624	394+375	394+400	TYPE-II	25
625	394+400	394+425	TYPE-II	25
626	394+425	394+450	TYPE-II	25
627	394+450	394+475	TYPE-II	25
628	394+475	394+500	TYPE-II	14
629	394+500	394+525	TYPE-II	25
630	394+525	394+550	TYPE-II	25
631	394+550	394+575	TYPE-II	25
632	394+575	394+600	TYPE-II	25
633	394+600	394+625	TYPE-II	25
634	394+625	394+650	TYPE-II	25
635	394+650	394+675	TYPE-II	25
636	394+675	394+700	TYPE-II-A	25
637	394+700	394+725	TYPE-II-A	14
638	394+725	394+750	TYPE-II-A	25
639	394+750	394+775	TYPE-II-A	25
640	394+775	394+800	TYPE-II-A	14

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
641	394+800	394+825	TYPE-II-A	25
642	394+825	394+850	TYPE-II-A	25
643	394+850	394+875	TYPE-II-A	25
644	394+875	394+900	TYPE-II-A	25
645	394+900	394+925	TYPE-II-A	14
646	394+925	394+950	TYPE-II-A	25
647	394+950	394+975	TYPE-II-A	25
648	394+975	395+000	TYPE-II-A	25
649	395+000	395+025	TYPE-II	25
650	395+025	395+050	TYPE-II	25
651	395+050	395+075	TYPE-II	25
652	395+075	395+100	TYPE-IV	25
653	395+100	395+125	TYPE-III-B	25
654	395+125	395+150	TYPE-I-C	14
655	395+150	395+175	TYPE-I-B	25
656	395+175	395+200	TYPE-I-A	25
657	395+200	395+225	TYPE-I-A	25
658	395+225	395+250	TYPE-I-A	25
659	395+250	395+275	TYPE-I-A	12
660	395+275	395+300	TYPE-I-A	25
661	395+300	395+325	TYPE-I-A	25
662	395+325	395+350	TYPE-I-B	25
663	395+350	395+375	TYPE-I-A	25
664	395+375	395+400	TYPE-I-A	25
665	395+400	395+425	TYPE-I-A	14
666	395+425	395+450	TYPE-I-A	25
667	395+450	395+475	TYPE-I-A	14
668	395+475	395+500	TYPE-I-A	25
669	395+500	395+525	TYPE-I-A	25
670	395+525	395+550	TYPE-I-A	25
671	395+550	395+575	TYPE-I-A	25
672	395+575	395+600	TYPE-II	25
673	395+600	395+625	TYPE-IV	25
674	395+625	395+650	TYPE-IV	25
675	395+650	395+675	TYPE-IV-B	14
676	395+675	395+700	TYPE-IV-B	25
677	395+700	395+725	TYPE-IV	25
678	395+725	395+750	TYPE-IV	25
679	395+750	395+775	TYPE-II-A	25
680	395+775	395+800	TYPE-II-A	25
681	395+800	395+825	TYPE-II-A	25

S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
682	395+825	395+850	TYPE-II-A	25
683	395+850	395+875	TYPE-II-A	25
684	395+875	395+900	TYPE-II	14
685	395+900	395+925	TYPE-II	25
686	395+925	395+950	TYPE-II	25
687	395+950	395+975	TYPE-II	25
688	395+975	396+000	TYPE-IV	25
689	396+000	396+025	TYPE-IV	25
690	396+025	396+050	TYPE-II	14
691	396+050	396+075	TYPE-II	25
692	396+075	396+100	TYPE-II	25
693	396+100	396+125	TYPE-II	25
694	396+125	396+150	TYPE-II	25
695	396+150	396+175	TYPE-II	25
696	396+175	396+200	TYPE-II	25
697	396+200	396+225	TYPE-II	25
698	396+225	396+250	TYPE-II	25
699	396+250	396+275	TYPE-II	14
700	396+275	396+300	TYPE-II	25
701	396+300	396+325	TYPE-II	25
702	396+325	396+350	TYPE-II	25
703	396+350	396+375	TYPE-II	25
704	396+375	396+400	TYPE-II	25
705	396+400	396+425	TYPE-IV	25
706	396+450	396+475	TYPE-IV-A	25
707	396+475	396+500	TYPE-II	25
708	396+500	396+525	TYPE-II	25
709	396+525	396+550	TYPE-II	25
710	396+550	396+575	TYPE-II	25
711	396+575	396+600	TYPE-II	14
712	396+600	396+625	TYPE-II	25
713	396+625	396+650	TYPE-II	25
714	396+650	396+675	TYPE-II	25
715	396+675	396+700	TYPE-II	14
716	396+700	396+725	TYPE-II	25
717	396+725	396+750	TYPE-II	14
718	396+750	396+775	TYPE-I	25
719	396+775	396+800	TYPE-I	25
720	396+800	396+825	TYPE-I	25
721	396+825	396+850	TYPE-I	25
722	396+850	396+875	TYPE-I	25

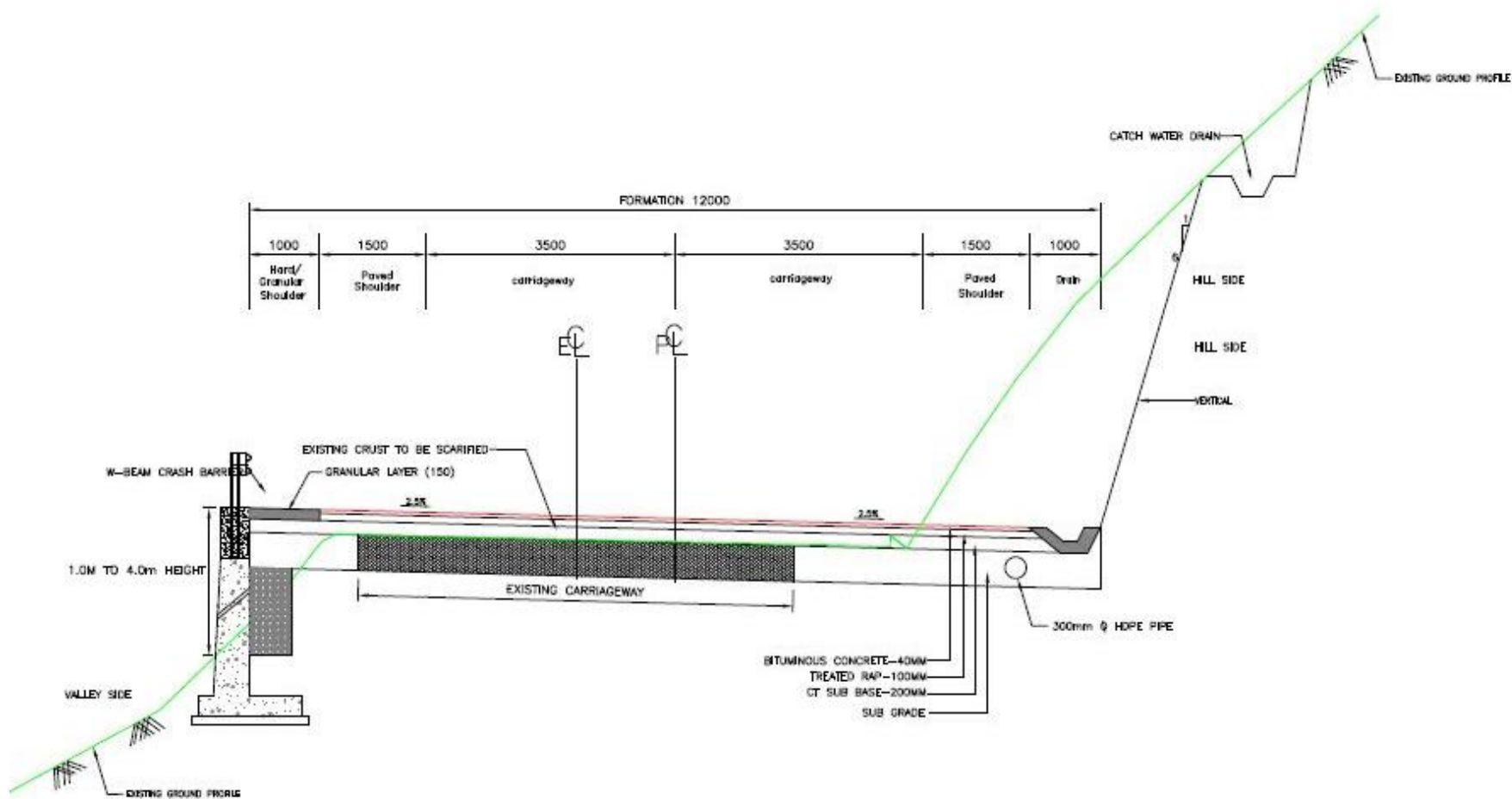
S. No.	Design Chainage (m)		TCS Type	Length (m)
	From	To		
723	396+875	396+900	TYPE-II	25
724	396+900	396+925	TYPE-II	25
725	396+925	396+950	TYPE-II	25
726	396+950	396+975	TYPE-II	14
727	396+975	397+000	TYPE-II	25
728	397+000	397+025	TYPE-II	25
729	397+025	397+050	TYPE-II	25
730	397+050	397+075	TYPE-II	25
731	397+075	397+100	TYPE-II	25
732	397+100	397+125	TYPE-II	25
733	397+125	397+150	TYPE-II	25
734	397+150	397+175	TYPE-II	25
735	397+175	397+200	TYPE-II	14
736	397+200	397+225	TYPE-II	25
737	397+225	397+250	TYPE-II	25
738	397+250	397+275	TYPE-II	25
739	397+275	397+300	TYPE-II	14
740	397+300	397+325	TYPE-II	25
741	398+275	398+300	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)**

