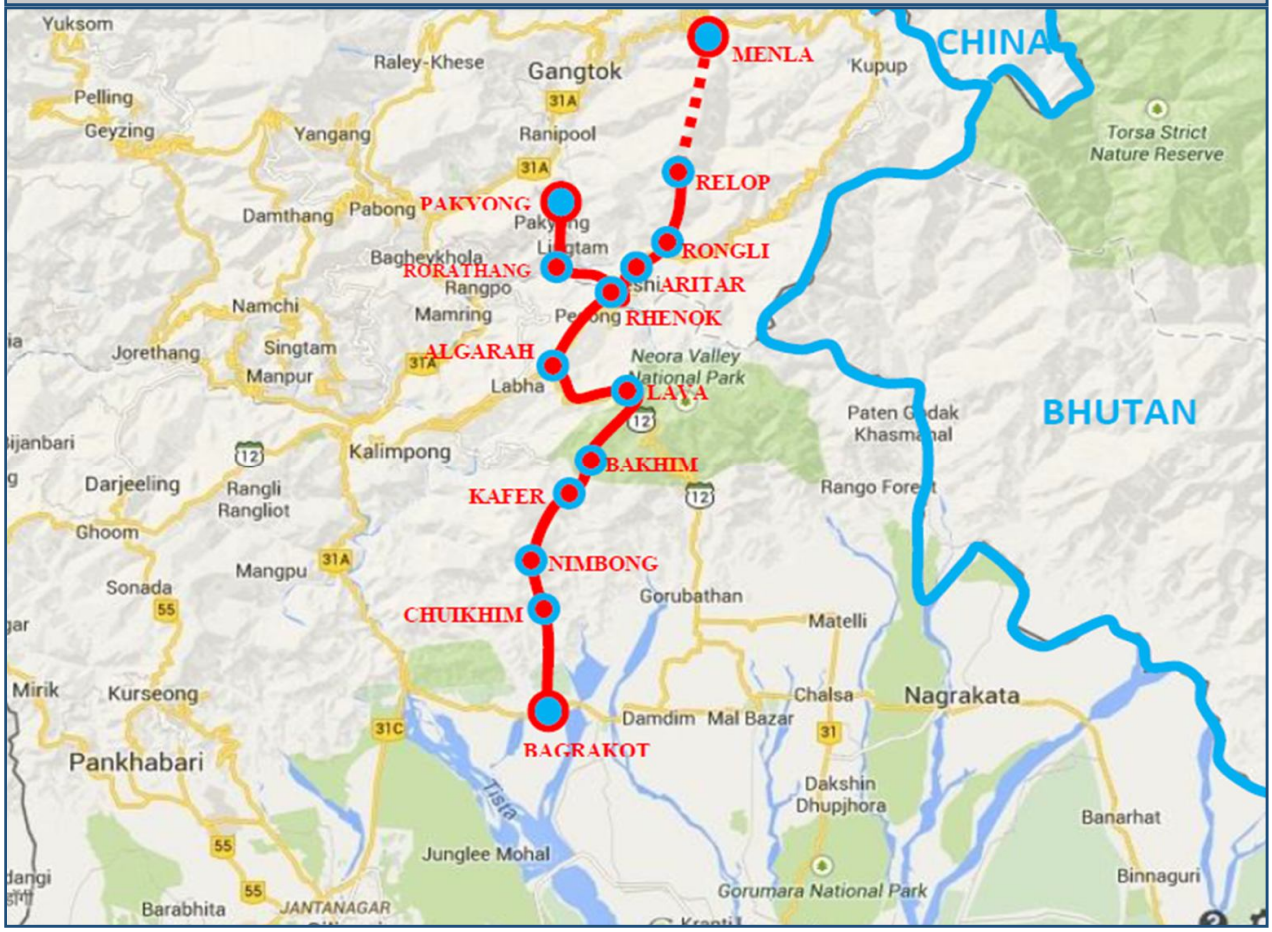
NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

(Ministry of Road Transport & Highways)

Consultancy for Preparation of Feasibility Report cum Preliminary Design for Alternative Highway to Gangtok in Sikkim via Bagrakot-Chuikhim-Nimbong-Kafer-Bakhim-Algarah-Rhenok in the State of West Bengal and from Rhenok-Rorathang-Pakyong along with Spur from Aritar-Relop-Menla in the State of Sikkim.

Main Report

PKG - IV D of (BAGRAKOT TO KAFER Km 26.100 to Km 40.000)



December, 2019

SA INFRASTRUCTURE CONSULTANTS PVT. LTD.
IN ASSOCIATION WITH
SPECIALIZED ENGINEERING SERVICES PVT. LTD.
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Executive Summary

1.1 Prelude

National Highways & Infrastructure Development Corporation Limited (NHIDCL), Government of India has decided to upgrade the newly declared National Highways to two lane/two lane with paved shoulder and /or strengthening of various sections of National Highways. The work would be taken up for up gradation on corridor concept. Therefore, corridors include strengthening (in adjoining stretches) in addition to widening to 2 lanes with paved shoulder standards in order to have a better facility in a long continuous stretch.

In pursuance of the above, SA Infrastructure Pvt. Ltd, Noida (UP) have been appointed as Consultants to carry out the Feasibility Study and Detailed Project Report for rehabilitation and upgrading to 2 lane with paved shoulders configuration of **Bagrakot to Kafer (Existing km 24+940 to Km 39+170)** of **NH-717A** in West Bengal State. The Agreement was signed and the commencement of services commenced w.e.f from 08-10-2014 with the reference of NHAI letter no. NHAI/Tech/WB/FRCPD/Sikkim/2014/444/5726 dated 08-10-2014.

Scope of Study

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

Stage	Report and Deliverables
1	QAP and Inception Report (IR)
2	Draft Feasibility Report (DFR)
3	Final Feasibility Report (FFR)

1.2 Socio - Economic Profile

The details on Socio-economic parameters will include per capita income, demographic Details, growth of primary, secondary and tertiary sectors of economy, GNP, NSDP, traffic growth rates, number of villages connected with the roads, density of road network and other modes of transport in the region, achievement of five year plan outlays and sectors having more emphasis in plan outlays of the State government etc. These details will be collected for the State and project road influence area giving true picture of the socio-economic profile of the region. The details collected will be utilized for the traffic forecasting and social analysis.

1.3 Project Description

National Highways & Infrastructure Development Corporation Limited (NHIDCL), Government of India has decided to upgrade the newly declared National highways into 2 Lane configurations. The work would be taken up for up gradation on corridor concept. Therefore, corridors include strengthening (in adjoining stretches) in addition to widening to 2 lanes / 2 lanes with paved shoulder standards in order to have a better facility in a long continuous stretch. The entire proposed project road is located in the state of West Bengal. The state occupies a total area of 88,752 square kilometres. Currently the state comprises 1 district Darjeeling in West Bengal. The project road has significant influence on West Bengal State and in particular on the Darjeeling district.

The key map of Project Road is given in **Fig 1.1.**

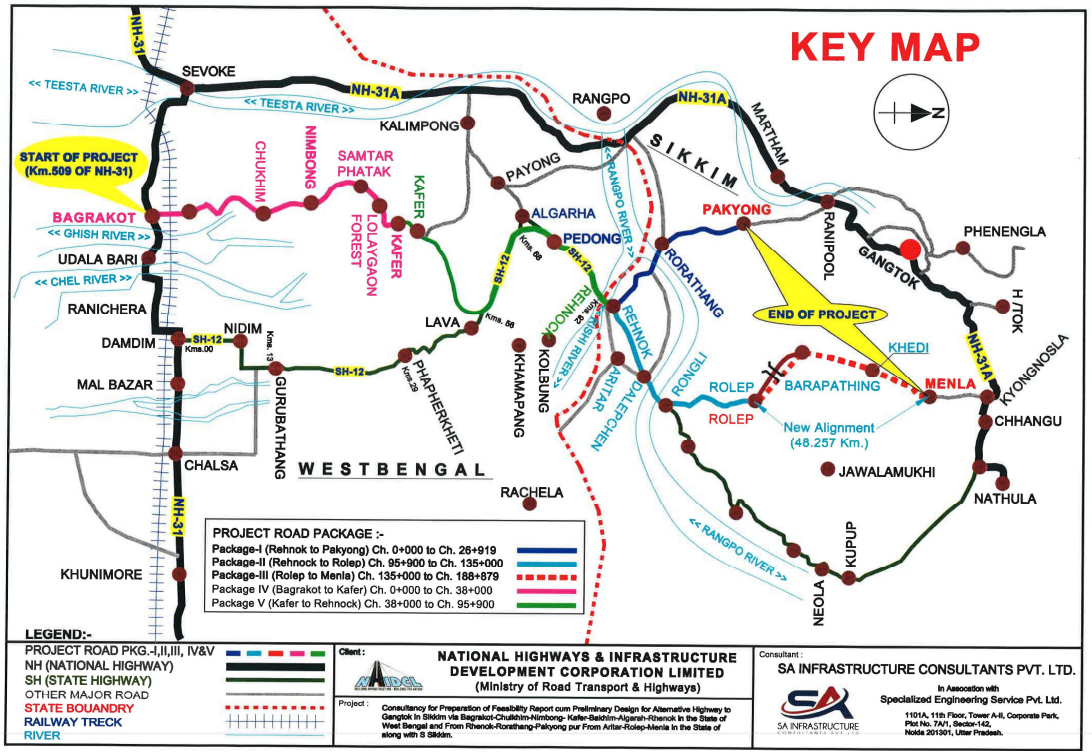

Fig 1.1 Key Map

Table 1.1: Project Road Characteristics

Existing Chainage		Carriageway Width(m)	Surface Type	Shoulder Width	Shoulder Type	Terrain /Type
Start	End					
24+940	39+170	3.5 - 5	Flexible	0.5-1	Earthen	Hilly

All major utilities follow the road alignment as the project road connects town namely Bagrakot.

1.3.1 Road Junctions

There is no Major junction in the project stretch and minor junctions are provided at village roads. Total 6 no. of minor junctions are there in the entire stretch.

Table 1.2: Details of Major Junction

Sr. No.	Design Chainage	Type	Link	Direction
Nil				

Table 1.3: Details of Minor Junction

Sl. No.	Design Chainage	Type of Intersection	Direction	Type of Road	Going To
			Left/Right	ER/BT/CC	
1	24+960	Y	Left	-	Gyasok Village
2	25+300	Y	Right	ER	Babangoan Village
3	26+120	Y	Left	ER	Nimbong Khasmahal
4	30+140	T	Right	BT	Pemling
5	30+400	Y	Left	BT	Kalimpong
6	38+830	T	Left	CC	Kafer Village

1.3.2 Existing Bridge & Cross Drainage Structures

There are no minor bridges, 13 slab culverts, 54 Causeway on the project road section.

Table 1.4: Summary of Existing Bridges and Culverts

Sl. No.	Type	Nos.
1	Major Bridges	0
2	Minor Bridges	0
3	Pipe Culverts	0
4	Slab Culverts	13
5	Causeway	54
Total		**67**

1.4 Traffic Survey Analysis and Forecast

It is very important, that the existing information on traffic flow, commodity movement and traffic pattern is required in order to assess the traffic behavior on a project road. To collect such information to satisfy the Terms of Reference (TOR) and project requirements, following various types of traffic surveys were carried out:

- Classified Traffic Volume Count Survey
- Origin – Destination (OD) Survey and commodity movement Surveys
- Axle Load Spectrum Survey
- Intersection Volume Count Survey
- Speed and Delay Survey

1.4.1 Classified Continuous Volume Count Survey

A comprehensive traffic survey plan has been prepared for the project road after considering traffic intensity on homogeneous sections and travel characteristics. Detailed site visit of project road and its influence/alternative transport network has been carried out between on 4th January to 16th January 2015. Traffic survey locations were finalized by consultation with client officials.

Table 1.5 Locations of Classified Volume Count Survey

Sr. No.	Location	Justification/Rational
Classified Volume Count Surveys (CVC)		
1	Sevoke/Kalijhora	Sevoke/Kalijhora has been selected to get the idea of traffic in Siliguri to Gangtok Section
2	Baluakhani Check Post	Baluakhani Check Post has been selected to get the idea of traffic in Alagarah to Lava Section
3	3rd Mile Check Post	3rd Mile Check Post has been selected to get the idea of traffic in Gangtok to Nathula Section

1.4.2 Annual Average Daily Traffic (AADT)

The seasonal correction factors are used to convert Average Daily Traffic (ADT) to Annual Average Daily Traffic (AADT). The Annual Average Daily Traffic for all traffic survey locations is presented vide Table below:

Table 1.6: Summary of Annual Average Daily Traffic (AADT)

Sr. No.	Location	Fast Moving Vehicles	Slow Moving Vehicles	Total AADT in Nos.	AADT in PCU
1	Sevoke/Kalijhora	5740	0	5740	8100
2	Baluakhani Check Post	352	2	354	353
3	3rd Mile Check Post	810	0	810	950

1.4.3 Turning Movement Count

There are six major intersections in the project stretch. TMC count is conducted at all locations. The intersection volume count surveys have been carried out during identified peak periods for 8 hours. The category-wise traffic is counted for all direction in a 15 - minute interval. The counts were recorded in the specified survey formats.

The survey data have been analysed to obtain the morning and evening peak hours with flow of vehicles in each direction. The summary of peak hour traffic flow through intersections is given in Table below:

Table 1.7: Peak Hour Traffic at Intersections

Sr. No.	Location	Type of Intersection	Peak Hour In Flow (PCU)		
			Morning	Evening	Total
1	Bagrakot Intersection	+	594	450	**1044**
2	Lava Intersection	+	41	35	**76**
3	Algarah Intersection	**Y**	6	7	**13**
4	Rhenock Intersection	+	123	119	**242**
5	Rorathang Intersection	**T**	77	89	**166**
6	Rongli Intersection	**T**	56	52	**108**

1.4.4 Axle Load Survey

In order to estimate vehicle loading spectrum on project road, and to determine vehicle damage factor for the commercial vehicles, the axle load surveys have been carried out at identified locations. The data collected from the Axle Load Survey has been compiled and analysed through "Fourth power" pavement damage rule to arrive at the vehicles damage factor (VDF). The survey is analysed to obtain Vehicle Damage Factor (VDF) and is presented below:

Table 1.8: Adopted VDF by Homogeneous Sections

Sr. No	Type of Vehicle	Kalijhora Near Sevoke (NH-31A)
1	LCV	1.6
2	2-Axle Truck	4.57
3	3-Axle Truck	1.36
4	Multi Axle Truck	1.49

The equivalent single axle loads (ESALs) have been calculated assuming that the project road will be opened to traffic in the year 2018.

Table 1.9: Summary of MSA

Section		Existing Chainage		Design MSA (2015-2032)
From	**To**	**From**	**To**	
Bagrakot	Kafer	24+940	39+170	25

1.4.5 Growth Rate

The various methods specified vide IRC 108: 2015 are taken in to consideration for arriving at reasonable growth rate for traffic in future. The results of such methods along with proposed growth rate for each type of vehicle are presented vide Table below:
Estimation of Traffic Growth Rates:

a) Elasticity for Different Modes in West Bengal x Economic Indicator Average Growth Rate for West Bengal = Mode wise growth rate for West Bengal
b) Mode wise Registered vehicle Average Growth Rate of West Bengal

Then, Weighted Traffic Growth Rates = adopted weighted Average of a & b item Weighted traffic growth for project is presented in Table 0.4.11(a).

Table 1.10: Future Traffic Growth Rates for Motorized Vehicles (%) - WEST BENGAL

Mode	Upto 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	7.70	7.32	6.98	6.68	6.40	6.15	5.93
Buses	6.98	6.66	6.38	6.12	5.89	5.68	5.50
LCV	7.78	7.39	7.04	6.73	6.44	6.19	5.96
Truck	7.68	7.30	6.96	6.65	6.38	6.13	5.91
2-W	11.85	11.27	10.76	10.29	9.87	9.50	9.16

Table 1.11: WEIGHTED Traffic Growth Rates for Motorized Vehicles (%) – Realistic Scenario

Mode	Up to 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	9.8	9.3	8.9	8.6	8.2	7.9	7.6
Buses	7.4	7.0	6.7	6.4	6.2	6.0	5.8
LCV	9.0	8.6	8.2	7.9	7.6	7.3	7.0
Truck	9.2	8.8	8.4	8.0	7.7	7.4	7.1
2-W	8.6	8.2	7.9	7.5	7.2	7.0	6.7

1.4.6 Capacity Analysis

Capacity analysis is fundamental to the planning, design and operation of roads. It is a valuable tool for evaluation of the investment needed for the future improvements. The capacity figures used for determining the desired carriageway width in differing terrain w.r.t. traffic volume and composition are as per IRC: 64-1990. As per IRC 64:1990, it is recommended that on major arterial routes LOSB should be adopted for the design purpose. On other roads under exceptional circumstances, LOS C could also be adopted for design. For LOS C, Design service volume can be taken as 40 % higher than those for LOS B.

For the purpose of augmentation of the facilities and up gradation of the project highway, the design service volume for the plain terrain condition and level of Service B & C is shown in Table.

Table 1.12: Design Service Volume for Different Lane Configurations

Lane Configuration	Design Service Volume (PCUs per day) *Level of Service B*	Design Service Volume (PCUs per day) *Level of Service C*
2-Lane with 1.5m Paved Shoulder	18000	25200
4-Lane with 1.5m Paved Shoulder	40000	60000

1.5 Lane Requirements

The consultant has carried out the capacity analysis for 2 lane road without paved shoulder

TABLE 1.13 - CAPACITY ANALYSIS OF PROJECT ROAD

Year	Section AB-BC-CD		Section DE		Section DF		Section FG	
	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)
2015	1027	LOS 'B'	896	LOS 'B'	131	LOS 'B'	35	LOS 'B'
2016	1124	LOS 'B'	980	LOS 'B'	143	LOS 'B'	38	LOS 'B'
2017	1285	LOS 'B'	1121	LOS 'B'	164	LOS 'B'	44	LOS 'B'
2018	1400	LOS 'B'	1221	LOS 'B'	179	LOS 'B'	47	LOS 'B'
2019	1525	LOS 'B'	1330	LOS 'B'	195	LOS 'B'	52	LOS 'B'
2020	1661	LOS 'B'	1448	LOS 'B'	213	LOS 'B'	56	LOS 'B'
2021	1810	LOS 'B'	1578	LOS 'B'	232	LOS 'B'	61	LOS 'B'
2022	1964	LOS 'B'	1712	LOS 'B'	252	LOS 'B'	66	LOS 'B'
2023	2132	LOS 'B'	1858	LOS 'B'	273	LOS 'B'	72	LOS 'B'
2024	2314	LOS 'B'	2017	LOS 'B'	297	LOS 'B'	78	LOS 'B'

Year	Section AB-BC-CD		Section DE		Section DF		Section FG	
	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)
2025	2511	LOS 'B'	2189	LOS 'B'	323	LOS 'B'	84	LOS 'B'
2026	2726	LOS 'B'	2375	LOS 'B'	350	LOS 'B'	91	LOS 'B'
2027	2949	LOS 'B'	2569	LOS 'B'	379	LOS 'B'	98	LOS 'B'
2028	3190	LOS 'B'	2779	LOS 'B'	411	LOS 'B'	106	LOS 'B'
2029	3451	LOS 'B'	3006	LOS 'B'	445	LOS 'B'	115	LOS 'B'
2030	3733	LOS 'B'	3252	LOS 'B'	481	LOS 'B'	124	LOS 'B'
2031	4039	LOS 'B'	3518	LOS 'B'	521	LOS 'B'	134	LOS 'B'
2032	4356	LOS 'B'	3794	LOS 'B'	562	LOS 'B'	144	LOS 'B'
2033	4699	LOS 'B'	4092	LOS 'B'	607	LOS 'B'	156	LOS 'B'
2034	5068	LOS 'C'	4413	LOS 'B'	655	LOS 'B'	168	LOS 'B'
2035	5467	LOS 'C'	4760	LOS 'B'	707	LOS 'B'	180	LOS 'B'
2036	5897	LOS 'C'	5134	LOS 'C'	763	LOS 'B'	194	LOS 'B'
2037	6343	LOS 'C'	5522	LOS 'C'	821	LOS 'B'	209	LOS 'B'
2038	6824	LOS 'C'	5940	LOS 'C'	884	LOS 'B'	224	LOS 'B'
2039	7340	LOS 'D'	6389	LOS 'C'	952	LOS 'B'	241	LOS 'B'
2040	7897	LOS 'D'	6872	LOS 'C'	1024	LOS 'B'	259	LOS 'B'
2041	8495	LOS 'D'	7392	LOS 'D'	1103	LOS 'B'	278	LOS 'B'

Conclusion

This analysis suggests that the project road will have smooth traffic flow at LOS ‘C’ up to the horizon year 2040. Only in the year 2040, the LOS will drop this year, the road could be upgraded by adding a paved shoulder.

Results of Engineering Surveys and Investigations.

1.5.1 Pavement Condition

It is the most important data needed for deciding upon the maintenance. The basic measurement of pavement condition is existing distresses. The information required is on the type, severity and amount of distress.
Pavement condition survey consists of observing and recording the various distresses like cracks, pothole, rutting, ravelling etc. of the existing carriageway, pavement shoulders and embankment. The details collected from pavement condition survey form the basis to decide strategy for adequate strengthening / rehabilitation measure of Existing pavement.

Table 1.14: Percentage wise distribution of Good Fair and Poor Road

Sl. No.	Condition	Length (Km)	% Condition
1	Good	0	0
2	Fair	0	0
3	Poor	13.546	100

1.5.2 Benkelman Beam Deflection

Structural strength of existing pavement has been assessed by conducting Benkelman beam test as per procedure specified vide IRC 81: 1997 and in accordance with TOR set-forth vide consultancy agreement as well as for identified control sections.

1.5.3 Pavement Investigation

Summary of the layer thickness as recorded from test pits are as under:

Table 1.15: Summary of Crust Thickness in mm

Type of Layer	Range of Pavement Thickness (mm)	
	80 % Location	20 % Location
SDBC	25	25
BM	100	100
WMM	100	100
GSB I	150	200
GSB II	100	
Soiling		300
Total thickness	475	725

1.6 Proposed design standards

Following is a summary of the recommended design standards proposed to be adopted for the project road other than service road and intersections

Table 1.16: Summary of Design Standards

(i)	**Design Speed (Km/hr)**		
a.	Plain Terrain	:	100 (Ruling), 80 (Minimum)
b.	Rolling Terrain	:	80 (Ruling), 65 (Minimum)
c.	Mountainous Terrain	:	50 (Ruling), 40 (Minimum)

d.	Steep Terrain	:	40 (Ruling), 30 (Minimum)
(ii)	**Level of Service**	:	B
(iii)	**Roadway Widths (m)**	:	11m for Two Lane Road
(iv)	**Roadway Elements**		
	Carriageway and Shoulders	:	Carriageway: 7m (Two lane) Shoulders:- Hill Side: 1.5m paved shouler, Valley side: 1.5m paved shoulder and 1.0m earthen shoulder
	Camber	:	Carriageway: 2.5%, Shoulder: 3%
	Right of Way	:	Open Area:- Normal: 24 m, Exceptional: 18 m Built up Area:- Normal: 20 m, Exceptional: 18 m
	Embankment/ Cutting Slope	:	In filling: 1V : 2 H In cutting: 1V : 1H
	Overtaking Sight Distance	:	640m for design speed of 100 km/hr 470m for design speed of 80 km/hr 235m for design speed of 50 km/hr
	Super-elevation	:	Maximum 7%
	Radii for Horizontal Curves	:	360 m for design speed of 100 km/hr 230 m for design speed of 80 km/hr 90 m design speed of 50 km/hr
	Ruling Gradient	:	2.5% for plain and rolling terrain 5% for mountainous and steep terrain having elevation more than 3000m above MSL
	Minimum K- factor		
	Summit Curve	:	75 for Design speed of 100 km/hr. 35 for Design speed of 80 km/hr. 10 for Design speed of 50 km/hr.
	Valley Curve	:	42 for Design speed of 100 km/hr. 30 for Design speed of 80 km/hr. 20 for Design speed of 65 km/hr. 10 for Design speed of 50 km/hr.
	Bridge Clearance		
	Railways	:	6.55 m for Electrified Railway
	Motor Vehicles	:	5.5 m
	Light Motor Vehicles	:	3.5 m
	Cattle (Camel) and Pedestrian	:	3.0 m

	Design Flood Frequency		
	Bridges	:	50 years
	Sewers and Ditches	:	10 years
	Minimum Drainage Channel Width	:	1.0 m
	Ditch Slopes (H:V)	:	1:1 (Fore slope or back slope)

1.7 Improvement Proposals

The improvement proposals for proposed widening include the provisions for the following major items:

a) Widening Proposal
b) Requirement of bypasses and realignment
c) Geometric Improvement Design
d) Proposed Pavement Design & Overlay Design
e) Traffic Control and Safety Measures
f) Bridge and Cross Drainage Structures

1.7.1 Widening Proposal

In order to meet future traffic requirement, the existing carriageway is proposed to upgrade to achieve high speed of travel with comfort and safety. Concentric widening scheme and Hill cutting is followed to minimize land acquisition issues and to ensure maximum utilization of existing carriageway. **Table 1.17** shows widening improvement proposed for the project road.

1.7.1.1 Typical Cross-sections

Proposed cross-sections along with widening schedule is shown in table given below.

Table 1.17 Typical Cross Section

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
1	26+100	26+430	330	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	VI
2	26+430	26+960	530	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
3	26+960	27+200	240	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
4	27+200	27+720	520	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
5	27+720	27+840	120	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
6	27+840	28+000	160	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
7	28+000	28+540	540	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
8	28+540	29+980	1440	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
9	29+980	30+010	30	Elevated Structure (including box abutment length)	VIII
10	30+010	30+180	170	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
11	30+180	31+040	860	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
12	31+040	31+150	110	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
13	31+150	31+320	170	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
14	31+320	31+440	120	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
15	31+440	31+600	160	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
16	31+600	31+740	140	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
17	31+740	32+560	820	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
18	32+560	32+660	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
19	32+660	33+480	820	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
20	33+480	33+560	80	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
21	33+560	33+700	140	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
22	33+700	33+800	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
23	33+800	34+000	200	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
24	34+000	34+180	180	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
25	34+180	34+280	100	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
26	34+280	34+380	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
27	34+380	34+880	500	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
28	34+880	34+900	20	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
29	34+900	34+960	60	Elevated Structure (including box abutment length)	VIII
30	34+960	35+360	400	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
31	35+360	35+440	80	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
32	35+440	35+900	460	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
33	35+900	35+980	80	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
34	35+980	36+600	620	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
35	36+600	37+270	670	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
36	37+270	39+500	2230	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
37	39+500	40+000	500	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
	Total Length		**13900**		

Table 1.18: TCS Summary:

TCS No.	Description	Total Length (m)
1	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	3110
2	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	3150
3	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	2160
4	Two lane with Paved shoulder Realignment (One Side Hill, One side Valley section)	1840
5	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	2880

TCS No.	Description	Total Length (m)
6	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	330
7	Two lane with Paved shoulder Realignment (Both Side Hill section)	340
8	Elevated Structure (including box abutment length)	90
	Total	**13900**

1.7.2 Requirement of Bypasses

This part of chapter describes brief about the existing alignment, alignment options with their Evaluation matrix and their necessities to upgrade the existing carriageway facility of project road into 2-lane paved carriageway in accordance to the Indian standard configuration. These improvement proposals are based on the findings from various engineering features carried out on the project roads such as Reconnaissance Survey, future traffic requirement, Inventory Data and Pavement Investigations. There is no bypass required in this section.

1.7.3 Pavement Design

The flexible pavement is adopted for proposed new carriageway, widening and reconstruction. Design period of 15 years considered for new carriageway as well as overlay design. The Pavement improvements proposal for entire project road is presented in **Table 1.19**.

Table 1.19: Improvement Proposal for Existing Pavement

Sl. No.	Description	Layer Thickness	Design MSA
1	BC	40mm	25
2	BSM	110mm	
3	CTSB	200mm	
4	Sub-Grade	500mm	

1.7.4 Traffic Control and Safety Measures

1.7.4.1 Road Marking & Traffic Signs

Road markings will be made for centre and edge lines using reflective thermoplastic paints. Appropriate road markings will also be provided at junctions and crossings. Road signs are to place according to IRC: 67-2012. The signs are to be placed on embankment so that extreme edge of sign would be 2.0m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines there in.

1.7.4.2 Proposal for Truck Lay byes/Parking cum Rest Area

As per the detailed field surveys and reconnaissance, truck lay bye/ Parking cum rest areas are proposed at the following two locations. The rest area will provide common facilities like petrol pump, first aid medical facilities, police office, restaurant and vehicle parking etc.

Table 1.21: Truck lay byes/ Parking cum Rest Area Location

Sr. No.	Existing Chainage	Proposed Chainage
NIL		

1.7.4.3 Bus Shelter

4No. bus shelter is proposed on the Project road. Details of which are given in the table below

Table 1.22: Details of Bus shelter

Sl. No.	Design Chainage	Sides
1	26+500	Right
2	27+300	Left
3	30+600	Left
4	39+500	Left

1.7.5 Major Bridge/ Minor Bridge & Cross Drainage Structures

1.7.5.1 Bridges

There are no minor bridges proposed.

1.7.5.2 Culverts

All type of culverts is to be replaced.

Table 1.23: Summary of structures

Sl. No.	DESCRIPTION	No. Of Structures	REMARKS
1	**HUME PIPE CULVERTS**		
(i)	Retaining & Widening	0	-
(ii)	Dismantling & Reconstruction Pipe Culvert With Box Culvert	0	-
(iii)	New Proposals	0	-
(iv)	Abandoned	0	
2	**SLAB CULVERTS**		
(i)	Retaining & Widening	0	-
(ii)	Dismantling & Reconstruction	**13**	-
(iii)	New Proposals	**1**	-
(iv)	Abandoned	0	
3	**BOX CULVERTS**		
(i)	Retaining & Widening	0	-
(ii)	Dismantling & Reconstruction	0	-
(iii)	New Proposals	0	-
(iv)	Abandoned	0	
4	**CAUSEWAY**		
(i)	Retaining & Widening	0	-

Sl. No.	DESCRIPTION	No. Of Structures	REMARKS
(ii)	Dismantling & Reconstruction to slab culvert	**54**	
(iii)	New Proposals	0	
(iv)	Abandoned	0	-
5	**MINOR BRIDGES**		
(i)	Retained	0	-
(ii)	Dismantling & Reconstruction	0	-
(iii)	Abandoned	0	
(iv)	New proposals	0	-
6	**MAJOR BRIDGES**		
(i)	Retained	0	
(ii)	New proposal	0	
(iii)	Flyovers	0	
(iv)	New proposal	0	-
8	**ROAD OVER BRIDGES WITH LOOP**		
(i)	To be Widened	0	-
(ii)	New Proposals	0	
RAMP SECTION			
(i)	New Proposals	0	

1.8 Minor Bridges

Table 1.24: Minor Bridges

Sl. No.	Existing Chainage (Km)	Design Chainage (Km)	Design no. of Spans with span length (m)	Existing no. of Spans with span length (m)	Existing Structure	Proposed Structure
NIL						

1.9 Culverts

Table: 1.25: Culverts for Reconstruction

Sl. No.	Existing Chainage (Km)	Type of Culvert	Existing No. of Spans with Span Length x Vertical Clearance (In m)	Recommendation	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (In m)
1	25+083	Cause way		Reconstruction	26+220	RCC Slab	1x3

Sl. No.	Existing Chainage (Km)	Type of Culvert	Existing No. of Spans with Span Length x Vertical Clearance (In m)	Recommendation	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (In m)
2	25+544	Cause way		Reconstruction	26+660	RCC Slab	1x3
3	25+776	RCC Slab	1X2	Reconstruction	26+900	RCC Slab	1X3
4	25+977	RCC Slab	1X2	Reconstruction	27+060	RCC Slab	1X3
5	26+103	RCC Slab	1X3	Reconstruction	27+180	RCC Slab	1X3
6	26+231	RCC Slab	1X1.5	Reconstruction	27+280	RCC Slab	1X3
7	26+460	RCC Slab	1X2	Reconstruction	27+480	RCC Slab	1X3
8	26+642	Causeway		Reconstruction	27+620	RCC Slab	1X3
9	26+774	Causeway		Reconstruction	27+920	RCC Slab	1X3
10	27+380	RCC Slab	1X2	Reconstruction	28+340	RCC Slab	1X3
11	27+728	Causeway		Reconstruction	28+680	RCC Slab	1X3
12	28+613	Causeway		Reconstruction	29+550	RCC Slab	1X3
13	28+715	Causeway		Reconstruction	29+650	RCC Slab	1X3
14	28+883	RCC Slab	1X2.8	Reconstruction	29+810	RCC Slab	1X3
15	29+221	RCC Slab	1X2	Reconstruction	30+160	RCC Slab	1X3
16	29+543	RCC Slab	1X2	Reconstruction	30+480	RCC Slab	1X3
17	29+774	RCC Slab	1X2.2	Reconstruction	30+700	RCC Slab	1X3
18	29+985	RCC Slab	1X3.1	Reconstruction	30+890	RCC Slab	2X3
19	30+025	Causeway		Reconstruction	30+920	RCC Slab	1X3
20	30+150	Causeway		Reconstruction	31+060	RCC Slab	1X3
21	30+250	Causeway		Reconstruction	31+175	RCC Slab	1X3
22	30+300	RCC Slab	1X3	Reconstruction	31+220	RCC Slab	1X3
23	30+508	Causeway		Reconstruction	31+450	RCC Slab	1X3
24	30+790	Causeway		Reconstruction	31+760	RCC Slab	1X3
25	30+814	Causeway		Reconstruction	31+805	RCC Slab	1X3
26	30+853	Causeway		Reconstruction	31+850	RCC Slab	1X3
27	31+016	Causeway		Reconstruction	31+960	RCC Slab	1X3
28	31+159	Causeway		Reconstruction	32+090	RCC Slab	1X3
29	31+194	Causeway		Reconstruction	32+140	RCC Slab	1X3
30	31+313	Causeway		Reconstruction	32+260	RCC Slab	1X3
31	31+424	Causeway		Reconstruction	32+360	RCC Slab	1X3
32	31+992	Causeway		Reconstruction	32+920	RCC Slab	1X3
33	32+214	Causeway		Reconstruction	33+140	RCC Slab	1X3
34	32+381	Causeway		Reconstruction	33+300	RCC Slab	1X3
35	32+483	Causeway		Reconstruction	33+400	RCC Slab	1X3
36	32+596	Causeway		Reconstruction	33+515	RCC Slab	1X3
37	33+000	Causeway		Reconstruction	33+930	RCC Slab	1X3
38	33+187	Causeway		Reconstruction	34+160	RCC Slab	1X3
39	33+427	Causeway		Reconstruction	34+390	RCC Slab	1X3

Sl. No.	Existing Chainage (Km)	Type of Culvert	Existing No. of Spans with Span Length x Vertical Clearance (In m)	Recommendation	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (In m)
40	33+769	Causeway		Reconstruction	34+715	RCC Slab	1X3
41	33+856	Causeway		Reconstruction	34+800	RCC Slab	1X3
42	34+099	Causeway		Reconstruction	35+080	RCC Slab	1X3
43	34+244	Causeway		Reconstruction	35+240	RCC Slab	1X3
44	34+487	Causeway		Reconstruction	35+460	RCC Slab	1X3
45	34+582	Causeway		Reconstruction	35+560	RCC Slab	1X3
46	34+591	Causeway		Reconstruction	35+575	RCC Slab	1X3
47	34+798	Causeway		Reconstruction	35+780	RCC Slab	1X3
48	34+904	Causeway		Reconstruction	35+900	RCC Slab	1X3
49	35+132	Causeway		Reconstruction	36+095	RCC Slab	1X3
50	35+185	Causeway		Reconstruction	36+145	RCC Slab	1X3
51	35+337	Causeway		Reconstruction	36+295	RCC Slab	1X3
52	35+456	Causeway		Reconstruction	36+410	RCC Slab	1X3
53	35+521	Causeway		Reconstruction	36+475	RCC Slab	1X3
54	35+670	RCC Slab	1X2	Reconstruction	36+625	RCC Slab	1X3
55	35+819	Causeway		Reconstruction	36+800	RCC Slab	1X3
56	35+929	Causeway		Reconstruction	36+900	RCC Slab	1X3
57	36+150	Causeway		Reconstruction	37+120	RCC Slab	1X3
58	36+218	Causeway		Reconstruction	37+180	RCC Slab	1X3
59	36+280	Causeway		Reconstruction	37+240	RCC Slab	1X3
60	36+377	Causeway		Reconstruction	37+340	RCC Slab	1X3
61	36+835	Causeway		Reconstruction	37+760	RCC Slab	1X3
62	37+377	Causeway		Reconstruction	38+295	RCC Slab	1X3
63	38+022	Causeway		Reconstruction	38+940	RCC Slab	1X3
64	38+222	Causeway		Reconstruction	39+100	RCC Slab	1X3
65	38+483	Causeway		Reconstruction	39+360	RCC Slab	1X3
66	38+585	Causeway		Reconstruction	39+460	RCC Slab	1X3
67	39+085	Causeway		Reconstruction	39+960	RCC Slab	1X3