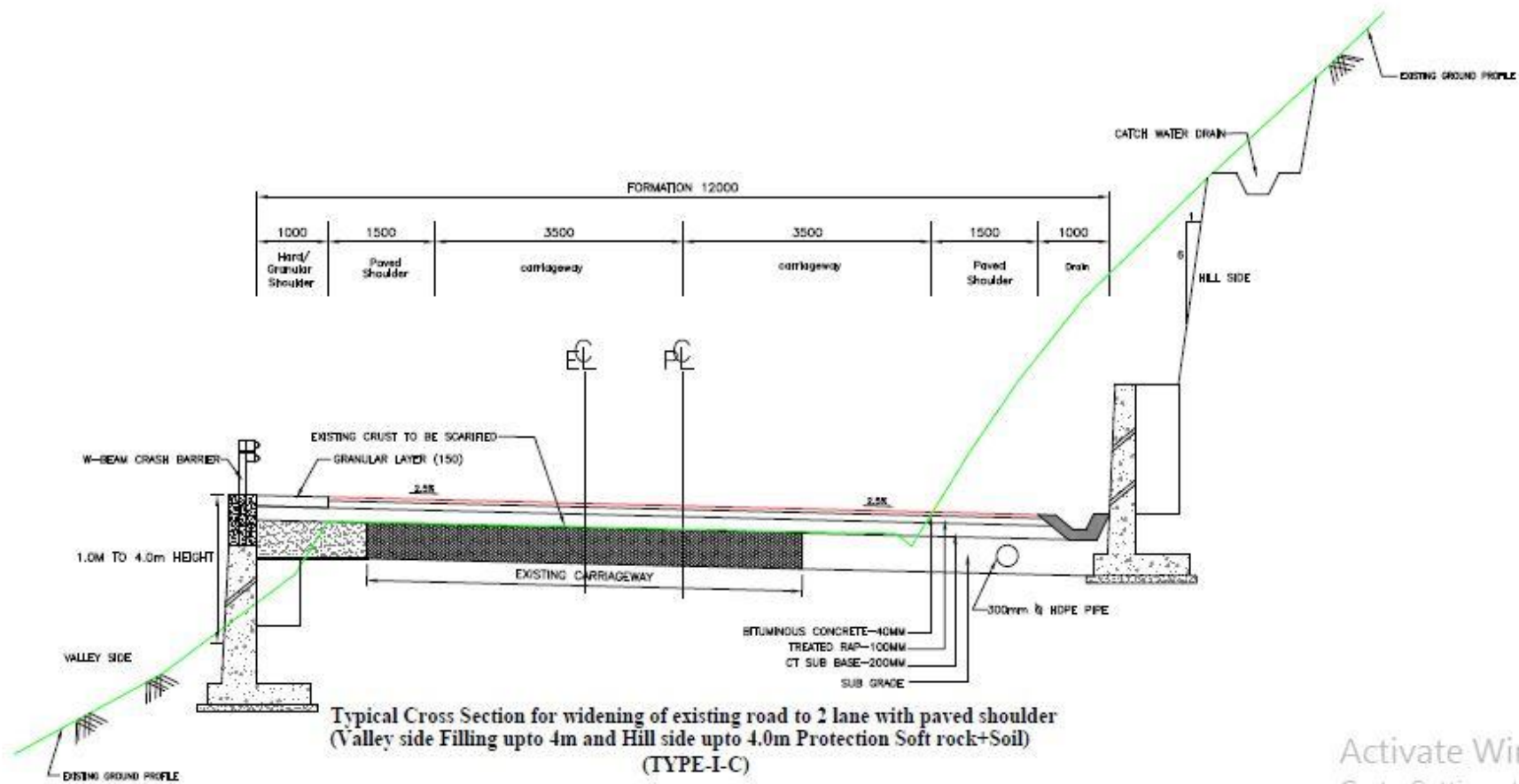
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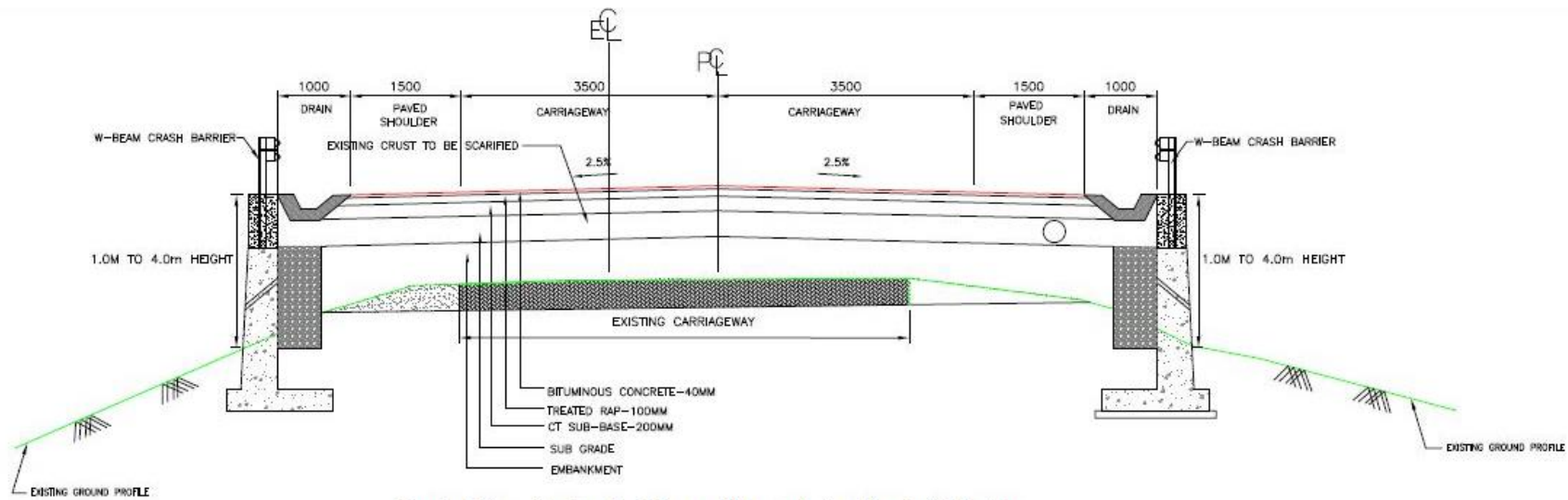


Typical Cross Section for widening of existing road to 2 lane with paved shoulder  
(Valley side Filling upto 4m Protection Soft rock+Soil)  
(TYPE-I-B)

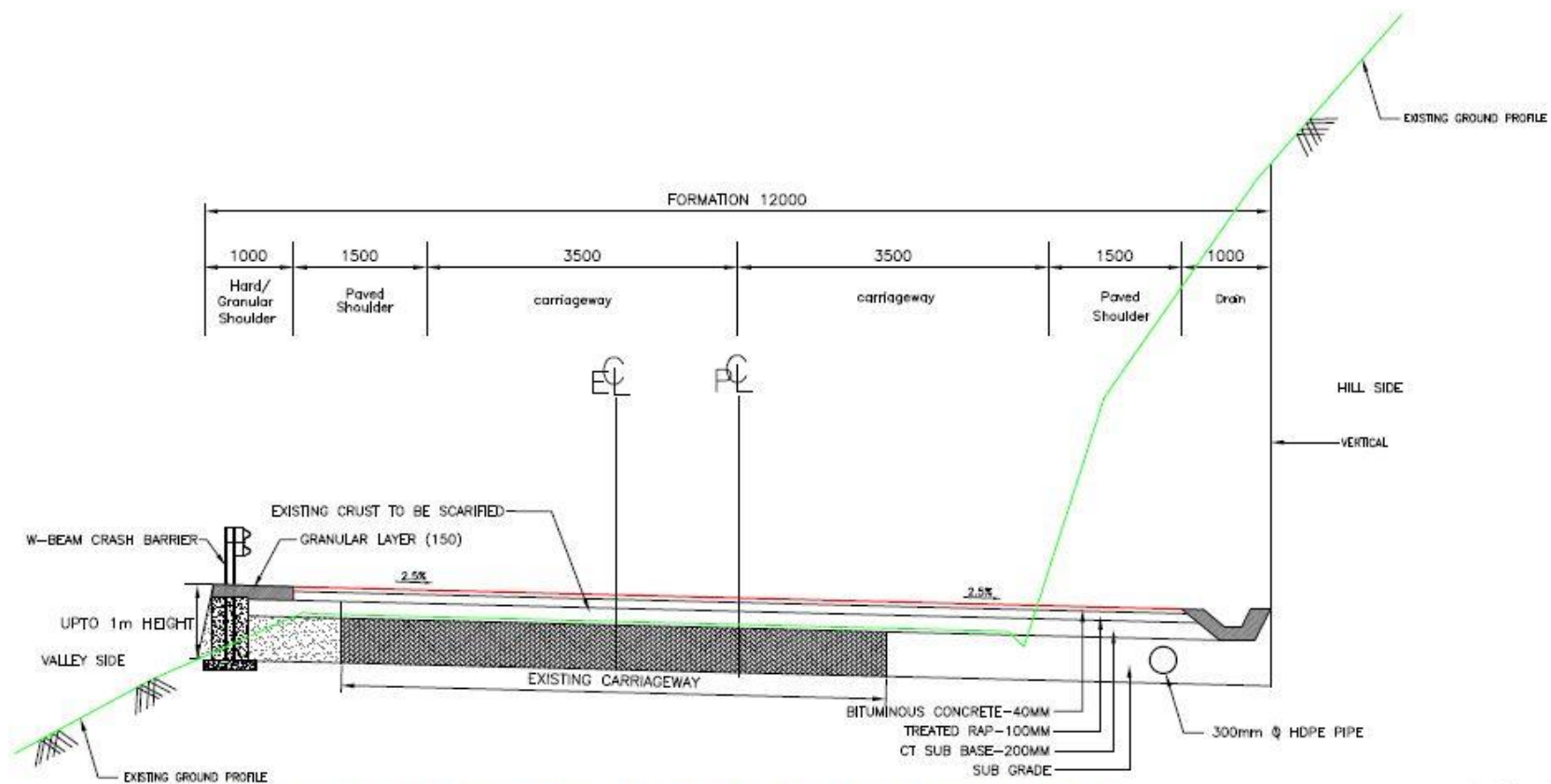
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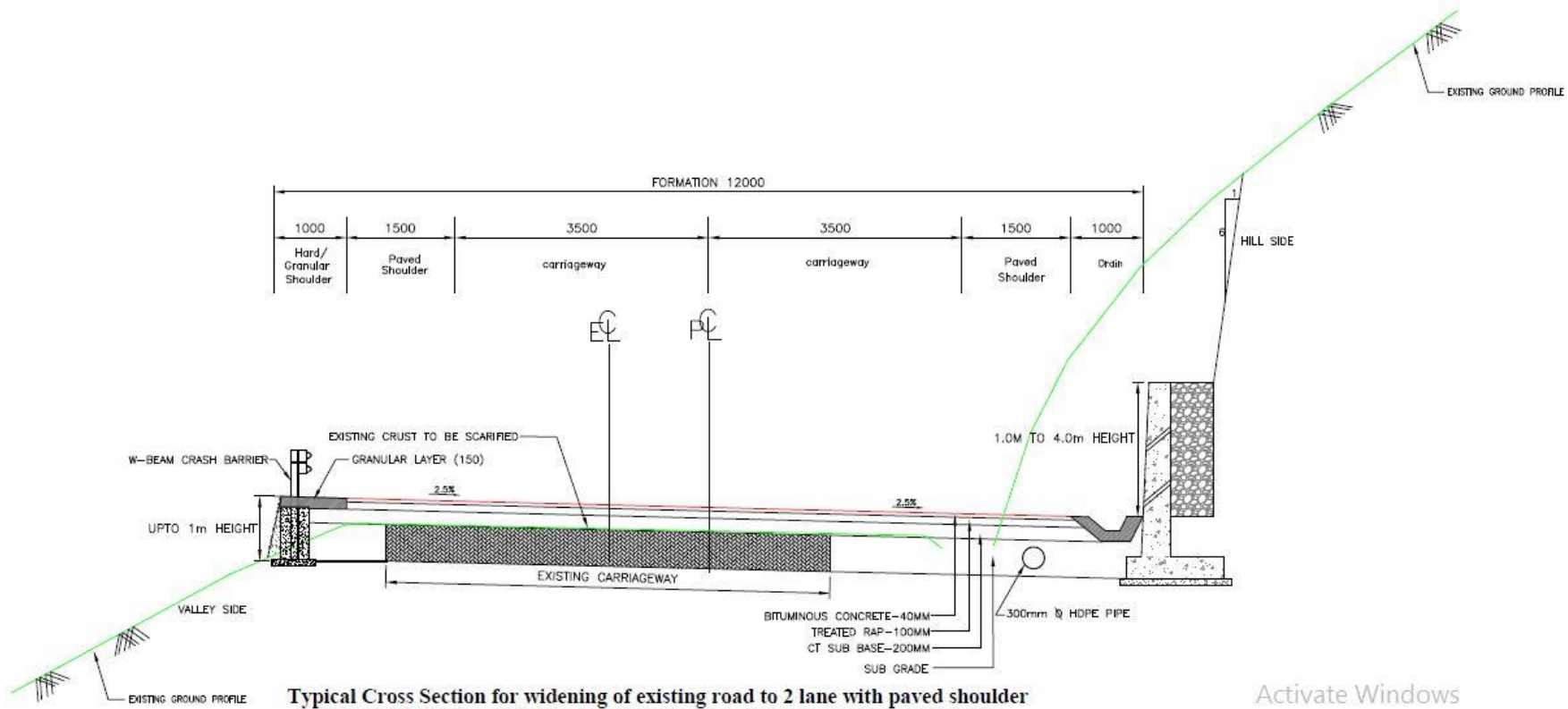
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**Typical Cross Section for 2 Lane with paved shoulder in fill Section  
(Both sides upto 4.0m Protection Soft rock+Soil)  
(TYPE-1-D)**

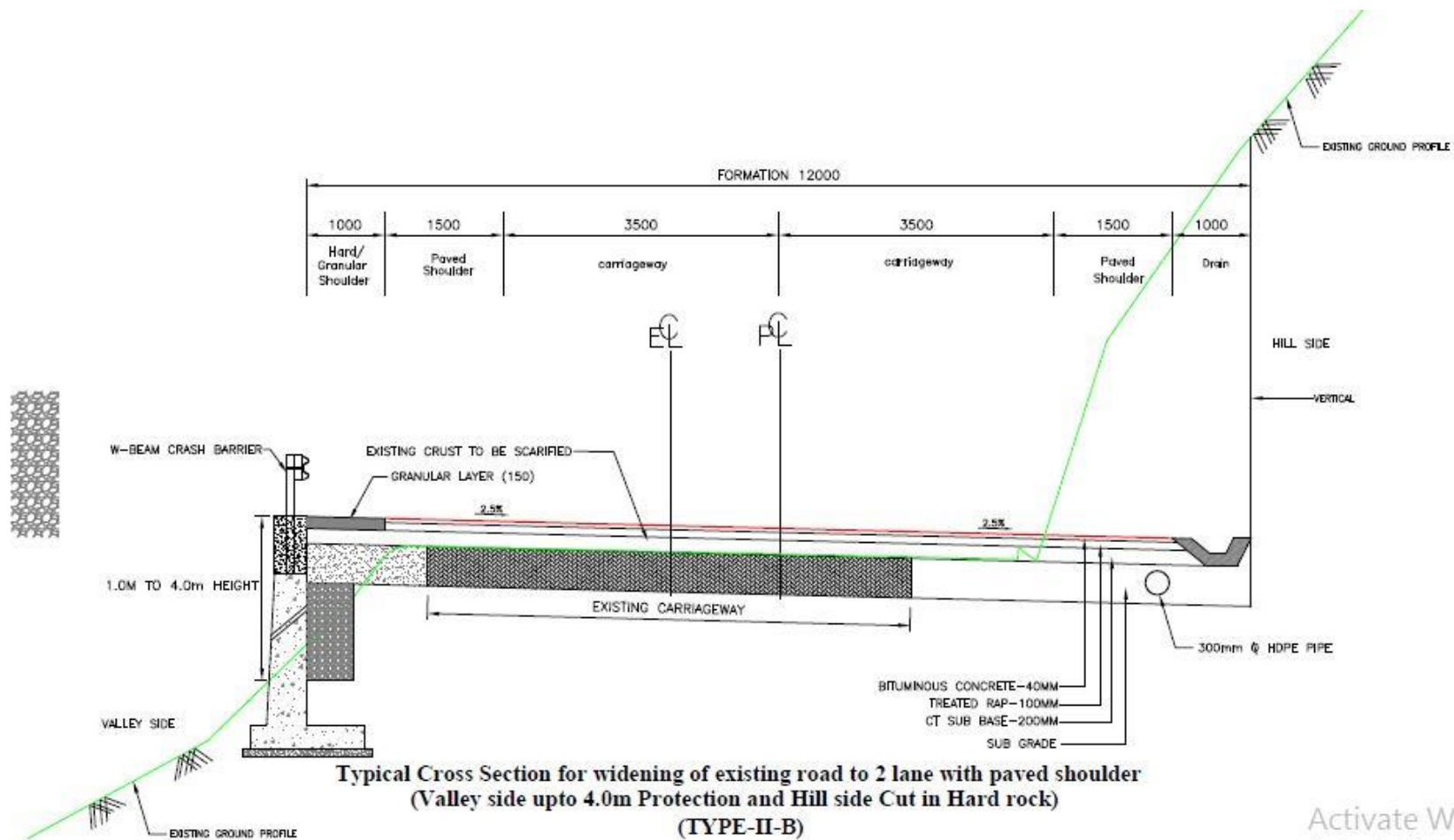


**Typical Cross Section for widening of existing road to 2 lane with paved shoulder  
(Valley side Filling upto 1m and Hill side Cut in Hard rock)  
(TYPE-II)**

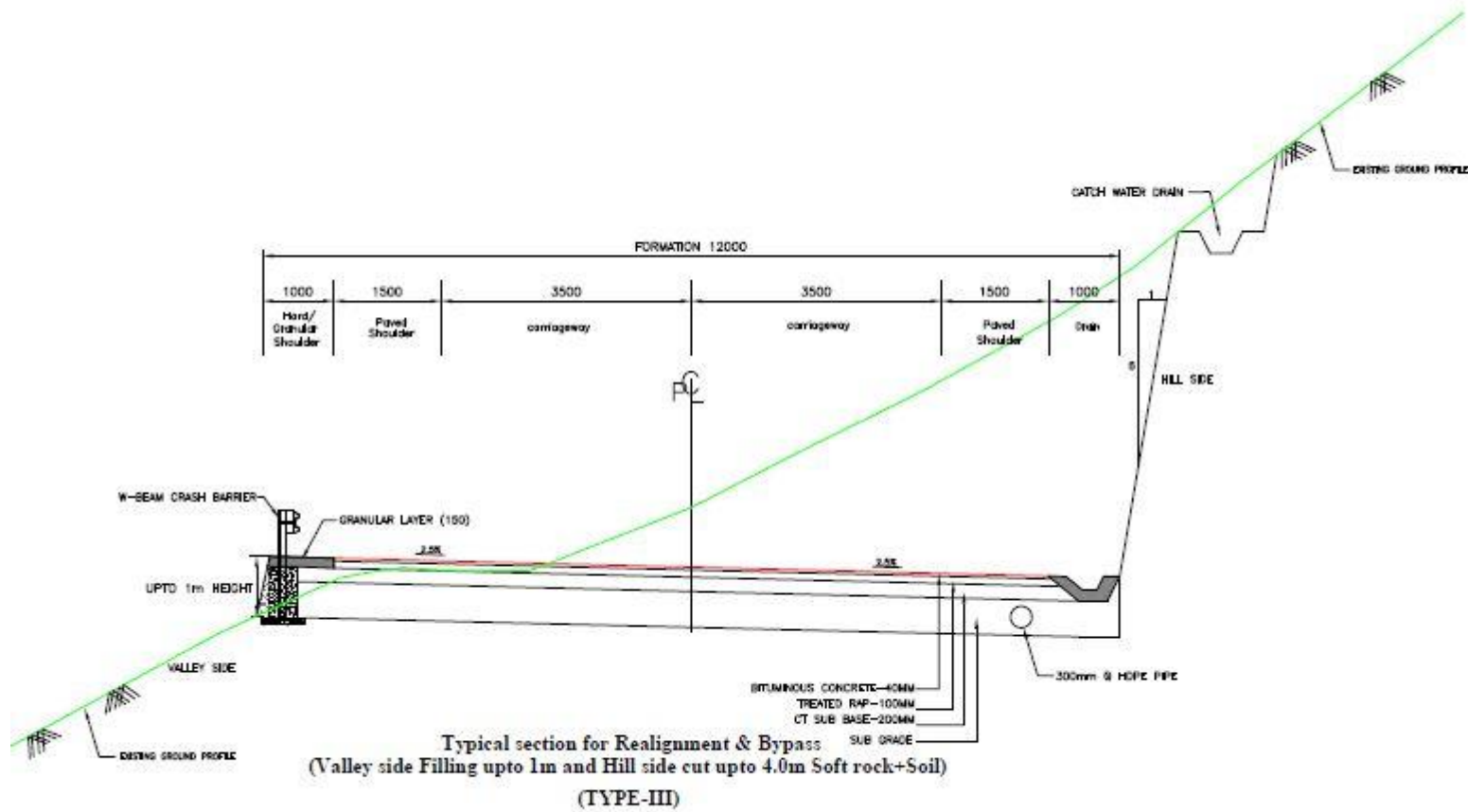


**Typical Cross Section for widening of existing road to 2 lane with paved shoulder  
(Valley side Filling upto 1m and Hill side upto 4.0m Protection Hard rock)  
(TYPE-II-A)**