Table 1.26: Proposed Culverts

Sl. No.	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (m)	Proposal
1	29+110	RCC SLAB	1X3	New Construction

1.10 Viaducts

Table 1.27: Proposed Viaducts

Sl. No.	Start Chainage	End Chainage	Span Arrangement up to Expansion joint (m)	Type	Width of Carriageway (m)	Length (m)
1	29+980	30+010	2X15	Voided Slab	9	30
2	34+900	34+960	4X20	Voided Slab	9	60
					Total Length	**90**

1.11 Retaining Walls

Table 1.28: Retaining Wall Locations

Retaining Walls Locations LHS:

Sl.No.	Proposed Chainage		Length (m)	Height (m)	Sl.No.	Proposed Chainage		Length (m)	Height (m)
	From	To				From	To		
1	26+210	26+220	10.00	4	34	30+200	30+210	10.00	6
2	26+220	26+230	10.00	5	35	30+210	30+220	10.00	5
3	26+230	26+240	10.00	5	36	30+750	30+760	10.00	5
4	26+240	26+250	10.00	4	37	30+760	30+770	10.00	5
5	26+290	26+300	10.00	4	38	30+770	30+780	10.00	5
6	26+320	26+330	10.00	5	39	31+080	31+090	10.00	4
7	27+170	27+180	10.00	6	40	31+090	31+100	10.00	7
8	27+180	27+190	10.00	5	41	31+170	31+180	10.00	5
9	28+120	28+130	10.00	4	42	31+180	31+190	10.00	4
10	29+550	29+560	10.00	4	43	31+190	31+200	10.00	5
11	29+560	29+570	10.00	8	44	31+210	31+220	10.00	4
12	29+570	29+580	10.00	4	45	31+220	31+230	10.00	6
13	29+590	29+600	10.00	5	46	31+230	31+240	10.00	6
14	29+680	29+690	10.00	7	47	31+290	31+300	10.00	6
15	29+690	29+700	10.00	6	48	33+050	33+060	10.00	4
16	29+700	29+710	10.00	5	49	33+060	33+070	10.00	4
17	29+710	29+720	10.00	5	50	33+500	33+510	10.00	5
18	29+860	29+870	10.00	5	51	33+710	33+720	10.00	8
19	29+870	29+880	10.00	6	52	33+720	33+730	10.00	10
20	29+880	29+890	10.00	5	53	33+730	33+740	10.00	8
21	29+890	29+900	10.00	6	54	37+460	37+470	10.00	5
22	29+900	29+910	10.00	4	55	37+470	37+480	10.00	8
23	29+920	29+930	10.00	5	56	37+480	37+490	10.00	8
24	29+950	29+960	10.00	5	57	37+490	37+500	10.00	7
25	29+960	29+970	10.00	9	58	37+500	37+510	10.00	7
26	29+970	29+980	10.00	11	59	37+510	37+520	10.00	7
27	30+000	30+010	10.00	9	60	37+520	37+530	10.00	6
28	30+010	30+020	10.00	10	61	37+530	37+540	10.00	5
29	30+020	30+030	10.00	9	62	37+960	37+970	10.00	4
30	30+030	30+040	10.00	7	63	38+270	38+280	10.00	4

Sl.No.	Proposed Chainage		Length (m)	Height (m)	Sl.No.	Proposed Chainage		Length (m)	Height (m)
	From	To				From	To		
31	30+040	30+050	10.00	5	64	38+280	38+290	10.00	4
32	30+050	30+060	10.00	6	65	38+290	38+300	10.00	4
33	30+190	30+200	10.00	7	**Total Length (m)**			**650.00**	

Retaining Walls Locations RHS:

Sl.No.	Proposed Chainage		Length (m)	Height (m)	Sl.No.	Proposed Chainage		Length (m)	Height (m)
	From	To				From	To		
1	26+210	26+220	10.00	5	46	30+680	30+690	10.00	9
2	26+220	26+230	10.00	5	47	30+690	30+700	10.00	5
3	26+230	26+240	10.00	4	48	30+880	30+890	10.00	7
4	26+250	26+260	10.00	4	49	30+890	30+900	10.00	9
5	26+260	26+270	10.00	4	50	30+900	30+910	10.00	4
6	26+270	26+280	10.00	5	51	30+990	31+000	10.00	7
7	26+280	26+290	10.00	5	52	31+000	31+010	10.00	7
8	26+290	26+300	10.00	5	53	31+010	31+020	10.00	6
9	26+300	26+310	10.00	5	54	31+020	31+030	10.00	8
10	26+310	26+320	10.00	5	55	31+030	31+040	10.00	7
11	26+320	26+330	10.00	6	56	31+040	31+050	10.00	5
12	26+330	26+340	10.00	6	57	31+430	31+440	10.00	7
13	26+340	26+350	10.00	4	58	31+440	31+450	10.00	8
14	26+900	26+910	10.00	6	59	31+450	31+460	10.00	7
15	26+940	26+950	10.00	4	60	31+460	31+470	10.00	7
16	27+050	27+060	10.00	5	61	32+600	32+610	10.00	5
17	27+060	27+070	10.00	5	62	33+710	33+720	10.00	6
18	27+170	27+180	10.00	9	63	33+720	33+730	10.00	7
19	27+180	27+190	10.00	6	64	33+920	33+930	10.00	4
20	27+320	27+330	10.00	6	65	34+880	34+890	10.00	6
21	27+330	27+340	10.00	5	66	34+950	34+960	10.00	10
22	27+580	27+590	10.00	6	67	36+210	36+220	10.00	4
23	27+590	27+600	10.00	5	68	36+220	36+230	10.00	4
24	28+420	28+430	10.00	7	69	36+230	36+240	10.00	5
25	28+890	28+900	10.00	6	70	36+240	36+250	10.00	5
26	28+900	28+910	10.00	5	71	36+250	36+260	10.00	5
27	29+090	29+100	10.00	9	72	36+260	36+270	10.00	5
28	29+100	29+110	10.00	10	73	36+270	36+280	10.00	5
29	29+110	29+120	10.00	7	74	36+280	36+290	10.00	6
30	30+110	30+120	10.00	5	75	36+400	36+410	10.00	4
31	30+170	30+180	10.00	4	76	37+360	37+370	10.00	4
32	30+180	30+190	10.00	8	77	37+370	37+380	10.00	4
33	30+190	30+200	10.00	8	78	37+380	37+390	10.00	5
34	30+200	30+210	10.00	7	79	37+390	37+400	10.00	4
35	30+220	30+230	10.00	5	80	37+440	37+450	10.00	4
36	30+230	30+240	10.00	5	81	37+450	37+460	10.00	6
37	30+240	30+250	10.00	5	82	37+460	37+470	10.00	8

Sl.No.	Proposed Chainage		Length (m)	Height (m)		Sl.No.	Proposed Chainage		Length (m)	Height (m)
	From	To					From	To		
38	30+250	30+260	10.00	5		83	37+470	37+480	10.00	9
39	30+300	30+310	10.00	4		84	37+480	37+490	10.00	8
40	30+310	30+320	10.00	6		85	37+490	37+500	10.00	7
41	30+340	30+350	10.00	6		86	37+500	37+510	10.00	7
42	30+350	30+360	10.00	11		87	37+510	37+520	10.00	6
43	30+360	30+370	10.00	10		88	37+520	37+530	10.00	5
44	30+370	30+380	10.00	10		89	37+530	37+540	10.00	5
45	30+380	30+390	10.00	6			**Total Length (m)**		**890.00**	

1.12 Breast Walls

Table 1.29: Proposed Breast Walls

Breast Wall	Left Side Length (m)	Right Side Length (m)
	6500	5100

1.13 Cost Estimate

Preliminary cost estimate for the project Road is finalized based on the improvement proposed. The preliminary cost estimate is worked out based on the quantities calculated for major items of work to be executed in the project and also rates derived after detail analysis.

Table 1.30: Cost of Civil Works

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
A	**ROAD WORKS**					
1	Site Clearance				8,394,023.40	0.839
2	Excavation	Cum			310,067,710.40	31.007
3	Earthwork Filling	Cum			8,944,156.95	0.894
4	Sub Grade	Cum			26,497,121.14	2.650
5	CTSB	Cum			150,492,715.82	15.049
6	BSM	Cum			147,499,418.14	14.750
7	Prime Coat	Sqm			4,131,275.39	0.413
8	Tack Coat	Sqm			3,098,456.54	0.310
9	BC	Cum			76,889,920.52	7.689
B	**BRIDGES and STRUCTURES**					
1	Culverts	No.	68			

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
					157,215,992.18	15.72
C	**SLOPE STRUCTURES**					
1	Elevated Structure	No.	2		98,971,984.78	9.90
2	Retaining Wall	Rnm	1540		118,645,861.64	11.86
3	Breast Wall	Rnm	11600		225,110,134.76	22.51
D	**JUNCTIONS**					
1	Minor Junctions	No	6.0		40,794,385.50	4.08
E	**DRAIN & PROTECTION WORK**					
1	Drainage Works	Km			81,585,127.87	8.16
2	Parapet Wall	Km	10.92		26,535,600.00	2.65
3	Other Protetive Works				381,817,800.00	38.18
F	**LAY BYES**					
1	Bus Shelter	Nos	4.0	1,500,000	6,000,000.00	0.60
G	**OTHER MISCELLANEOUS ITEMS**					
1	Miscellaneous Items	Total			1,893,900.00	0.19
2	Traffic Signs, Marking and Road Appurtenances	Total			6,614,661.51	0.66
3	Reflective Road Studs	Nos	3060		2,553,019.20	0.26
	TOTAL CIVIL COST				**1883753265.73**	**188.375**
	COST PER KM (LENGTH = 13.900 KM) IN CRORES ...					**13.55**

1.14 Environmental Impact Assessment

The data collected as part of the environmental impact assessment was analyzed for:

- Identification of direct and indirect and natural environmental impacts, positive as well as negative, likely to result from the proposed project. Since the proposed project is an important infrastructure project, the assessment also considered the environmental impacts from the secondary / induced development that the project might generate.

- Appraisal of natural hazards and social risks during construction and operation of the project.
- Exploration of opportunities for enhancement of environmental, aesthetic and socio-economic quality through the proposed project.
- Suggesting requisite feasible and cost effective mitigate measures for each potentially adverse environmental impact, including relocation or rebuilding of the cultural properties, rehabilitation of borrow areas / quarries from where the construction materials are to be procured; and computation of the cost estimates in implementing these measures.
- Delineation of impacts that are unmanageable, or cannot be avoided or mitigated.
- Determining any significant economic and environmental issues requiring additional studies and analysis.
- Estimation of quality of available data, key data gaps, if any, and levels of uncertainty of environmental impact predictions.

The results of this analysis was quantified, tabulated and plotted on maps to identify any major environmental risks / conflicts, which the proposed road is likely to generate, and show the resultant classification of highway sections as:

- Those with minor or no potential impacts and hence requiring a limited social and environmental analysis, for all the civil works components of the project to determine mitigatory measures.

Those with major socio-environmental issues which should either be excluded from the road programme or is the subject of a full and detailed EA to determine appropriate mitigation measures.

A reconnaissance survey has been undertaken to ascertain the aspects of the social structure, religious and cultural composition, occupational pattern, vulnerability of the people, which cannot be ascertained through the secondary sources of data. While conducting the sample survey, the care has been taken to select people for survey in such a manner so that the real situation of the area could be ascertained.

1.15 List Clearances required for the Project

Following clearances are required before the commencement of construction work. Out of these, few are critical and need to be obtained immediately to avoid the time lag at later date.

Table 1.31: Project Clearances

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
1	The EIA Notification, 14th September 2006 and subsequent amendments	Identifies "(i) New National Highways; and (ii) Expansion of National Highways greater than 30 Km involving additional right of way greater than 20m involving land acquisition" under (item 7 (f) of schedule) as one of the	Not required	New National Highway NH -717A (Category of project - A)	MoEF&CC

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
		projects requiring prior clearance.			
2	Notification for use of Fly ash, 3rd November 2009	Reuse fly ash discharged from Thermal Power Station to minimise land use for dispersal and minimise borrow area material. The onus shall lie with the implementing authority to use fly ash unless it is not feasible as per IRC.	NO	If Projects within power 500 km of plant will cover under this notification (SO 1396 (E). 25 March 2015	MoEF&CC, SPCB
3	The Water (Prevention and Control of Pollution) Act, 1974	Central and State Pollution Control Board to establish/enforce water quality and effluent standards, monitor water quality, prosecute offenders, and issue licenses for construction/operation of certain facilities.	NO	Consent required if ground water is being used for consent purpose	CPCB /SPCB
4	Noise Pollution (Regulation And Control) Act, 1990	Standards for noise emission for various land uses	Yes	construction machineries and vehicles to conform to the standards for construction	State pollution control board
5	Forest (Conservation) Act, 1980	Conservation and definition of forest areas. Diversion of forest land follows the process as laid by the act	Yes	For diversion of forest land for road construction	State forest department, MoEF&CC
6	Coastal Regulatory Zone Notification, 2011	Protect and manage coastal areas	No	The project area is not within designated coastal zone	MoEF&CC, State forest department,
7	Wild Life Protection Act, 1972	Protection of wild life in sanctuaries and National Park	NO		
8	Ancient Monuments and Archaeological sites and Remains Act 1958	To protect and conserve cultural and historical remains found.	No	For world heritage sites and monuments	Archaeological Survey of India, Dept. of Archaeology
9	The Motor Vehicle Act. 1988	Empowers State Transport Authority to enforce standards for vehicular pollution. From August 1997 the "Pollution Under Control Certificate is issued to reduce vehicular emissions.	Yes	All vehicles used for construction will need to comply with the provisions of this act.	State Motor Vehicles Department
10	The Explosives Act (& Rules) 1884 (1983)	Sets out the regulations as to regards the use of explosives and precautionary measures while blasting & quarrying.	Yes	If new quarrying operation is started by the concessionaire / contractor	Chief Controller of Explosives
11	Public Liability And Insurance Act,1991	Protection to the general public from accidents due to hazardous materials	Yes	Hazardous materials shall be used for road construction	Project Implementation Unit/ Contractor

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
12	Hazardous Wastes (Management and Handling) Rules, 1989	Protection to the general public against improper handling and disposal of hazardous wastes	Yes	Hazardous wastes shall be generated due to activities like of maintenance and repair work on vehicles	CPCB/SPCB
13	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Protection against chemical accident while handling any hazardous chemicals resulting	Yes	Handling of hazardous (flammable, toxic and explosive) chemicals during road construction	District & Local Crisis Group headed by the DM and SDM
14	Mines and Minerals (Regulation and Development) Act, 1957 as amended in 1972	Permission of Mining of aggregates and sand	Yes	Permission of Sand Mining from river bed & aggregates	Department of Mining for state and central level
15	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Employing Labour / Workers	Yes	Employing Labour/ workers	District labour Commissioner

1.16 Economic and Financial Analysis

1.16.1 Economic Analysis

The economic evaluation for the project has been undertaken separately considering linkages of network, and also for the project as a whole, using HDM-4 model. The economic feasibility has been determined by utilizing the discounted cash flow technique, over a period of 20 years. The economic evaluation has been carried out for both "with" and "without" project situations.

1.16.2 Vehicle Operating Cost

The unit vehicle operating costs (VOC) for respective vehicles have been worked out based on IRC: SP 30-2009 Manual on Economic Evaluation of Highway Projects in India (Second Revision).

1.16.3 Assessment of Economic Benefit

The economic benefits likely to result by construction of alternative highway to Gangtok has been identified and quantified in monetary values. These are expected in terms of savings in road user costs comprising the cost of vehicle operation on different options / alternatives, value of travel time and accident losses.

In order to assess economic benefits, vehicle operating costs (VOC) for cars, buses and trucks and road users' time costs for passengers and goods in transit have been worked out in economic terms for vehicle mix and user groups under different traffic flow conditions for

"without" and "with" the project situations. The VOC model has been run for alternate traffic scenarios. The model produces total VOC benefits under "with" and "without" scenarios. The congestion level due to proposal has also been considered and the committed plans for improvement of other links of the existing road network in the region. The net VOC savings under "with" and "without" project situations has been considered as economic benefits.

The savings in passenger time has been determined by making use of the income method for passengers using private and public modes of transport. The savings in freight consignment cost have been determined based on the accounting rate of return on the value of goods in transit, estimated from the commodity composition, average pay-load by vehicle type, and current price level of selected commodities.

The accident costs arising out of injuries and death of victims and damages to vehicles have been determined by using the 'ex-post' methodology (cost incurred by the community due to accident having taken place). The cost elements include such items as

(i) Cost to the injured party,
(ii) Cost to the insurance company due to damage of vehicles and fatalities,
(iii) Administrative expenses of courts and Police Departments,
(iv) Damage to property, etc.

The savings in accident costs is related to the net change in accident rates due to improved traffic flow condition.

1.16.4 Assess Economic Cost

The total project cost, estimated in financial terms at perceived market prices, will be converted into economic cost to reflect the resource cost to the national economy. The financial cost of the project distributed among major cost components. The principal elements of economic cost estimates mainly comprises of:

a) Civil works and construction (including cost of land and ROW, environmental and social impact mitigation) ;
b) Capital cost - initial cost of machinery and equipment required;
c) Consulting services and training;
d) Incremental administrative costs (including cost of staffing and auditing);
e) Initial working capital.

To the base cost, contingency allowances (reflecting physical and price changes that can reasonably be expected to increase a base cost estimate), interest during construction, and other financial charges have been added.

1.16.5 EIRR and Sensitivity Analysis

The economic analysis worked out based on economic internal rate of return (EIRR) and Net Present Value (NPV) using cost - benefit approach. The annual streams of project benefits and costs computed for 20 years have been used in this analysis. The sensitivity analysis has also been carried out by varying cost and benefit independently as well as in combination. The end results of this study are presented in a series of NPVs.

1.16.6 Risks on DBFO Projects

The project would involve a number of identifiable risks. The primary risks are:

- Construction risks (time and cost overrun)
- Financing risks (adequacy, interest rate fluctuation, exchange parity, etc.)
- Traffic and revenue risks (traffic volume and toll collection)
- Political risks (stability of government policy and socio-political scenario).

All the above factors have been carefully examined and evaluated while assessing the financial viability of the project on DBFO basis.

1.17 Recommendations

- Based on the lane capacity analysis results, the project road requires 2 lanes with paved shoulder for capacity augmentation and efficient movement of traffic up to project common concession period of 15 years i.e. horizon year 2033.
- The project road can be improved without causing significant adverse environmental impacts to the natural, social, economic or cultural environments.
- Ribbon development is observed on the project road near Pedong town. To segregate local traffic and traffic travelling on national highway and also considering the future traffic projections, the raised footpath cum drain is proposed.
- The process of land acquisition has to be initialised immediately after the approval of the alignment, to expedite construction of bypass and widening sections.
- The project can be constructed within 24 months period with strategic planning and through one construction package. The estimated basic cost is give below table (Amount in Crores)

Section	Proposed Length (km)	Civil Cost In Cr.
Bagrakot to Kafer (26+100 to 40+000)	13.900	188.375

- On the basis of preliminary analysis, nature of impacts and observations of the various affected groups due to project, it is concluded that the proposed National Highway can be developed without causing significant adverse environmental impacts to the natural, social, economic agricultural environment of the study area, assuming the mitigation measures identified in EIA report will be incorporated into design and implementation stage. The important points are:
- Appropriate mitigation measures as suggested in environmental assessment report shall be incorporated. Construction of National Highway in the state of West Bengal is not expected to result in any significant adverse environmental impacts.
- Forest clearance will be applicable for diverting reserved and protected forest for road construction. All the necessary clearances will be required from concern departments at different stage of the project implementation.

1. Introduction

1.1 General

National Highway Authority of India (Ministry of Road Transport and Highways, Government of India) represented by the Chairman is engaged in the development of National Highway and as part of this endeavour, the Authority has decided to take up the development of alternative Highway to Kafer in West Bengal via Kafer – Bakhim –Lava – Algarah - Pedong –Reshi Border in the State of West Bengal through Engineering, Procurement and Construction (EPC) mode and accordingly taken up Feasibility Study cum Preliminary Design Report.

In pursuance of the above, M/s SA Infrastructure Consultants Pvt. Ltd. in association with Specialized Engineering Services Pvt. Ltd has been appointed as consultant to carry out the Feasibility Study cum Preliminary Design Report for alternative Highway to Kafer in West Bengal via Kafer – Bakhim –Lava – Algarah – Pedong – Reshi Border in the State of West Bengal by the Authority.

The Agreement was signed and the commencement of services has been started from dated 08-10-2014 with the reference of NHAI letter no: NHAI/Tech/WB/FRCPD/Sikkim/2014/444/5726, dated 08-10-2014.

1.2 The Consultants

The Consultancy services for preparation of Feasibility Report cum Preliminary Design for Alternative Highway to Kafer in West Bengal via Kafer – Bakhim –Lava – Algarah – Pedong – Reshi Border in the State of West Bengal has been entrusted to M/s SA Infrastructure Consultants Pvt. Ltd. in association with Specialized Engineering Services Pvt. Ltd. The field studies shall be carried out from the site office however report finalisation shall be carried out from the corporate office. The address of the corporate office is given hereunder:

Corporate Office:-

SA Infrastructure Consultants Pvt. Ltd.
In Association With
Specialized Engineering Services Pvt. Ltd.
1101A 11th Floor, Tower A/2, Corporate Park, Plot No.7A/1
Sector-142, Noida-201301(Uttar Pradesh)
Tel. No-0120-6148000,6148031

1.3 Objective of Consultancy

The objective of this consultancy (the "Objective") is to undertake Feasibility Study cum Preliminary Design and prepare a Feasibility Report of the Project Highway for the purpose of firming up the Authority's requirements in respect of development and construction of the Project Highway and Project Facilities and enabling the prospective bidders to assess the Authority's requirements in a clear and predictable manner with a view to ensuring:

(i) Enhanced safety and level of service for the road users;
(ii) Superior operation and maintenance enabling enhanced operational efficiency of the Project Highway;
(iii) Minimal adverse impact on the local population and road users due to road construction;
(iv) Minimal adverse impact on environment;
(v) Minimal additional acquisition of land; and
(vi) Phased development of the Project Highway for improving its financial viability consistent with the need to minimise frequent inconvenience to traffic.

1.4 Scope of Services

As per the Terms of Reference (TOR), the general scope of Work will include the following primary tasks to be performed by the Consultants:

(i) Traffic surveys and demand assessment
(ii) Engineering surveys and investigations
(iii) Location and layout of toll plazas
(iv) Location and layout of truck lay byes
(v) Location and layout of bus bays and bus shelters
(vi) Social impact assessment
(vii) Environment impact assessment
(viii) Preliminary Designs of road, bridges, structures, etc.
(ix) Preparation of Land Plan Schedules and Utility Relocation Plans
(x) Preparation of indicative BOQ and rough Cost Estimates
(xi) Preparation of Schedules A, B, C, D, H and I of the Contact Agreement.

1.5 Project Stages

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

Sl. No.	Description of Deliverables
A	Inception Report and QAP
B	Report on Alignment and First Traffic Survey
C	Land Plan Schedules
D	Utility Relocation Plans
E	Reports on Environment and Social Impact Assessment
F	Report on Indicative GAD of structures (bridges, grade separators, ROB/RUBs)
G	Draft Feasibility cum preliminary design Report and Schedules to the Contract Agreement(EPC)
H	Final Feasibility cum preliminary design Report
I	Completion of Services including assistance during Bid Process

1.6 The Draft Feasibility cum Preliminary Design Report (DFR)

The Draft Feasibility Report consists of two parts as described herein below:

Part - A : Main Report

Part - B : Drawings

1.6.1 The Part - A: Main Report consists of the following chapters

Chapter No	Name of Chapter
0	Executive Summary
1	Introduction
2	Project Appreciation
3	Detailed Methodology
4	Mobilisation and Work Programme
5	Draft Design Standards

1.6.2 The Part - B: Drawings consists of the following

- Location Plan
- Alignment Plan
- Typical Cross Sections
- General Arrangement Drawings

TCS No.	Description	Total Length (m)
1	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	3110
2	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	3150
3	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	2160
4	Two lane with Paved shoulder Realignment (One Side Hill, One side Valley section)	1840
5	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	2880
6	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	330
7	Two lane with Paved shoulder Realignment (Both Side Hill section)	340
8	Elevated Structure (including box abutment length)	90
	Total	**13900**

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CHAPTER – 2

Preliminary Environmental Assessment

2.0 Introduction

The Environmental Impact Assessment (EIA) has been carried out as per ADB/IRC guidelines and for the purpose of Environmental Assessment 10 km area from project boundary was considered for study. The objective of environmental impact assessment study is to identify the adverse and positive impacts due to project implementation and to suggest avoidance, mitigation and enhancement measures in project design and to prepare environmental management plan for pre-construction, and construction and operation phases of the project.

his section deals with the description of existing environmental set-up of the proposed study area in the State of West Bengal. The environmental baseline data comprises the salient features present within the surrounding of project area. The study area includes environmental features like forest cover, protected areas, water bodies (rivers, ponds, wetlands, lakes and reservoirs), industries, tourisms, and other valued environmental components (VECs), common property resources (CPRs) *etc.* The scope of this chapter is limited to only those issues, which are of major concern in the environmental impact assessment. The data and existing environmental features documented here under have been collected through field investigations, interactions with local people and communities, review of published data.

The environmental impact study includes all areas where physical, biological and chemical changes may be expected. The field studies have been carried out to substantiate projected effects and develop mitigation plans to protect the biota and natural integrity along the proposed project corridor. In this regard, the baseline environmental setup covers the following environmental attributes.

2.1. Physiography

West Bengal is located in East India on the Bay of Bengal. It is India's fourth-most populous state, with over 91 million inhabitants. It has a total area of 34,267 sq mi (88,752 km^2). A part of the ethno-linguistic Bengal region, it borders Bangladesh in the

east and Nepal and Bhutan in the north. It also has borders with five Indian states, including Odisha, Jharkhand, Bihar, Sikkim and Assam .

A major agricultural producer, West Bengal is the sixth-largest contributor to India's net domestic product.[4] It is noted for its cultural activities and the presence of cultural and educational institutions; the state capital Kolkata is known as the "cultural capital of India"

The lands along the project roads are mostly forest land and at few locations have habitation, commercial and cultivated (tea garden) areas in West Bengal. The project road alignment traverses through mountainous and steep terrain throughout the stretch from the start point of the project which traverses through hilly terrain in the west bengal.

Darjeeling hill areas are unique from environmental Eco-perception. The relief varies from 100 m above sea level to the mighty Kanchanjungha peak. The Darjeeling hills are formed of comparatively recent rock structure that has a direct bearing on landslides. The causes of the landslides vary from one locality to another. Heavy monsoon precipitation is however a very common cause of these disasters. More over soils of Darjeeling hill areas are extremely varied, depending on elevation, degree of slope, vegetative cover and obviously geo-lithology.

The natural system of erosion in the hill gets more complicated when man interferes. As the mountains serve as the source of resources for the population residing in the hills as well as in the plains, the form of environmental degradation is quite extensive other particularly is applied to the extraction of timber and other forest produces, mining and agriculture are taken into account. Due to unprecedented growth of population during the last few decades in the Darjeeling hill areas, nature has started reacting sharply to the accumulated human guilt.

Landslide hazards, especially during rainy season have become a common factor to the people of the hill. The Hill areas of Darjeeling District are located within the Lesser and Sub - Himalayan belts of the Eastern Himalayas. The area is bounded by the Sikkim Himalaya in the north, the Bhutan Himalaya in the east and Nepal Himalaya in the west. The southern foothill belt is demarcated by a highly dissipated platform of terrace deposits extending along the east west axis. The inner belt is defined by a ridgeline stretching from the Darjeeling Hill to the west and Kalimpong Hill to the east, overlooking

the southerly flowing Tista valley in between. Prominent rivulets contributing to the Rammam - Rangit basin, dissipate the northern slope of Darjeeling Hills. The Kalimpong Hill is rather rugged in topography and is dissipated by radically descending gullies and streams that contribute to the Teesta and Jaldhaka River system.

2.2 Climate

These regions have five seasons: winter, summer, spring, autumn, and monsoon. This region has a temperate climate (subtropical highland climate) with wet summers caused by monsoon rains. The annual mean maximum temperature is 15.98 °C (60.76 °F) while the mean minimum temperature is 8.9 °C (48.0 °F), with monthly mean temperatures range from 5 to 17 °C (41 to 63 °F). The lowest temperature recorded was −24 °C (−11 °F) in February 1905. The average annual precipitation is 373.6 cm (147.08 in), with an average of 126 days of rain in a year. The highest rainfall occurs in July. The heavy and intense rainfall is experienced in the region, aggravated by deforestation and haphazard planning, often causes devastating landslides, leading to loss of life and property. Fog affects most parts of the region during winter and the monsoons, making transportation perilous. Despite its small area, the climate ranges from sub-tropical to high alpine. Kangchenjunga, the world's third-highest peak, is located on the border of Sikkim with Nepal.

The amount of rainfall plays a very important role in causing instability of slopes. A very high intensity of rainfall within a short span of time is not uncommon in Darjeeling and sikkim hill areas. Besides seasonality, another climatic feature in the Darjeeling hills is created by orographic factor; causing the vertical zonation of temperature and decline of precipitation. Thus the mountain front is exposed to heavy rainfall, especially the middle parts of the southern hills. The mean annual temperature fluctuate from 24ºc in the plains and drops below 12ºc on the ridge. During summer month the temperature reaches 16ºc-17ºc on the ridge and during winter drops at 5ºC-6ºC.

There is no distinct relation between total rainfall and altitude. The southern slopes of the ridges get much higher (4000-5000 mm) precipitation than the leeward sides (2000-2500 mm). The next main ridge with Tiger Hills gets 3000 mm while to the north the Great Rangit valley receives about 2000 mm of rainfall. The annual total rainfall in Darjeeling town fluctuates between 1870-3690 mm.

2.3 Geology and Seismicity

2.3.1 Geology

The Darjeeling Himalaya has never been and will never be free from ubiquity of weak geology, slope instability, frequent seismicity, soil erosion etc. mainly due to natural causes and partly as a result of accelerated degradation. These adverse conditions in tandem can exacerbate the existing fragile, vulnerable and multi-functional mountain ecosystem. So far disasters caused by landslides, earthquakes, floods etc. have not lead to large scale human tragedy in Darjeeling in recent history. However, there is ever increasing human demand of natural resources, especially land for urban development and mega dams in an apparently unsustainable manner, making some of the denizens to adapt and survive at dangerous margins. The emerging crisis can perhaps be minimized by indigenous knowledge based and modern technological interventions. To safeguard against accelerated degradation and improve the living standards of the hill people, the Governments (Centre and State) need to address hill specific issues through systematic and effective integration of the ecosystem services and development, highland and lowland linkages etc. Without a replicable and hill specific developmental policy, the ever present threat from devastating landslides, earthquake, floods *etc.* remains and the options and the opportunities of the progeny in jeopardy.

The hilly terrain of project area mainly consists of gneissose and half-schistose rocks, producing generally poor and shallow brown clay soils. The soil is coarse, with large concentrations of iron oxide; it ranges from neutral to acidic and is lacking in organic and mineral nutrients. This type of soil tends to support evergreen and deciduous forests. Most of this region is covered by precambrian rock, which is much younger in age than the hills. The rock consists of phyllites and schists, and is highly susceptible to weathering and erosion. This combined with the heavy rainfall, causes extensive soil erosion and the loss of soil nutrients through leaching. As a result, landslides are frequent, often isolating rural towns and villages from the major urban centres.

2.3.2 Seismicity

The tectonic frame work and the seismicity of the northern eastern states including Sikkim and west Bengal are considered as a result of collision tectonics in the Himalayan

arc and sub-duction tectonics below the Myanmarese arc. Studies have indicated a very complex tectonic setting of the region due to constant movement of the Indian plate from South to North & Myanmarese from East to West. The two major structural elements in the Eastern Himalaya are the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT). The MCT is shown passing through Gangtok to Mangan and then to lower Tolung to north of Sada from where it cuts through North of Labdang-Tashiding to Gyalshing and then to Kaluk to Soreng before coming out of Sikkim border at an area where it meets the MBF (India-Nepal border). The existing unsafe and non-engineered building stock still remains and is practically impossible to address the entire such building stock. The alternative left is to retrofit only the life line buildings such as hospitals, schools, cinema halls, multi-storied hostel/apartments *etc*.

The Foot Hill Thrust (FHT)/Main Frontal Thrust (MFT) along the Southern edge of the Himalayan bring the Siwaliks in Juxta-position with the thick recent sediments of the Indo-gangetic plain. There are also a large number of prominent lineaments in this region, some of which are reported to extend for several kilometers beneath the Himalayan Foredeep. The Teesta lineaments which pass through Parbatipur area of Bangladesh to Bhadrapur area of Nepal, is considered to demarcate the Western limit of Eastern Himalayan seismicity.

The magnitude, intensity and frequency of Himalayan landslides vary from East to West and from South to North. The variation is controlled, mainly by climate, neo-tectonism and seismicity. The eastern Himalaya including Sikkim is a hot-spot for natural hazards, particularly landslides and earthquakes. Landslides of all types and size occur in almost all types of rocks and quaternary formations of Sikkim. The Daling Group of rocks, especially, Gorubathan Formation appears more prone to landslides than the inhomogeneous quaternary deposits and gneisses and schists of Higher Himalaya. The high landslide susceptibility of the Daling Group of rocks has been attributed to their severe shear distortion due to loading and unloading during orogenesis, higher rate of weathering and mineral composition.