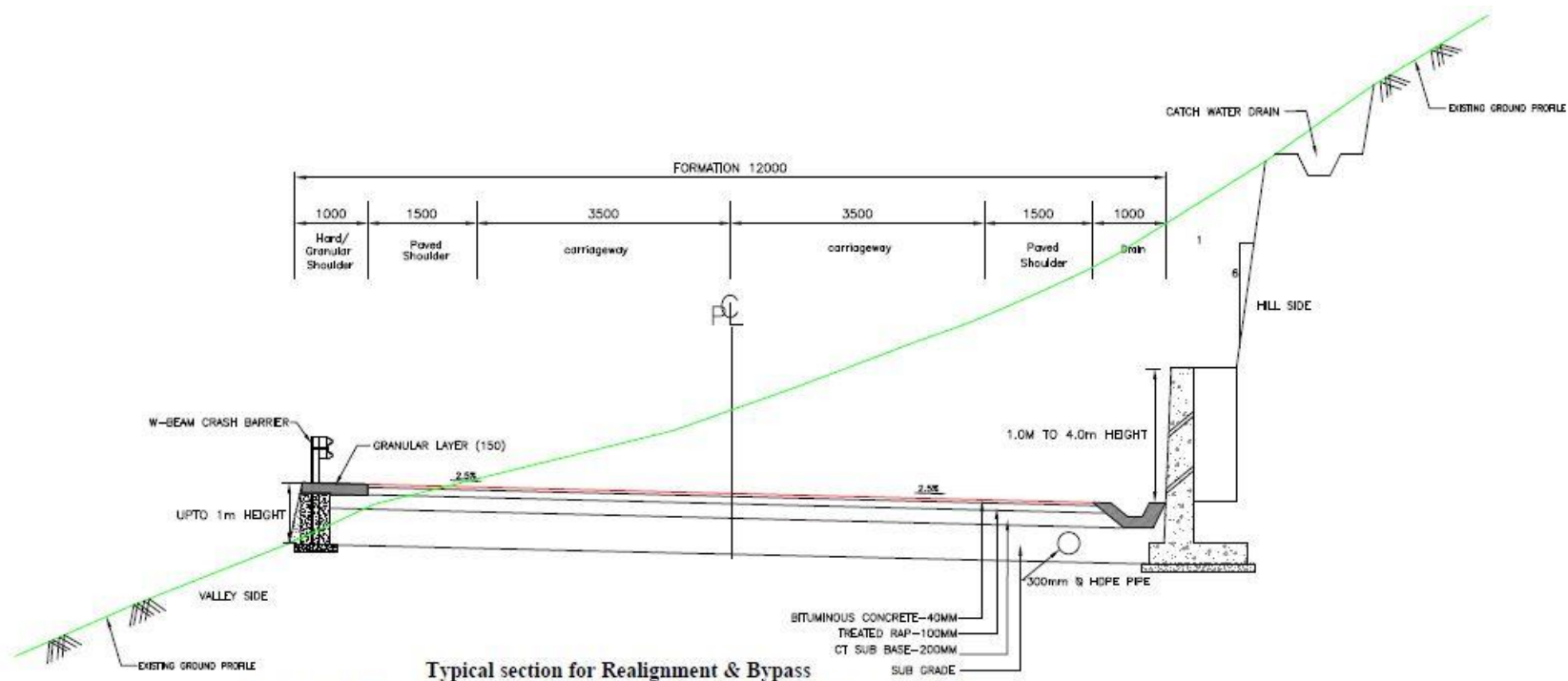
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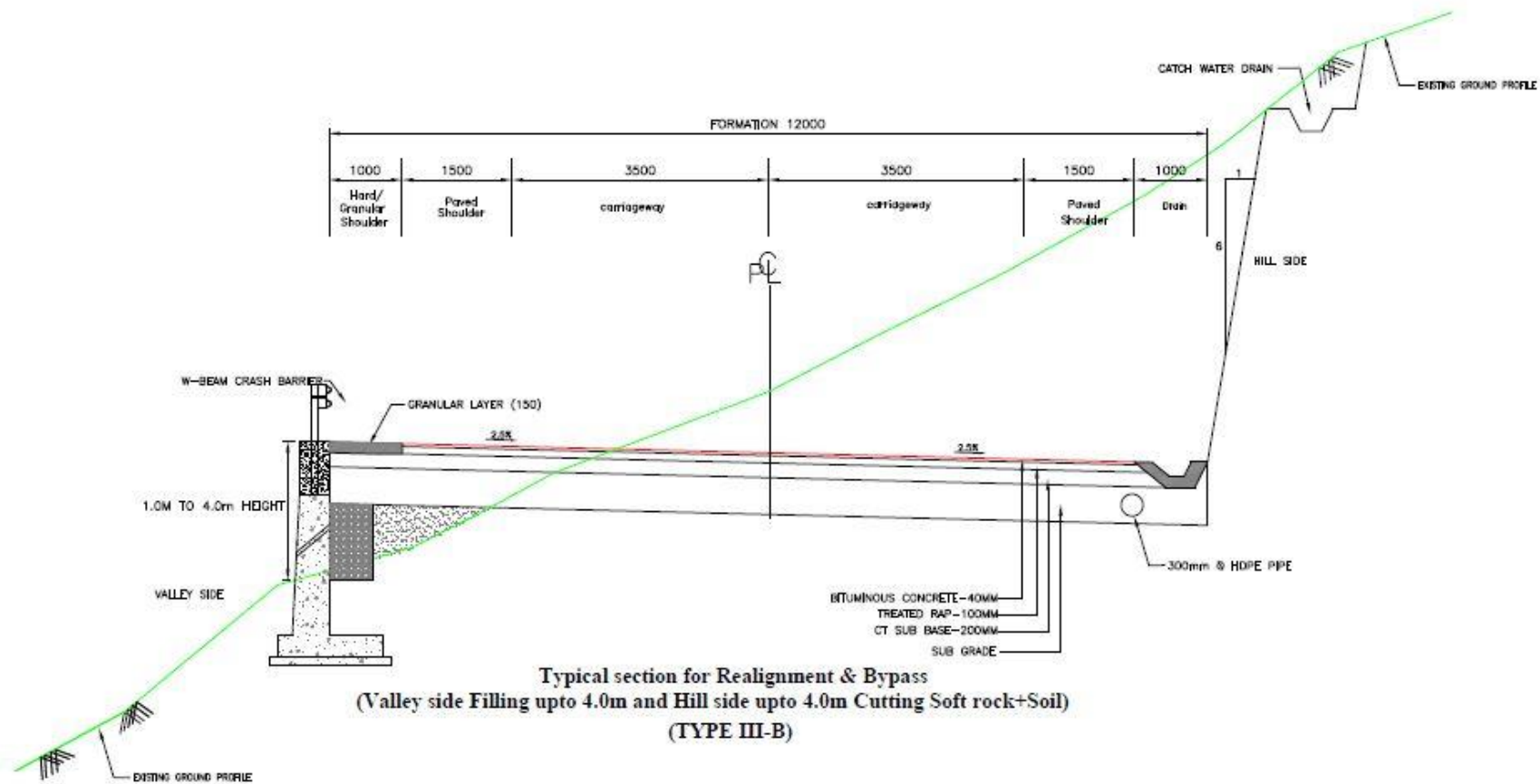


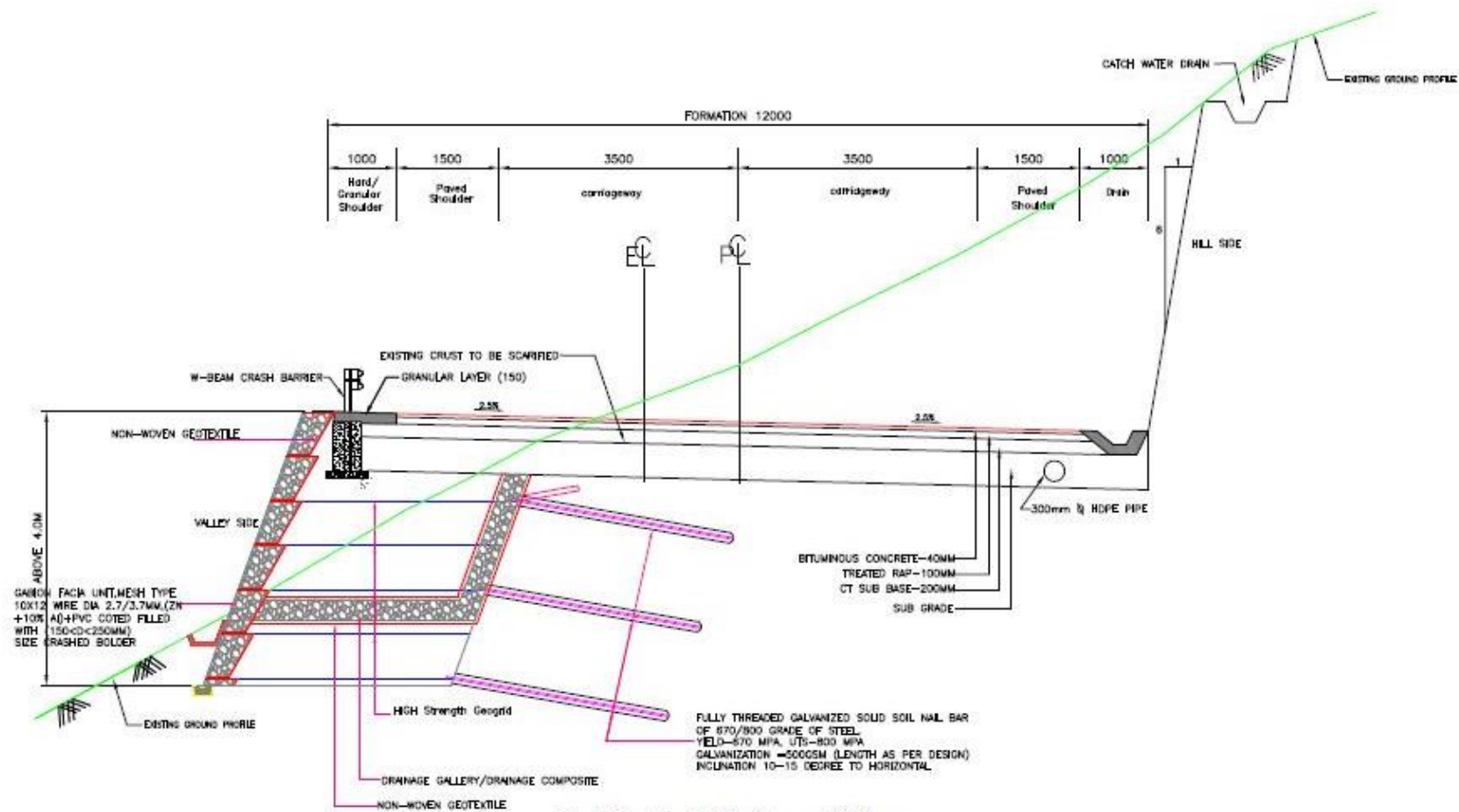




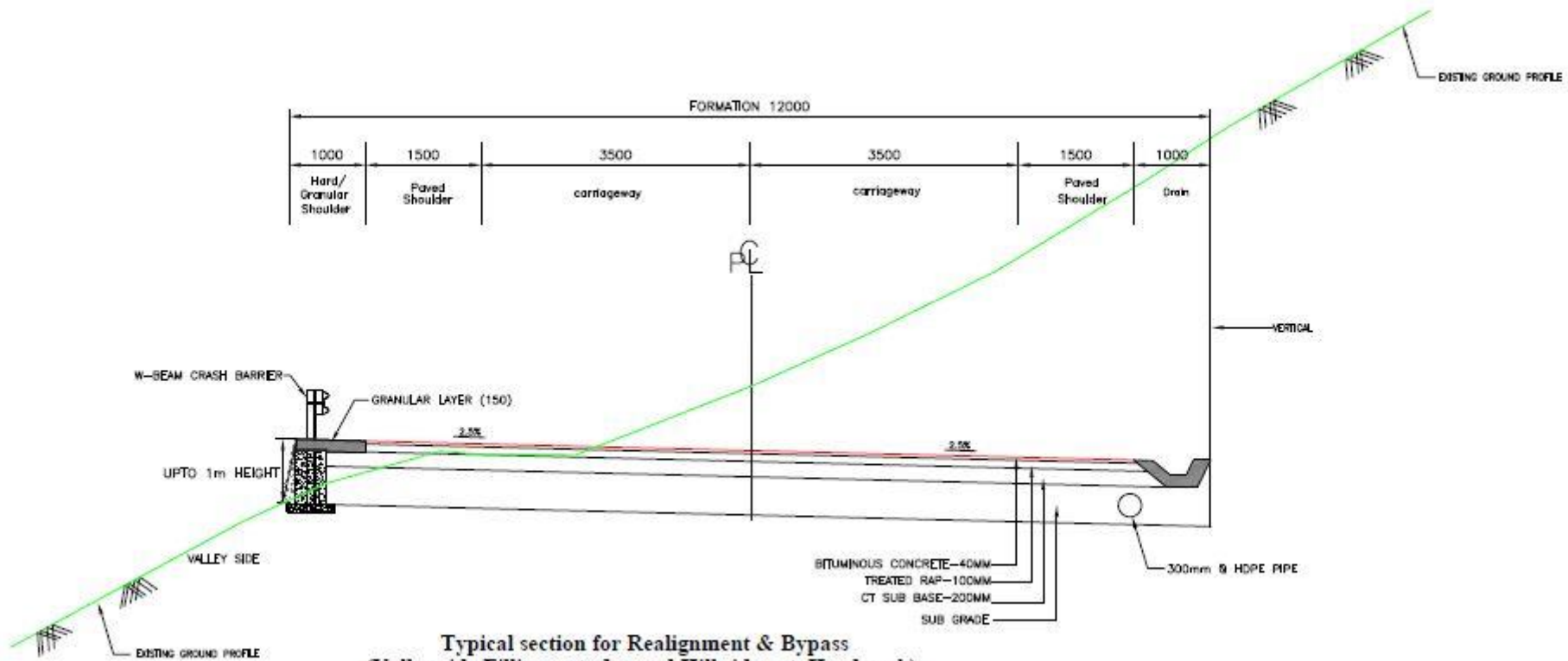
**Typical section for Realignment & Bypass**  
**(Valley side Filling upto 1m and Hill side upto 4.0m Protection Soft rock+Soil)**  
**(TYPE-III-A)**