Almost all the landslides in West Bengal occur after prolonged exposure to monsoon rains and occasionally during or just after cloudbursts or precipitation intensity exceeding 135-145 mm in 24 hours. Natural hazardous events such as earthquakes, landslides, floods

etc. in the Himalayas are a reality. Man and man-made structures stand no chance against the awesome power and fury of such events when they strike. Therefore, a mechanism is needed to safeguard against massive and unwarranted loss of life and property in the event of a calamity. In August 2004, the Government of India came out with a detailed status report on Disaster Management in India. The report specifies various programmes and strategies of the Nation to tackle and mitigate all forms of destructive natural events. The seismic zones of India have been depicted in **Table – 2.1** and **Figure – 2.1** as given below. Earthquake hazard map for West Bengal is provided in **Figure 2.2**

Table – 2.1: Showing intensity and area of seismic zones of India

Seismic Zones	**Intensity on Modified Mercalli Scale**	**% of Total Area**
Zone–II (Low intensity zone)	VI (or Less)	43
Zone–III (Moderate intensity zone)	VII	27
Zone–IV (Severe intensity zone)	VIII	18
Zone–V (Very severe intensity zone)	IX (and above)	12
	Total	**100%**

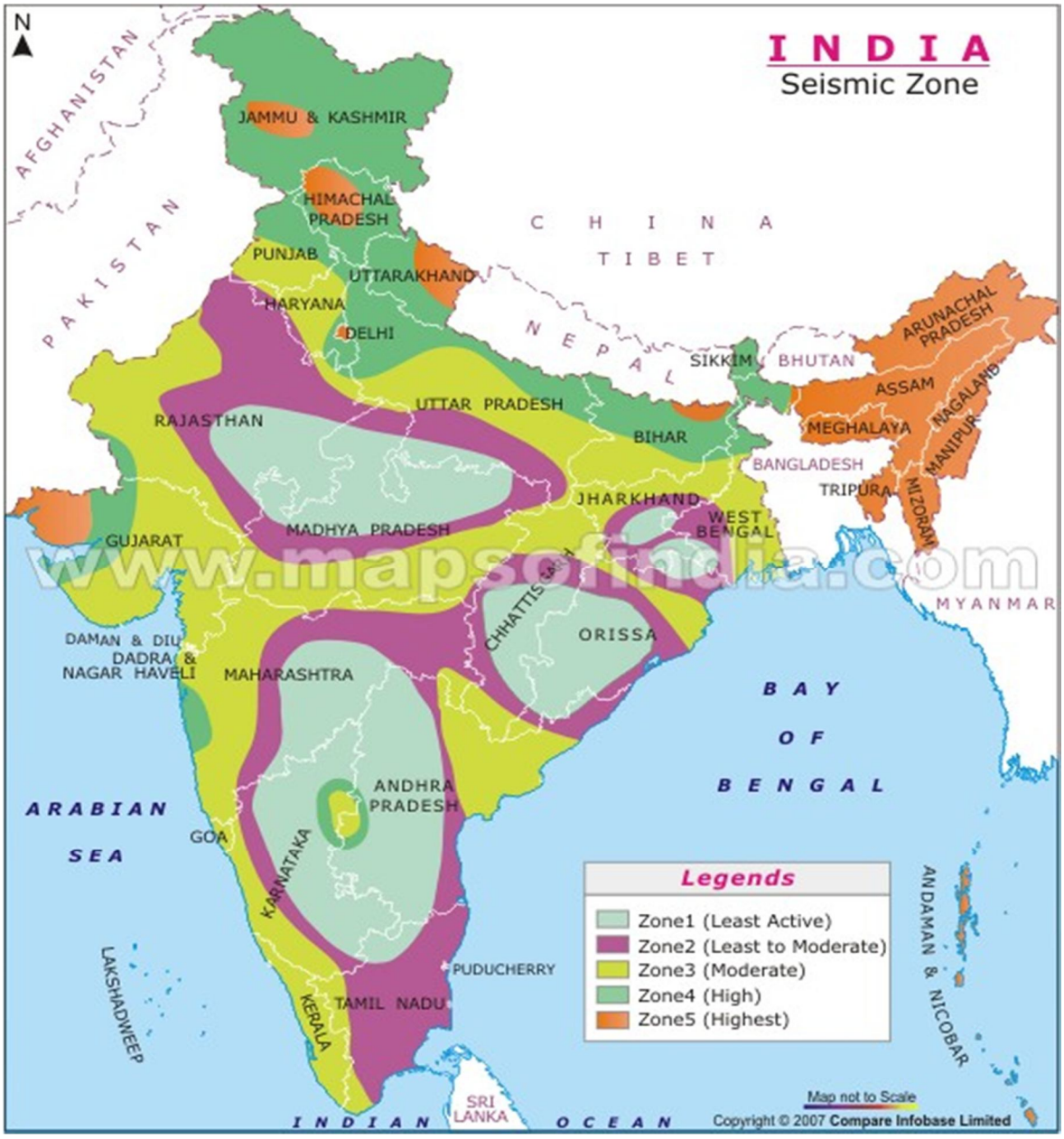

Figure – 2.1: Map showing major seismic zones in India

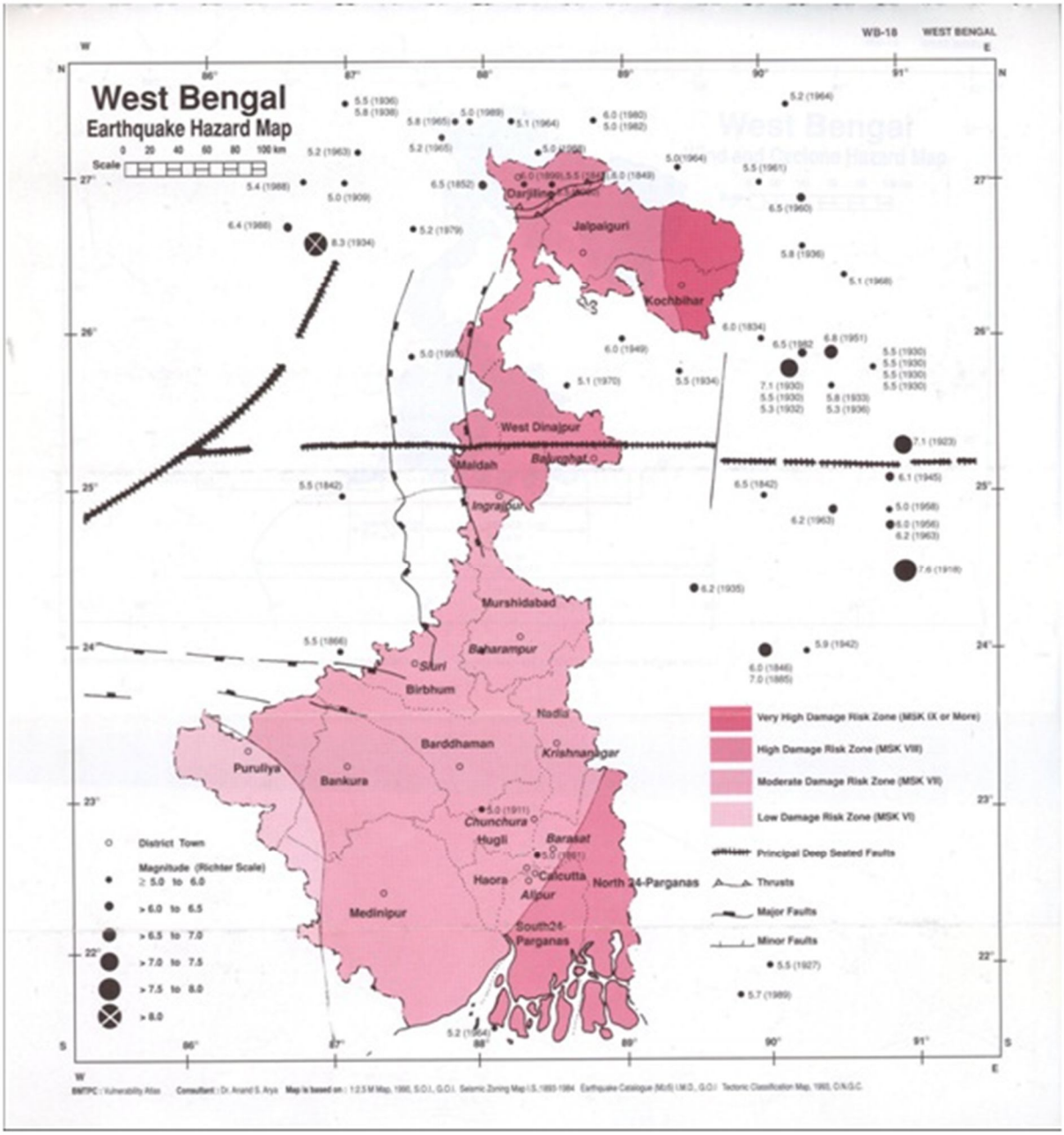

Figure 2.2 Earthquake Hazard map of West Bengal

2.4 Soil and Minerals

2.4.1 Soil

The soil of Darjeeling Hill Area is developed depending upon the underlying geological structure. But, in general, the soils have been developed by both fluvial action and lithological disintegration. the soils that have developed in the Kalimpong area are predominantly reddish in colour. Occasional dark soils are found due to extensive presence of phyllitic and scists. soils in the high lands stretching from the west to the east to the district along most of the interfluvial areas are mainly mixed sandy loam and loamy, while those on the southern slopes of Mirik and Kurseong are mainly clayey loam and reddish in colour. Sandy soils are mainly found in the east of the river tista.

All the soils are definitely acidic in nature with the tendency to increase slightly in depth in most cases indicating the lacking of bases from surface and accumulation in the lower horizons. The weathering of lateritic type is the substantial mechanism in the transformation of the substratum. The variable thickness of the regolith and soils depend on the rate of weathering and gradient of the longitudinal slope profiles and intensity / gravity of mass movements. The basic soil types are yellow soils, red brown soils and brown forest soils. Red and yellow soils have developed on gneiss while brown on schists and shales. Coarse pale yellow to red brown soils are found on the Siwaliks while clayey dark soils are developed on Daling series.

The character of the bedrock is reflected only in the grain size composition of the soil. On the Darjeeling gneiss, very coarse-grained (50%-80%) particles are found. In Damuda and Daling series percentage of sandy and coarse particles in the soils are high. On the Siwaliks, silty – clay fraction is higher. The chemical content of the soil over Darjeeling gneiss is characterized by a high proportion of potassium derived from feldspar and muscovite mica. This soil is poor in lime, magnesium, iron oxides, phosphorous and nitrogen. Therefore lime is used in the tea plantation areas.

2.4.2 Mineral Resources

West Bengal stands third in the country in terms of mineral production. The state contributes about one-fifth to the total production of minerals in the country. Major minerals which are foundinthisstateare fireclay, chinaclay, limestone, copper, iron,wolfram, manganese and dolomit e are mined in small quantities. There are good possibilities of obtaining mineral oil and natural

gas in the areas near the Bay of Bengal, in Purba Medinipur, Sundarbans, South 24 Parganas and North Bengal plains. Research is undergoing for finding natural gas in various places.

West Bengal is the third largest state for coal production, accounting for about half of India's total. Coal is extracted from about 228 mines in the Raniganj and Asansol region of Bardhaman district.

Highgrade bituminouscoal isminedat Raniganj, Dishergarh,Santaldih, Kulti, Barakar, Ghushik, K ajora. Coalfields stretch over an area of about 1,550 km^2 (598 sq mi). The coalfields of Raniganj support the Asansol-Durgapur industrial belt by providing fuel to the industries as well as generation of thermal power. Lignite mined inDarjeeling is used to make briquettes. Coal deposits are also found along the Ajoy river in Birbhum district.

West Bengal ranks next to Bihar and Madhya Pradesh in production of fireclay. Most of this mineral is extracted in the Raniganj region along with few amount is also extracted from Birbhum and Purulia. Chinaclay used
inthe pottery, paper, textile, rubber and paintindustries is unearthed at Mohammad Bazar in Birbhum and Mejia in Bankura. Rest of the production comes from Purulia, Bardhaman, Darjeeling and Jalpaiguri. In 1993-94 1.24 lakh metric tons of fireclay were produced in West Bengal.

Limestone which is used in cement industry is mined
in Bankura, Purulia, Darjeeling and Jalpaiguri. There are copper mines in Jalpaiguri and Darjeeling. Small quantities of low quality iron-ore are mined in Bardhaman, Purulia, Birbhum and Darjeeling. There are manganesein the Jhargram region of Paschim Medinipur, Purulia and Bardhaman. Wolfram is mined at Jhilimili in Bankura. The state's production of dolomite comes from the Dooars region of Jalpaiguri. 38.5 thousand tonnes of dolomite were raised in 1993-94.

2.5 Physical Environment

2.5.1 Metrology

The proposed project area is located in north east of west Bengal. Metrological data of IMD station at gangtok, Sikkim has been used for the study for macro scale metrological information. Data was collected from state pollution control board website. Mean monthly minimum temperature (°C), maximum temperature (°C), rainfall in mm, mean monthly relative humidity at

830 IST (%), mean monthly relative humidity at 1730 IST (%), and mean monthly wind speed of Gangtok are shown here in tabular format.

Table No. 2.2 Mean Monthly Maximum and Minimum temperature of Gangtok

Mean monthly Maximum and Minimum temperature of Gangtok (°C)												
Month /Year	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
JAN	06.0	11.8	07.6	13.5	06.9	15.0	04.8	11.2	04.4	10.2	05.2	13.3
FEB	05.3	12.8	09.0	16.6	07.6	15.4	08.1	15.0	07.2	14.5	08.2	16.7
MAR	10.3	17.9	10.7	18.4	12.2	19.0	10.8	18.3	09.9	17.4	11.2	19.2
APR	12.9	20.3	13.5	20.7	14.5	22.0	12.3	20.6	12.6	20.3	12.5	19.6
MAY	14.6	21.6	14.7	21.2	15.4	22.1	15.0	21.8	15.1	22.9	15.0	20.6
JUN	17.0	21.1	17.1	22.8	17.1	22.3	17.1	22.2	17.5	21.6	17.7	22.1
JUL	17.7	21.9	18.2	22.3	17.9	21.8	17.7	21.1	17.9	21.6	18.0	21.5
AUG	17.6	21.3	18.0	21.7	18.0	21.9	17.5	21.7	17.8	22.4	17.6	21.8
SEP	16.4	21.6	17.0	22.8	17.0	21.0	17.1	21.6	16.9	21.2	17.1	22.0
OCT	13.7	20.9	14.4	21.1	14.5	20.2	14.0	20.6	13.1	19.9	14.1	19.2
NOV	10.5	17.9	10.7	17.0	11.1	16.2	10.0	105.3	09.4	17.0	10.0	17.4
DEC	09.0	13.9	07.6	13.3	07.0	14.6	07.6	13.7	07.0	13.9	07.2	12.9

Table No. 2.3 Monthly cumulative rainfall (mm) of Gangtok

Monthly cumulative rainfall (mm) of Gangtok						
Month/ Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
JAN	017.7	011.3	000.0	027.8	028.6	006.0
FEB	006.8	007.5	017.4	045.6	042.6	047.3
MAR	155.3	107.5	224.6	073.8	047.9	168.2

APR	350.1	300.6	444.9	172.1	458.9	372.3
MAY	179.0	365.0	431.7	375.2	227.9	669.7
JUN	786.5	463.5	623.3	706.8	859.5	570.4
JUL	661.9	502.4	746.5	744.7	687.0	666.8
AUG	628.9	546.9	601.2	638.8	557.5	395.7
SEP	437.4	248.4	445.3	451.6	522.6	319.8
OCT	106.2	221.7	141.3	060.7	127.0	368.9
NOV	029.0	002.7	064.0	100.9	000.2	084.8
DEC	018.5	009.1	000.2	004.7	003.2	008.4

Table No. 2.4 Mean Monthly Relative humidity of Gangtok

Mean monthly relative humidity at 830 Hrs and 1730 Hrs IST (%) of Gangtok												
Month/Year	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**	
	0830 Hrs	1730 Hrs	0830 Hrs	1730 Hrs	830 Hrs	1730 Hrs	0830 Hrs	1730 Hrs	0830 Hrs	1730 Hrs	0830 Hrs	1730 Hrs
JAN	84	81	84	78	74	66	85	76	83	81	76	63
FEB	83	76	82	74	83	72	84	76	83	76	71	66
MAR	80	80	68	65	81	78	75	73	76	68	76	74
APR	82	81	81	79	79	84	75	77	80	83	80	81
MAY	85	84	85	81	87	84	88	84	80	78	90	88
JUN	96	93	93	88	93	89	93	88	94	93	93	90
JUL	96	93	95	92	94	92	96	93	95	94	95	93
AUG	95	93	95	92	95	93	94	92	93	91	94	92
SEP	92	90	91	88	93	91	93	91	93	91	94	91

OCT	77	79	82	79	86	85	83	82	84	80	87	86
NOV	76	73	80	78	87	84	82	81	78	73	75	73
DEC	83	83	87	81	76	71	81	75	80	74	85	82

Table No. 2.5 Mean Monthly Wind Speed (KM/Hr) of Gangtok

Mean Monthly Wind Speed (KM/Hr) of Gangtok						
Month/Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
JAN	002	002	002	001	002	002
FEB	002	002	002	002	002	003
MAR	003	003	002	003	002	003
APR	003	003	003	004	003	003
MAY	003	004	003	002	003	002
JUN	001	002	002	002	002	002
JUL	001	001	001	001	001	001
AUG	001	001	001	001	001	001
SEP	002	001	001	001	001	001
OCT	003	002	002	002	002	002
NOV	002	002	001	002	002	002
DEC	001	001	002	001	001	002

2.5.2 Water Resources

West Bengal covers 2.7 per cent of the national territory and renders home to 8 per cent of the Indian population. The State is endowed with 7.5 per cent of the water resource of the country and that is becoming increasingly scarce with the uncontrolled growth of population, expansion of irrigation network and developmental needs.

The Irrigation and Waterways Department (1987) of the Government of West Bengal made an assessment of the available water resource within the State in 1987. The Expert committee made a detailed exploration in the 26 river basins and stated that though the surface water in this state is estimated to be 13.29 Mham, only about 40 percent of it is utilizable. On the other hand, the available ground water though being 1.46 Mham only, is totally utilisable. The Central Ground Water Board estimated the annual available ground water as1.76 m.ham while the Irrigation Commission of Government of India put it as 2.38 m.ham. (Goswami, 1995, 2002).

2.5.3 Ambient Air Quality

The ambient air quality monitoring data was collected from secondary sources of state pollution control board official website. To control, prevent and abate air pollution in the country, the Government of India enacted Central legislation called the Air (Prevention & Control of Pollution) Act 1981. Every polluting industry must obtain a consent from the State Pollution Control Board for discharge of air pollutants in any form through chimney or otherwise. The State Board may lay down suitable conditions while giving consent to discharge air pollutants in the light of emission standards developed by the Central Board, subsequently notified through the rules framed under the Environment (protection) Act, 1986 Rules.

Air Quality monitoring data as per state of Environment Pollution Report 2004 are represented in the **Table 2.6**

Table 2.6 Ambient Air Quality in and around Gangtok (Yearly Average conc.) in µg/m^3

Sl. No.	Name of sites	Category	SPM	SO_2	NO_2
1	Tadong	Residential	108	16.2	15.7
2	Indira bye-pass	Commercial	137	17.4	22.6
3	Deorali	Residential	118	18.6	16.1
4	Bazar area (near metro point)	Commercial	145	22.3	20.4
5	Hospital point	Sensitive	122	19.6	18.6
6	Zero point	Sensitive	98	10.2	12.3
Reference: State of Environment Pollution Report 2004					

- **Oxides of Sulphur**

Eight hourly Sulphur dioxide concentration of the sample shows that Bazar area with 22.3 µg/m3 has highest concentration on yearly average while the zero point shows minimum concentration with 10.2 µg/m^3. The other stations viz: Tadong (16.2 µg/m^3), Indira bye-pass (7.4 µg/m^3) Deorali (16. µg/m^3), and Hospital Point (18.6 µg/m^3).All the values are, however, within the prescribed limit.

- **Oxides of Nitrogen**

The Eight hourly averages of Nitrogen oxides samples were collected and further analyzed in the lab. The result is presented in the table above. The highest concentration of oxides of Ni-trogen as NO_2 was recorded from Indira Bye-pass with 22.6 µg/m^3 followed by Bazar area (20.4 µg/m^3), Hospital Point (18.6 µg/m^3), Deorali (16.1 µg/m^3), Tadong (15.7 µg/m^3) and lowest was recorded from zero point with 12.3 µg/m^3. All the values are however, within Indian standard.

- **Suspended Particular Matter (SPM)**

The yearly average of suspended particulate matter is presented in table above. It can be inferred that Bazar area (near metro point) with 145 µg/m^3 of SPM has highest concentration while zero point with 98 µg/m3 shows minimum concentration of SPM. The highest value in Bazar area is mainly due to heavy vehicular movement in this area. Tadong monitoring site recorded 108 µg/m^3 of SPM and like-wise Indira bye-pass (137 µg/m3), Deorali (118 µg/m^3) and Hospital point (122 µg/m^3).

2.5.4 Water Quality Monitoring

Sikkim is bestowed with abundant hydrological resources primarily because of its geomorphology and its location in the Eastern Himalayas. The Himalayas obstruct the rain bearing winds of the south-west monsoon resulting the Himalayas to receive annual rainfall which ranks as the highest in the world, making the Himalayas a source of a large number of mighty rivers perennial streams and snow cover mountains. Of all the Lakes of Sikkim the study on the Environment status of the three revered lakes of East Sikkim, Viz., Changu, Menmoitso, & Kupuk Lakes have been carried out under the Central sponsored scheme Prevention & Abatement of Pollution. The Changu, Menmoitso, Kupuk Lakes are regarded as extremely sacred & are places of Tourist interest besides military base is situated in their vicinity. These lakes form an important stopover for various ducks besides being home to resident brahminy ducks (Tendora ferruginea). These lakes

also form the habitat for introduced brown trout (Salmo trattafario). Comparative Water analysis of lakes is shown in the following **Table 2.7**

Table 2.7: Comparative water analysis of Mirikh and Sinchal lake in Darjeeling district.

Parameter	Mirikh Lake	Sinchal Lake	Unit
Ammonia-N	0.36	BDL	mg/l
BOD	5.3	2.5	mg/l
Conductivity	88.8	30.9	µS/cm
Dissolved (DO)	10	8.9	mg/l
Fecal Coliform	4000	2000	MPN/100ml
Nitrate-N	0.49	0.6	mg/l
pH	6.61	7.18	-
Temperature	8	8	°C
Total Coliform	8000	4000	MPN/100ml

- **pH**

The annual average pH of Mirikh was lowest with 6.61 compared to Sinchal which had aproximately the 7.18 value in average. Lower pH value in Mirikh may be attributed to religious offerings and the impact of flow of tourists during tourist season whereas in sinchal lake flow of tourist is comparatively low.

- **Dissolved oxygen**

The highest annual average of dissolved oxygen was observed at Mirikh with 10 mg/l and the lowest no. at sinchal with 8.9 mg/l. The low no Value of sinchal shows the tendency towards eutrophic condition of the lake. In all the sites no content shows a marked seasonality with oxygen levels decreasing during winter months which might be due to cumulative influence of low insulation, low temperature, over turn of lake water and minimal photo synthetic activity.

- **B.O.D & C.O.D**

The annual average B.O.D value of mirikh was 5.3 mg/l which is comparatively higher than other study site. Sinchal shows 2.5mg/l whereas lowest BOD. Maximum values of B.O.D and C.O.D was observed during rainy season which may be due to heavy input of Variety of nutrients along with eroded material and prevalence of favourable environmental conditions for microbial activities. The higher B.O.D and C.O.D values infer to the pollution potential.

Thus it can be inferred that Changu lake has suffered undesirable changu than the other two lakes.

2.5.5 Noise Quality Monitoring

Noise has rapidly become a source of environmental pollution with increasing industrialization, urbanization and the rapid expansion of the means of transportation. The Ambient noise level termed as the total noise associated with a given environment and usually comprise of sounds from many sources both near and far.

The measurement of Ambient Noise level was done by noise level meter. The measurements which were taken for seven consecutive days in each sites were in three slots i.e. morning 8.00 am to 10 am, afternoon 14.00 to 16.00 pm, and night 18.00 to 20.00 pm. The average measurements are represented below.

Table 2.8 Average Ambient Noise Level at Various Places in Gangtok

Sl. No.	Place	Day Average leq in dB (A)	Night Average leq in dB (A)
Silence Zone			
1.	Hospital Point	62	63
2.	District Court	50	44
Residential Zone			
1.	Tadong	61	58
2.	Deorali Govt.Quarter	61	57
3.	Development area	66	50.7
Commercial Zone			
1.	M.G. Marg	70	62
2.	Indria Bye-Pass	73	69
Reference : SPCB, Government of West Bengal			

2.6 Agriculture System

Agriculture is the major economic activity. Economy of the State broadly depends on agriculture, which provides livelihood and productive engagement to the majority of the population. However, its progress has remained limited due to difficult topography and other natural barriers. More than 64% of the population is dependent on agriculture and related activities for their livelihood. The agriculture system followed in project area is economically viable for individual farmer and environmentally sound. Such a system enhances farmers' quality of life and provides gainful engagement for the rural population. The main crops grown in project districts are maize, rice, millet, buckwheat, pulses and oilseeds. Paddy is grown in rain fed condition. In view of hilly terrain and wide range of agro-climatic condition in project district (Sub-tropical type to alpine) no single variety of the crop can suit to all elevation ranges. The agro-ecological condition of the area is conducive for loss of soil and nutrients from the farming systems. Low yielding traditional cultivars continue to dominate the agrarian scenario while the department is exerting sincere efforts to replace them with the improved varieties. The agriculture is dominated by high dependency on organic sources of nutrients. All this leads to low per unit productivity as compared to national average. In such hilly terrain and small size of land holding, the most suited farming system is the mixed farming. It is envisaged to enhance farm production and productivity with sustainable development, providing adequate attention toward management of natural resources.

The land use practices play the most important role in determining the stability factors in respect of landslide hazards. The land use map of Darjeeling Hill Areas explains that there are agricultural activities, tea and medicinal plant plantations, construction works along with forests, rivers, jhoras etc. The main problem in respect of land use in the Darjeeling Hill Areas is related to high density of population. There is very limited scope for extension of agricultural land to cope up with increasing pressure of population. As a result pressure on forested and other restricted areas is gradually increasing.

Another problem related to land use and consequent landslide is that in Darjeeling Hill Areas, roads have never been examined with its carrying capacity respect with geology etc. Along with new road construction the vehicular movements have increased to a great extent with the rapid growth of trade and commerce. Heavy traffic movements along with heavy rainfall are responsible for most of the landslide occurrences especially on the roads. In recent years, it has been observed that there is a constant increase in the vehicular traffic, especially heavy vehicles like trucks and buses.

2.7 Irrigation System

Darjeeling is wholly a mountainous district and is rich in water resources. The major portion of the state is covered by forest and snow.. It falls within high rainfall zone and especially during the monsoons the state receives high precipitation. The annual rainfall ranges from 2,000 mm to 4,000 mm. It receives high precipitation from May to September. However, the rainfall is not scattered evenly all over the state and also time of occurrences of the precipitation and the time of irrigation do not coincide for a variety of crops. Some crops like vegetables, flowers, fruits, cereals, root and tuber crops *etc*. need frequent irrigation and these crops are grown round the year and for these crops perennial supply of irrigation from assured source is essential. Hence, the need to have assured irrigation system for the cultivation of number of crops like vegetables, flowers, spices *etc*. that are more profitable and viable for the State is important. Besides, the soil condition and steep terrain do not permit retention of the rain water for longer period. Therefore, to intensify or to enhance the agriculture produce, it is important to properly harness or augment water resources available in the rivers and rivulets to boost the agri-horticulture production in the state.

The state has fertile land and varied altitudes and climate conditions favourable for growth of large varieties of crops. But the growth in farm sector can be intensified and achieved only through assured irrigation system. The availability of assured irrigation system would increase the cropping intensity and the

coverage under high yielding and improved varieties thereby enable to enhance the production and improve the Gross Domestic Products of the state, besides improving the living condition of the masses in the rural areas. The state Government is emphasizing on the improvement of the living condition of rural population and their self-sustainability. The vision of the State Government can be achieved through the improvement in the farm sector vis-à-vis irrigation. Horticulture and Floriculture are in the top agenda of the State Government and both these sectors need assured irrigation system for development.

2.8 Livestock

The livestock population of the Darjeeling district is 116684 (Livestock Census 2014). Animal Husbandry is the major source of the supplementary income of the rural households. Livestock production had always been an integral part of the rural livelihood in West Bengal. The livestock wealth of West Bengal still constitutes a natural resource base with immense livelihood implications. West Bengal's Agriculture economy depends upon symbiosis of crop and livestock production. However, in view of the limited cultivable land holdings and decline in soil fertility, livestock production is the ultimate answer to provide sustainable economic upliftment of the rural masses.

2.9 Forests

The forest cover, based on interpretation on State of forest report,2015, Total recorded forest land in the state is **11,879 sq.km.**, of which **7,054 sq.km. is Reserved Forest**, **3,772 sq.km. is Protected Forest** and **1,053 sq.km. is Unclassed State Forest**, thus constituting 13.38% of the geographical area of the state. District wise forest cover of the state is given below in the **Table-2.9.** Growth rate of forest cover in West Bengal from 1998-2006 given in **Table 2.10.**

Table - 2.9: District wise forest cover in West Bengal

District	Geographical Area (Sq. Km.)	Recorded Forest Area (Sq.Km.)	% age of Recorded Forest Area
Darjeeling	3,149	1,204	38.23%
Jalpaiguri	6,227	1,790	28.75%
Cooch Behar	3,387	57	1.68%
Bankura	6,882	1,482	21.53%
Midnapur	14,081	1,709	12.14%

District	Geographical Area (Sq. Km.)	Recorded Forest Area (Sq.Km.)	% age of Recorded Forest Area
Burdwan	7,024	277	3.94%
Purulia	6,259	876	14.00%
Birbhum	4,545	159	3.50%
Hooghly	3,149	3	0.10%
Nadia	3,927	12	0.30%
Mushidabad	5,324	8	0.15%
Malda	3,733	20	0.54%
Uttar Dinajpur	3,140	10	0.32%
Dakshin Dinajpur	2,219	8	0.36%
Calcutta	104	-	0.00%
Howrah	1,467	-	0.00%
24-Parganas (S)	10,159	4,221	41.54%
24-Parganas (N)	3,997	43	1.08%
Total	**88,752**	**11,879**	**13.38%**

Table - 2.10: Growth rate of forest cover in West Bengal from 1998-2006

Survey Period	Recorded Forest Land	% Forest cover
1988	13.38%	14.32%
1991	13.38%	14.97%
1994	13.38%	15.06%
1997	13.38%	15.16%
2000	13.38%	15.30%
2004	13.38%	15.52%
2006	13.38%	15.68%

(Source: Govt. of West Bengal, Forest Department)

2.9.2 Forest Type in West Bengal (Darjeeling Hills)

The principal economy of Darjeeling Hill Area depends on tea production, horticulture, agriculture and forestry. The major portions of the forests are today found at elevations of 2000 m and above. The area located in between 1000 – 2000 m is cleared either for tea plantation or cultivation. The four major forest types according to altitudinal variation found in Darjeeling Hill Areas are:

1. *Tropical moist deciduous forest (300 – 1000 m)*
2. *Tropical evergreen lower montane forest (1000 – 2000 m)*
3. *Tropical evergreen upper montane forest (2000 – 3000 m)*
4. *Temperate forest (3000 – 3500 m)*
5. *Sub temperate forest (above 3500 m)*

About 30% of the forest covers found in the lower hills are deciduous. Evergreen forest constitutes only about 6% of the total forest coverage. The Sal (*Shorea robusta*) remains the most prominent species of Tropical moist deciduous forest along with heavy under growth. In the slopes on southern portion of the Teesta and the Great Rangit valley and in the Goke forests, this type is found. These species cannot thrive in areas of lower precipitation.

Tropical lower montane evergreen forests are found on steep higher slopes, where drainage condition is good; Dhupi (*Cryptomaria Japonica*) is a known variety. The impact of man on this variety is very conspicuous.

Tropical upper montane evergreen forests are found in the areas where high humidity along with dense fogs and less sunlight is available. Undergrowth is dense and contains Nettles, Raspberries, Ferns and bamboos. On the steep ridges, Rhododendrons and bamboos are abundant.

The hilly areas of Darjeeling District is divided into 3 forest divisions *viz.*,

1. Darjeeling, 2. Kurseong and 3. Kalimpong Forest Division but the proposed project exists in Kalimpong Forest Division of West Bengal and East (Territorial) Forest Division of West Bengal states. The growing pressure of population during the last two decades has left clear marks on the forest resources of the region. Marked decline in forest cover were observed in Takdah-Ghoom-Simana- area of Darjeeling Sadar, Sukhna, Pankhabari regions of Kurseong, and Chel, Jaldhaka catchments of Kalimpong division.

2.10 Protected Areas (National Park and Wild Life Sanctuaries)

India has at present four categories of protected area (PAs), these are 1. National Parks, 2. Wildlife Sanctuaries 3. Conservation Reserves and 4. Community Reserves, which are provided legal sanctity by the Wildlife (Protection) Act 1972. However, there are six categories specified by the IUCN (International Union for Conservation of Nature & Natural

Resources) and different countries have different categories of PAs as per their requirements and norms laid by their Governments.

With reference to Project state West Bengal, there are 21 Protected Areas (Pas), which comprises of 6 National Park and 15 Wildlife Sanctuaries that covers almost 4.54% of the total geographical area of the state. Within 10 km radius from project boundary Pangolakha Wild Life Sanctuary is exists as protected area in northeast direction of the project.

2.11 Biodiversity (Flora & Fauna)

India is recognized as one of the 12 mega diversity centres of the world. Out of the 12 Biodiversity hot-spots in the world, India owns 2, namely the Western Ghats and the Eastern Himalayas. West Bengal covering just 0.2% of the geographical area of the country has 26% of the country's total biodiversity and has been identified as one of the **'HOT-SPOT'** in the Eastern Himalayas.

- There are 10 bio-geographic zones & 25 biotic provinces--- which have 16 major forests types & > 200 sub types as per (Champion & Seth 1968).
- West Bengal falls under Himalayan (2) Bio-geographic zone & Central Himalaya (2c) biotic province----having about 9 types of forests types (Champion & Seth).

Nature has been particularly generous in her gift of sylvan treasures to the state of West Bengal. Luxuriant forest, abound in all part of state and variety of medicinal plants, herbs, shrubs, bamboos and trees growing in state is truly rich. In the forest, there are number of plants whose medicinal values have been well recognized by local people as well as by different pharmaceutical, insecticidal and perfumery sectors. Medicinal plants ought to be given the status of a "National Resources" because their sustained availability is essential to sustain one of the world's oldest medicinal traditions, a priceless legacy of the Indian people. The local inhabitants for treatment of various ailments use numerous herbal

remedies. Furthermore, modern medicines owes to the flora of these mountains. Many inhabitants for treatment of various ailments use numerous herbal remedies. Many species of Himalayan origin have revolutionized the allopathic systems of medicine.

2.12 Biodiversity of West Bengal

West Bengal is an eastern State of amazing extreme stretches from the Himalayas through the gangetic plains to the bay of Bengal over the course of about 483 km and displays almost all the geographical features and its associated biodiversity. The northern most district , Darjeeling , is called the lap of the colossal Himalayas, followed by tarai region which supports a huge diversity of biodiversity.

Nature has bestowed the state of West Bengal with a treasure house of Biodiversity, covering only 2.7% of the geographical area of the country it is home to 12.27% of Indian biodiversity till date. The state has almost 7000 species of described flora including bacteria, algae, fungi, bryophytes, pteridophytes and angiosperms and more than 10000 species of described fauna.

The forest of west bengal is classified into seven categories; Tropical Semi Evergreen Forest, Tropical Moist deciduous Forest, Tropical Dry Deciduous Forest, Littoral and swamp Forest, Sub Tropical Hill forest, Eastern Himalayas wet temperate forest and alpine forest.

Table 2.13 : Major Forest Types In West Bengal

Type of the Forest	Location	Area	Major Species
NORTHERN TROPICAL WET EVERGREEN FORESTS	Plains of North Bengal upto 150 m. altitude.	167 sq.km.	Sal, Nageshwar, Jam, Kainjal, Lator, Malagiri, Lali & Canes.
NORTHERN SUB-TROPICAL SEMI-EVERGREEN FORESTS	North Bengal, Sumbong, Peshok, Buxaduar	25 sq.km.	Champ, Panisaj, Gokul, Angare **.**
NORTH INDIA MOIST DECIDUOUS FORESTS	North Bengal, Almost entire duars and terai area	1757 sq.km.	The most important forests of the State are in this sub-montane belt consisting of Sal with Champ, Chilauni, Chikrassi, Gamar etc. representing succession from riverian to climax sal.

Type of the Forest	Location	Area	Major Species
LITTORAL & SWAMP FORESTS - THE MANGROVES	The tidal mangrove forests of Ganga-Brahmaputra delta (Sunderbans):	4263 sq.km.	**Important species are : Goran (** Ceriops roxburghiana **), Gnewa (** Excoecaria agallocha **), Sundari (** Heritiera minor **), Baen (** Avicennia officinalis **), Dhundal (** Carpa obovata **)**
LITTORAL & SWAMP FORESTS-TROPICAL SEASONAL	Malda & Dinajpur (N & S)	20 sq.km	**Hijal (** Barringtonia acuteangula **)**
NORTHERN TROPICAL DRY DECIDUOUS FORESTS	Bankura, Purulia, Midnapur, Birbhum, Burdwan	4527 sq.km.	**Sal (** Shorea robusta **), Peasal (** Pterocarpus marsupium **), Kend (** Diospyros melanoxylon **), Mahul (** Madhuka latifolia **), Kusum (** Schleichera trijuga **), Karam (** Adina cordifolia
NORTHERN SUB-TROPICAL BROAD-LEAVED WET HILL	North Bengal hills 300m-1650m altitude.	800 sq km	The species commonly found are Mowa, Chilaune, Katus, Panisaj, Lampate, Phaleado, Saur, Tarsing, Angare, Melo Kapasi, Utis, Toon and Malagiri along with Kutmero, Jhingni,
NORTHERN MONTANE WET TEMPERATE FORESTS	North Bengal hills 1650m-3000m.altitude.	150 sq.km.	The principal species found here are Pipli(**Bucklandia populnea**), Utis, Saur, Katus, Kapasi, Arkula, Mowa, Khankpa etc.
EAST HIMALAYAN MOIST TEMPERATE FORESTS	North Bengal hills 1500m-1800m	150 sq.km.	The species commonly found are Mowa, Chilaune, Katus, Panisaj, Lampate, Phaleado, Saur, Tarsing, Angare, Melo Kapasi, Utis, Toon, and Malagiri
SUB-ALIPINE FORESTS	North Bengal hills 3000m-3700m	20sq.km.	Important spp. are Putli, Lekh Kapasi, Lekh Pipli, Kapasi, Arupate, Sindure Katus(**Castanopsis sp.)** , Yew (**Taxus bacata)** , Rhododendrons,

2.12 Symbols of Project States (West Bengal)

The state symbols of West Bengal have been depicted in **Plates – 1 to 4** as given below.

	
Plate-1: State Animal – Fishing Cat **Zoological Name –** *Prionailurus viverrinus*	**Plate-2: State Bird –** White throated Kingfisher **Zoological Name –** *Halcyon smyrensis*
	
Plate-3: State Flower – Night-flowering Jasmine **Botanical Name -** *Nyctanthes arbor-tristis*	**Plate-4: State Tree -** Chatim tree **Botanical Name -** *Alstonia scholaris*

State Symbols of West Bengal

2.13 Land use of West Bengal

District and category wise distribution of Land use / Land Cover in West Bengal as per Bhuvan data base 2011-12 provided in **Figure 2.3** and Description has been provided in **Table 2.14.**

Figure 2.3 Land use pattern of West Bengal

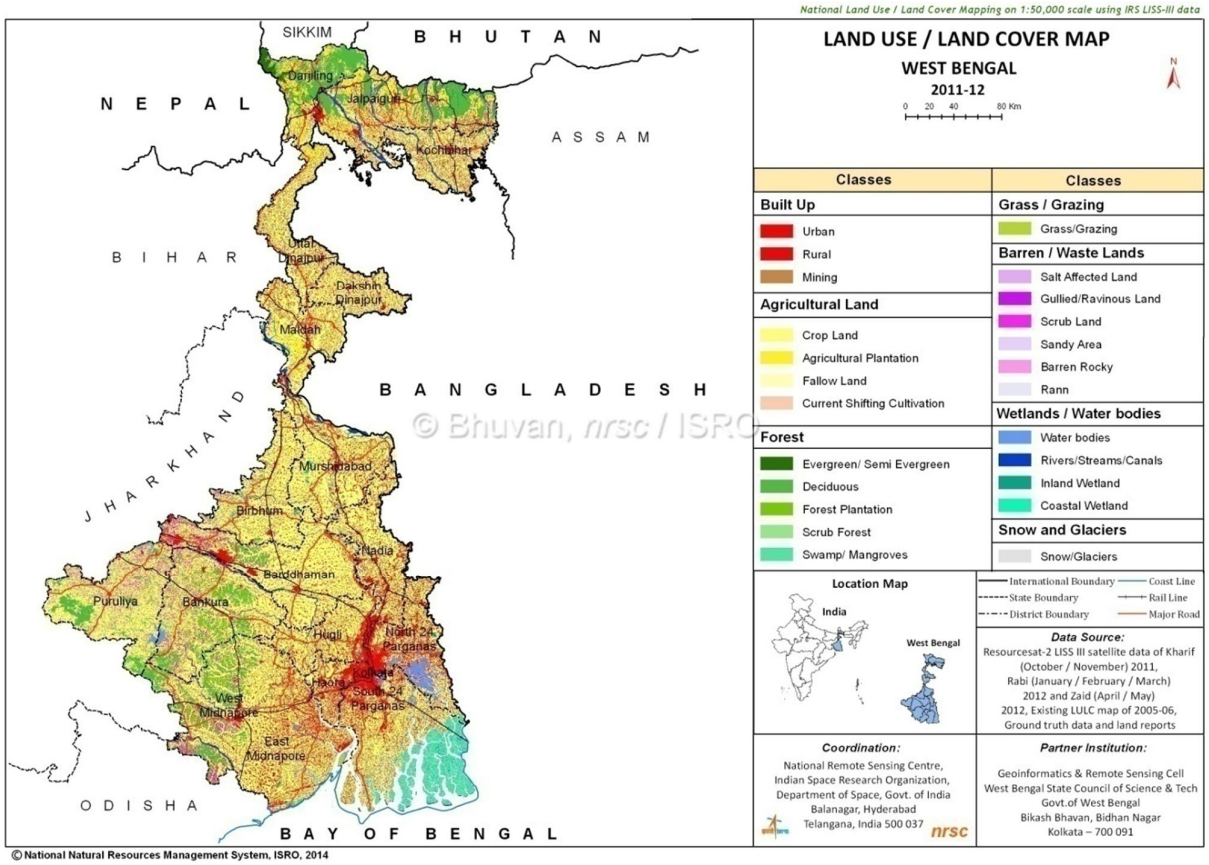

Table 2.14 Details of Land Use District Wise

Land use type	Description of land	District Darjeeling (sq. km.)
Agriculture	Crop land	1790.49
	Plantation	653.90
	Fallow	2.38
	Current shifting cultivation	-
Barren/ unculturable/ Waste lands	Sandy Area	0.07
	Gullied/ Ravinous land	-
	Barren Rocky	3.13
	Rann	-
	Salt Affected Land	-
	Scrub Land	24.60
Built-up	Urban	61.14
	Rural	191.26
	Mining	0.37
Forest	Evergreen/Semi evergreen	184.63
	Deciduous	1354.22
	Forest Plantation	4.26
	Scrub Forest	19.81
	Swamp / Mangroves	-
Grass / Grazing	Grass / Grazing	0.75
Snow and Glacier	Snow and Glacier	-
Wet lands/ water bodies	Inland Wetland	1.09
	Coastal Wetland	-
	River/ Stream/ Canals	94.23
	Water Bodies	1.87

2.14 Potential Impacts on Environment and Mitigation measures

The anticipated impact due to project activities is likely to arise in three phases of the project.

1. Impact due to design / pre-construction phase
2. Construction phase
3. Operational phase

Impact due to design / pre-construction phase (Mitigation measures)

Impact due to land acquisition

The major impact due to pre-construction and design phase are related with the land acquisition, since widening needs land area throughout the corridor. Mitigation measures due to land acquisition are suggested below:

Mitigation measures for land acquisition

- A separate R&R policy has been framed after identified different category of entitlement and benefits to each category to address the issues pertaining to the Project Affected People and their rehabilitation & resettlement depending upon the Entitlement.
- The acquisition of land and private properties will be carried out in accordance with the RAP and entitlement framework for the project.
- Early identification of entitlement for Compensation and Advance planning of Resettlement and Rehabilitation Action Plan to Compensate the Losses.
- All the affected people will be compensated as per NPRR, 2007 before commencement of Construction works and the cost of compensation will be finalized by the Competent Authority and the Project Proponent will pay the compensation at all the entitles persons through the Competent Authority.
- It will be ensured that all R & R activities including implementation of Environment Management Plan are completed before the start of work.
- PIU has to ascertain that any additional environmental impacts resulting from acquisition of land are addressed and integrated into the EMP and other relevant documents.
- The NHAI has appointed Competent Authority in each affected districts. The Competent Authority is from District Revenue Department. The Competent Authority will assess the cost of the losses and then decides the compensation for each properties and assets as well as identifies the affected persons as per records. The NHAI accordingly will pay the compensation to the affected persons through the competent authority.
- All the affected hand pumps, wells and water tanks will be relocated at suitable locations before commencement of construction activities.

Impact due to tree felling

The present project will have varying levels of impact on the roadside plantations throughout the entire stretch of the road. This impact is viewed critical due to long duration required for its reversal and sometimes it is irreversible. Roadside plantations not only provide a healthy aesthetics to the road users but also provide shade and protect the users from harmful effects of contaminants by absorbing them through vegetation canopy.

Effort will be made to minimize the tree felling by restricting tree felling within the formation width only. The baseline studies showed that there is no any endangered or rare tree species located within the project area. The predominant tree species are Babool (Acacia nilotica), Neem (Azadirachta indica), Siris (Albizia lebbeck), Goldmolar (Delonix regia) and Shisam (Dalbergia sissoo), etc.

Mitigation measures for tree felling

- Permission of Roadside cutting will be obtained from the line department, i.e. Forest Department.
- All efforts will be made to preserve trees by restricting tree cutting within the formation width. Special attention will be given for protecting giant trees, and locally important trees (having cultural importance)
- Compensatory plantation will be carried out along the space available within the proposed ROW in the ratio of at least 3 times as much the trees are proposed to cut as per Forest (Conservation) Act in consultation with local Forest Department
- A general guideline for tree plantation will be followed as per IRC: SP: 21:2009
- Median plantation has also been proposed. These plantation will not only compensate the loss but at the same time will enhance the aesthetic along the highway and enhance the pollution alleviation capacity of the area.
- The avenue plantation programme will be promptly adopted to restore and further enrich the loss of vegetation.

Impact due to construction phase (Mitigation measures)

The construction phase, in general, has adverse influence on all the components of environment. Most of these impacts are primarily due to negligent practices but are short lived and reversible in nature. A proper care is essential to minimize the adverse impacts to the possible extent to facilitate the restoration of the environment and can be discussed under following sub-heads.

The standard road construction works involve are site clearance, excavation, filling of earth materials and sub grade materials, laying of bituminous mixtures, handling of hazardous materials like bitumen, diesel, etc, dumping of unusable debris materials,

transportation of materials from production site to construction site, and other constructional activities and associated works like mobilization of constructional equipments, setting up of different construction plants, setting up of workforce camps, quarrying, transportation of materials, material storage etc. These activities have certain impacts of various magnitudes on different components of environment. The anticipated impacts due to all these activities have been described below:

Impact on land resources

Clearing and grubbing and excavation of the land within the extent of formation width of the proposed alignment as well as the proposed bypasses are the primary activity to prepare the bed for road construction. The excavation activity will lead into generation of excavated materials which would mainly soil mixed with pebbles and rocks in the project area. Most of these materials will be re-used as fill materials, aggregates and for construction of retaining walls. However still about 10 percent of the excavated material will need to be disposed off due to non-suitability for use in road fill materials. The disposal of debris materials in haphazard manner will not only hamper the aesthetic look of the area but at the same time they are potential contaminant for the surrounding land.

Some land would be needed to establish site offices and construction camps worker/labour camps. These will require temporary land acquisition for a short period. Substantial amount of land would also be required for extraction of borrow materials.

For fulfilling the requirement of soil and aggregates certain land acquisition will be required followed by excavation of that land area. Such type of activity can lead into disfiguration of topography of the area. Water stagnation in the borrow pit provides ideal breeding sites for mosquitoes and thereby can spread malaria and dengue if borrow pit is not properly managed. Pits near settlements can pose health risk.

Mitigation measures for land resources

- The Construction camps will be located preferably on barren land and sufficiently away from settlements and water bodies.

- The Construction camp will be provided with necessary sanitation arrangements and basic facilities.
- After dismantling of Camp the natural condition of the land will be restored.
- No scare will be left unattended after excavation activity.
- The Borrow area will be located preferably on barren land or unirrigated land.
- The Borrow pits will not be dug within 800 m of town or village settlement or within ROW
- After excavation is over, the borrow area will be suitable rehabilitated either by backfilling it of by dressing the sides of the borrow pit to create slope consistent to the adjoining land.
- Where pit can be developed as water recharging pond depending upon the terrain of the area
- Proper reclamation of pits will be done
- Cut face of the pit will be merged with the slope of the adjoining terrain
- Bottom of the pits will be graded towards natural outfalls to prevent water accumulation
- The reclaimed area will be seeded to provide grass coverage.
- Quarrying of metal will be done only at licensed quarry and the area will be suitable rehabilitated after quarrying is over.

Impact on soil

The site clearance process includes excavation and vegetation clearance which ultimately induces vegetation loss as well as loss of top soil. Since vegetation clearance shall be confined to the minimum area required for widening activities beyond the ROW, the area affected would be very less. The activities associated with the site preparation and excavation plus movement of vehicles and equipments can disturb the surrounding lands.

Soil Contamination during construction stage is anticipated primarily due to construction and allied activities. The sites where construction vehicles are parked and serviced are likely to be contaminated because of leakage or spillage of fuel and lubricants. Pollution of soil can also occur in hot-mix plants from leakage or spillage of asphalt or bitumen. Refuse and solid waste from labour camps can also contaminate the soil. Contamination of soil during construction might be a major long-term residual negative impact. Unwarranted disposal of construction spoil and debris will add to soil contamination. This contamination is likely to be carried over to water bodies in case of dumping being done near water body locations.

However, by following mitigation measures such as maintenance of vehicles and machines and fuel refilling is carried out in a confined area can avoid contamination of soil to a great extend. The provision for oil interception chamber is suggested in EMP for treating the waste water generated from vehicle washing, refilling and maintenance areas. Fuel storage and refilling sites should be kept away from cross drainage structures and important water bodies. All spoils shall be disposed off as desired and the site shall be fully cleaned before handing over. These measures are expected to minimize the impact on soil contamination.

Mitigation measures to conserve soil

- The excavation activities and vegetation clearance will strictly be limited to formation width only.
- All the usable excavated materials will be re-used as fill materials and aggregates.
- Fill materials for the embankments are to be arranged from places located outside RoW.
- The movement of construction vehicles and equipments will be restricted to only designated route.
- Designated storage site for fill materials and adequate stockpiling to prevent erosion and runoff related problem.
- Construction of temporary berms, sediment basins, slope drains and use of temporary mulches fabrics or other control measures necessary to control soil erosion and sedimentation will be done at site

Impact on water resources

The proposed widening will result in increase of surface run-off. It will have adverse impact on ground water recharging if measures are not taken during the design and construction of longitudinal drainages. As the depth of the ground water table is very high no adverse impact is anticipated on ground water. Lying of pavement within the formation width may lead to reduction in the ground water recharge capacity. But as the area involved in the road construction is very less, the chances of this influence will be non-significant.

The water and soil quality monitoring results revealed no contamination with vehicular emission. Due to increasing traffic i.e. increasing emission, the adjoining soil and receiving water bodies may get contaminated with vehicular emission and spillages.

The Source of water for construction shall be identified by the Concessionaire depending upon the location of construction sites, construction camp and plant site locations in consultation with line department and NHAI and will obtain all necessary statutory permits for usage of water before start of abstraction of water.

Mitigation measures for water resources

- Longitudinal drains of sufficient capacity will be provided on both sides of the road to accommodate increased run-off.
- In urban stretches, the lined drains will be provided with cut in between to facilitate ground water recharging. The cut will be made of granular coarse material, which will increase the infiltration rate.
- In rural stretches the unlined drains will be connected with ponds. New small ponds will be dug if necessary. It will help in rainwater harvesting.
- Rainwater Harvesting pits will be provided in consultation with Ground Water Boards at an average interval of 500 m covering the entire project stretch including in new proposed bypasses depending upon the water table status (The recharge pit can only be provided at those locations where the water table is greater than 5 m deep) .
- The Contractor will arrange separate water supply arrangement for construction work and will not interfere with the normal public water supply.
- All water and liquid wastes arising from construction activities will be properly disposed off and will not be discharged into any water body without adequate treatment.
- Littering or unauthorized discharge will not be permitted.
- Permission of the engineer and the concern regulatory authorities will be obtained for disposal of the waste as the designated disposal point.
- The stream course and drain will be kept free from dumping of solid wastes and earth materials.
- The construction materials and debris will be stored away from water bodies or water ways and only on the designated sites along the construction zones.

Impact on Ambient Air Quality

The air quality parameter is the most common environmental feature, which is being affected by any road improvement projects at different stages i.e. during constructional as well as operational

phase. The major indicators of Ambient Air Quality relevant to the road project are the concentration of suspended particulate matters (SPM), Particulate matters of size less than 10 µ (PM10), particulate matters of size less than 2.5µ (PM2.5), sulphur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO) in the atmosphere. The majority of the air pollutants are emitted from the traffic as there is no major activity along the project road except for few small scale industries. The result of the measurement of these parameters in the atmosphere along the project road showed that the concentration of these air pollutants are well below the safe limit as prescribed for the National Ambient Air Quality laid by Ministry of Environment and Forests, Government of India at all the places.

Significant amount of dust would be generated due to site clearance and excavation activities, exhaust of mobile and stationary construction equipment, crushing plant, batching plant, HMP, demolition, embankment and grading activities, transportation of earth materials and dumping of spoils, which have potential deterioration of air quality during the process. This can increase the localized concentration of fugitive during construction phase. During asphalt preparation, operation of hot mixing plants needs burning of fuels that result into release of significant amount of gaseous pollutants into the atmosphere like oxides of sulfur, hydrocarbons and particulate matters. These are likely to deteriorate the air quality in general and also cause occupational exposure in particular. These impacts are, however, temporary one that will remain only upto the period of clearance and excavation processes. Besides this, air quality deterioration is also expected at deposits and borrows sites, materials treatment areas, quarries, access roads and the site where facilities provided for project workers due to dust generation and gaseous pollutant emission. Additional vehicular emission is expected during the mobilization of construction equipments, transportation of materials, etc. due to the increased vehicular number at the project sites but that will be minor in extent as there will not be significant increase in vehicle numbers.

The improper sanitation at work camps and waste disposal usually lead to odour problem. Foul odour may also cause during lying of pavement. The abovementioned problems related to the deterioration of air quality, however, will temporal in nature till the construction period only. Further, the activities will not be confined to any one place rather, it will progressively move along the ROW, so prolonged deterioration in air quality will not occur at any one site. The minor volume of dust generated will cause a short-term localized problem through settlements.

Mitigation measures for Ambient air quality

Dust control measures

- Water will be sprayed during construction phase, in earth handling sites, asphalt mixing sites and other excavation areas for suppressing fugitive dust.
- Water sprinkling and transporting construction materials with tarpaulin coverage duringthe construction stage.
- During the sub-grade construction, sprinkling of water will be carried out on regular basis during the entire construction period especially in the winter and summer seasons.
- In case fly ash is used, dust emission during its loading and unloading, storage at open place and handling for road construction shall be suppressed by regular water sprinkling.
- Dust emission from stock piles of excavated material will be controlled either by covering the stockpiled materials or water spraying over it.
- Special attention will be given when working near educational institutions and health centers and settlement areas.
- As soon as construction is over all the surplus earth will be utilized properly all loose earth will be removed from the site.

Measures for plants & Equipments

- The Stone crusher plant, Hot mix plant and Wet Mix Plant will be located sufficiently away from settlement towards downwind direction and will conform to the siting and operation requirements under Environmental (Protection) Rules, 1986.
- Proper management of all Plant sites having stone crusher unit, Hotmixplants, Batchmix plant, stockyards.
- All the vehicles used during the construction stage to have valid PUC certificate
- Provision of effective air pollution control systems in stone crushers, Hotmix Plant, Batchmix plants such as Dust containment cum suppression system for the equipment, Construction of wind breaking walls along periphery of plant sites, construction of the metalled roads within the premises, regular cleaning and wetting of the ground within the premises, etc.

Measures for Gaseous pollution

All the Construction vehicles and machineries will be regularly maintained to conform to the emission standards stipulated under Environment (Protection) Rules, 1986.

- Asphalt mixing /Stone Crusher plans should be located at least 800 m away from any habitation or sensitive environmental site and at least 250 m away from highway towards downwind direction.
- All the DG sets will conform to the emission standards as stipulated under Environment (Protection) Rules, 1986.
- The workers working at asphalt mixing and subsequent application of asphalt mix on road surface will be provided with heat resistant shoes and masks.

Impact on Ambient Noise level

Operation of heavy machineries; movement of heavy vehicles, stone crushing aggregate mixing activities generates high noise increasing the ambient noise level in the surrounding. The behavior of truck drivers also plays roles in increasing the noise level by the injudicious frequent use of blow horns. Especially in the settlement area this can pose a problem.

Workers working near the noise generating equipments and plants are likely to be exposed to high noise level. The acceptable limit (for 8 hour duration) of the equivalent noise level exposure during one shift is 90 dB (A). Hence, noise generated due to various activities in the construction camps may affect health of the workers if they are continuously exposed to high noise level. For reasons of occupational safety, exposure to impulses or impact noise should not exceed 140 dB (A) (peak acoustic pressure). Exposure to 10,000 impulses of 120 dB (A) are permissible in one day. The noise likely to be generated during excavation, loading and transportation of material will be in the range of 90 to 105 dB (A) and this will occur only when all the equipment operate together and simultaneously. This is however, is a remote possibility. The workers in general are likely to be exposed to an equivalent noise level of 80 to 90 dB (A) in an 8-hour shift, for which all statutory precautions should be taken into consideration. However, careful planning of machinery selection, operations and scheduling of operations can reduce these levels. A typical Noise generation due to different activities has been given in the **Table 2.15**

Table 2.15 Typical Noise Levels of Principal Construction Equipment

CLEARING	
Bulldozer	80
Front end loader	72 - 84
Dump truck	83 - 94
Jack hammer	81 - 98
Crane with ball	75 - 87

EXCAVATION AND EARTH MOVING	
Bulldozer	80
Backhoe	72 - 93
Front end loader	72 - 84
Dump truck	83 - 94
Jack hammer	81 - 98
Scraper	80 - 93
STRUCTURE CONSTRUCTION	
Crane	75 - 77
Welding generator	71 - 82
Concrete mixer	74 - 88
Concrete pump	81 - 84
Concrete vibrator	76
Air compressor	74 - 87
Pneumatic tools	81 - 98
Bulldozer	80
Cement and dump trucks	83 - 94
Front end loader	72 - 84
Dump truck	83 - 94
Paver	86 - 88
GRAND AND COMPACTING	
Grader	80
Roller	73
PAVING	
Paver	86
Truck	83
Tamper	74
LANSCAPING AND CLEAN UP	
Bulldozer	80
Backhoe	72 - 93
Truck	83 - 94
Front end Loader	72 - 84
Dump Truck	83 - 94
Paver	86 - 88

Source: CPCB, Govt. of India

It is clear from the above table that the operation of construction machinery e.g. hot-mixer, bulldozer, loader, backhoes, concrete mixer, etc will lead to rise in noise level to the range between 80-95 dB (A). Vehicles carrying construction materials will also act as the noise sources. The magnitude of impact from noise will depend upon types of equipment to be used, construction methods and also on work scheduling. However, the noise pollution generated due to different construction activities is a temporary affair. Each type of activity can generate different

type and levels of noise that continue for a short period during the operations of those activities. Implementing proper mitigation measures can reduce a lot of problem associated with noise pollution due to construction activities.

Mitigation measure for Noise Quality

- All noise generating equipments will be installed sufficiently away from settlement areas.
- The main stationary noise producing sources such as generator sets shall be provided with noise shields around them. The noise shields can either be a brick masonry structure or any other physical barrier which is effective in adequate attenuation of noise levels. A three meter high enclosure made up of brick and mud with internal plastering of a non-reflecting surface will be very effective in these regards.
- The plants and equipment used for construction will strictly conform to CPCB noise standards.
- Vehicles and equipments used will be fitted with silencer and maintained accordingly.
- Noise to be monitored as per monitoring plan and if the noise level at any time found to be higher than immediate measure to reduce noise in that area will be ensured.
- Noise standards of industrial enterprises will be strictly enforced to protect construction workers from severe noise impacts. All the workers working very close to the noise generating machinery shall be provided Earplugs to avoid any ill impacts on their health.
- An awareness programme will be organized for drivers and equipment operators to make them aware of the consequences of noise and to act properly at site

Impact on Ecological Resources

The baseline study of the biological environmental within the project area did not show any endangered or significant flora or fauna and within the corridor of impact and there is no wildlife migration route reported, therefore, any potential direct impact on biological environmental characteristics such as, loss of rare or endangered species, habitat fragmentation and wild life migrations is not envisaged. The area is not characterized by any significant ecosystem so loss of habitat is not there. Moreover, the alignment of proposed road widening is mostly along the existing road, the potential for habitat fragmentation negligible. Similarly, since the road improvement is proposed for the already existing one the extent of impact is minimum. The temporary impact may be in the visual appearance of the trees and shrubs as construction activity may lead to deposition of dust cover over the leaves and foliage. This is limited to construction period and gets washed away with the first monsoon shower.

During Construction it shall be ensured that the Contractor shall be abide by all the rules and regulations pertaining to Forest Protection as well as Wild life Protection. Strict monitoring will be done to ensure that there is no trespassing within the boundary of Wildlife Sanctuary. No labour camp or plant site will be established in the vicinity of the Wildlife Sanctuary and siting criteria for establishing the construction plants as per CPCB and MPCB norms will be strictly followed.

Aesthetics impacts

Disturbance of landscape aesthetics due to excavation of borrow pits, extensive quarrying, disposal site of spoils, is expected during the constructional phase. However, it is only temporary one and it can be restored with proper management plans within a short period such as roadside plantation, etc. During operational phase this will be enhanced with the activities associated with the maintenance of landscape such as plantation programme, by providing road side amenities, parks etc.

Mitigation measures for Aesthetics

- The site will be cleaned immediately after the construction activity is over.
- The debris materials will be disposed off only at identified area for disposal and proper leveling will be done after disposing the materials and shall be covered with top soil and some plantation will be done at the disposal site.
- The borrow area will be rehabilitated as per site condition. It can either be developed as ponds, backfilled and leveled matching with the surrounding terrain.

Construction camps

Construction workers are a very neglected group in the country. Unless the workers are provided proper amenities to live at the construction site the environmental issues of road construction cannot be properly met. Apart from labour camps, separate construction Camps also established where various plants and equipments as well as offices and residential unit for technical and non technical staff are located and often labour camps are also provided in the same premises. Location of the Construction camp also has certain impacts on surrounding environment if not properly managed.

At labour and construction camps lot of wastes are generated. These wastes are refuge from the plants, and equipments, waste water and other domestic waste. These wastes are solid as

well as liquid waste mainly refuse water and kitchen waste. The disposal of such waste material to the surrounding land can potentially damage the land and would generate health risk to not only surrounding area but within the premises itself. Improper drainages system within the premises also creates insanitation condition thereby enhancing health risk.

Mitigation measures

- The Construction/labour camps will be established only on area approved by Supervision Consultant.
- The worker's/labour camp will be located away from water bodies, schools and residential areas. The camp will be constructed with proper accommodation facilities.
- The workers camp will be provided with drinking water supply system so that local water sources are not disturbed.
- The camp should be provided with fuel for cooking like kerosene and /or LPG to avoid any cutting of trees for fuel wood.
- All camps will be provided with proper sanitation facilities, separate toilets and bathrooms for female and male workers, septic tanks with soak pits of sufficient size, dust bins etc.
- Waste water from domestic uses and solid wastes will be disposed of without violating environmental norms. The measures will be site specific.
- The labour camps will be provided with crèche, first aid facilities, etc as required under Factory Act.
- After completion of construction, the contractor will dismantle the camp and restore it to the original condition of the area before handing over the site to the land owner.

Impact due to Operational phase (Mitigation measures)

During operation stage, the main sources of environmental impacts are the increased traffic volume and speeds and better access to forest lands. The increase in traffic volume and speed may enhance the safety risk especially in the rural area. The better access to the forest area can stimulate the human interference in these areas. No sudden change in the traffic volume is expected due to this road as the road is already existing one and opened for public traffic. The project also provides the opportunities of the restoration of vegetation around the vicinity of the worksite and roads by implementing the compensatory plantation programme, which will not only enhance the aesthetic view but can also help in reclamation of soil. During

operational phase this will be enhanced with the activities associated with the maintenance of landscape such as plantation programme, by providing roadside amenities, parks etc.

During the operational phase when the plantation works will be adequately implemented will enhance the aesthetic as well as hygienic environment thereby reducing the chances of diseases due to vehicular emission. Widening will ensure smooth plying of the vehicles and also will help in reducing the congested zone and thus will reduce the emission rate of vehicles. Various impacts during operation phase are discussed below:

Impacts on water quality

During the operation phase, the possibility of degradation of water quality is very less.

The impact on the surface water quality during operation can be expected due to accidental spillage. However the probability of such accidents is minimal since enhancement of road safety measures such as improvement of curves and widening of the roads and other pedestrian facilities are taken care of in the design stage.

Impact on Ambient Air Quality

The baseline data shows that the major air pollutants are well within permissible limit at all monitoring locations except for fine dusts in terms of PM10 and PM2.5. The dry condition and exposed area, earthen shoulders along the highway sections is the main reason behind the high concentration of PM10 and PM2.5 in the ambient air. Improvement in road surface condition such as roughness, pot, patch, congestion, etc., improvement of curves and junctions, provisions of organized parking, segregation of local traffic and through traffic will ensure the smooth traffic flow and reduce idling time of engines thus will reduce the emission rate of vehicles and also the vehicle maintenance cost thereby reducing the magnitude of air quality degradation. Further, roadside avenue plantation with pollution abating tree species will also help in reducing the ambient pollution levels. Moreover, widened road will provide more space for dispersion and thereby the concentration of pollutants will be diluted faster.

Thus the net air quality impact following construction of new road is anticipated to be beneficial. The project will not stimulate the traffic flow significantly as this road is already in use. The traffic will however rise with the current growth rate and the number of vehicles plying over will certainly be increased whether the project will come or not. Although the emission rate per

vehicle will reduce as stated earlier, but the total emission can increase in future with the increase in traffic.

Mitigation Measures

During the initial years after the implementation of the project, the air quality of the study area will improve due to increased traffic speed all along the project road. For congested areas a single row of plantation will be provided on both sides of the road to act as a sink for pollutants. Special care will be taken to avoid the location of truck parking and bus bays in congested areas. Further technical improvement in form of superior engine design in order to meet the stringent Government regulations will also reduce emissions in the years to come.

Impact on Noise Quality

Noise level is a matter of concern. Interrupted movement of heavy and light vehicles at high speeds and movement in upward direction increase ambient noise levels along the roadway.

Noise produced by vehicles using the road can be attributed to the engine, vibration, friction between tires and the road, and horns. Increased levels of noise depend upon volume of traffic, road condition, vehicle condition, vehicle speed, congestion of traffic and the distance of the receptor (home, store etc.) from the source. The friction caused due to contact between tires and pavement increases the traffic noise. The proposed work includes smoothening of pavement, reduction of gradient and curves at several places that will reduce the overall noise level.

2.15 Clearances Required

Clearances required for the project are provided in **Table 2.16**

Table 2.16 Clearances required for the project

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
1	The EIA Notification, 14th September 2006 and subsequent amendments	Identifies "(i) New National Highways; and (ii) Expansion of National Highways greater than 30 Km involving additional right of way greater than 20m involving land acquisition" under (item 7 (f) of schedule) as one	Not required	New National Highway NH - 717A (Category of project - A)	MoEF&CC

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
		of the projects requiring prior clearance.			
2	Notification for use of Fly ash, 3rd November 2009	Reuse fly ash discharged from Thermal Power Station to minimise land use for dispersal and minimise borrow area material. The onus shall lie with the implementing authority to use fly ash unless it is not feasible as per IRC.	NO	If Projects within power 500 km of plant will cover under this notification (SO 1396 (E). 25 March 2015	MoEF&CC, SPCB
3	The Water (Prevention and Control of Pollution) Act, 1974	Central and State Pollution Control Board to establish/enforce water quality and effluent standards, monitor water quality, prosecute offenders, and issue licenses for construction/operation of certain facilities.	NO	Consent required if ground water is being used for consent purpose	CPCB /SPCB
4	Noise Pollution (Regulation And Control) Act, 1990	Standards for noise emission for various land uses	Yes	construction machineries and vehicles to conform to the standards for construction	State pollution control board
5	Forest (Conservation) Act, 1980	Conservation and definition of forest areas. Diversion of forest land follows the process as laid by the act	Yes	For diversion of forest land for road construction	State forest department, MoEF&CC
6	Coastal Regulatory Zone Notification, 2011	Protect and manage coastal areas	No	The project area is not within designated coastal zone	MoEF&CC, State forest department,
7	Wild Life Protection Act, 1972	Protection of wild life in sanctuaries and National Park	NO		

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
8	Ancient Monuments and Archaeological sites and Remains Act 1958	To protect and conserve cultural and historical remains found.	No	For world heritage sites and monuments	Archaeological Survey of India, Dept. of Archaeology
9	The Motor Vehicle Act. 1988	Empowers State Transport Authority to enforce standards for vehicular pollution. From August 1997 the "Pollution Under Control Certificate is issued to reduce vehicular emissions.	Yes	All vehicles used for construction will need to comply with the provisions of this act.	State Motor Vehicles Department
10	The Explosives Act (& Rules) 1884 (1983)	Sets out the regulations as to regards the use of explosives and precautionary measures while blasting & quarrying.	Yes	If new quarrying operation is started by the concessionaire / contractor	Chief Controller of Explosives
11	Public Liability And Insurance Act,1991	Protection to the general public from accidents due to hazardous materials	Yes	Hazardous materials shall be used for road construction	Project Implementation Unit/ Contractor
12	Hazardous Wastes (Management and Handling) Rules, 1989	Protection to the general public against improper handling and disposal of hazardous wastes	Yes	Hazardous wastes shall be generated due to activities like of maintenance and repair work on vehicles	CPCB/SPCB
13	Chemical Accidents (Emergency Planning,	Protection against chemical accident while handling any hazardous chemicals resulting	Yes	Handling of hazardous (flammable, toxic and	District & Local Crisis Group headed by the DM and SDM

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
	Preparedness and Response) Rules, 1996			explosive) chemicals during road construction	
14	Mines and Minerals (Regulation and Development) Act, 1957 as amended in 1972	Permission of Mining of aggregates and sand	Yes	Permission of Sand Mining from river bed & aggregates	Department of Mining for state and central level
15	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Employing Labour / Workers	Yes	Employing Labour/ workers	District labour Commissioner

2.16 Environmental Management Plan

An environmental management plan (EMP) will be proposed along with institutional arrangement for effective implementation, monitoring and reporting in the next stage of submission. It is envisaged that all stake holders i.e. the NHIDCL, forest department, supervision consultant, design consultant, contractor, environmental consultant and public/NGOs will play their role in effective implementation of EMP. The efforts of all the agencies will be brought together by the 'Environmental management Unit' proposed to be setup under the project implementation unit of NHIDCL. This unit will also arrange training of the staff involved in monitoring of the implementation of Environmental Management Plan beside taking steps to create awareness amongst the public and stakeholders.

2.17 Conclusions and Recommendation

On the basis of preliminary analysis, nature of impacts and observations of the various affected groups due to project, it is concluded that the proposed National Highway can be developed without causing significant adverse environmental impacts to the natural, social, economic agricultural environment of the study area, assuming the mitigation measures identified in EIA report will be incorporated in to design and implementation stage. The important points are:

Appropriate mitigation measures as suggested in environmental assessment report shall be incorporated. Construction of National Highway in the state of west bengal is not expected to result in any significant adverse environmental impacts.

Forest clearance will be applicable for diverting reserved and protected forest for road construction. All the necessary clearances will be required from concern departments at different stage of the project implementation.

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3.0 Engineering Survey, Material Investigation & Pavement Design

3.1 General

A sound engineering approach has been developed based on the requirement enumerated in Terms of Reference for conducting the required field surveys. Following data were collected from site and detailed desk study has been carried out to formulate a systematic and meticulous approach towards the present assignment. Following primary field surveys and investigations have been carried out on the project road: Inventory.

- Road
- Bridge and Cross Drainage Structures

- Condition Surveys
  - Pavement condition and Roughness survey
  - Bridges and Cross Drainage Structures

- Topographic Survey
  - Longitudinal alignment
  - Cross sections at 50m interval
  - Cross section of Bridges & Cross Drainage Structures

- Pavement Investigations
  - Trial Pit Investigation
  - Sub-grade Investigation
  - Benkelman Beam Deflection Test
  - Axle load Survey

- Material Survey
  - Soil Borrow Area
  - Aggregate Sources
  - Sand Sources
  - Other construction Material like Cement, Bitumen etc.

3.2 Inventory and Condition Survey of Road and Pavement

The scope of improvement measures and economic justification thereon depend on the condition of the existing road and its associated inventory. To collect the inventory of the existing road and allied features of road and structure, inventory surveys were carried out.

3.2.1 Road Inventory Survey

While conducting Inventory Survey of Road the existing physical features and surrounding condition of the project road was ascertained. Road Inventory of this report**.** Some of the salient features of the existing road has been described under following paragraphs.

The information collected, analysed and cross-checked, constitute the core database for formulating improvement proposals for further validation and finalisation in light of results of detailed topographical survey and investigations. The information has been utilised to decide the following:

- Decision on the widening of the carriageway is concentric for throughout the project road.
- Formulate the best-fit cross section with due consideration to terrain conditions, available land width and roadside features.
- Treatment to be given to congested built-up stretches.
- Number of tress to be affected by road improvement/construction works, the anticipated environmental impacts and extent of rehabilitation and resettlement.
- Provision of wayside amenities.
- Existing utility lines by type, location and extent that would require relocation.

3.2.2 Existing Carriageway

Project stretch is generally Single Lane to Intermediate Lane having 3.5 to 5.50 m width in project road. The existing road has earthen shoulder of about 0.5 m to 1 m on either sides of the project road. ROW available for most of the length of the project road is 4m - 6m as per the data provided by PWD.

Pavement From km 16+000 to 16+500

3.2.3 Alignment and Geometry

An average travel speed is 45-60 km/hr can be achieved in the project stretch but in pedong there geometry and gradient is so poor. There are number of hair pin band. which reduces the speed of the vehicle. Poor geometry can be observed in the locations like pedong.

3.2.4 Terrain and Land Use

The existing road passes through predominantly agricultural, govt land, forest and built-up areas (urban settlements). Project road passes through hilly and mountainous terrain in entire length.

At Navgaon **At Sonisidara**

3.2.5 Existing Major and Minor Junctions

The project road traverses through various habitations and towns. Many other important cross roads join the project road at different locations. There is no major intersection and 6 minor intersections sighted on the road. List of major intersection is given in **Table 3.1 & 3.2** below. In general no safety arrangements viz. road signs, markings, etc are provided at these intersections. no junction development has been observed in these junction.

Table 3.1: Existing Major Intersections

Sr. No.	Existing Chainage	Type	Link	Direction	Remarks
Nil					

Table 3.2:Existing Minor Intersections

Sl. No.	Design Chainage	Type of Intersection	Direction	Type of Road	Going To
			Left/Right	ER/BT/CC	
1	24+960	Y	Left	-	Gyasok Village
2	25+300	Y	Right	ER	Babangoan Village
3	26+120	Y	Left	ER	Nimbong Khasmahal
4	30+140	T	Right	BT	Pemling
5	30+400	Y	Left	BT	Kalimpong
6	38+830	T	Left	CC	Kafer Village

3.2.5.1 Embankment and Surface Drainage

The project road runs generally at ground profile and at generally high embankment is available in the some stretch. In Built-up stretches the project road is generally at the same level of the ground .There are few built-up drains in the project stretches like in Pedong etc , Project road requires an efficient drainage network. Also it is observed during rainy season water is logged in the built-up location due to poor condition of the drainage work. Proper built-up drainage work should be provided in these locations ,if bypasses are not proposed.

3.2.5.2 Existing Railway Crossings/ROB

There is no existing Railway Level crossing in the project road.