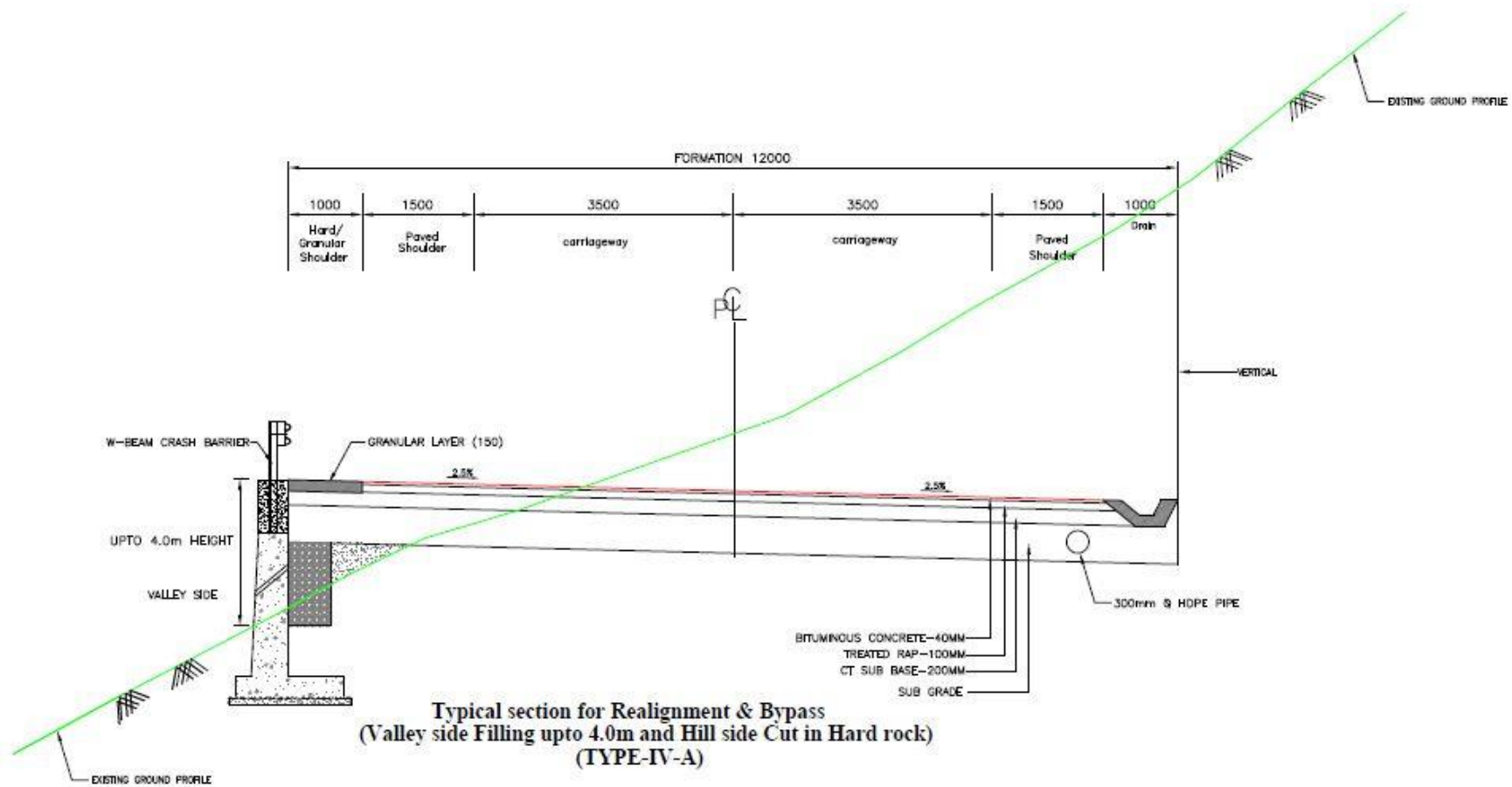


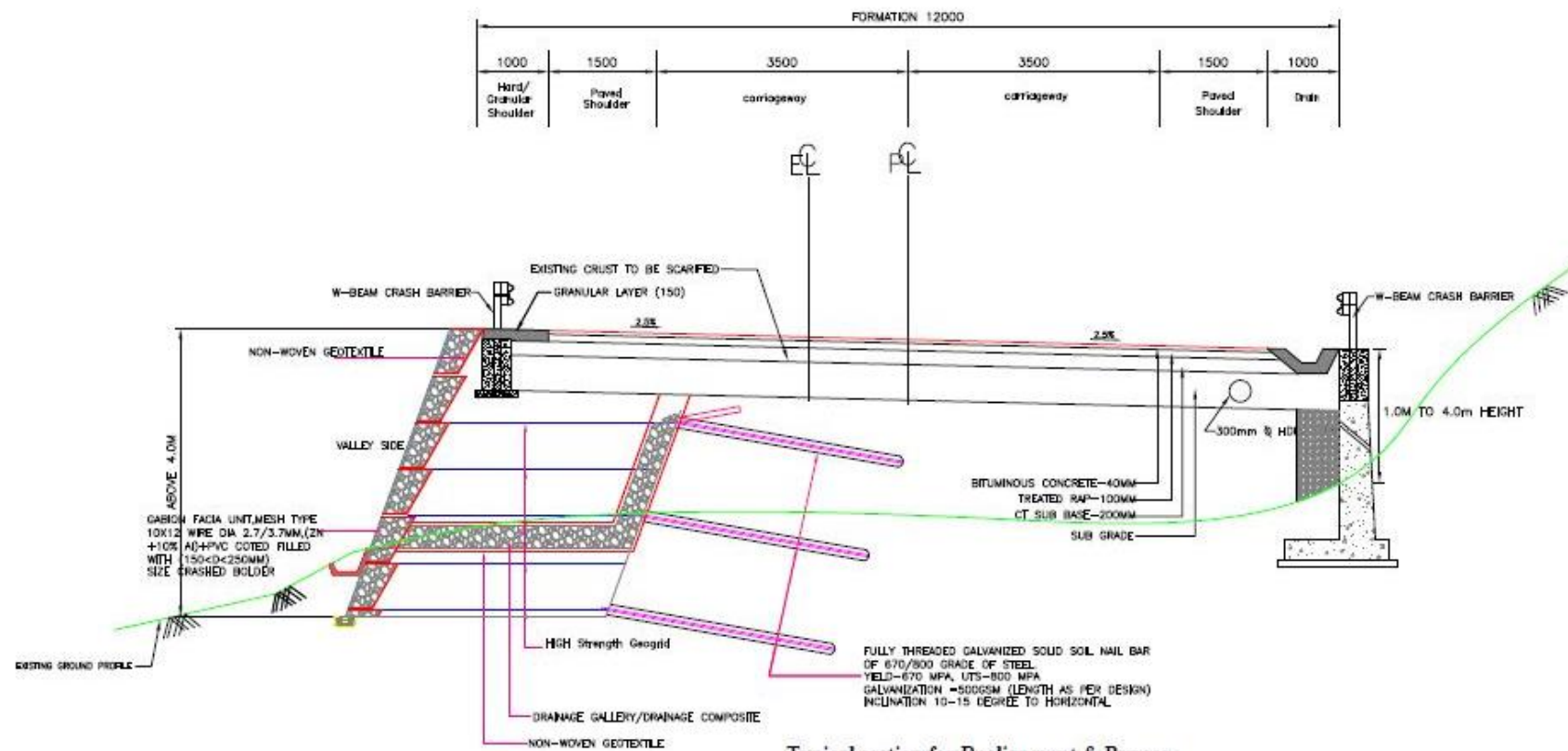


Typical section for Realignment & Bypass  
(Valley side Filling >4.0m in soft rock )  
(TYPE III-C)