3.2.6 Pavement Condition Survey

3.2.6.1 Condition Survey of Pavement

It is the most important data needed for deciding upon the maintenance. The basic measurement of pavement condition is existing distresses. The information required is on the type, severity and amount of distress. The most commonly occurring distress forms are:

1	Bleeding	6	Patch deterioration
2	Block cracking	7	Polishing of aggregate
3	Corrugation	8	Ravelling
4	Depressions	9	Rutting
5	Pot hole		

Pavement condition survey consists of observing and recording the various distresses like cracks, pothole, rutting, ravelling etc of the existing carriageway, pavement shoulders and embankment. The details collected from pavement condition survey form the basis to decide strategy for adequate strengthening / rehabilitation measure of Existing pavement.

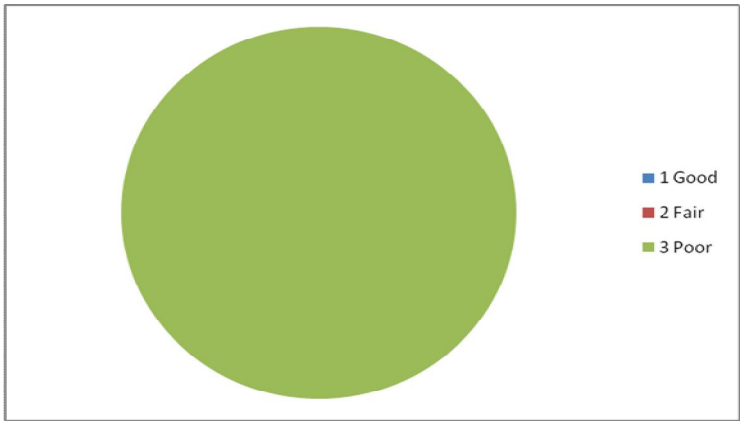
3.2.6.2 Pavement Condition Survey by Visual Inspection

a) General observation

Pavement condition of the Project stretch can be summarized as given below

Table 3.3: Percentage wise distribution of Good Fair and Poor Road

Sr.	Condition	Nos of Km	% Condition
1.	Good	0	0
2.	Fair	0	0
3.	Poor	39+800	100%



According to Maintenance Manual of Primary, Secondary and Urban Roads, Published by MoRTH, pavement condition data can be analyzed in terms of Good, Fair and Poor with the following criteria.

3.3 Topographic Survey

Topographical surveys have been carried out as per IRC: SP 19-2001, "Manual for Survey, Investigation and Preparation of Road Project" and as per TOR, for the preparation of alignment plans, strip plans, longitudinal sections, cross sections and other details like drainage works, earth retaining structures, control points and reference pillars required in view of consideration of vertical and horizontal alignments. Surveys were carried out as follows:

(a) Planimetric Control

The co-ordinates of basic plan control points were established by GPS in interval of 5km on RCC pillars as primary control station. Between two control points, bench marks were fixed in interval of 250m on RCC pillars, which serve the purpose of starting and closing bearings for Total Station Traverse.

(b) Height Control

Double tertiary levelling was done along the entire stretch with precision automatic level connecting bench marks and reference control points established near the project road. The misclosures were all seen to be below the tolerance limit of 0.12mm k, where k is the length of the levelling line in km in between the starting and closing bench marks. The misclosures were adjusted and height available at, given to all bench marks were connected to BMs established by contracting GTS Benchmark available in the vicinity of the project road.

(c) Detailed Survey

The detail of project influence area is up to minimum (building line) in case of urban area and 60m in case of realignments. The limit was extended further in case of anticipated junction improvement along the finalised centre line which were surveyed by running Total Station Traverse X, Y and Z coordinates of relevant points of survey to establish ground profile captured by this Total Station Traverse besides other details like electric/telephone poles, tree, building, well, visible property line etc.

(d) Creation of DTM

Data collected through topographical survey clubbed with the findings of inventory surveys have been used to develop a Digital Terrain Model (DTM) in Mx_Roads Software. Supplemented with the silting of important cross drainage structures along with their desired deck levels, horizontal and vertical profile of each road has been finalised after the careful application of the relevant design standard.

Traverse and LS/CS surveys were fed into computer to carry out the followings:

(i) Sort out the geometric (horizontal) deficiencies in the existing alignment.

(ii) Design the best fit centre line of the existing alignment considering all obligatory/nodal points with relevant design standards.

(iii) Examine the feasibility of proposed laning requirement within existing available ROW or proposal of bypass if any.

(iv) As far as possible obviate existing buildings, functional infrastructure facilities within the proposed ROW to minimise utility relocation.

(v) Examine each existing junction for its usefulness and determine the improvement measures.

3.4 Pavement Investigation

3.4.1 General

Pavement Investigation comprise of carrying out Sub grade characteristics and strength, investigation of required Sub-grade and sub soil characteristics, Pavement composition by excavating trial pits, evaluate Sub-grade strength, Pavement condition Surveys, Pavement Structural strength by conducting Deflection test by Benkelman Beam on existing road, DCP test and various laboratory tests.

3.4.2 Benkelman Beam Deflection Test

3.4.2.1 Pavement Structural Strength

There are several design methods used to determine the thickness of flexible overlay required. The most common procedures are:

- Based on deflection testing; and
- Effective thickness procedure

Above two methods are empirical in nature and are liable to produce different results. Therefore, it is important that a consistent methodology backed by experience and sound engineering judgment to be used. However, Deflection method is widely used in India.

3.4.2.2 Deflection Method

The structural strength evaluation by deflection method had been carried out by following scheme:

- Main line testing.

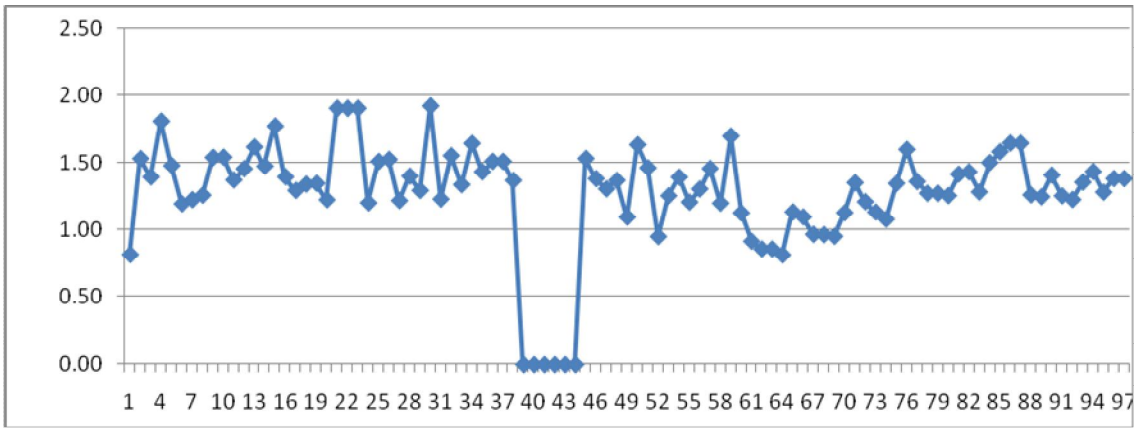
3.4.2.3 Mainline line Testing

In the mainline testing, BBD survey had been carried out at every 500m interval all along the project road in staggered manner. Ten reading in each 100m section has been taken in staggered manner. The collected data had been analysed separately as per procedure given in IRC: 81-1997 to find out the Characteristic Deflection.

Characteristic deflection is calculated using the initial, intermediate and final readings according to the IRC Guidelines by applying temperature correction of 0.01 mm/0^C and seasonal correction as per codal provision.

The characteristics deflection computed in main line survey has been further determined for the homogeneous section. Project Road is divided into three homogeneous section.. Homogeneous Deflection sections, project road are divided in seven number of homogenous section as presented in **Table 3.5.**

Figure 3.2: Homogeneous Section Worked out by Cumulative Difference Approach



(Average Deflection in mm)

Table 3.5 : Homogeneous Section based Deflection

Section	Deflection	Avg. defection	Total length(km)
1	1.2-1.60	1.40	13.900

Characteristics Deflection obtained from analysis for each kilometre is further analysed as per homogeneous section given in **Table 3.5** using IRC: 81-1997 for overlay determination. A detail of overlay is given in Pavement Design chapter.

3.4.2.4 Sub grade Investigations

Investigations of existing sub grade were carried out to assess the adequacy of the existing pavement layers apropos to present sub grade strength so that the strengthening and reconstruction requirement can be established for the design traffic loadings. Objectives of investigations also included evaluation of the existing pavement composition; characteristics of existing sub grade for design of pavement by means of in-situ and

laboratory tests as well as need for further investigations along the widened part / proposed new alignment.
The requirements of TOR were met the rough the following steps:

- Collection of minimum three Sub-grade soil samples in each identified homogeneous section;
- Recording the existing pavement crust composition at every 500 m intervals;
- Conducting tests on in-situ properties and characteristics of sub grade soils;
- Conducting laboratory tests on collected samples;
- Analysis of field and laboratory test results;
- Providing specific recommendation for existing Pavement; and
- Evaluation of problematic sub soil, if any.

Methodology

Project road was divided into suitable number of homogenous sections during field investigation. Minimum three large test pits has been dug out in each homogenous section to evaluate sub grade characteristics and strength while small test pits were excavated at every 500m interval. Test pits were excavated manually up to sub grade level at the pavement shoulder interface.

3.4.3 Test Pits for Sub grade Investigation

3.4.3.1 Large Pits

Large pits of size about 1.5 m x 1.5 m were excavated manually at pavement shoulder interface, extending through the pavement layers down to the sub grade level. The sub grade soil was tested for in situ density test using sand replacement method as per IS: 2720, Part 28. Dynamic Cone Penetration test using Dynamic Cone Penetrometer was carried out from the top of Sub-grade to Bottom level of Sub grade to evaluate in situ sub grade strength. Sub grade soil sample (about 40 kg) was taken from each pit for detailed laboratory test.
Following test were carried out on the sub grade soil sample in the laboratory.

- Atterberg's limits — As per IS: 2720, Part- V - 1985
- Grain size analysis — As per IS: 2720, Part- IV- 1985
- MDD (heavy compaction) — As per IS: 2720, Part- VIII- 1983
- Optimum Moisture Content — As per IS: 2720, Part- VIII- 1983
- CBR (4 days soaked at 3 energy level) — As per IS: 2720, Part- XVI- 1987

3.4.3.2 Small Pits

Small pits (0.7 m x 0.7 m) were excavated at an interval of 500 m between two consecutive large pits and staggered similar to large pits. The existing pavement composition were measured and recorded, sub grade soil sample (about 10 kg) was taken

Following test were carried out on the sub grade soil sample in the laboratory.

- Atterberg's limits — As per IS: 2720, Part- V- 1985
- Grain size analysis — As per IS: 2720, Part- IV- 1985

3.4.4 Existing Pavement Composition

In order to meet TOR requirement detailed layer composition of the existing pavement was recorded at every 500 m interval by digging test pits of size about 0.70 m x 0.70 m. The test pits were excavated manually at pavement shoulder interface, dug up to the sub grade level. When sub grade layer reached thickness of various pavement layers were measured at exposed face and recorded.

During investigation of crust composition namely three types of layers were observed i.e. wearing coarse ,base course and Sub-base course . The wearing course consists of bituminous material termed as Bituminous Top (BT). The base course comprises of Water Bound Macadam (WBM). The total thickness of the pavement varies from 400 mm to 470 mm with an average of 448 mm.

3.4.4.1 Sub grade Characteristics and Strength

In Situ Tests

Large pits were excavated on the project road extending through the pavement layers down to the sub grade level. At this level, Various field tests are conducted to determine their in-situ properties of existing sub-grade soils namely field dry density, sub-grade moisture content (at sub-grade level), and in-situ CBR from TRL-DCP test. The samples from Pits were collected to determine the soil characteristics and engineering properties of sub-grade soil. The excavated trial pit was backfilled with the same material with thorough compaction and the surface was made good. All field test results are tabulated in along with laboratory results.

DCP - CBR

Field CBR Test using Dynamic Cone Penetrometer method was conducted to assess the in-situ CBR at sub-grade and below sub-grade level as per TRL - Road Note 8. The CBR value was determined for the various soil layers encountered by using Penetration v/s Number of Blows graph. Change in Slope, penetration v/s number of blows. From the graph, layer thickness from respective slopes (penetration mm / blow) could be worked out.

DCP-CBR value was calculated using the following formula (TRL - Road Note 31 using 60º cone)

$\log_{10}(CBR) = 2.48 - 1.057 \times \log_{10}(\text{mm / blow})$

The DCP - CBR value was converted to an overall or equivalent CBR value using the material depth data.

3.4.5 Laboratory Test on Test Samples

Various laboratory tests are conducted on collected Sub-grade soil samples from pits. The results and corresponding interpretation along with in-situ condition were influential to carry out the actual pavement design.

The laboratory test results comprise of determination of Atterberg's Limits, compaction characteristics, 4 days soaked CBR at three energy level, gradation analysis etc. The test results for sub-grade soils are discussed below:

3.4.5.1 Classification

The soil samples have been primarily classified on the basis of Bureau of Indian Standards (BIS), which is based on the Unified Soil Classification System. Soil samples are containing clayey as well Silt particle along with low to intermediate plasticity. As per

soil classification systems majority samples are classified as ML (Silt with intermediate plasticity), SM (Sand with Silt), and CL (Clay with Low Plasticity).

3.4.5.2 Atterberg Limits

From the test results it is noted that liquid limit varies from 28% to 36%, and PI varies from 14% to 24%, the results are within the limit of MoRT&H specification (V^{th} revision) (LL should be <70% and PI should be < 45%).This implies that sub-grade soil along the existing alignment is clayey with intermediate plastic in nature.

3.4.5.3 Compaction Characteristics

The collected soil samples from large test pits were compacted with different moisture content in the laboratory in order to obtain dry density v/s moisture content relationship. The method of heavy compaction in accordance with IS: 2720 (Part- 8) was used to determined Maximum dry density. The maximum dry density varies from 1.88 gm/cc to 2.12 gm/cc**.**

3.4.5.4 Laboratory California Bearing Ratio (CBR) Test

Laboratory CBR test was conducted on samples obtained from Test Pit as per IS: 2720 (Part- 16). CBR moulds prepared by compacting the soil in five layers giving 10, 30 and 65 blows of heavy rammer, and soaked CBR value with swelling factor, was worked out. Quantity of water taken during remoulding CBR specimen is added equal to optimum moisture content. The dry density of soil compacted at various blows was determined. The graph of dry density versus soaked CBR value was drawn and CBR at corresponding value of 97% of MDD was calculated.

Table 3.7 : Summary of Test Results of Sub grade Soil

Type of Test	Maximum	Minimum	Average
Liquid Limit %	36.45	27.50	32.07
Plastic Limit %	23.81	14.74	20.10
Plasticity Index%	15.39	8.55	11.97
MDD gm/cc	2.120	1.854	1.946
OMC %	12.52	8.37	10.86
Soaked CBR %	13.10	10.10	11.6

3.5 Source of Material

1- Bitumen : for this project Bitumen is taken from Barauni.

2-Emulsion: for this project emulsion is taken from Haldia.

3-Quarry Material: Quarry material has been taken from Damodarpuri.

4- Cement: Cement is been taken from Guwahati because of the nearest manufacturing plant of star cement.

5- Steel: Due to availability of SAIL authorised dealers in siliguri steel is being taken from this location.

3.5.1 Type of Materials

The various construction materials are listed below.

- Metal
- Sand
- Bitumen
- Steel
- Cement

.

3.6 Axle Load Survey

Axle Load Survey is required to know the existing loading characteristics of the vehicles. The road side direct interview method was adopted. A portable wheel load weighing pad, duly calibrated was used for measuring the axle loads. Axle Load measuring points were arranged on shoulder approaches with adequate sight distance to the on coming and going vehicles. These approaches were away from the main carriageway and wide enough to accommodate the lined up sampled vehicles for questioning and allow safe passage for un-sampled vehicles during the progress of the survey. The vehicles were stopped systematically at random based on their arrival with the help of police. These Vehicles were guided to mount on the axle load pad, axle-wise, in the order of front most axle to the rear most axles. Axle load of commercial vehicles, i.e. LCVs, 2-Axle, 3-Axle, Multi Axle Trucks and Buses were recorded in approved formats. Representative samples were captured uniformly over the entire period of survey for each category of goods vehicles.

3.6.1 Analysis of Axle Load Survey

In order to estimate vehicle loading spectrum on project road, and to determine vehicle damage factor for the commercial vehicles, the axle load surveys have been carried out at three identified locations.

The consultant carried out sample survey for “Axle Loading Pattern” using Haenni wheel load WL 103. These are new axle pads which were calibrated on 08.01.2015 by the manufacturer, Haenni of Switzerland. Sufficient trucks were stopped at surveyed locations to have different category of goods vehicles with different types of commodities loaded.

In order to have a safe and durable pavement design, the VDF in each direction of traffic was calculated as shown in **Table 3.8**. The data collected from the Axle Load Survey has

been compiled and analysed through "Fourth power" pavement damage law to arrive at the vehicles damage factor (VDF).

Design of Pavement is based on the cumulative number of 8.16 tonne equivalent standard axle (ESA) that will pass per lane during the analysis period. The categories of traffic which apply significant loads to the pavement are bus, minibus 2–Axle, 3–Axle and multi-axle vehicles. In calculating ESA, the standard axle loads taken are as under:

i) Single Axle dual type = 8.1 tonnes
ii) Tandem Axle dual type =15.1 Tonne

The ESA for each axle has been calculated using the fourth Power low, as under

$$ESA = \left[\frac{Actual\ Axle\ Load}{S\tan dard\ Axle\ Load} \right]^4$$

The Vehicle Damage Factor is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions.

Table 3.8: Adopted VDF by Homogeneous Sections
Estimation of Vehicle Damage AT KALIJHORA NEAR SEVOKE (NH-31A)

MODE	Silliguri-Sikkim			Sikkim-Siliguri			Recommended
	Equivalence Factor	No. of Vehicles	VDF	Equivalence Factor	No. of Vehicles	VDF	
LCV	164.72	142	1.16	17.98	110	0.16	1.16
2 - AXLE	849.87	186	4.57	68.52	115	0.6	4.57
3 Axle	2.73	2	1.36	14.07	4	3.52	3.52
MAV	1.49	1	1.49	3.65	1	3.65	3.65

3.7 Inventory and Condition Survey of Bridges and Culverts

It is observed that the land along the existing alignment are open land ,agricultural land, passing through major Towns and Terrain is mostly hilly. It is observed that all along the alignment most of the structures like buildings, substructures for bridges, village roads etc., constitute of brick and stone masonry

Brief details of existing CD structures along the project alignment are as below.

Table 3.9: Existing CD structures

Sr. No.	Type	No's of structures	Retained	Reconstruction	Widened	New Proposed
1	Major Bridges	0	0	0	0	0
2	Minor Bridges	0	0	0	0	0
3	Pipe Culverts	0	0	0	0	0
4	Slab Culverts	13	0	67	0	1
5	Viaduct	0	0	0	0	2
6	Causeway	54	0	0	0	0
Total		**67**	**0**	**67**	**0**	**3**

Salient features of major structures are described as below.

3.7.1 Bridges

There are no minor bridges in the project rod.

3.7.2 Inventory of Culverts

There are 13 slab culverts and 54 causeway on project road. Photographic views of existing culverts are described as below.

4.0 Traffic Surveys and Analysis

4.1 General

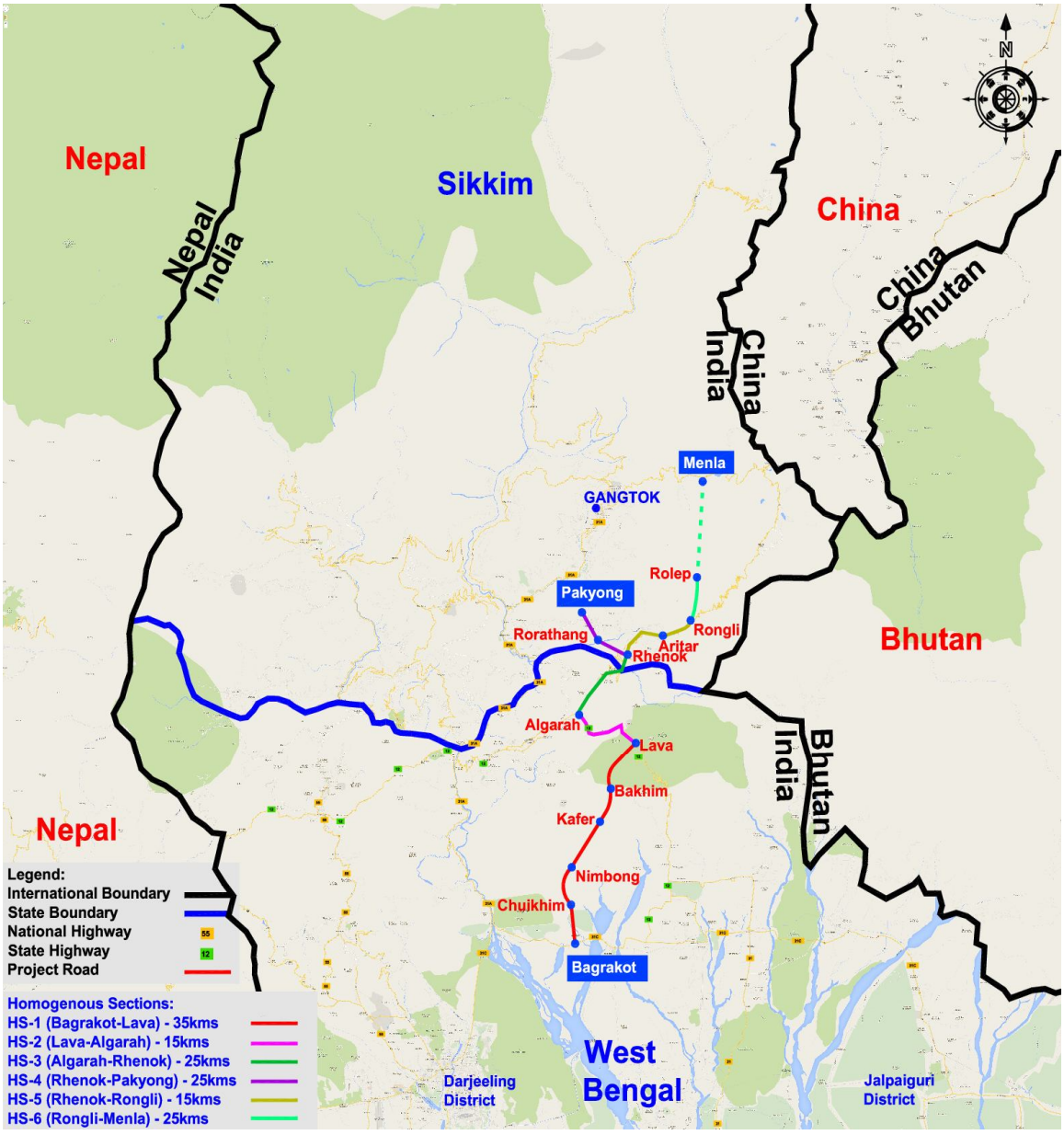
Traffic surveys, analysis and demand forecast are an important element of any feasibility /detailed project report preparation. Traffic analysis and demand forecasting are directly related to several important aspect of project road planning and design i.e. capacity augmentation proposals, geometric design features, planning and design of toll plaza, pavement design, economic and financial analysis etc. Towards this the consultant has undertaken detailed traffic surveys, analysis, forecasting and carry out lanning requirements. Various steps followed in this regard are described in the subsequent paragraphs.

4.2 Objectives

- To carry out traffic surveys and estimation of base year traffic demand
- Identification of travel pattern and influence area of project road
- Traffic demand forecasting up to project life
- Assess capacity requirement of project road, to estimate tollable traffic & to identify toll plaza locations.

4.3 Project Road & Alternate Transport Network

The project road passing through the two Indian States (West Bengal and Sikkim), Jalpaiguri and Darjeeling district in the West Bengal and East Sikkim district in the state of Sikkim. The project road starts from NH-31 near Bagrakot in the district of Jalpaiguri and ends at two points in the district of East Sikkim (Pakyong and Menla). The length of project road is about 75kms (Bagrakot – Rhenok) in the state of West Bengal, 25 kms (Rhenok-Pakyong) and about 40 kms (Rhenok-Menla) in the state of Sikkim. The project road passes through hilly terrain road and serves Military, civil as well as tourist traffic. The road is proposed to be built on DBFOT pattern and the users of this facility have to pay toll to use the entire length or part of it.



4.4 Traffic Homogeneous Section

The project road is divided in to six homogenous section for better demand assessment of traffic in each section.

The homogenous sections are:

Homogenous Section (HS)-1	Bagrakot (Start of the project road) to Lava - Length – 35kms approx.(West Bengal)
Homogenous Section (HS)-2	Lava to Algarah – Length – 15 kms approx. (West Bengal)

Homogenous Section (HS)-3	Algarah to Rhenok – Length – 25 kms approx. (West Bengal)
Homogenous Section (HS)-4	Rhenok to Pakyong – Length – 25 kms approx. (Sikkim)
Homogenous Section (HS)-5	Rhenok to Rongli – Length – 15kms approx. (Sikkim)
Homogenous Section (HS)-6	Rongli to Menla – Length – 25kms approx. (Sikkim)

4.5 Traffic Surveys Schedule

It is very important, that the existing information on traffic flow, commodity movement and traffic pattern is required in order to assess the traffic behaviour on a project road. To collect such information to satisfy the Terms of Reference (TOR) and project requirements, following various types of traffic surveys were carried out:

1) Classified Volume Count (CVC) Survey
2) Origin –Destination and Commodity Movement Surveys
3) Axle Load Spectrum Survey
4) Intersection Volume Count Survey
5) Speed and Delay surveys
6) Pedestrian/Cattle Crossing Surveys
7) Truck Terminal Survey

Traffic survey locations were selected after detailed reconnaissance survey and in line with the TOR. All the traffic surveys were carried out as per the IRC guidelines given in IRC: SP 19-2001, IRC 37:2012, IRC: 108-2015, IRC SP: 41-1994, IRC: 102-1988, IRC 103- 2012 and IRC: 09-1972 etc.

All the above surveys were carried out manually by employing sufficient number of trained enumerators recording information in the pre-designed formats. The enumerators were selected from locally available educated people familiar with traffic characteristics and condition of the project road. They were properly briefed and trained about the survey work before putting them on actual survey work in field. An experienced supervisor was kept in-charge for all the locations.

The locations for the various surveys were so selected that all vehicles can be viewed and interpreted easily without endangering the safety of enumerators and drivers. The most important part of all traffic survey was to exercise adequate quality control. The quality assurance was achieved through:

- Proper briefing and demonstration to enumerators before the start of work;
- Continuous independent checking by Traffic engineers / supervisor in the field during the survey work;
- Checking of filled in survey formats by Traffic engineer; and
- Validation of computer data entry with raw surveyed data

The survey data were recorded in the pre-designated approved formats for each type

of survey. All the above traffic surveys were carried out as per the schedule finalised after considering requirements of TOR and project requirements as presented below.

4.6 Classified Traffic Counts at Mid Block and Intersection Location

Classified traffic counts were carried out for a period of 7 consecutive days at 3mid-block locations and for a period of 12 hours at 6 intersection locations along the project road. The surveys were carried out manually by trained enumerators. The data served as population base for the base year and will be used to project traffic. The Survey locations are presented in Figure 2.1.The survey data are presented in Annexure – 1.

4.7 Road Side OD Surveys

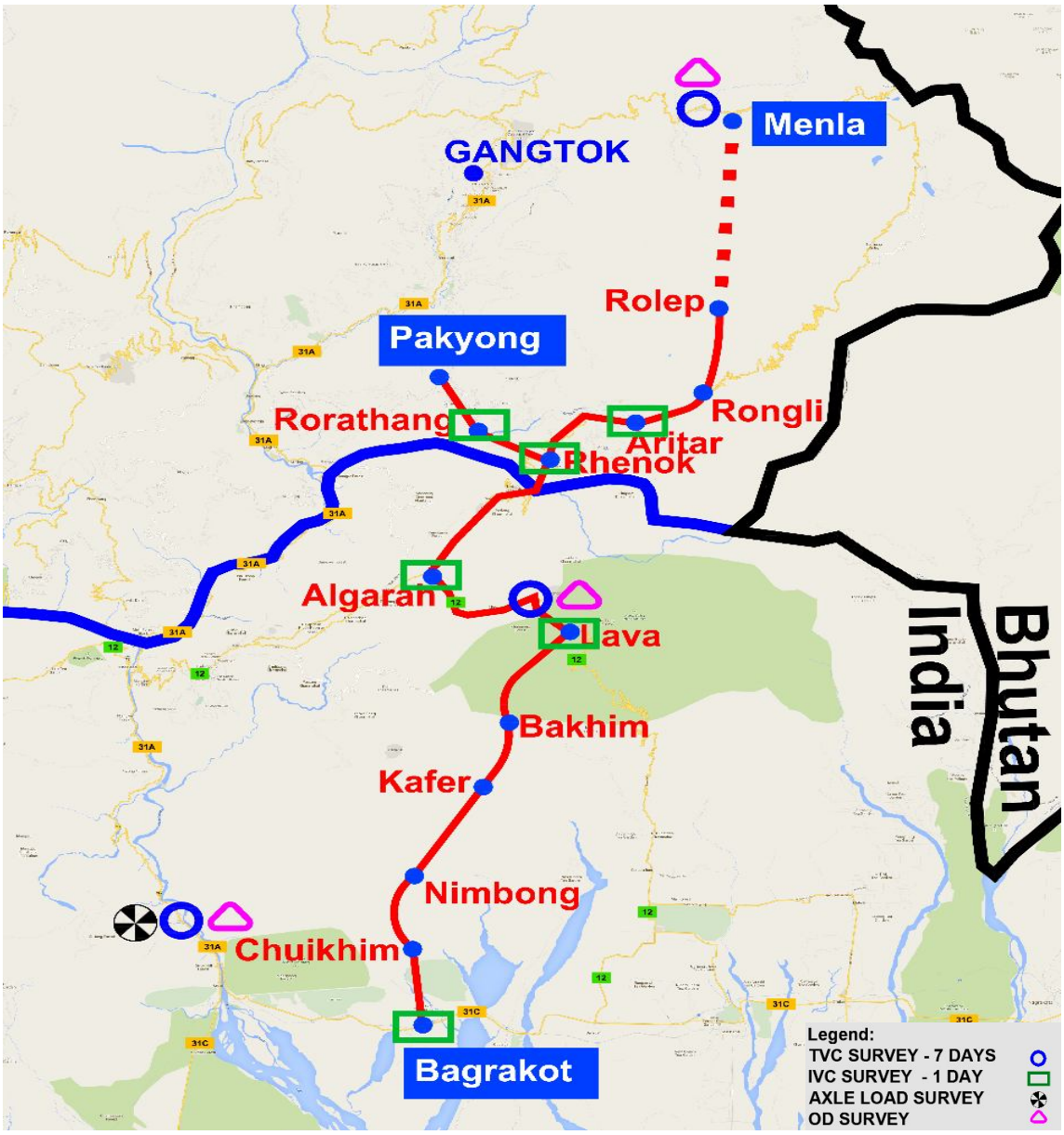
These surveys were carried out on sample basis by trained enumerators for a period of 24 hours at same locations as the classified traffic counts. The vehicles were stopped on random sample basis with police help and the drivers were asked about their trip and travel characteristic on a prepared survey format. The vehicles selected were Light Commercial Vehicles (LCV) Medium Commercial Vehicles (MCV) or trucks and Heavy Commercial Vehicles (HCV) having more than 2 Axle among the goods vehicles, while the passenger vehicles included Cars, Buses, 2 wheelers and 3 Wheelers. The buses were not stopped but their origin and destination was noted from the board on front or side and their occupancy was estimated on visual basis. Care was taken not to obstruct the flow during survey by randomly selecting the vehicles and releasing them before taking on the next vehicle.

4.8 Axle Load Surveys

The Axle Load Surveys were carried out at one location for a period of 12 hours. The Vehicles selected were light Commercial vehicles, Trucks and MAV's. A few samples of empty vehicles were also included besides the loaded trucks. The left side wheels of stopped vehicles (front and rear) were mounted on a weigh pad to note the wheel/dual assembly Load. This was multiplied by 2 to calculate the Axle Load. Each Axle of the selected vehicle was considered and the Axle Load spectrum was prepared at office.

TABLE 4.1 SURVEY LOCATIONS ALONG PROJECT ROAD

S. No.	Type of Survey	Location Code	Location Name	Survey Date	Remark
1	Traffic Volume Count	TVC - 01	1. Near Kalijhora on NH-31A	4th January 2015 to 10th January 2015	7 Days
		TVC-02	2. Near Algarah (Baluwakhani Checkpost) - SH-12	8th January 2015 to 14th January 2015	
		TVC-03	3. Near 3rd Mile Checkpost on NH-31A (JLN Marg)	10th January 2015 to 16th January 2015	
2	Origin - Destination Survey	OD-01	1. Near Kalijhora on NH-31A	14th January 2015	1 Day
		OD-02	2. Near Algarah (Baluwakhani Checkpost) - SH-12	8th January 2015	
		OD-03	3. Near 3rd Mile Checkpost on NH-31A (JLN Marg)	10th January 2015	
3	Axle Load Survey	Axl - 01	1. Near Kalijhora on NH-31A	14th January 2015	1 Day
4	Turning Movement Survey	INT-01	1. Start point of the project/ Jn. With NH-31	8th January 2015	1 Day
		INT-02	2. Lava Jucntion near kms 56 of SH-12	6th January 2015	
		INT-03	3. Algarah Junction	6th January 2015	
		INT-04	4. Rehnok Junction	5th January 2015	
		INT-05	5. Rorathang Junction	7th January 2015	
		INT-06	6. Dalepchen near Rongli	5th January 2015	



Traffic Survey Location

4.9 TRAFFIC VOLUME COUNT AT MID BLOCK LOCATION

The classified traffic volume counts at 3 mid-block location were carried out by trained enumerators for 7 days continuously to note to the weekly and daily traffic trends on a pre-designed format at 15 minutes interval. The data is recorded by direction.