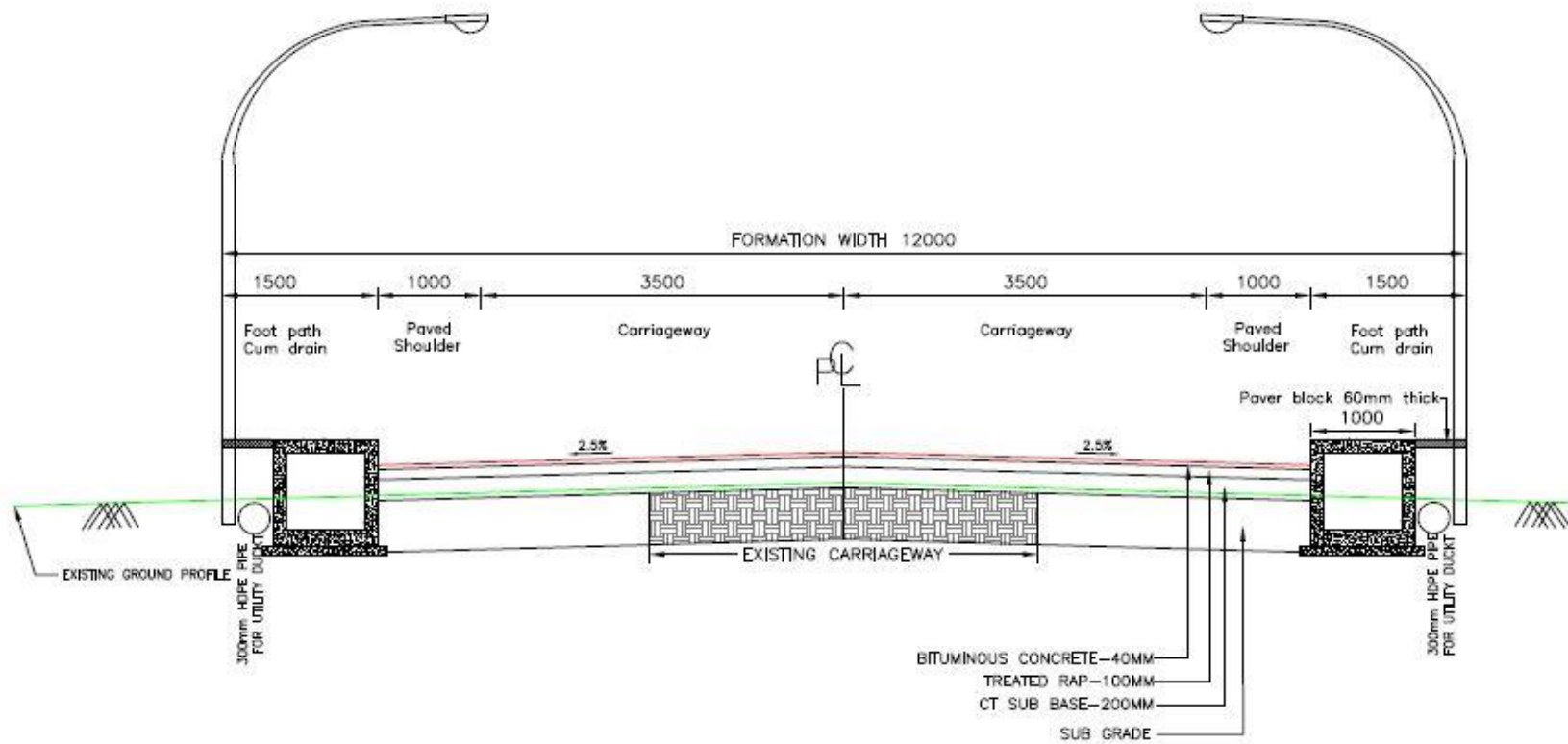


Typical section for Realignment & Bypass  
(Valley side Filling upto 1m and Hill side cut Hard rock)  
(TYPE-IV)

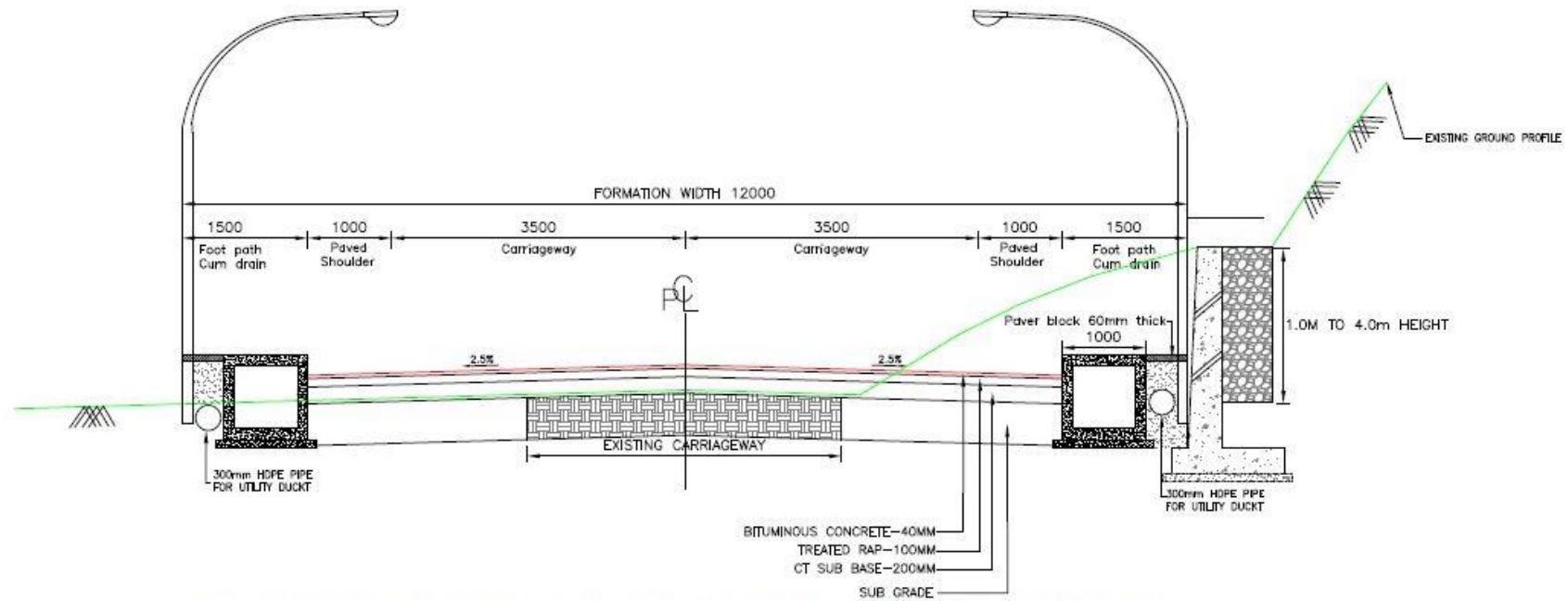




Typical section for Realignment & Bypass  
(Both sides protection in Hard rock )  
(TYPE-IV-B)

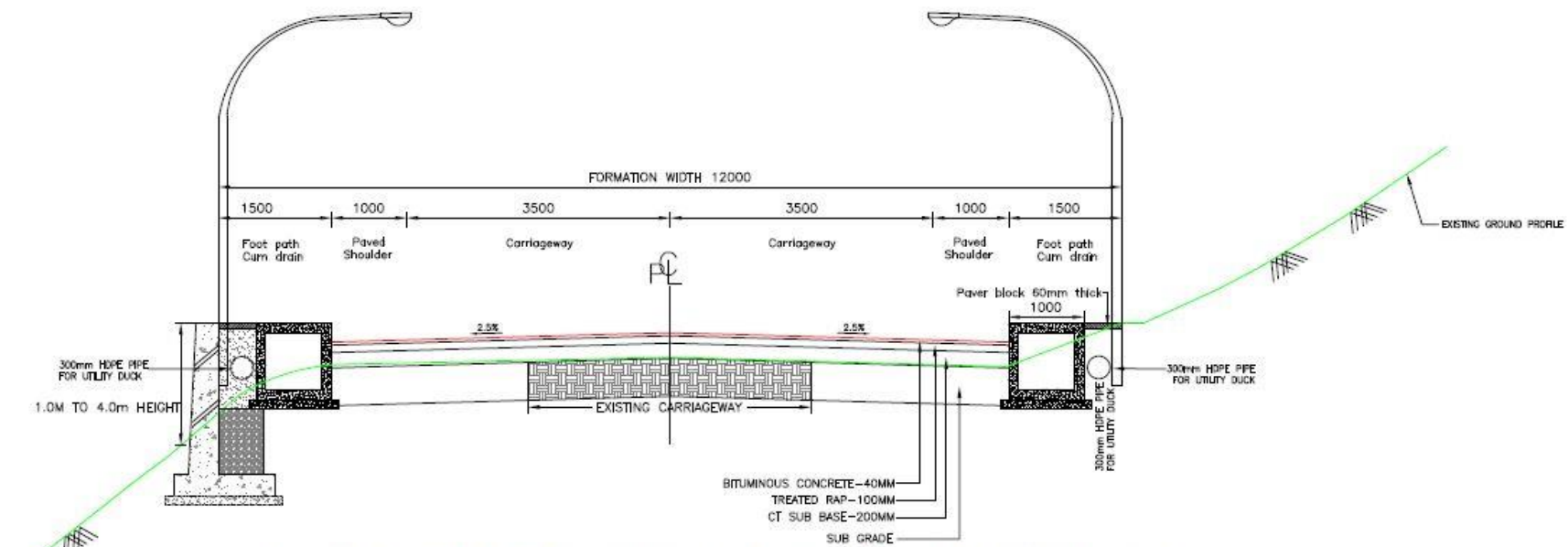


**Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(12.0m formation width)  
(TYPE-V)**



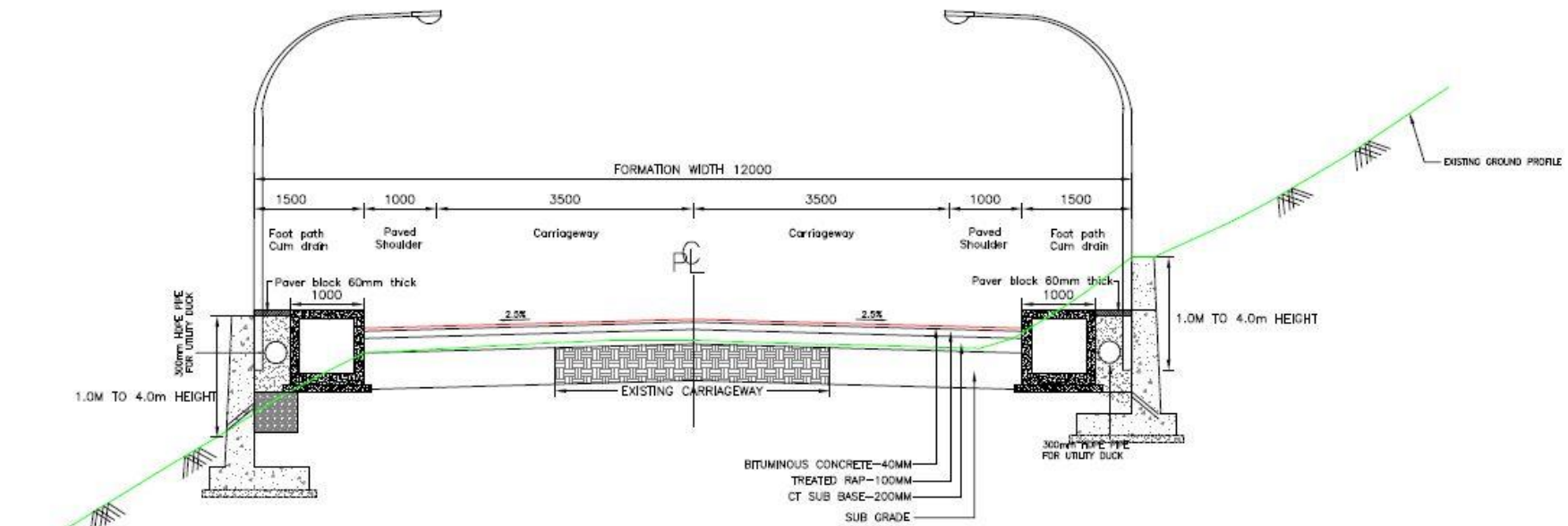
**Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(Hill side Upto 4 m Protection ) (12.0m formation width)  
(TYPE-V-A)**