4.9.1 PCU (Passenger Car Unit) Conversion Factor

For the analysis of traffic counts carried out at selected Intersection along the project corridor for study, the PCU Factor adopted is presented in **Table 4.1.**

TABLE 4.1 PASSENGER CAR UNITS FOR THE CONVERSION AS PER IRC 64-1990

Vehicular Modes	PCU VALUE
Car/ Van/ Jeep/ Taxi	1.0
2-Wheeler	0.5
3-Wheeler	1.0
Bus	3.0
Mini Bus	1.5
LCV	1.5
2-Axle Truck	3.0
3-Axle Truck	3.0
Multi Axle Vehicles (MAV)	4.5
Agricultural Tractor - Without Trailer	1.5
Agricultural Tractor- With Trailer	4.5
Cycle	0.5
Cycle-Rickshaw	2.0
Hand Cart	3.0
Bullock Cart	6.0

Source: IRC: 64-1990

4.9.2 Average Daily Traffic

The analysis shows that the Average Daily Traffic (ADT) varies from 362 PCU at TVC-02 to 8571 PCU at TVC-01. The details are presented in **Table 4.2.**

TABLE 4.2 TRAFFIC CHARACTERISTICS (ADT) AT MID BLOCK LOCATIONS

Mode		TVC-01 (Nr. Sevok, Kalijhora, NH-31)	TVC-02 (Baluakhani Checkpost, Near Algarah, SH-12)	TVC-03 (3rd Mile Check Post, JLN Marg)
Heavy Fast Passenger Vehicles	Standard Bus	**12**	**0**	**0**
	Mini Bus	**130**	**1**	**0**
Light Fast Passenger Vehicles	Car/ Van/ Jeep/ Taxi	**3643**	**257**	**676**
	3-Wheeler	**0**	**0**	**0**
	2-Wheeler	**282**	**51**	**18**
Goods Commercial Vehicles	LCV	**712**	**49**	**11**
	2-Axle Truck	**1036**	**1**	**16**
	3-Axle Truck	**30**	**0**	**0**
	MAV	**2**	**0**	**0**
Toll Exempted Vehicles	Govt. Car/ Van/ Jeep	**26**	**1**	**43**
	Govt. Bus/ Truck	**66**	**0**	**62**
	Govt. LCV/ Mini Bus	**0**	**0**	**0**
Agricultural Vehicles	Tractor	**0**	**0**	**0**
	Tractor Trailer	**0**	**0**	**0**
Slow Vehicles	Cycle	**0**	**2**	**0**
	Cycle Rickshaw	**0**	**0**	**0**
	Animal/ Hand Drawn	**0**	**0**	**0**
Total Vehicles		**5941**	**361**	**827**
Total PCU		**8517**	**362**	**981**

Source: Traffic Survey, January 2015

4.9.3 Directional Distribution of Traffic

At TVC-01, the directional distribution of traffic shows that the traffic moving between Silliguri and Sikkim is slightly high as 51% while 49% traffic move in opposite direction. At TVC-02, the directional distribution of traffic shows that the traffic moving between Algarah and Lava is 2% lower than the traffic moving in opposite direction. At TVC-03, the directional distribution of traffic shows that the traffic moving between Nathula and Gangtok is 4% higher than the traffic flow in opposite direction. The details are presented in **Table 4.3.**

TABLE 4.3 DIRECTIONAL DISTRIBUTION OF AVERAGE DAY TRAFFIC

Mode		TVC-01 (Nr. Sevok, Kalijhora, NH-31)			TVC-02 (Baluakhani Checkpost, Near Algarah, SH-12)			TVC-03 (3rd Mile Check Post, JLN Marg)		
		Silliguri-Sikkim	Sikkim-Siliguri	Both Direction	Algarah-Lava	Lava-Algarah	Both Direction	Gangtok-Nathula	Nathula-Gangtok	Both Direction
Heavy Fast Passenger Vehicles	Standard Bus	8	4	**12**	0	0	**0**	0	0	**0**
	Mini Bus	69	61	**130**	0	0	**1**	0	0	**0**
Light Fast Passenger Vehicles	Car/ Van/ Jeep/ Taxi	1951	1693	**3643**	123	134	**257**	336	339	**676**
	3-Wheeler	0	0	**0**	0	0	**0**	0	0	**0**
	2-Wheeler	133	149	**282**	27	24	**51**	8	10	**18**
Goods Commercial Vehicles	LCV	305	407	**712**	25	24	**49**	5	6	**11**
	2-Axle Truck	537	500	**1036**	1	0	**1**	4	12	**16**
	3-Axle Truck	13	18	**30**	0	0	**0**	0	0	**0**
	MAV	1	1	**2**	0	0	**0**	0	0	**0**
Toll Exempted Vehicles	Govt. Car/ Van/ Jeep	15	11	**26**	1	1	**1**	20	23	**43**
	Govt. Bus/ Truck	35	31	**66**	0	0	**0**	28	34	**62**
	Govt. LCV/ Mini Bus	0	0	**0**	0	0	**0**	0	0	**0**
Agricultural Vehicles	Tractor	0	0	**0**	0	0	**0**	0	0	**0**
	Tractor Trailer	0	0	**0**	0	0	**0**	0	0	**0**
Slow Vehicles	Cycle	0	0	**0**	2	0	**2**	0	0	**0**
	Cycle Rickshaw	0	0	**0**	0	0	**0**	0	0	**0**
	Animal/ Hand Drawn	0	0	**0**	0	0	**0**	0	0	**0**
Total Vehicles		**3066**	**2875**	**5941**	**178**	**183**	**361**	**403**	**424**	**827**
Total PCU		**4373**	**4144**	**8517**	**178**	**184**	**362**	**467**	**514**	**981**
% age distribution (PCU)		**51%**	**49%**	**100%**	**49%**	**51%**	**100%**	**48%**	**52%**	**100%**

Source: Traffic Survey, January 2015

4.9.4 Traffic Composition

The traffic composition chart shows that the share of cars varies from 61% (at TVC-01) to 82% (at TVC-03) among the TVC locations .The share of 2-wheelers is varying from 2% to 14% while the share of buses and slow vehicles are negligible at all location. The share of LCV's varies from 1% (at TVC-03) to 14% (at TVC-02), the share of Trucks are varies from 2% (at TVC-03) to 18% (at TVC-01). The details are graphically presented in **Figure 4.1.**

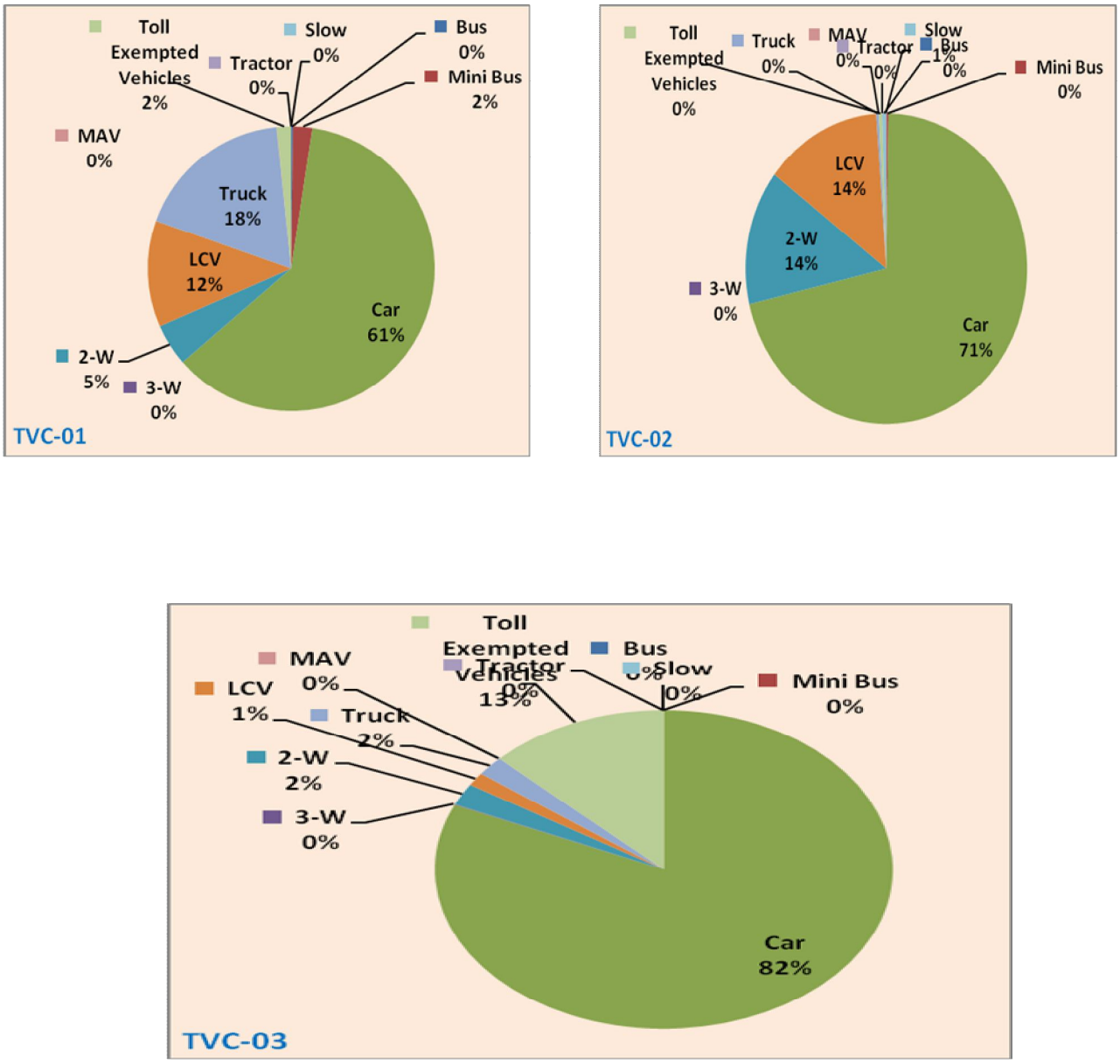


FIGURE 4.1 TRAFFIC COMPOSITION AT MID BLOCK LOCATIONS

4.9.5 Day wise Variation of Traffic

The traffic along the regional routes varies by day on account of the local factors like weekly markets, land use, traffic regulations etc. or due to regional factors. Traffic demand on a peak day may lead to excessive congestion and delays as the road infrastructure is unable to cope with the demand. This trend too was witnessed at the locations along which traffic counts were carried for this project.

The analysis shows that at TVC-01, the observed ADT was 8517 PCU while the day wise traffic varies from 7580 PCU (Sunday) to 10701 PCU (Monday). At TVC-02, the observed ADT was 365 PCU and the day wise traffic varies from 301 PCU (Saturday) to 392 PCU (Monday). At TVC-03, the average daily traffic was 981 PCU while the day wise traffic varies from 894 PCU (Sunday) to 1044 PCU (Wednesday).The details are presented in **Table 4.4** and graphically presented in **Figure 4.2 to 4.3.**

TABLE 4.4 DAYWISE VARIATION OF TRAFFIC AT MID BLOCK LOCATIONS

Days	Date	Day	TVC-01 (Nr. Sevok, Kalijhora, NH-31)		Date	Day	TVC-02 (Baluakhani Checkpost, Near Algarah, SH-12)	
			Vehicles	PCU			Vehicles	PCU
1	4-Jan-15	Sunday	5735	7580	8-Jan-15	Thursday	359	364
2	5-Jan-15	Monday	7596	10701	9-Jan-15	Friday	380	375
3	6-Jan-15	Tuesday	5567	8044	10-Jan-15	Saturday	297	301
4	7-Jan-15	Wednesday	5519	8337	11-Jan-15	Sunday	342	343
5	8-Jan-15	Thursday	5529	8086	12-Jan-15	Monday	391	392
6	9-Jan-15	Friday	5996	8624	13-Jan-15	Tuesday	375	372
7	10-Jan-15	Saturday	5643	8246	14-Jan-15	Wednesday	385	388
Mean			**5941**	**8517**			**361**	**362**
Standard Deviation			**748**	**1014**			**33**	**31**

Days	Date	Day	TVC-03 (3rd Mile Check Post, JLN Marg)	
			Vehicles	PCU
1	10-Jan-15	Saturday	756	953
2	11-Jan-15	Sunday	729	894
3	12-Jan-15	Monday	859	1013
4	13-Jan-15	Tuesday	855	997
5	14-Jan-15	Wednesday	891	1044
6	15-Jan-15	Thursday	867	1020
7	16-Jan-15	Friday	833	945
Average			**827**	**981**
Standard Deviation			**61**	**52**

Source: Traffic Survey, January 2015

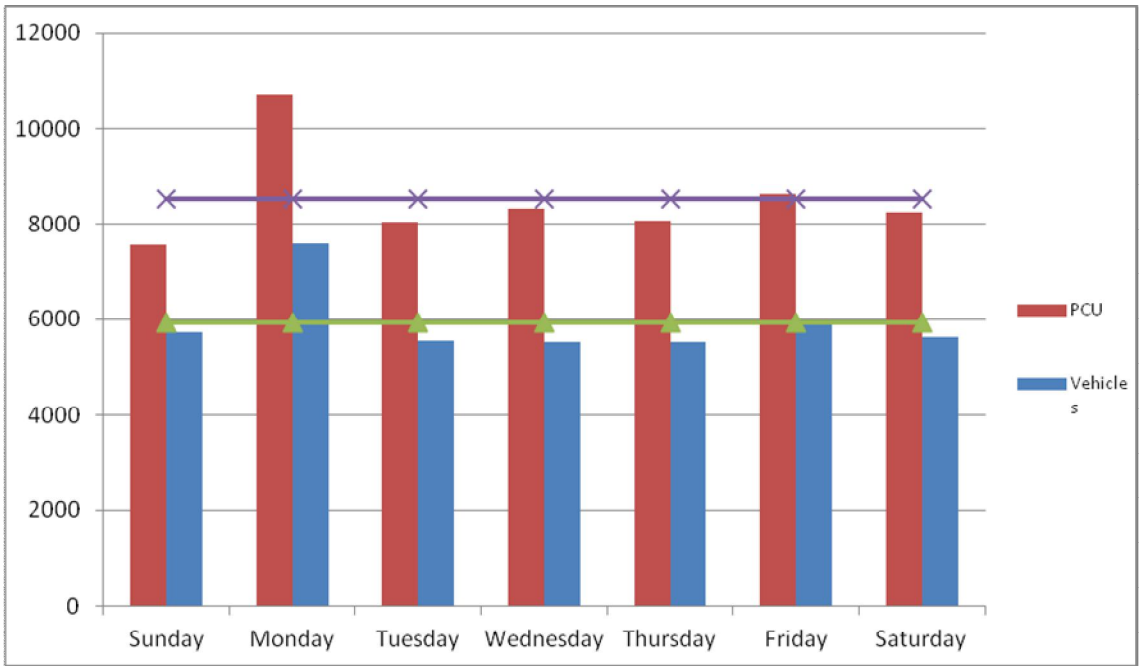


FIGURE 4.2 DAY WISE VARIATION OF TRAFFIC AT TVC-01

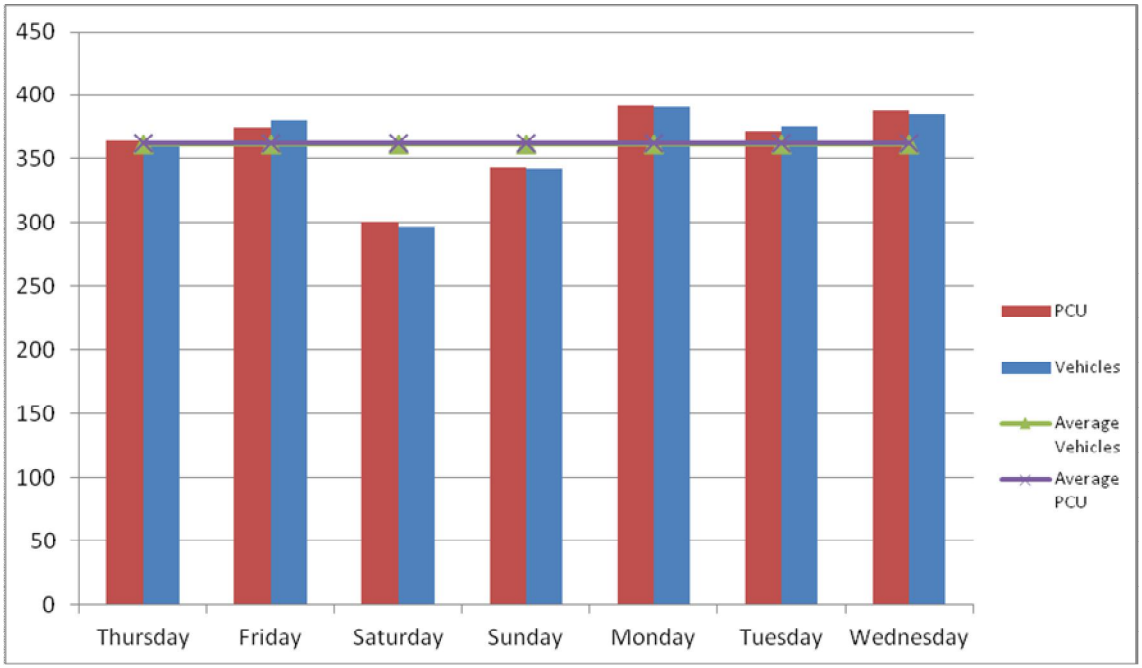


Figure 4.3 day wise variation of traffic at tvc-02

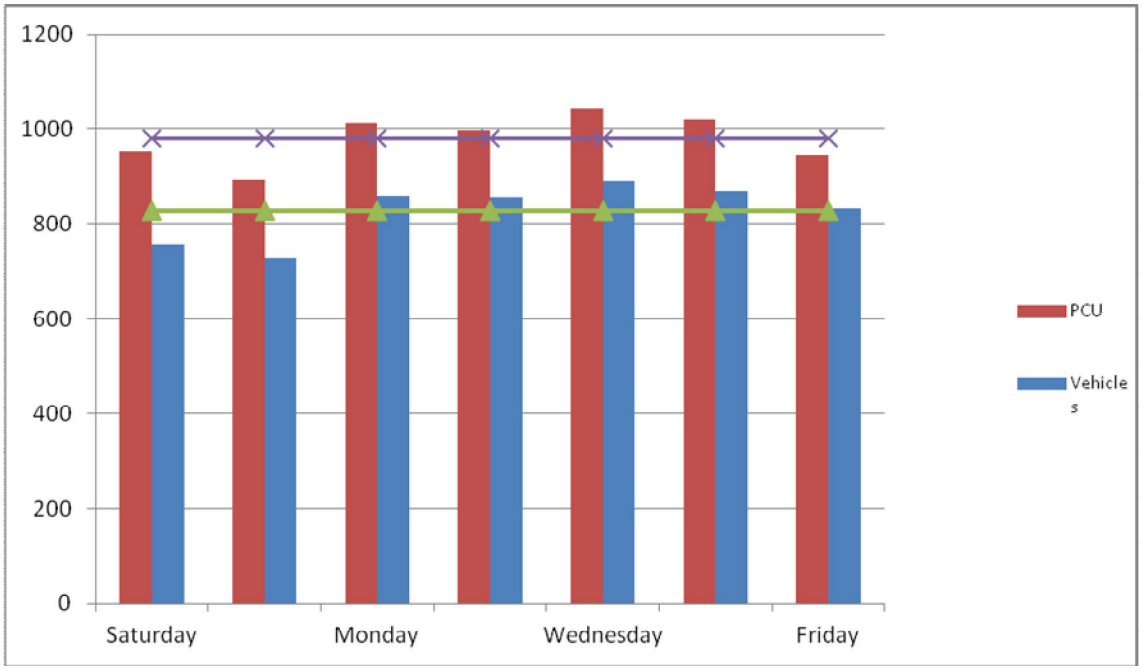


Figure 4.4 day wise variation of traffic at tvc-03

4.9.6 Peak Hour Share of Traffic

The analysis shows that the share of peak hour traffic is varying from 7% to 18% during morning peak and7% to 9% during evening peak hour. The details are presented in **Table 4.5**.

TABLE 4.5 SHARE OF PEAK HOUR TRAFFIC

S.No.	Location	Total Volume (PCU)	Morning Peak Hour			Evening Peak Hour		
			PCU	% share	Peak Hour Time	PCU	% share	Peak Hour Time
1	TVC-01 (Nr. Sevok, Kalijhora, NH-31)	**8517**	**623**	7%	0900-1000	**612**	7%	1900-2000
2	TVC-02 (Baluakhani Checkpost, Near Algarah, SH-12)	**362**	**34**	9%	0900-1000	**32**	9%	1700-1800
3	TVC-03 (3rd Mile Check Post, JLN Marg)	**981**	**178**	18%	0900-1000	**67**	7%	1700-1800

Source: Traffic Survey, January 2015

4.9.7 Hourly Variation of Traffic

The hourly variation of traffic count shows the pattern of traffic flow during the survey period. The hourly variation chart shows that the peak period during morning peak hours between 0900 AM and 1200 AM and during evening peak hour between 1600 PM and 2000 PM. The traffic during night hours is negligible. The hourly variation of traffic is graphically presented in **Figure 4.5 to 4.7.**

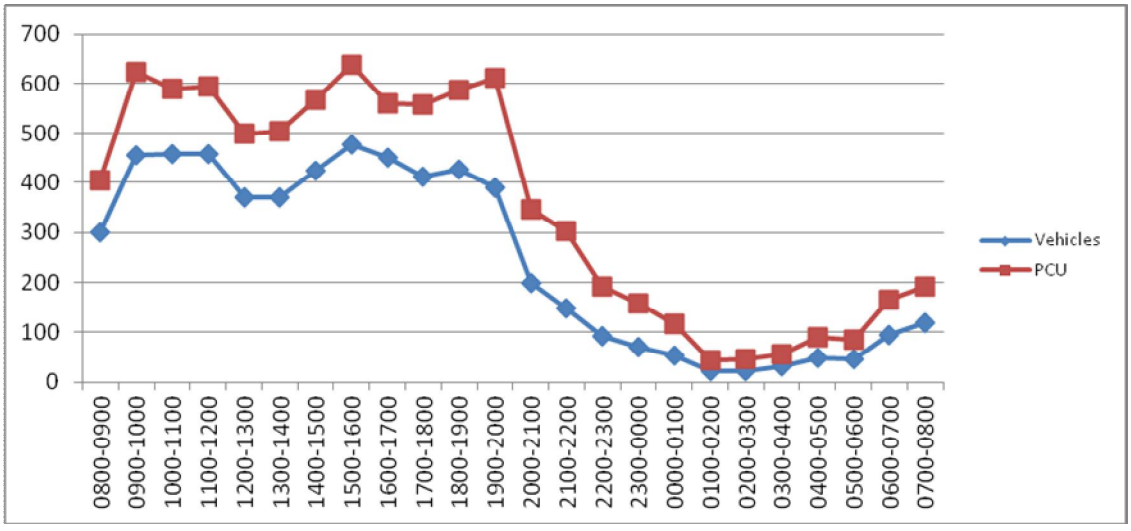


Figure 4.5 Hourly Variation of Traffic aT TVC-01

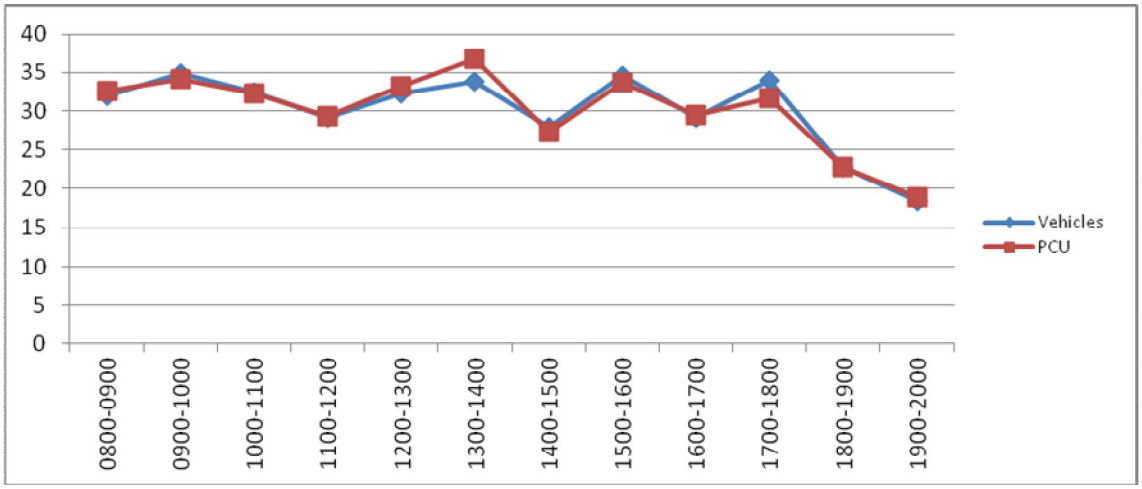


FIGURE 4.6 HOURLY VARIATION OF TRAFFIC AT TVC-02

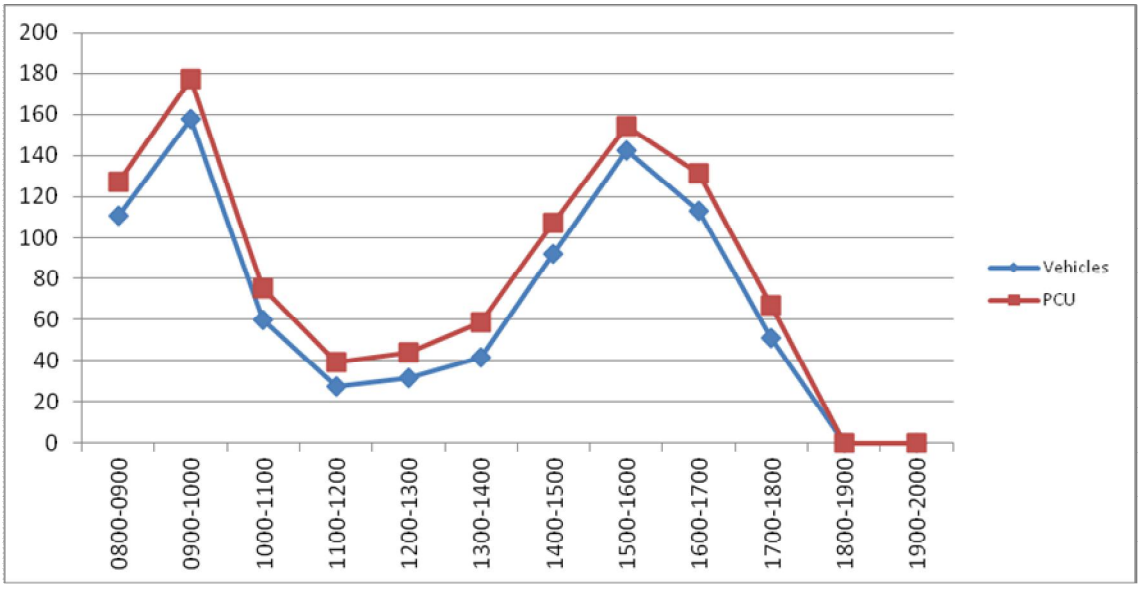


FIGURE 4.7 HOURLY VARIATION OF TRAFFIC AT TVC-03

4.9.8 Annual Average Daily Traffic

Traffic during different months of the year is not likely to be the same. During the harvest season, there is a significant goods vehicle movement, during school holidays there is lots of personal vehicle movement, during festival season there is lots of personal vehicle movement. In order to obtain an accurate estimate of the

variations it is essential that this phenomenon is captured in the traffic study. This manifest is estimation of a metric called Annual Average Daily Traffic (AADT)

Traffic engineers estimate the seasonal impacts by using a factor called as the "Seasonal Correction Factor (SCF)".The seasonal correction factor is generally derived from secondary data sources such as historical month-wise traffic data on the project road, monthly toll revenues from existing tolled highways in the immediate influence area, for this study this is done by the estimation of Seasonal Correction Factor using month wise with Fuel Sale data variations. The seasonal correction factor (SCF) is presented in **Table 4.6(a) & (b).**

TABLE 4.6(A) SEASONAL CORRECTION FACTOR (SCF) ALONG NH-31A

Month/ Year	Hill View Fill Station Sevoke Bazar Siliguri, West Bengal			*Seasonal Correction Factor (SCF)*		
	Diesel in Litres	Petrol in Litres	Total	Diesel	Petrol	Total
Mar-13	40500	17900	58400	0.99	1.00	0.99
Apr-13	40000	16900	56900	1.00	1.06	1.02
May-13	39000	15900	54900	1.03	1.13	1.06
Jun-13	34500	15400	49900	1.16	1.17	1.16
Jul-13	34300	14700	49000	1.17	1.22	1.18
Aug-13	36300	16700	53000	1.10	1.08	1.09
Sep-13	38500	16900	55400	1.04	1.06	1.05
Oct-13	40000	19900	59900	1.00	0.90	0.97
Nov-13	43500	21900	65400	0.92	0.82	0.89
Dec-13	47800	20900	68700	0.84	0.86	0.84
Jan-14	***44000***	***19900***	***63900***	***0.91***	***0.90***	***0.91***
Feb-14	42000	18700	60700	0.95	0.96	0.96
Total	**40033**	**17975**	**58008**			

Source: Fuel Sale Data

TABLE 4.6(B) SEASONAL CORRECTION FACTOR (SCF) ALONG JLN MARG

Month/ Year	*Sri R.A.L Mangal KSK, Rhenock East Sikkim, Sikkim*			*Seasonal Correction Factor (SCF)*		
	Diesel in Litres	Petrol in Litres	Total	Diesel	Petrol	Total
Jun-14	9000	9000	18000	2.69	2.28	2.49
Jul-14	27000	18000	45000	0.90	1.14	0.99
Aug-14	27000	27000	54000	0.90	0.76	0.83
Sep-14	27000	27000	54000	0.90	0.76	0.83
Oct-14	27000	27000	54000	0.90	0.76	0.83
Nov-14	22000	18000	40000	1.10	1.14	1.12

Month/ Year	*Sri R.A.L Mangal KSK, Rhenock East Sikkim, Sikkim*			*Seasonal Correction Factor (SCF)*		
	Diesel in Litres	Petrol in Litres	Total	Diesel	Petrol	Total
Dec-14	29000	18000	47000	0.84	1.14	0.95
Jan-15	***26000***	***19000***	***45000***	***0.93***	***1.08***	***0.99***
Feb-15	28000	22000	50000	0.87	0.93	0.90
Mar-15	26000	23000	49000	0.93	0.89	0.91
Apr-15	23000	20000	43000	1.05	1.03	1.04
May-15	20000	18000	38000	1.21	1.14	1.18
Total	**24250**	**20500**	**44750**			

Source: Fuel Sale Data

The consultant has estimate the SCF for project road is based on the average SCF of locations for diesel and petrol propelled vehicles. The average SCF is 0.92 and 0.99 for diesel and petrol propelled vehicles respectively.

For the estimation of Annual Average Daily Traffic (AADT), the Seasonal Correction Factor (SCF) is used for the month of January. The seasonal correction factor for Diesel vehicles is 0.92and petrol vehicles is 0.99. This means that the diesel sale in the month of January was 8% above the average monthly sale while petrol sale during month of January (coinciding with the survey month) was1% above the normal sale. Accordingly the number of diesel propelled vehicles has to be decreased by 8% and number of petrol propelled vehicles have to decrease by 1%.

The annual average daily traffic will be estimated by multiplying the Average Day Traffic of petrol propelled vehicles by 0.99 and for diesel propelled vehicle by 0.92. The Average Daily Traffic (ADT) has been presented in Table 4.2 while the Estimated Annual Average Daily Traffic (AADT) is presented in **Table.4.7.**

TABLE 4.7 ANNUAL AVERAGE DAILY TRAFFIC (AADT)

Mode		TVC-01 (Nr. Sevok, Kalijhora, NH-31)	TVC-02 (Baluakhani Check post, Near Algarah, SH-12)	TVC-03 (3rd Mile Check Post, JLN Marg)
Heavy Fast Passenger Vehicles	Standard Bus	11	0	0
	Mini Bus	119	1	0
	School Bus	0	0	0
	School Mini Bus	0	0	0
Light Fast Passenger	Car/ Van/ Jeep/ Taxi	3607	254	669

Mode		TVC-01 (Nr. Sevok, Kalijhora, NH-31)	TVC-02 (Baluakhani Check post, Near Algarah, SH-12)	TVC-03 (3rd Mile Check Post, JLN Marg)
Vehicles	3-Wheeler	0	0	0
	2-Wheeler	279	50	18
Goods Commercial Vehicles	LCV	655	45	10
	2-Axle Truck	954	1	15
	3-Axle Truck	28	0	0
	MAV	2	0	0
Toll Exempted Vehicles	Govt. Car/ Van/ Jeep	24	1	39
	Govt. Bus/ Truck	61	0	57
	Govt. LCV/ Mini Bus	0	0	0
Agricultural Vehicles	Tractor	0	0	0
	Tractor Trailor	0	0	0
Slow Vehicles	Cycle	0	2	0
	Cycle Rickshaw	0	0	0
	Animal/ Hand Drawn	0	0	0
Total Vehicles		**5740**	**354**	**810**
Total PCU		**8100**	**353**	**950**

Source: Consultant Estimates

4.10 TURNING MOVEMENT VOLUME COUNT

The classified turning traffic volume count were carried out at 6 location along project road for the period of 12 Hrs. at each location (0800 AM – 0800 PM). The analysis results are presented below.

4.10.1 Approach Traffic

The table shows that the approach traffic during survey period along project road varies from 540 PCU (at INT-06, Rongli) to 5597 PCU (at INT-01, Bagrakot). The share of morning peak hour traffic at the intersection varies from 10% to 13% while the share of evening peak hour is varies from 8% to 11%. The approach traffic for each intersection is presented in **Table 4.8.**

TABLE 4.8 APPROACH TRAFFIC (PCU) AT STUDY INTERSECTIONS

Sr. No.	Intersections	Locations Name	Approach Arm	Inflow/ Outflow	Entire Day	Morning Peak	Evening Peak
1	INT -01	Bagrakot (Start Point of Project Road), NH-31	Sevoke	Inflow	2462	237	217
				Outflow	2306	248	178
				Both	4767	485	395
			Bagrakot	Inflow	727	68	41
				Outflow	555	90	35
				Both	1281	158	76
			Damdim	Inflow	2409	290	192
				Outflow	2641	267	221
				Both	5050	557	413
			Oodalabari	Inflow	284	47	19
				Outflow	380	37	36
				Both	664	84	55
Total Inflow at Intersection					5597	594	450
2	INT -02	Lava Intersection (SH-12)	Algara	Inflow	167	18	13
				Outflow	174	18	18
				Both	340	36	31
			Rishop	Inflow	35	4	4
				Outflow	21	3	1
				Both	56	6	5
			Lava	Inflow	176	20	18
				Outflow	191	23	15
				Both	367	43	33
			Chumung Forest	Inflow	41	6	1
				Outflow	33	4	2
				Both	73	9	3
Total Inflow at Intersection					377	41	35
3	INT -03	Algarah	Algarah	Inflow	286	18	40
				Outflow	292	57	17
				Both	578	75	57
			Pedong	Inflow	310	60	19
				Outflow	307	19	45
				Both	617	79	64
			Baluwakh	Inflow	41	2	5

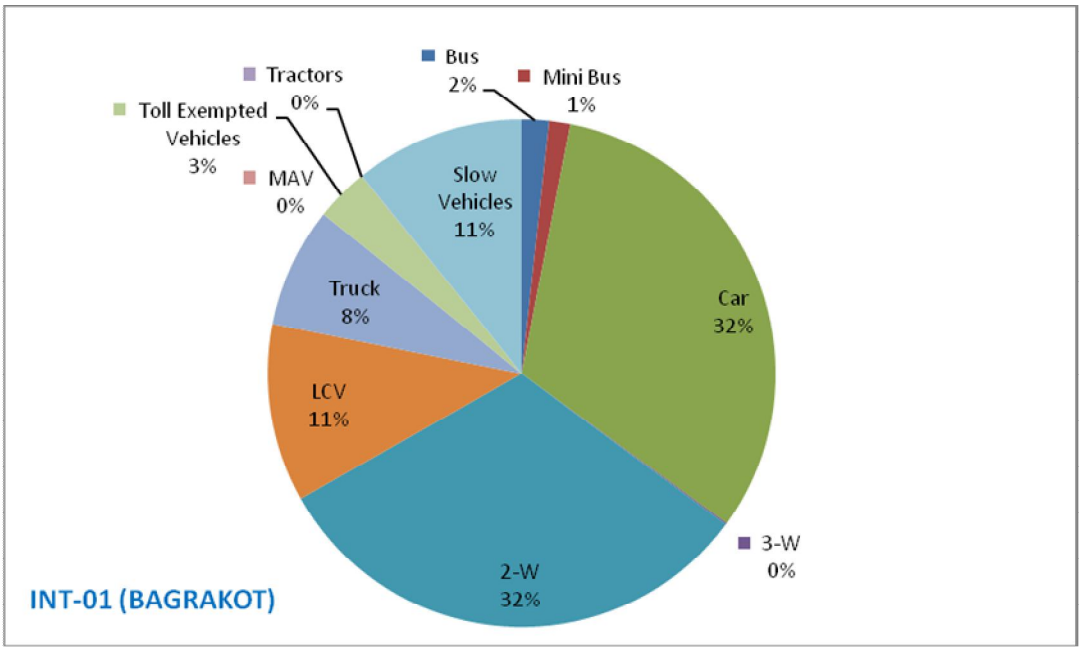
Sr. No.	Intersections	Locations Name	Approach Arm	Inflow/ Outflow	Entire Day	Morning Peak	Evening Peak
			ani	Outflow	38	4	2
				Both	78	6	7
Total Inflow at Intersection					596	78	59
4	INT -04	Rhenock	Algara	Inflow	218	24	18
				Outflow	239	21	31
				Both	456	45	49
			Roarthang	Inflow	505	54	52
				Outflow	486	68	57
				Both	991	122	109
			Rongali	Inflow	192	34	22
				Outflow	221	30	18
				Both	413	63	40
			Rhenock Bazaar	Inflow	536	65	67
				Outflow	505	58	53
				Both	1041	123	119
Total Inflow at Intersection					914	111	92
5	INT -05	Roarthang Bridge	Rangpu	Inflow	447	36	56
				Outflow	367	51	35
				Both	814	87	90
			Roarthang	Inflow	222	33	15
				Outflow	210	16	12
				Both	431	48	27
			Rhenock	Inflow	372	38	33
				Outflow	465	40	57
				Both	837	77	89
Total Inflow at Intersection					669	69	71
6	INT -06	Rongali	Algarah	Inflow	192	20	17
				Outflow	156	15	20
				Both	348	35	37
			Roarthang	Inflow	111	11	12
				Outflow	138	15	10
				Both	248	26	22
			Rongali	Inflow	237	25	23
				Outflow	246	27	23