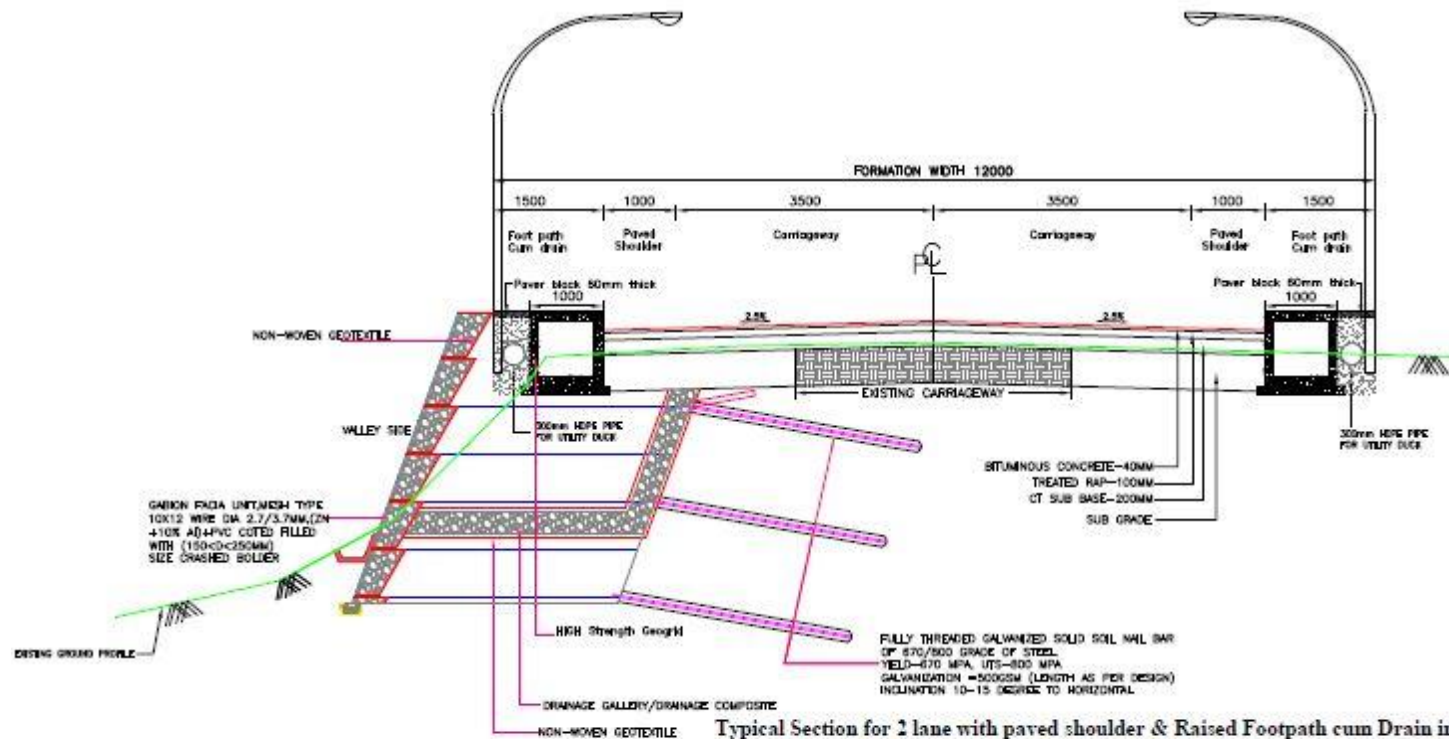
**Typical Section for 2 lane with paved shoulder & Raised Footpath cum Drain in Built-up Area)  
(Valley side Upto 4 m Protection and hill side no Protection ) (12.0m formation width)  
(TYPE-V-B)**





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)

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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)



## 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 below:

**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) analyzed after axle load survey is presented below:

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.

### 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 below:

### 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	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 below:

### Recommended Pavement Thickness

Pavement Composition	Pavement Thickness (in mm)
Bituminous Concrete (BC)	50
Aggregate inter layer	100
Cement treated base	90
Cement treated Sub base	250
Total thickness of Pavement (excluding Subgrade)	490 mm

### **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 as under –

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

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



**Bridge Cross Section with Footpath**

width of bridges to be considered for this project shall be 12.0m including 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 multi pull strand system of



- |    |   |   |
|----|---|---|
| b) | Cables  | "Freyssinet" or "ISMALCCL" or equivalent<br>: 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 sqmm 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  
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,  
: 40mm thick bituminous concrete wearing course for minor bridge,  
: 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-

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

Where,

$$Ah = Horizontal seismic co-efficient = (Z/2) \times (S_a/g)/(R/I)$$

$$Z = Zone factor$$

- I = Important factor and is taken as 1.5 for important Bridges.  
R = Response reduction factor and is equal to 2.5  
Sa/g = 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.

**p. 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) Modeling & analysis of Superstructure**

Modeling is substituting the actual structure to an equivalent mathematical structure, which is amenable to computer analysis. In modeling, 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 modeled accurately. We will pay special attention to the modeling / 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:

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

Where  $S_X$  &  $S_Z$  are seismic forces in longitudinal & transverse direction respectively, while  $S_Y$  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 (Io),  $I_o = (FIT)^*(T+1)$  I (1+1) Critical rainfall intensity,

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

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

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

Where,

$t_c$  = Time of concentration i.e. time taken by runoff from periphery of catchment (hrs)

$I_o$  = One hour rainfall in cm

$I_c$  = 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 as under.

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 as under:

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.
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.

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 07 No of Bridges proposed to be constructed new on the Project road.

#### Proposal of Additional New Bridges

S. No.	Design Chainage (km)	Proposed span	Type of Bridge
1	368+385	1 x 30	PSC
2	378+320	1 X 10	Solid Slab
3	384+720	1 x 50	Steel composite
4	385+310	1 x 10	Solid Slab
5	385+595	1 x 20	RCC T
6	386+310	1 x 20	RCC T
7	396+440	1 x 10	Solid Slab

#### 7.3.4.2 Culverts

There are 99 numbers of culverts along the project road which is reconstructed as shown below:

#### Proposed reconstructed culverts

S. No.	Design Chainage (km)	Culvert No.(As per Inventory)	Proposal	Span Arrangement (m)	Proposed type of Culvert
1	368+100	369/1	Reconstruction	4	Box
2	368+500	369/3	Reconstruction	6	Box
3	368+600	369/4	Reconstruction	4	Box
4	368+855	369/5	Reconstruction	6	Box
5	369+290	370/1	Reconstruction	4	Box
6	370+015	370/2	Reconstruction	4	Box
7	370+270	371/1	Reconstruction	4	Box
8	370+440	371/2	Reconstruction	4	Box
9	370+785	371/3	Reconstruction	4	Box
10	370+860	371/4	Reconstruction	4	Box
11	370+910	371/5	Reconstruction	4	Box
12	370+995	371/6	Reconstruction	4	Box
13	371+390	372/1	Reconstruction	4	Box
14	371+440	372/2	Reconstruction	4	Box
15	371+910	372/3	Reconstruction	4	Box
16	372+350	373/1	Reconstruction	4	Box
17	372+730	373/2	Reconstruction	4	Box

S. No.	Design Chainage (km)	Culvert No.(As per Inventory)	Proposal	Span Arrangement (m)	Proposed type of Culvert
18	372+920	373/3	Reconstruction	4	Box
19	373+470	374/1	Reconstruction	4	Box
20	373+650	374/2	Reconstruction	4	Box
21	373+780	374/3	Reconstruction	2	Box
22	373+880	374/4	Reconstruction	2	Box
23	373+940	374/5	Reconstruction	4	Box
24	374+415	375/1	Reconstruction	6	Box
25	374+880	375/2	Reconstruction	4	Box
26	375+065	376/1	Reconstruction	4	Box
27	375+805	376/2	Reconstruction	2	Box
28	376+065	377/1	Reconstruction	2	Box
29	376+325	377/2	Reconstruction	4	Box
30	377+065	378/1	Reconstruction	2	Box
31	377+730	378/2	Reconstruction	2	Box
32	378+230	379/1	Reconstruction	2	Box
33	378+795	379/3	Reconstruction	6	Box
34	379+840	381/1	Reconstruction	6	Box
35	380+425	381/2	Reconstruction	4	Box
36	380+815	381/3	Reconstruction	4	Box
37	382+275	383/1	Reconstruction	4	Box
38	382+570	383/2	Reconstruction	6	Box
39	382+960	384/1	Reconstruction	6	Box
40	383+075	384/2	Reconstruction	4	Box
41	383+160	384/3	Reconstruction	4	Box
42	385+145	386/1	Reconstruction	2	Box
43	385+220	386/2	Reconstruction	4	Box
44	385+520	386/3	Reconstruction	6	Box
45	385+670	386/4	Reconstruction	4	Box
46	385+840	387/1	Reconstruction	4	Box
47	386+355	387/2	Reconstruction	2	Box
48	386+545	387/3	Reconstruction	2	Box
49	386+865	388/1	Reconstruction	6	Box
50	387+085	388/2	Reconstruction	4	Box
51	388+085	389/1	Reconstruction	4	Box
52	389+290	390/1	Reconstruction	4	Box
53	389+360	390/2	Reconstruction	2	Box
54	389+570	390/3	Reconstruction	2	Box
55	389+660	391/1	Reconstruction	2	Box
56	389+840	391/2	Reconstruction	2	Box
57	389+960	391/3	Reconstruction	2	Box
58	390+245	391/4	Reconstruction	2	Box
59	390+435	391/5	Reconstruction	2	Box
60	390+535	391/6	Reconstruction	2	Box
61	390+640	391/7	Reconstruction	2	Box
62	390+720	392/1	Reconstruction	2	Box

S. No.	Design Chainage (km)	Culvert No.(As per Inventory)	Proposal	Span Arrangement (m)	Proposed type of Culvert
63	391+000	392/2	Reconstruction	4	Box
64	391+200	392/3	Reconstruction	4	Box
65	391+410	392/4	Reconstruction	4	Box
66	391+535	392/5	Reconstruction	4	Box
67	391+920	393/1	Reconstruction	4	Box
68	392+045	393/2	Reconstruction	4	Box
69	392+175	393/3	Reconstruction	4	Box
70	392+395	393/4	Reconstruction	4	Box
71	392+710	394/1	Reconstruction	4	Box
72	392+910	394/2	Reconstruction	4	Box
73	393+065	394/3	Reconstruction	4	Box
74	393+360	394/4	Reconstruction	4	Box
75	393+485	394/5	Reconstruction	4	Box
76	393+575	394/6	Reconstruction	4	Box
77	393+710	395/1	Reconstruction	4	Box
78	393+895	395/2	Reconstruction	4	Box
79	393+965	395/3	Reconstruction	4	Box
80	394+040	395/4	Reconstruction	4	Box
81	394+230	395/5	Reconstruction	4	Box
82	394+480	395/6	Reconstruction	4	Box
83	394+725	396/1	Reconstruction	4	Box
84	394+800	396/2	Reconstruction	4	Box
85	395+005	396/3	Reconstruction	4	Box
86	395+140	396/4	Reconstruction	4	Box
87	395+255	396/5	Reconstruction	6	Box
88	395+465	396/6	Reconstruction	4	Box
89	395+890	397/1	Reconstruction	4	Box
90	396+040	397/2	Reconstruction	4	Box
91	396+265	397/3	Reconstruction	4	Box
92	396+595	398/3	Reconstruction	4	Box
93	396+685	398/4	Reconstruction	4	Box
94	396+735	398/5	Reconstruction	4	Box
95	396+965	398/6	Reconstruction	4	Box
96	397+190	398/7	Reconstruction	4	Box
97	397+290	398/8	Reconstruction	4	Box
98	397+490	399/1	Reconstruction	4	Box
99	397+975	399/2	Reconstruction	4	Box