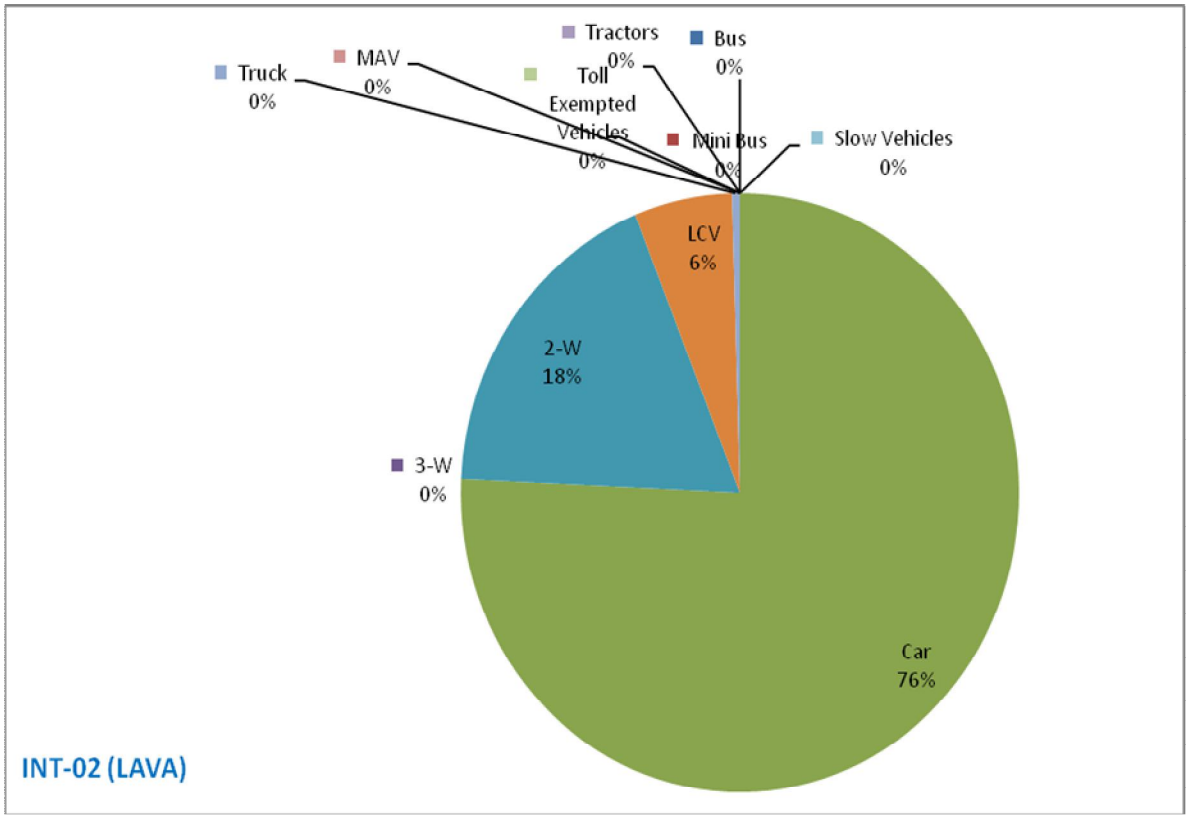
Sr. No.	Intersections	Locations Name	Approach Arm	Inflow/ Outflow	Entire Day	Morning Peak	Evening Peak
				Both	483	51	46
Total Inflow at Intersection					540	56	52

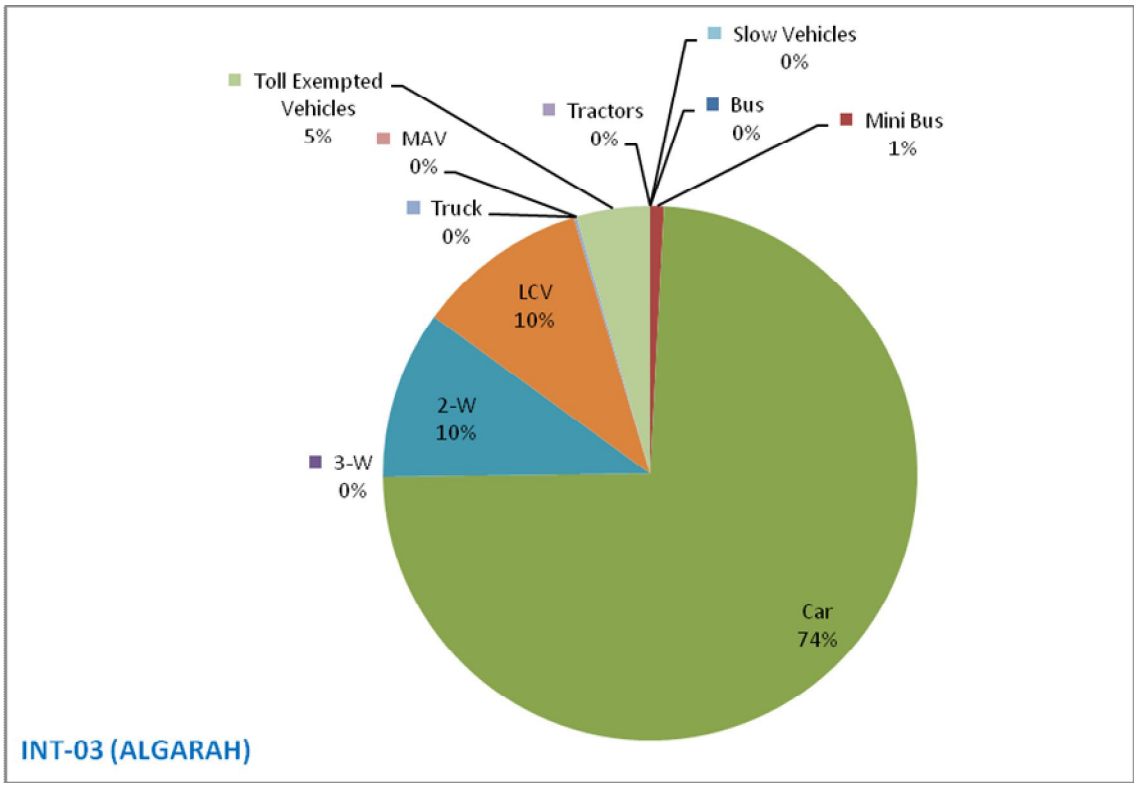
Source: Traffic Survey, January 2015

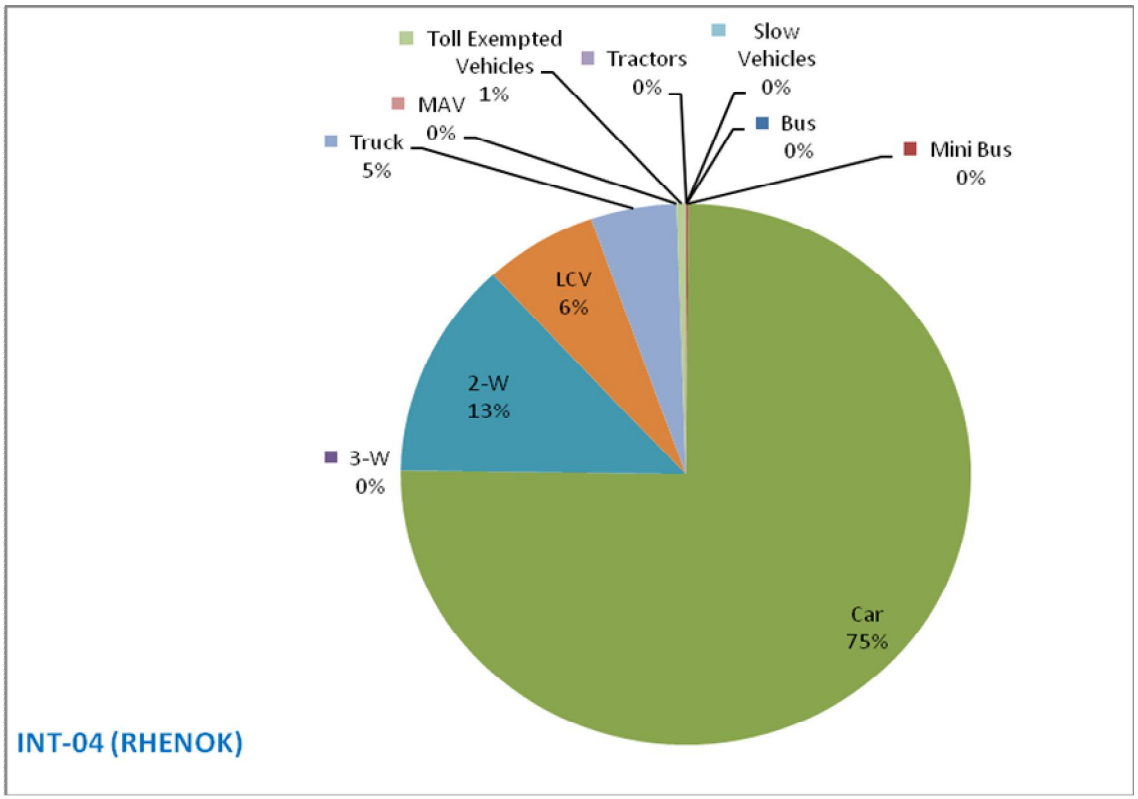
4.10.2 Traffic Composition at Study Intersection

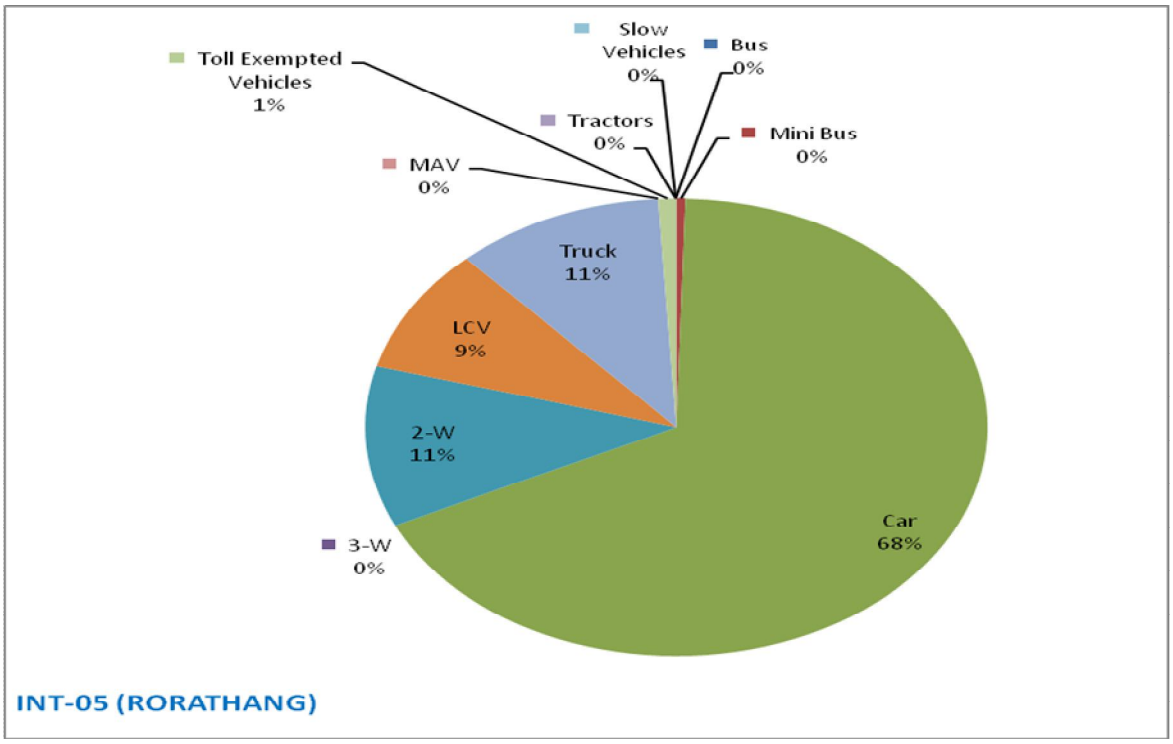
The traffic composition chart shows that the share of cars are varies from 32% to 75%, share of 2-wheelers are varies from 10% to 32% among the six intersection location. The share of LCV's are varies from 6% 11% while the share of trucks are varies from 1% to 11% among the location. The share of buses and slow vehicles are negligible. The traffic composition at each intersection is presented in **Figure 4.8.**




Tractors 0%
Bus 0%
Truck 0%
MAV 0%
Toll Exempted Vehicles 0%
Mini Bus 0%
Slow Vehicles 0%
LCV 6%
2-W 18%
3-W 0%
Car 76%
INT-02 (LAVA)


Slow Vehicles 0%
Toll Exempted Vehicles 5%
Tractors 0%
Bus 0%
Mini Bus 1%
MAV 0%
Truck 0%
LCV 10%
2-W 10%
3-W 0%
Car 74%
INT-03 (ALGARAH)


Toll Exempted Vehicles 1%
Tractors 0%
Slow Vehicles 0%
MAV 0%
Bus 0%
Truck 5%
Mini Bus 0%
LCV 6%
2-W 13%
3-W 0%
Car 75%
INT-04 (RHENOK)



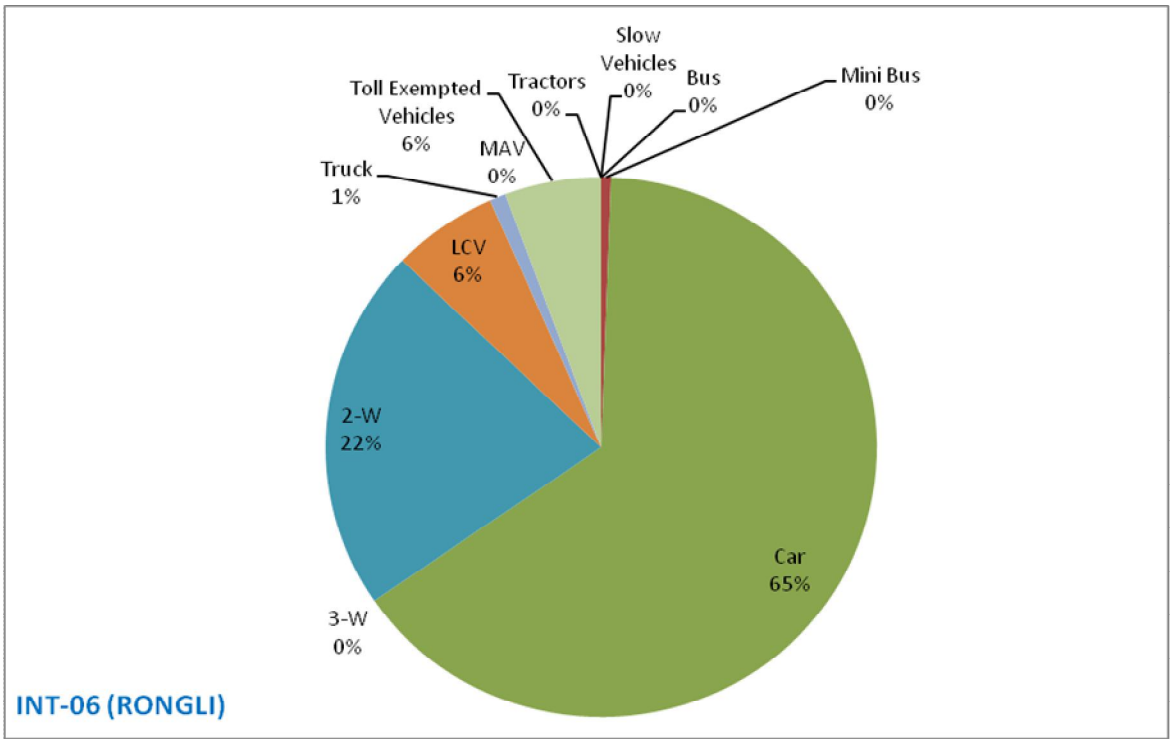
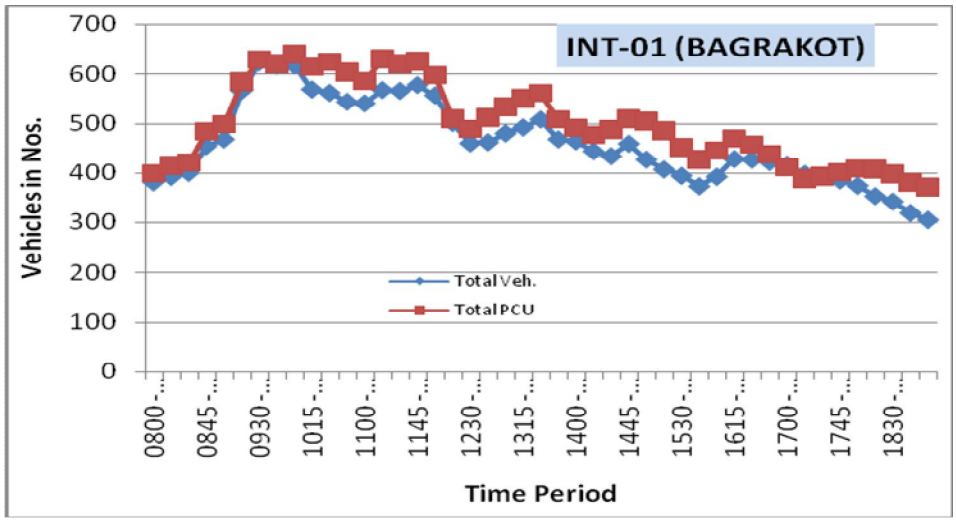
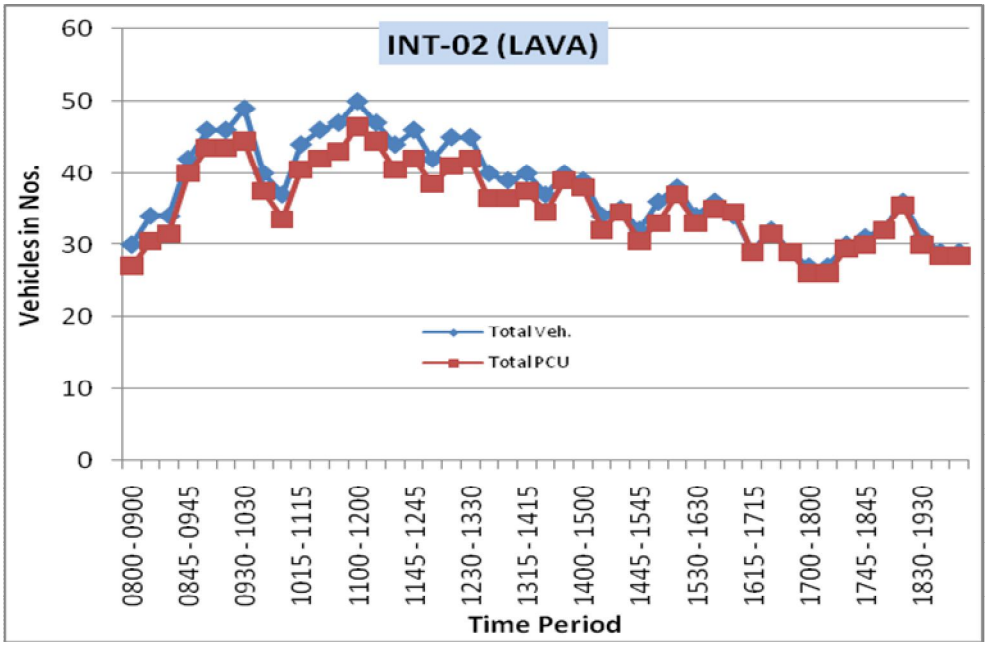


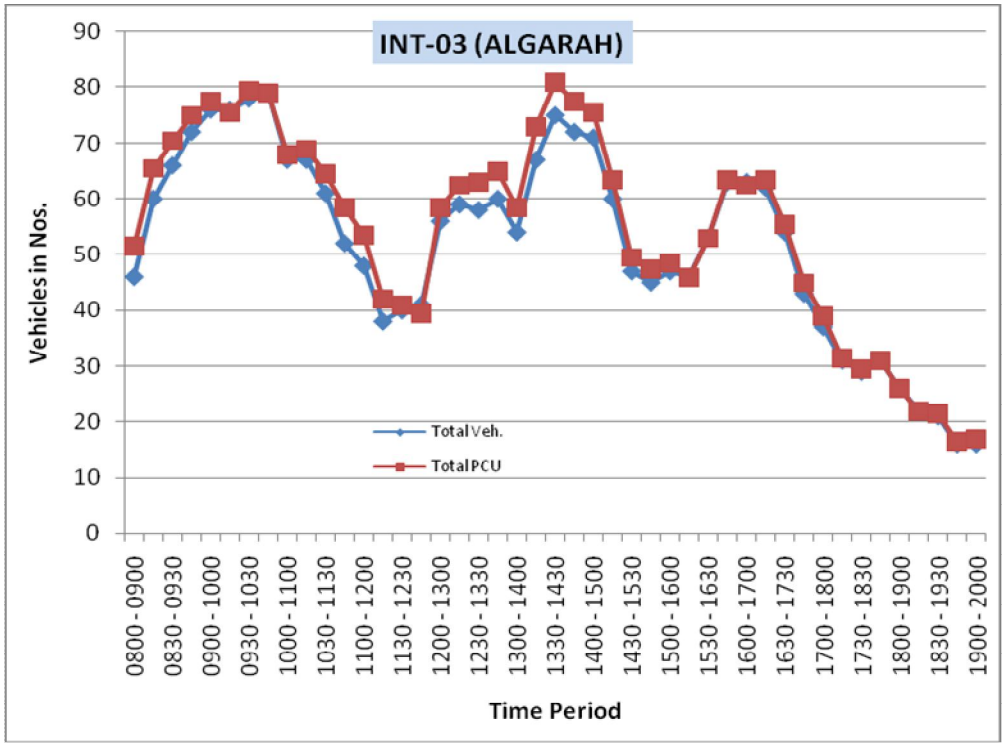
FIGURE 4.8 TRAFFIC COMPOSITION AT STUDY INTERSECTION

4.10.3 Hourly Variation of Traffic at Study Intersection

The Hourly variation of total approach traffic by hour is presented in Figure 5.9. It could be observed from the graphs the peak hour extend for more than one hour at most intersections while the distinct peaks are visible during morning and evening peak hour.






INT-03 (ALGARAH)
Vehicles in Nos.
Time Period
Total Veh.
Total PCU
0
10
20
30
40
50
60
70
80
90
0800 - 0900
0830 - 0930
0900 - 1000
0930 - 1030
1000 - 1100
1030 - 1130
1100 - 1200
1130 - 1230
1200 - 1300
1230 - 1330
1300 - 1400
1330 - 1430
1400 - 1500
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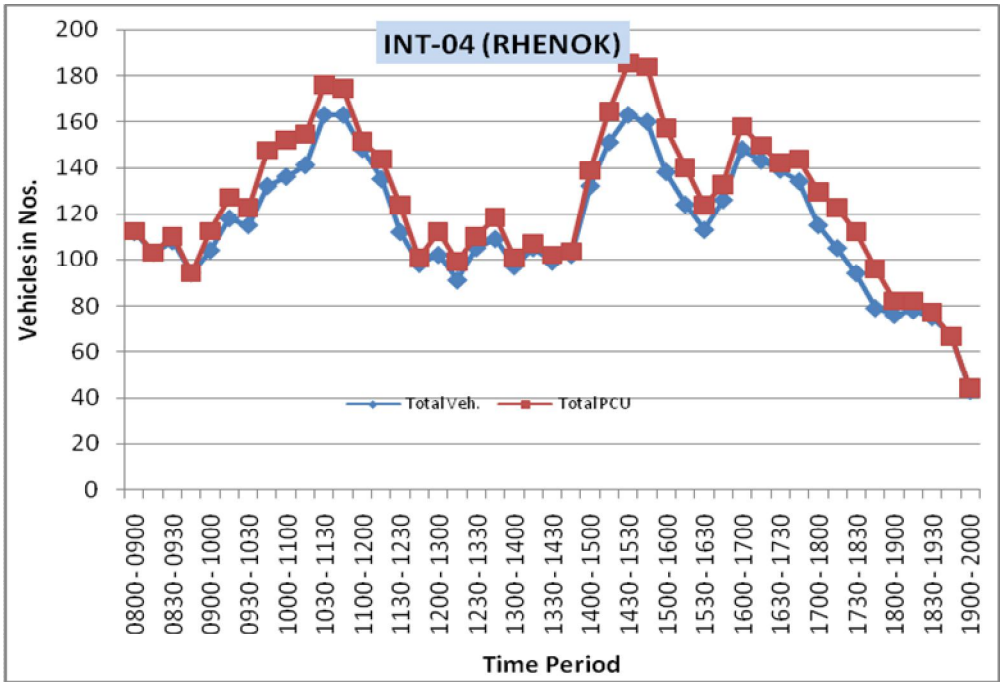
1630 - 1730
1700 - 1800
1730 - 1830
1800 - 1900
1830 - 1930
1900 - 2000


INT-04 (RHENOK)
Vehicles in Nos.
Time Period
Total Veh.
Total PCU
0
20
40
60
80
100
120
140
160
180
200
0800 - 0900
0830 - 0930
0900 - 1000
0930 - 1030
1000 - 1100
1030 - 1130
1100 - 1200
1130 - 1230
1200 - 1300
1230 - 1330
1300 - 1400
1330 - 1430
1400 - 1500
1430 - 1530
1500 - 1600
1530 - 1630
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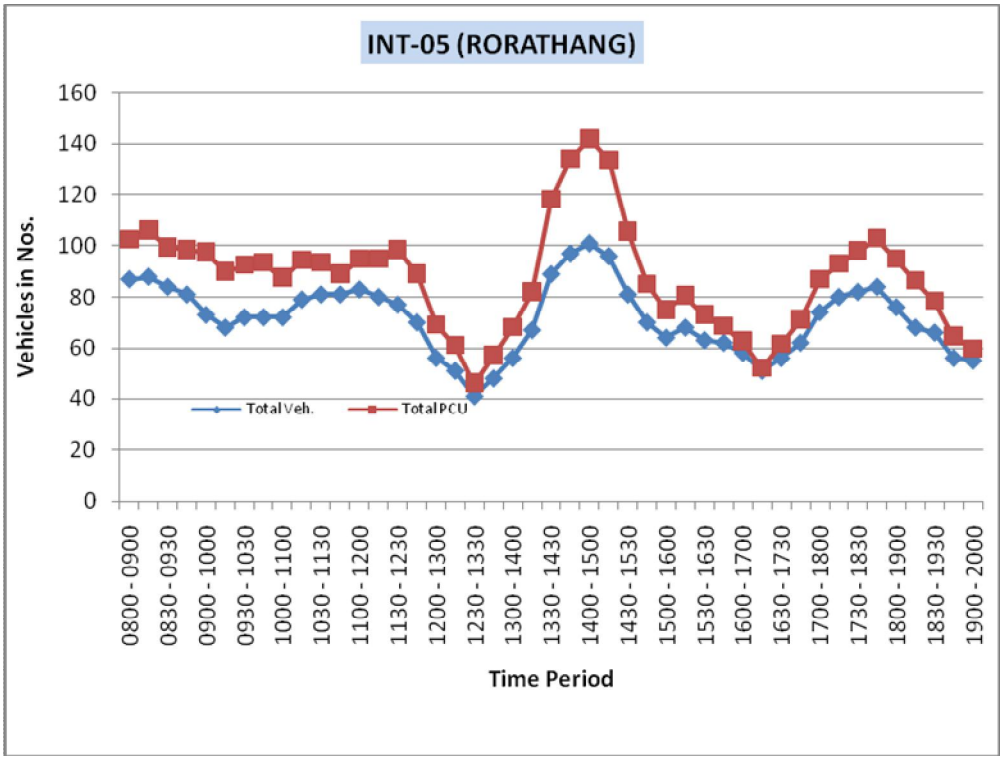
1630 - 1730
1700 - 1800
1730 - 1830
1800 - 1900
1830 - 1930
1900 - 2000



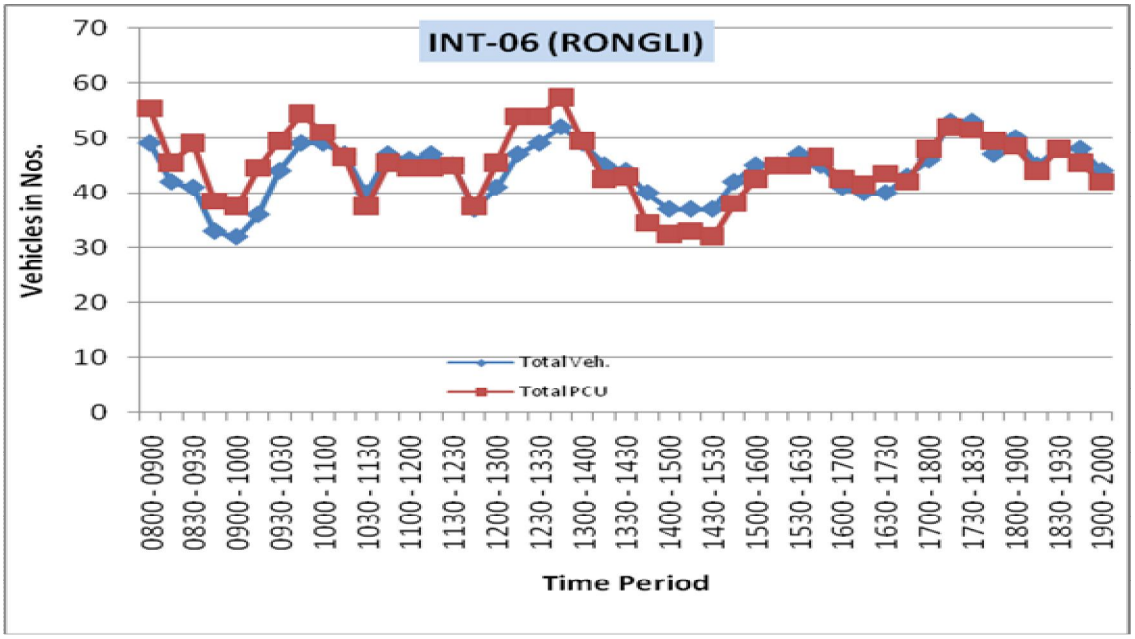


FIGURE 4.9 HOURLY VARIATION OF TRAFFIC AT STUDY INTERSECTION

4.10.4 Traffic Flow Diagram along project corridor at Intersections

The traffic flow diagram at study intersections during entire day and peak hours in terms of PCU's are presented in **Appendix 4.1.**

4.11 TRIP CHARACTERISTICS

4.11.1 Sample Size of Traffic

The vehicles were stopped on random sampling basis to avoid any bias in data. The sample size varied across modes and by locations depending on the police support, traffic volumes and site condition. These sample size achieved for passenger and goods vehicles is presented in **Table 4.9.**

TABLE 4.9 MODEWISE SAMPLE SIZE ACHIEVED

Mode	OD-01 Kalijhora (NH-31A)	OD-02 (Baluwakhani Check Post) SH-12	OD-03 (3rd Mile Check Post) JLN Marg
Car/Van/ Jeep	20%	46%	45%
Mini Bus	15%	70%	-
Bus	85%	-	-
2-W	14%	32%	5%
LCV	37%	84%	73%
2-Axle Truck	38%	-	74%
3-Axle Truck	40%	-	-
MAV	54%	-	-

Source: Field Surveys, January 2015

4.11.2 Traffic Zoning Scheme

The project road has start point from Bagrakot in the District of Jalpaiguri (West Bengal) and end at Pakyong in the district of East Sikkim (Sikkim). The project road also passing through the district of Darjeeling (West Bengal). The project road direct connects the two Indian State, Sikkim and West Bengal. The Immediate Influence District of project road is Jalpaiguri, Darjeeling in the West Bengal and East Sikkim in the State of Sikkim. The consultant has done zoning of the influence districts based on districts tehsils boundary for the assessment of trip distribution and analysis of potential divertible traffic. The total numbers of zones are 23 for the estimation of potential divertible traffic. While 17 zones are categorized into zones of immediate influence around the study area, 4 zones belong to rest of India and 2 nos. of zones as neighbouring countries. The description of zoning scheme is presented in **Table 4.11** and the graphically presented in **Figure 4.10 and 4.11.**

TABLE 4.10 ZONING SCHEME

Zone.No.	Zone Name	District	State
1	Chungthang, Lachung, Mangan, Mangshila	North District	Sikkim
2	Gangtok, Rumtek, Ranipool	East District	
3	Nathu La, Menla, Chhanggu, Tsongmo Lake, Kupup		
4	Nathang Valley, Aritar, Rhenok, Rongli, Lungthang		
5	Pakyong, Rorathang		
6	Yangang, Ravangla, Raley-Khese, Damthang, Pabong, Khamdong, Ravong	South District	
7	Singtham, Bardang, West Pendam, Majtar, Rangpo, Phong, Manpur, Namchi		
8	Yuksom, Pelling, Legship, Gyalshing, Kaluk, Sorong, Nayabazar	West District	
9	Ghoom, Darjeeling, Senchal, Rangliot, Tukdah Forest, Pandom, Pattabong, North-West Point, Pullbazar, Sukiapokhri	Darjiling District	West Bengal
10	Khoribari, Naxalbari, Bagdogra, Matigarahat, Mallaguri, Mirik, Kurseong, Pankhabari, Sevok, Phonsidewa		
11	Riyong Forest, Mangwa Forest, Sunwar Gaon, Tista Bazar, Kalimpong, Chandralake		
12	Pedong, Labha, Dalepchan Reserve Forest, Pudung Khasmahal, Palla Khasmahal, Mansong		
13	Khampong, Lava, Kolbong Forest, Rishop, Ladam Khasmahal, Neora Valley National Park, Nim Khasmahal, Gorubathan	Jalpaiguri District	
14	Bagrakot, Dim Dam, Mal Bazar, Mal Forest, Dhalabari, Kraanti, Lataguri		
15	New Jalpaiguri Railway Station, Silliguri City, Ambari		
16	Jalpaiguri City, Mayanguri, Panbari, Madhya Khagrabari		
17	Nagrakta, Kurti, Chalsa, Mangalbari, Matiali, Banarhat, Dhupguri		
18	Alipurduar & Cooch Behar District	Alipurduar & Cooch Behar District	
19	Rest of West Bengal	-	
20	North East Region	-	Rest of India
21	Rest of India	-	
22	Bangladesh	-	Other Country
23	Nepal	-	

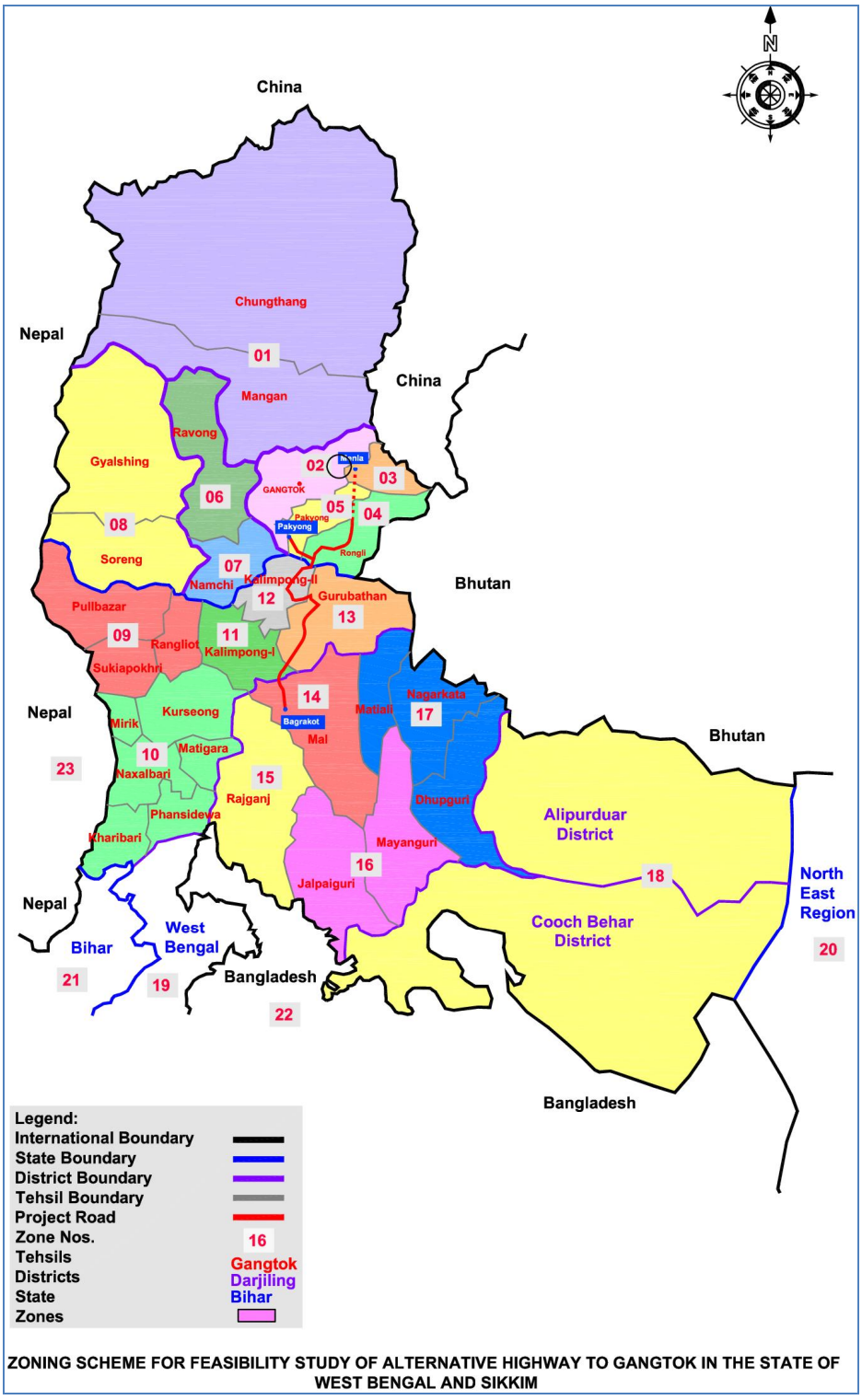


FIGURE 4.10 ZONING SCHEME (IMMEDIATE INFLUENCE AREA)

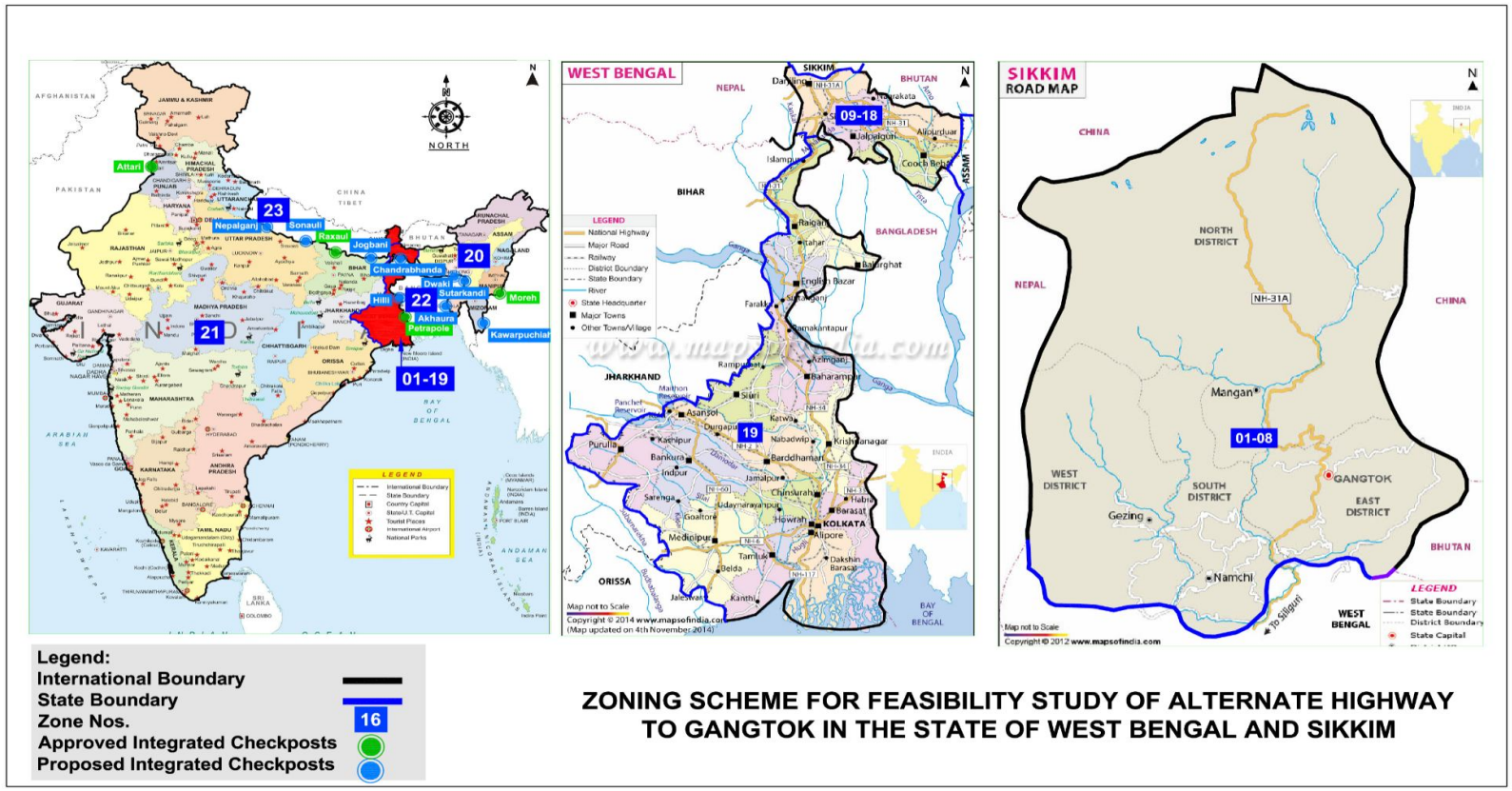


FIGURE 4.11 ZONING SCHEME (BROAD INFLUENCE AREA)

4.11.3 Trip Characteristics of Passenger Vehicle

The passenger trips are categorized into four categories, Internal-Internal trips (within the immediate influence districts of project road), Internal-External Trips - IE (Study area to Outside), External-Internal – EI (Outside to Study Area) and External-External- EE (Through traffic).