### Proposed New Culvert

S. No.	Design Chainage (km)	Span Arrangement (m)	Width (m)	Proposed type of Culvert
1	369+100	2	12	Box

S. No.	Design Chainage (km)	Span Arrangement (m)	Width (m)	Proposed type of Culvert
2	370+700	6	12	Box
3	371+200	2	12	Box
4	371+550	2	12	Box
5	372+075	4	12	Box
6	372+650	2	12	Box
7	372+810	6	12	Box
8	373+000	2	12	Box
9	373+245	6	12	Box
10	374+010	2	12	Box
11	374+085	2	12	Box
12	375+175	2	12	Box
13	375+425	4	12	Box
14	375+675	4	12	Box
15	376+505	4	12	Box
16	376+650	2	12	Box
17	376+900	2	12	Box
18	377+450	2	12	Box
19	377+590	2	12	Box
20	377+900	2	12	Box
21	378+065	6	12	Box
22	378+615	6	12	Box
23	378+975	2	12	Box
24	379+185	6	12	Box
25	379+465	6	12	Box
26	379+650	2	12	Box
27	380+965	4	12	Box
28	381+200	4	12	Box
29	381+385	4	12	Box
30	382+500	6	12	Box
31	383+675	2	12	Box
32	383+925	2	12	Box
33	384+175	4	12	Box
34	384+350	2	12	Box
35	384+515	6	12	Box
36	385+000	4	12	Box
37	386+095	4	12	Box
38	386+450	2	12	Box



S. No.	Design Chainage (km)	Span Arrangement (m)	Width (m)	Proposed type of Culvert
39	387+340	2	12	Box
40	387+595	2	12	Box
41	387+850	2	12	Box
42	388+270	4	12	Box
43	388+350	4	12	Box
44	388+460	4	12	Box
45	388+550	4	12	Box
46	388+990	4	12	Box
47	391+725	2	12	Box
48	392+535	2	12	Box
49	393+235	4	12	Box
50	395+420	4	12	Box
51	395+665	4	12	Box

## 7.4 PROJECT FACILITIES

### 7.4.1 Bus Shelters

In hilly areas, there are several locations, where buses make short stops overs 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:

#### Bus Shelters

S. No.	Design Chainage (km)	Village	Side
1	369+600	Lameri	Both Side
2	369+850	Tilni	Both Side
3	371+450	Sumerpur	Both Side
4	373+900	Ratura	Both Side
5	376+000	Kalnahodli	Both Side
6	377+400	Sandh	Both Side
7	378+250	Shivanandi	Both Side
8	380+000	Gholteer	Both Side

S. No.	Design Chainage (km)	Village	Side
9	382+350	Nagrasu	Both Side
10	385+000	Kameda	Both Side
11	387+000	Gouchar	Both Side
12	391+700	Dhari nagar	Both Side
13	392+850	Chatvapepal	Both Side
14	398+000	Karanparyag	Both Side

#### 7.4.2 Truck Laybye

##### Truck laybye

S. No.	Design Chainage (km)	Village	Side
1	371+075	Tilani	One Side

#### 7.4.3 Parking with Rest areas

S. No.	Design Chainage (km)	Village	Side
1	368+850	Lameri	One Side

#### 7.4.4 Rescue areas with helipads

There is 01 rescue area with helipad in sub package-III

S.No	Chainage	Location	Remarks
1	Km 391.000	Gauchar	Retained

#### 7.4.5 Scenic overlook

At several locations land is available on valley side after improvement of curves. After examining all the engineering aspects one location has been proposed to develop as scenic over look. The proposed locations for scenic overlook is tabulated below:

S.No	Existing Chainage	Location
1	Km 372.725	Sumerpur
2	Km 376.875	Sur Shivanandi
3	Km 377.400	Shivanandi
4	Km 396.275	Galnao

## **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 stops 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 safe and size 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 giveaway 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 Giveaway.

### **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 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 IRC-25



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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 OF QUANTITIES**

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 and then computing the volume of each of the resultant prisms. 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. The accuracy of the results of the Triangle command is limited only by the accuracy of the DTMs used.

**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. These have been quantified and cost under separate bill Nos.3&4 respectively. Pavement work includes construction of new proposed two lane carriageway and flexible overlays for strengthening of existing 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. Laid over road formation. The quantities have been worked using MX Software. The quantities of profile corrective course and scarification also have been calculated with this software. Overall quantities include road pavement regulations and scarifying quantities.

### **8.3.2 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 of standard sizes as per MORT&H.

### **8.3.3 Bridges**

There are 06 numbers of existing bridges between km 430 to km 468. Though most of the bridges are in fair condition, it is not possible to use any, as the existing bridges do not fall on our proposed alignment out of which 01 are Major Bridges and 05 are Minor Bridges.

### **8.3.4 Drainage and Protection Works**

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 and Compensation for Structure**

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, replantation, 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 August Muni SOR, Government of PWD Uttarakhand published on 15.09.2017 for 2017-2018 .For non-SOR items, rates analysis has been done based on market rates.

#### 8.4.1 Material Rates

The material rates adopted are based on the rates given in Schedule of rates of Uttarakhand PWD August Muni Schedule of Rates 2017-18. 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 2017-18.

#### 8.4.3 Machinery Hire Charges

The machinery rates are adopted based on the rates given in Uttarakhand PWD August Muni Schedule of Rates 2017-18 suitably modified with cost escalation factors. The unit rates of the machinery which is not provided in the standard data book have been assessed / adopted from market rates.

#### 8.4.4 Labour Rates

The labour rates are based on the preliminary market rates

### 8.5 PROJECT TOTAL COST

Grand total Project cost of construction is 275.21cr.

### 8.7 DETAILED BILL OF COST

The summary of the project cost bill wise and the bill of quantities and their cost for the package is given in table 7.1:

**Table 8.1: Summary of Cost**

Bill No.	Description	Item Price (Cr.)
1	SITE CLEARANCE	2.98
2	EARTH WORK AND DRAINAGE	10.40
3	CEMENT TREATED SUB BASE & BASE COURSE	15.99
4	SURFACE COURSES (BITUMEN)	32.99
5	TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES	24.20
6	DRAINAGE & PROTECTION WORKS	38.60
7	STRUCTURE	49.88
	<b>Total Civil Cost (A)</b>	<b>175.047</b>
	Maintenance during DLP (4 years) payable to contractor @5% of 'A'	8.75

Bill No.	Description	Item Price (Cr.)
	<b>Cost put to tender (A+B)</b>	<b>183.80</b>
	Add Contingencies over civil cost @2.80% of (A)	4.90
	Construction Supervision Charges @ 3% of (A)	5.25
	Administrative Charges @3% of (A)	5.25
	Quality Control @0.25% on 'A'	0.44
	Road Safety Cell Audit Charges @ 0.25% of 'A'	0.44
	Escalation @ 5% per annum for 1.5 years during construction payable to contractor of (A)	13.13
	Total cost of civil works including centage charges (C+D+E+F+G+H+I)	213.21
	Land Acquisition and Structure Cost	60.00
	Utility and Shifting	2.00
	<b>Total project cost (J+K+L)</b>	<b>275.21</b>

## 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 in nature rest all are short to medium term. Most of the operation phase impacts are continuous in nature. 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 relative value to the 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:

$$EIV = \sum_{m=1}^m I = \sum_{j=1}^n (IS)_I (PI)_j$$

Where,

EIV = Environmental Impact Value

(IS)<sub>I</sub> = Impact Scale Value for the activity

(PI)<sub>j</sub> = Environmental Component Value for Environmental Component

m = No. of activities

n = No. of environmental Components

However actual quantification is difficult because of subjective nature of the valuation of environmental component and the impacts. Both environmental and social impacts are difficult to quantify, specifically to judging a project. So quantification approach has not been considered further. However valued environmental components have been identified and the impact assessed

based on the impacts on these components. Environmental components considered for assessment of impacts for this project are given in Table – 8.1 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
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.

## 9.3. ENVIRONMENTAL MANAGEMENT PLAN (EMP)

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 and operation activities may impose 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 – CAPACITY BUILDING**

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 and monitoring, the group will be equipped to develop following services;

#### **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 property. 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, Volume – VII – Cost Estimates. 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 (MoEF), Government of India. 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 required 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.

Marginal land acquisition means land acquisition not exceeding a total width of 20 meters on either side of the existing alignment put together. The bypasses would be treated as stand-alone projects and would require central environmental clearance only if the cost of the project exceed Rs. 100 crores.

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.

## CHAPTER10: 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:

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 below:

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 below:

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 below:

<b>Concession Period (years)</b>	<b>30</b>
Project Construction period	2.5 years
Project Operations date	1 march 2018
Road Length (km)	29.125

## 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 below:

<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 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 below:

Mode	Toll Rate
<b>Car</b>	160.00
<b>Mini Bus</b>	255.00
<b>Bus</b>	535.00
<b>LGV</b>	255.00
<b>2T</b>	535.00
<b>3T</b>	830.00
<b>MAV</b>	830.00
<b>Heavy Comm Veh</b>	1030.00

Mode	Toll Rate
ML	240.00

The toll rates arrived for the year 2017-18 for Option 3is provided in the table below:

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 CommVeh	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 below:

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 below:

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 below:

#### 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	<b>44,241.00</b>
Total Project Cost including Escalation Charges	8,404.60	16,809.20	16,809.20	<b>42,023.00</b>
Total Economic Cost of Project (@90%)	9,210.40	18,420.80	18,420.80	<b>46,052.00</b>

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 below:

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 below:

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
At 2014 Prices with escalation @ 5% per annum				
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 below:



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 below:

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 CO2  
**Emission Reduction from Project:** Baseline Emission (In without project, BAU) - Project Emission (Direct Project Emission + Indirect Project Emission)

The price of per tonnes of CO2 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 present the estimate of the CO2 emission due to combustion of petrol and diesel:

	Petrol	Diesel
<b>Carbon Emission (Tonnes per litre of fuel combustion)</b>	0.0023	0.0027
<b>Cost per ton of CO2 (in Rs per tonnes)</b>	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 below:

(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 below:

Urban Areas	EIRR	Hurdle Rate	Viability
Option 1	14.06%	12%	Economically Viable

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## **CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS**

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### **11.1 GENERAL**

The preceding Chapters of this report well on the various aspects of the study carried out by the Consultants for the two laning and strengthening of the project road. 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 STATUS OF THE 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 06 minor bridges and 106 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 and other related aspects.

The design standards have been formulated for design speed of 20-40 kmph, in general. A carriageway of 7.0 m with paved shoulder. Most of the existing culverts are damaged and therefore reconstruction is proposed. For strengthening the existing carriageway, minimum 200 mm CT Sub Base has been proposed, prior to Treated RAP and BC overlays. The people in the area have the unanimous opinion that the project would benefit the people and their co-operation in its implementation would be forth coming, even though it may entail some temporary inconvenience to them.

### **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. 275.21 crores.

### **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:

**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:

**Table 11.2: Economic Analysis**

EIRR	Hurdle Rate	Viability
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.