The result shows that at OD-01, the share of bypassing trips of passenger vehicles are 46% and 23% passenger vehicles are moving from inside to outside and 29% trips moving outside to inside. The share of Internal-Internal trips are negligible. At OD-02, the share of bypassing trips are negligible while the share of internal-internal trips are 97%. At OD-03, the share of external trips are 99% and the share of other trips are negligible. The details are presented in **Table 4.11**.

TABLE 4.11 TRIP CHARACTERISTICS OF PASSENGER VEHICLES

Location	Mode	I-I	I-E	E-I	E-E	Total
OD-01 (Kalijhora) NH-31	**Car**	30 (1%)	847 (23%)	1106 (30%)	1662 (46%)	**3645 (100%)**
	Mini Bus	0 (0%)	15 (12%)	29 (22%)	85 (66%)	**129 (100%)**
	Bus	0 (0%)	1 (10%)	4 (40%)	5 (50%)	**10 (100%)**
	2-W	5 (2%)	87 (31%)	58 (21%)	130 (46%)	**280 (100%)**
	Total	**35 (1%)**	**950 (23%)**	**1197 (29%)**	**1882 (46%)**	**4064 (100%)**
OD-02 (Baluwakhani Check post) SH-12	**Car**	245 (96%)	7 (3%)	3 (1%)	0 (0%)	**255 (100%)**
	Mini Bus	1 (100%)	0 (0%)	0 (0%)	0 (0%)	**1 (100%)**
	Bus	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	2-W	50 (100%)	0 (0%)	0 (0%)	0 (0%)	**50 (100%)**
	Total	**296 (97%)**	**7 (2%)**	**3 (1%)**	**0 (0%)**	**306 (100%)**
OD-03 (3rd Mile Check post) JLN Marg	**Car**	2 (0%)	2 (0%)	0 (0%)	670 (99%)	**674 (100%)**
	Mini Bus	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	Bus	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	2-W	0 (0%)	0 (0%)	0 (0%)	10 (100%)	**10 (100%)**
	Total	**2 (0%)**	**2 (0%)**	**0 (0%)**	**680 (99%)**	**684 (100%)**

Source: Field Surveys, January 2015

4.11.4 Trip Characteristics of Goods Vehicle

The analysis of trip characteristics of Goods vehicles show that at OD-01, the share of bypassing trips of goods vehicles are 39% and 29% passenger vehicles are moving from inside to outside and 30% trips moving outside to inside. The share of Internal-Internal trips are only 3%. At OD-02, the share of bypassing trips are negligible while the share of internal-internal trips are 100%. At OD-03, the share of external trips are 24% and the share of internal-internal trips negligible. The details are presented in **Table 4.12**.

TABLE 4.12 TRIP CHARACTERISTICS OF GOODS VEHICLES

Location	Mode	I-I	I-E	E-I	E-E	Total
OD-01 (Kalijhora) NH-31	LCV	27 (4%)	213 (30%)	207 (29%)	264 (37%)	**711 (100%)**
	2-Axle	29 (3%)	284 (27%)	314 (30%)	408 (39%)	**1035 (100%)**
	3-Axle	1 (4%)	8 (29%)	3 (11%)	16 (57%)	**28 (100%)**
	MAV	0 (0%)	1 (100%)	0 (0%)	0 (0%)	**1 (100%)**
	Total	**57 (3%)**	**506 (29%)**	**524 (30%)**	**688 (39%)**	**1775 (100%)**
OD-02 (Baluwakhani Check post) SH-12	LCV	48 (100%)	0 (0%)	0 (0%)	0 (0%)	**48 (100%)**
	2-Axle	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	3-Axle	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	MAV	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	Total	**48 (100%)**	**0 (0%)**	**0 (0%)**	**0 (0%)**	**48 (100%)**
OD-03 (3rd Mile Check post) JLN Marg	LCV	0 (0%)	1 (10%)	4 (40%)	5 (50%)	**10 (100%)**
	2-Axle	0 (0%)	4 (27%)	10 (67%)	1 (7%)	**15 (100%)**
	3-Axle	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	MAV	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	Total	**0 (0%)**	**5 (20%)**	**14 (56%)**	**6 (24%)**	**25 (100%)**

Source: Field Surveys, January 2015

4.12 TRAVEL CHARACTERISTICS OF PASSENGER VEHICLES

4.12.1 Travel Purpose for Passenger Vehicles

The analysis shows that the share of work trips is 46% followed by business trips 12%. The share of recreation/ tourism is 28% while other trips are 13%. The details are presented in **Table 4.13.**

TABLE 4.13 PURPOSE OF WORK OF PASSENGER VEHICLES

Purpose	OD-01 (Sevoke)		OD-02 (Baluwakhani Check post)		OD-03 (3rd Mile Check post)		Total	
	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age
Work	1972	48%	252	82%	109	16%	**2333**	46%
Business	583	14%	3	1%	0	0%	**585**	12%
Education	58	1%	6	2%	0	0%	**64**	1%
Recreation/ Tourism	785	19%	44	14%	572	83%	**1401**	28%
Other	672	17%	4	1%	5	1%	**680**	13%
Total	**4070**	**100%**	**308**	**100%**	**685**	**100%**	**5063**	**100%**

Source: Field Surveys, January 2015

4.12.2 Travel Frequency of Passenger Vehicles

The analysis of travel purpose of passenger vehicles shows that the share of daily trips is highest at all the survey locations. The share of frequent trips is also high (24%)at OD-01 location. The details are presented in **Table 4.14.**

TABLE 4.14 TRAVEL FREQUENCY OF PASSENGER VEHICLES

Frequency	OD-01 (Sevoke)		OD-02 (Baluwakhani Checkpost)		OD-03 (3rd Mile Checkpost)		Total	
	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age
Daily	1739	43%	181	59%	672	98%	**2591**	51%
Weekly	706	17%	86	28%	13	2%	**806**	16%
Bi-Weekly	317	8%	8	3%	0	0%	**326**	6%
Monthly	332	8%	31	10%	0	0%	**363**	7%
Occasionally	975	24%	2	1%	0	0%	**977**	19%
Total	**4070**	**100%**	**308**	**100%**	**685**	**100%**	**5063**	**100%**

Source: Field Surveys, January 2015

4.12.3 Travel Length Frequency of Passenger Vehicles

The trip lengths of Individual modes at different locations is presented in **Table 4.15**. The weighted trips length of passenger vehicles are 89 kms, 30 kms and 20 kms respectively for OD-01, OD-02 and OD-03.

TABLE 4.15 WEIGHTED TRIP LENGTH FREQUENCY FOR PASSENGER VEHICLES (IN KMS.)

Mode	OD-01 Sevoke	OD-02 Baluawakhani Checkpost	OD-03 3rd Mile Checkpost
Car	92	32	20
Mini Bus	94	125	0
Bus	95	0	0
2-W	54	17	10
Total	**89**	**30**	**20**

4.13 TRAVEL CHARACTERISTICS OF GOODS VEHICLES

4.13.1 Commodities Carried by Goods Vehicles

The analysis of commodity carried by goods vehicles shows that the 46% goods vehicles moving around project road with no commodity while 23% goods vehicles carried building materials. About 14% goods vehicles was carried perishable items while 4% goods vehicles carried chemicals and medicine products. The details are presented in **Table 4.16.**

TABLE 4.16 COMMODITY CARRIED BY GOODS VEHICLES

Commodity Type	OD-01 (Sevoke)		OD-02 (Baluwakhani Check post)		OD-03 (3rd Mile Check post)		Total	
	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age
Empty	824	**46%**	13	**27%**	21	**75%**	**858**	**46%**
Building Material	415	**23%**	13	**26%**	5	**20%**	**433**	**23%**
Coal/ Ore Minerals	3	**0%**	0	**0%**	0	**0%**	**3**	**0%**

Commodity Type	OD-01 (Sevoke)		OD-02 (Baluwakhani Check post)		OD-03 (3rd Mile Check post)		Total	
	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age
Food Grains	93	**5%**	1	**2%**	0	**0%**	**94**	**5%**
Vegetables/ Fruit/ Fish	166	**9%**	0	**0%**	0	**0%**	**166**	**9%**
Chemicals/ Medicine	81	**5%**	0	**0%**	0	**0%**	**81**	**4%**
Petroleum Product	24	**1%**	1	**2%**	1	**5%**	**26**	**1%**
Milk & milk Product	3	**0%**	2	**5%**	0	**0%**	**5**	**0%**
Machinery Parts	16	**1%**	3	**7%**	0	**0%**	**20**	**1%**
Cloths	11	**1%**	0	**0%**	0	**0%**	**11**	**1%**
Wooden	15	**1%**	5	**10%**	0	**0%**	**20**	**1%**
Iron	14	**1%**	0	**0%**	0	**0%**	**14**	**1%**
Fiber/ Plastic	30	**2%**	0	**0%**	0	**0%**	**30**	**2%**
Parcels	16	**1%**	0	**0%**	0	**0%**	**16**	**1%**
Other	70	**4%**	10	**20%**	0	**0%**	**80**	**4%**
Total	**1781**	**100%**	**49**	**100%**	**27**	**100%**	**1857**	**100%**

Source: Field Surveys, January 2015

4.13.2 Travel Frequency of Goods Vehicles

The analysis of frequency of travel of Goods vehicles shows that the share of daily and weekly trips is highest at all locations. The details are presented in **Table 4.17.**

TABLE 4.17 TRAVEL FREQUENCY OF GOODS VEHICLES

Frequency	OD-01 (Sevoke)		OD-02 (Baluwakhani Checkpost)		OD-03 (3rd Mile Checkpost)		Total	
	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age	No. of Trips	% age
Daily	1217	68%	24	49%	25	91%	**1266**	68%
Weekly	450	25%	24	49%	3	9%	**476**	26%
Bi-Weekly	43	2%	0	0%	0	0%	**43**	2%
Monthly	29	2%	1	2%	0	0%	**30**	2%
Occasionally	41	2%	0	0%	0	0%	**41**	2%
Total	**1781**	**100%**	**49**	**100%**	**27**	**100%**	**1857**	**100%**

Source: Field Surveys, January 2015

4.13.3 Travel Length Frequency of Goods Vehicles

The analysis of trip length of LCV's are 89 kms, 27 kms and 44 kms for OD-01, OD-02 and OD-03 respectively. The weighted trips length of goods vehicles are 97 kms, 27 kms

and 53 kms respectively for OD-01, OD-02 and OD-03. The details are presented in **Table 4.18**.

TABLE 4.18 WEIGHTED TRIP LENGTH FREQUENCY DISTRIBUTION FOR GOODS VEHICLES (IN KMS.)

Mode	OD-01 Sevoke	OD-02 Baluawakhani Check post	OD-03 3rd Mile Check post
LCV	89	27	44
2/3 Axle Truck	103	-	58
MAV	25	-	-
Total	**97**	**27**	**53**

Source: Field Surveys, January 2015

4.14 AXLE LOAD DATA ANALYSIS

The Axle Load survey was carried out at one location (Kalijhora, Near Sevoke along NH-31A) to appreciate the loading characteristics of goods vehicles and the damage potential of these vehicles have been estimated using a metric called **Vehicle Damage Factor (VDF)**.

The consultant have carried out axle load survey on sample basis at one locations. The sample were taken randomly for goods vehicles (LCV, Trucks).The estimated sample size achieved at survey location is presented in **Table 4.19.**

TABLE 4.19 SAMPLE SIZE ACHIEVED FOR AXLE LOAD SURVEY AT KALIJHORA NEAR SEVOKE (NH-31A)

Mode	Siliguri-Sikkim			Sikkim-Siliguri			Total		
	Surveyed Vehicles	Volume Count	**Sample**	Surveyed Vehicles	Volume Count	**Sample**	**Surveyed Vehicles**	**Volume Count**	**Sample**
LCV	142	305	**47%**	110	407	**27%**	**252**	**712**	**35%**
2 - AXLE	186	537	**35%**	115	500	**23%**	**301**	**1037**	**29%**
3 Axle	2	13	**15%**	4	18	**22%**	**6**	**31**	**19%**
MAV	1	1	**100%**	1	1	**100%**	**2**	**2**	**100%**

Source: Field Surveys, January 2015

The consultant have estimate Vehicle Damage Factor (VDF) using equivalence factor for different types of commercial vehicles as IRC:37-2012 “Design of Flexible Pavement”. The results of analysis shows that the average VDF in direction of travel from Silliguri to Sikkim is high as 3.08 while only 0.45 average VDF in the direction of travel from Sikkim to Silliguri. The reason for the high VDF in one direction of travel that most of the trucks load commodities from Silliguri Side and unload commodities to Gangtok Side and their return trips of trucks are

empty. Therefore the analysis shows high VDF in one direction of travel from Silliguri to Sikkim. The details are presented in **Table 4.20.**

Table 4.20 Estimation of Vehicle Damage AT KALIJHORA NEAR SEVOKE (NH-31A)

MODE	Silliguri-Sikkim			Sikkim-Siliguri		
	Equivalence Factor	No. of Vehicles	VDF	Equivalence Factor	No. of Vehicles	VDF
LCV	164.72	142	1.16	17.98	110	0.16
2 - AXLE	849.87	186	4.57	68.52	115	0.60
3 Axle	2.73	2	1.36	14.07	4	3.52
MAV	1.49	1	1.49	3.65	1	3.65

4.15 TRAFFIC FORECAST

4.15.1 APPROACH

Traffic growth on a road facility is generally estimated on the basis of historical trends. Demand changes are usually due to shifts in the pattern of economic activities in the surrounding regions. Hence, future traffic estimation necessitates a preview, however imprecise, of the probable pattern of future growth of the economy. Growth of traffic on the project road depends on existing development and future growth prospects of the connecting regions. The time series data of state income at constant prices (2004-2005 base) i.e. the NSDP (by industry of origin) for the PIA state of Sikkim and West Bengal, published by various organizations has been studied to assess the past performance of influencing state economies.

4.15.2 METHODOLOGY FOR TRAFFIC GROWTH RATE ESTIMATION

The exercise of traffic growth rate estimation has been carried out by the consultants using the elasticity approach. The elasticity method mathematically relates traffic growth to changes in the related economic parameters. According to IRC-108, 1996, elasticity based econometric model for highway projects could be derived in the following form:

$\text{Log}_e (P) = A_0 + A_1 \text{Log}_e (E.I.)$

Where;

P = Registered Vehicles

E.I. = Economic Indicator i.e. GDP, NSDP and PCI

A0 = Regression Constant

A1 = Regression Co-efficient (Elasticity Index)

The main stages in carrying out this analysis are as follows:

Stage 1*- At this stage the Time Series socio economic data has been collected regarding vehicle registration, Per capita income, Net State Domestic Product; and population of Sikkim and West Bengal. Data has also been collected on trends in Gross domestic Product (GDP) of country. These are categorized as dependent and independent variables.*

Stage 2 - *After the completion of stage 1, the average mode wise growth rates of these parameters has been calculated.*

Stage 3 - *Regressing the dependent variable with the independent variable will fetch elasticity between socio-economic parameters and average mode wise growth rates. This is done to make projections of traffic relatively more accurate and realistic.*

Stage 4 –*Multiplying mode wise elasticity with growth rate of respective socio-economic parameters will yield mode wise growth rates.*

4.15.3 TRAFFIC PATTERN IN PROJECT INFLUENCE AREA (PIA)

To identify the influence areas, that generate maximum trips in the study area, a Zone Influence Factor (ZIF) table was prepared from the OD data. This table revealed that the majority of trips are generated in Sikkim and West Bengal. The ZIF table is presented in **Annexure-3**.

The analysis of contribution of trip shows that the share of for Cars, Buses, LCV's and Trucks trips in the state of Sikkim is 39%, 25%, 35% and 38% respectively while the respective share of these modes in in the state of West Bengal is 61%, 75%, 65% and 62%. The details are presented in **Table 4.1.**

TABLE 4.1 PERCENTAGE CONTRIBUTION OF TRIPS AMONGST PIA STATES (%)

State	Car	Bus	LCV	Trucks
Sikkim	39	25	35	38
West Bengal	61	75	65	62
Total	100	100	100	100

Source: Field surveys, January 2015

4.15.4 ECONOMIC DATA ANALYSIS

The consultants have collected past economic data from website of Reserve Bank of India (RBI), Planning Commission, Directorate of Economics and Statistics.

The economic statistics shows that the growth rate of GDP of the country was 7.97% during 2004-05 to 2012-13. The average growth rate of NSDP of the state of Sikkim was 17.37% over the 9 year and the PCI growth rate was 15.97% during the same period. The details are presented in **Table 4.2.**

TABLE 4.2 ECONOMIC DATA OF SIKKIM (AT 2004-05 CONSTANT PRICES)

Years	GDP (Rs. Billion)	Growth %	NSDP (Rs. Billion)	Growth %	PCI (NSDP) Rs.	Growth %	POP	Growth %
2004-2005	29715	-	15	-	26690	-	566129.64	-
2005-2006	32531	9.48%	17	9.99%	29008	8.68%	572945.39	1.20%
2006-2007	35644	9.57%	18	5.90%	30293	4.43%	580992.31	1.40%
2007-2008	38966	9.32%	19	5.80%	31722	4.72%	586974.34	1.03%
2008-2009	41587	6.72%	21	13.10%	35394	11.58%	595016.1	1.37%
2009-2010	45161	8.59%	37	73.74%	60774	71.71%	602066.67	1.18%
2010-2011	49185	8.91%	40	10.08%	66136	8.82%	609048.02	1.16%
2011-2012	52475	6.69%	45	12.91%	73704	11.44%	617062.85	1.32%
2012-2013	54821	4.47%	49	7.43%	78427	6.41%	622999.73	0.96%
Average		**7.97%**		**17.37%**		**15.97%**		**1.20%**

Source: Reserve Bank of India

The analysis of West Bengal statistics between year 2004-05 & 2012-13 shows that the average growth rate of NSDP was 6.22%. The per capita income growth rate is 5.18% while the population growth rate was about 1%. The economic data of West Bengal is presented in **Table 4.3.**

TABLE 4.3 ECONOMIC DATA OF WEST BENGAL (AT 2004-05 CONSTANT PRICES)

Years	GDP (Rs. Billion)	Growth %	NSDP (Rs. Billion)	Growth %	PCI (NSDP) Rs.	Growth %	POP	Growth %
2004-2005	29715	-	1900	-	22649	-	83901718	-
2005-2006	32531	9.48%	2020	6.30%	23808	5.12%	84842910	1.12%
2006-2007	35644	9.57%	2178	7.85%	25400	6.69%	85767323	1.09%
2007-2008	38966	9.32%	2348	7.78%	27094	6.67%	86660515	1.04%
2008-2009	41587	6.72%	2443	4.03%	27914	3.03%	87505195	0.97%
2009-2010	45161	8.59%	2632	7.77%	29799	6.75%	88335179	0.95%
2010-2011	49185	8.91%	2792	6.06%	31314	5.08%	89158523	0.93%
2011-2012	52475	6.69%	2894	3.67%	32164	2.71%	89986942	0.93%
2012-2013	54821	4.47%	3077	6.32%	33889	5.36%	90802325	0.91%
Average		**7.97%**		**6.22%**		**5.18%**		**0.99%**

Source: Reserve Bank of India

4.15.5 REGISTRED VEHICLES

Registered Vehicles in Sikkim

The analysis of registered vehicles data shows that, the average growth rate of registered car is about 14% over 8 years while growth rate of trucks is 12%. The average growth rate of buses is at8.6%. The average growth rate of 2-wheelers is 6%. The details are presented in **Table4.4.**

TABLE 4.4 REGISTERED VEHICLES OFSIKKIM

Years	Car	Growth %	Buses	Growth %	LCV	Growth %	Trucks	Growth %	2-W	Growth %
2004-2005	12028	-	263	-	417	-	1769	-	4957	-
2005-2006	13944	15.9%	273	3.8%	489	17.3%	1915	8.3%	5282	6.6%
2006-2007	15815	13.4%	278	1.8%	585	19.6%	2270	18.5%	5549	5.1%
2007-2008	16665	5.4%	283	1.8%	605	3.4%	2490	9.7%	5793	4.4%
2008-2009	18758	12.6%	307	8.5%	750	24.0%	2755	10.6%	5956	2.8%
2009-2010	22736	21.2%	373	21.5%	795	6.0%	3214	16.7%	6308	5.9%
2010-2011	26925	18.4%	435	16.6%	823	3.5%	3547	10.4%	6843	8.5%
2011-2012	30319	12.6%	462	6.2%	947	15.1%	3930	10.8%	7447	8.8%
Average		**14.2%**		**8.6%**		**12.7%**		**12.1%**		**6.0%**

Source: Road Transport Year Book (2005-2012)

Registered Vehicles in West Bengal

It could be observed from the **Table 4.5**, the average growth rate of car is about 7.8% over 8 years while growth rate of trucks is 7.8%. The average growth rate of 2-wheeler is 12.2% over the 8 years. The details are presented in **Table 4.5.**

TABLE 4.5 REGISTERED VEHICLES OF WEST BENGAL

Years	Car	Growth %	Buses	Growth %	LCV	Growth %	Trucks	Growth %	2-W	Growth %
2004-2005	616974	-	38436	-	257277	-	257277	-	1698286	-
2005-2006	648919	5.2%	48422	26.0%	268720	4.4%	268720	4.4%	1845061	8.6%
2006-2007	698885	7.7%	49422	2.1%	289523	7.7%	289523	7.7%	2092596	13.4%
2007-2008	767652	9.8%	53538	8.3%	323092	11.6%	323092	11.6%	2402242	14.8%
2008-2009	812498	5.8%	55661	4.0%	343207	6.2%	343207	6.2%	2602670	8.3%
2009-2010	876612	7.9%	59358	6.6%	369894	7.8%	369894	7.8%	2923589	12.3%
2010-2011	958750	9.4%	61793	4.1%	401620	8.6%	401620	8.6%	3341752	14.3%
2011-2012	1045960	9.1%	63212	2.3%	434839	8.3%	434839	8.3%	3798808	13.7%
Average		**7.8%**		**7.6%**		**7.8%**		**7.8%**		**12.2%**

Source: Road Transport Year Book (2005-2012)

4.15.6 ELASTICITY OF TRANSPORT DEMAND

Elasticity of travel demand is the rate at which travel demand changes due to change in the corresponding economic variables selected. The growth rate for calculating elasticity is adopted from vehicles registration in West Bengal and Sikkim because the growth rates observed are more realistic as compared to the past traffic data.

For commercial vehicles, a model is developed for zones of immediate influence in the states of West Bengal and Sikkim by relating the growth of commercial vehicles to Net State Domestic Product (NSDP) in these influence states. This is done to relate the growth at origin and destination of commercial traffic in study corridor. The growth of commercial traffic at the national level has also been calculated by relating commercial vehicles population in country to the Gross Domestic Product (GDP). For the models developed for expressing the growth of commercial vehicles at state level as well as at national level, R^2 values, elasticity values and growth factors are derived.

In order, to estimate the elasticity of travel demand, the consultants have established the relationship between the growths of registered vehicles and the economic variables. This necessitates developing the regression equations to express dependent variable in terms of one or more independent variables. In this case, the dependent variable is registered vehicle, which is proxy variable for vehicle population Zone of Influence (State). The independent variable are socio-economic parameters; For the passenger vehicle like Cars, growth has been related to Per Capita Income and buses are related to population growth, while Commercial vehicles have been regressed with Economic parameters like GDP and NSDP of the country/ states through which this road passes while the growth of trucks is regressed with GDP Growth, the LCV's are regressed with NSDP changes over the analysis period.

4.15.7 ESTIMATE OF ELASTICITY

Based on the regression analysis the consultants have estimated the elasticity of growth of different modes. These results presented in **Table 4.6.**

TABLE 4.6 RESULTSOF REGRESSION ANALYSIS-SIKKIM

Registered Vehicles (Dependent Variable)	Independent Variable	Coefficient of Elasticity (b)	R Square - (Strength of relationship)
Car	Per Capita Income	0.75	0.93
Buses	Population	7.01	0.88
LCV	NSDP	0.57	0.81
Trucks	GDP	1.44	0.99
2-W	PCI	0.3	0.89

Source: Consultant Estimates

TABLE 4.7 RESULTS OF REGRESSION ANALYSIS-WEST BENGAL

Registered Vehicles (Dependent Variables)	Independent Variable	Coefficient (b) of Elasticity	R Square (Strength of relationship)
Car	PCI	1.46	0.98
Buses	Population	6.38	0.91
LCV	NSDP	1.25	0.99
Trucks	GDP	0.95	0.99
2-W	PCI	2.22	0.99

Source: Consultant Estimates

Based on past experience, the consultants have found that as a region grows, the travel demand increases. Consequently as the regional growth stabilizes, the rate of change reduces. It has been assumed for this study that that the elasticity values of respective modes will reduce by 10% every 5 years. This means that in the period of growth stabilization, the registration of vehicles will reduce by 10% every 5 years. The details are presented in **Table 4.8.**

TABLE 5.8 ELASTICITY FOR DIFFERENT HORIZON YEARS-SIKKIM

Mode	Up to 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	0.75	0.67	0.61	0.55	0.49	0.44	0.40
Buses	7.01	6.31	5.68	5.11	4.60	4.14	3.73
LCV	0.57	0.51	0.46	0.42	0.38	0.34	0.30
Trucks	1.44	1.29	1.16	1.05	0.94	0.85	0.76
2-W	0.30	0.27	0.25	0.22	0.20	0.18	0.16

Source: Consultant Estimates

TABLE 4.9 ELASTICITY FOR DIFFERENT HORIZON YEARS-WEST BENGAL

Mode	Up to 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	1.46	1.31	1.18	1.06	0.96	0.86	0.78
Buses	6.38	5.74	5.17	4.65	4.18	3.77	3.39
LCV	1.25	1.12	1.01	0.91	0.82	0.74	0.66
Trucks	0.95	0.85	0.77	0.69	0.62	0.56	0.50
2-W	2.22	2.00	1.80	1.62	1.45	1.31	1.18

Source: Consultant Estimates

4.15.8 FUTURE TRAFFIC GROWTH RATES AND SENSTIVITY ANALYSIS

As discussed earlier, the consultants have estimated traffic growth rates for future years by multiplying elasticity values of the respective mode with the growth parameters of economy, considered for analysis. The growth rates of traffic for future years for commercial and passenger vehicles in Sikkim and West Bengal have been shown in **Table 4.10 & 4.11** respectively.

Estimation of Traffic Growth Rates:

a) Elasticity for Different Modes in West Bengal x Economic Indicator Average Growth Rate for West Bengal = Mode wise growth rate for West Bengal

b) Elasticity for Different Modes in Sikkim x Economic Indicator Average Growth Rate for Sikkim = Mode wise growth rate for Sikkim

c) Mode wise Registered vehicle Average Growth Rate of Sikkim and West Bengal

Then, Weighted Traffic Growth Rates =adopted weighted Average of a & b item

Weighted traffic growth for project is presented in **Table 4.12(a).**

TABLE 4.10 FUTURE TRAFFIC GROWTH RATES FOR MOTORIZED VEHICLES (%) - SIKKIM

Mode	Upto 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	13.08	12.49	11.95	11.46	11.03	10.64	10.28
Buses	8.53	8.10	7.72	7.38	7.07	6.80	6.55
LCV	11.31	10.82	10.37	9.97	9.61	9.28	8.99
Truck	11.79	11.22	10.70	10.24	9.82	9.45	9.11
2-W	5.44	5.19	4.97	4.78	4.60	4.44	4.30

Source: Consultant Estimates

TABLE 4.11 FUTURE TRAFFIC GROWTH RATES FOR MOTORIZED VEHICLES (%) - WEST BENGAL

Mode	Upto 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	7.70	7.32	6.98	6.68	6.40	6.15	5.93
Buses	6.98	6.66	6.38	6.12	5.89	5.68	5.50
LCV	7.78	7.39	7.04	6.73	6.44	6.19	5.96
Truck	7.68	7.30	6.96	6.65	6.38	6.13	5.91
2-W	11.85	11.27	10.76	10.29	9.87	9.50	9.16

Source: Consultant Estimates

TABLE 4.12(A) WEIGHTED TRAFFIC GROWTH RATES FOR MOTORIZED VEHICLES (%) – REALISTIC SCENARIO

Mode	Up to 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	9.8	9.3	8.9	8.6	8.2	7.9	7.6
Buses	7.4	7.0	6.7	6.4	6.2	6.0	5.8
LCV	9.0	8.6	8.2	7.9	7.6	7.3	7.0
Truck	9.2	8.8	8.4	8.0	7.7	7.4	7.1
2-W	8.6	8.2	7.9	7.5	7.2	7.0	6.7

Source: Consultant Estimates

Sensitivity Analysis

The growth rates estimated for various modes represent the realistic scenario of traffic growth based on trends observed and experiences/ opinion of experts associated with study. But there is

lot of imponderables/ unforeseen situations that might not have been perceived at time of analysis. To consider their impact, a sensitivity analysis has been carried out to cover the risks associated with these imponderables in each scenario. A scenario analysis has been carried out to estimate the traffic ranges and revenues that the concessionaire may earn for each range.

Realistic Scenario: Normal Growth Rates as per Calculation

Optimistic Scenario: Growth rates 10% more than realistic scenario

Pessimistic Scenario: Growth rates 10% less than realistic scenario

The weighted traffic growth rate estimate based on trip pattern of Sikkim and West Bengal. The share of trips of Sikkim and West Bengal is presented in **Table 4.1.**The weighted traffic growth rates are presented in **Table 4.12(b).**

TABLE 4.12(B) WEIGHTED TRAFFIC GROWTH RATES FORMOTORIZED VEHICLES (%) IN DIFFERENT SCENARIO

Mode	Upto 2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Optimistic Growth Rate (%)							
Car	10.8	10.3	9.8	9.4	9.0	8.7	8.4
Buses	8.1	7.7	7.4	7.1	6.8	6.6	6.3
LCV	9.9	9.5	9.0	8.7	8.3	8.0	7.7
Truck	10.2	9.7	9.2	8.8	8.5	8.1	7.8
2-W	9.5	9.1	8.7	8.3	8.0	7.7	7.4
Pessimistic Growth Rate (%)							
Car	8.8	8.4	8.0	7.7	7.4	7.1	6.9
Buses	6.6	6.3	6.0	5.8	5.6	5.4	5.2
LCV	8.1	7.7	7.4	7.1	6.8	6.5	6.3
Truck	8.3	7.9	7.5	7.2	6.9	6.7	6.4
2-W	7.8	7.4	7.1	6.8	6.5	6.3	6.1

Source: Consultant Estimates

4.15.9 ESTIMATION OF DIVERTED TRAFFIC ALONG PROJECT ROAD

This chapter specifically deals with estimation of diverted traffic in future along the proposed road. As discussed earlier, the road alignment, start from Bagrakot (at NH-31) and end to Pakyong with spur at Menla. The project road form as a new link. The future traffic along the project roads will be a combination of

- Diverted traffic

  Diverted Traffic is the traffic diverted on to, or away from, the route or mode being studied. Thus the construction or improvement of a road may take away traffic from a

railway line. In that case, what appears as a benefit to the highway project due to increased traffic is actually a dis benefit to the railways.

- Induced traffic

  Induce traffic is the new traffic that develops because of new traveler making use of the improved or new facility.

The traffic along the existing network in the Project Influence Area (PIA) is likely to grow at normal rate of growth. The diversion of traffic on or from project roads is likely to be significant if the proposed link results in significant reduction in travel time/ cost between a pair of origin and destination. If trip generating activities/ land uses proposed along the bypass are revenue generating measures, it will result in significant amount of Induced traffic along bypass.

The diversion of traffic on or from project road will take place after the road is constructed. On account of proposed low level of developments in the area, the induced traffic, if any, is likely to be insignificant. The induced traffic is likely to grow @ 5 % per annum. The estimate of diverted traffic along project road and its constituent links has been estimated using Diversion Curve Equations.

Methodology for Estimating Diverted Traffic

The estimate of diverted traffic will be done in two stages.

Stage-1:

Find out potential divertible Origin and Destination (OD) pairs and thereby the potential divertible traffic from different origins and destinations on competing routes.

Stage-2:

i) Find out the Road User Cost (RUC) (Rs./ Km) for average speed for project road as well as other competing road for each mode on different types of network of road using tools of Road User Cost Knowledge System (RUCKS), HDM-4 developed by World Bank Organization. The Road User Cost (Rs./ Km) consist of Vehicle Operating Cost, Value of Travel Time, Road Safety Cost and also Carbon Emission Cost.

ii) Find out Toll Cost if applicable for each competing route and estimate toll rates for project road using standard toll notification (The Gazette of India)

iii) Calculate total generalized cost = RUC+Toll for each competing route.

iv) For each competing route find the cost ratio with respect to the proposed road i.e., the ratio of Proposed Road Cost/Alternate Road Cost.

Apply the percentage of traffic diversion based on above mentioned cost ratio on potential divertible traffic calculated in Stage-1. These diversion percentage equations were developed by WSA for ADB and are approved as diversion theory by ADB.

Stage-3:

- Calculate Cost Ratio (Generalized Cost (Rs.) along Project Road / Generalized Cost (Rs.) along Alternate Route for each competing route pairs.
- Calculate percentage of mode wise diversion using Diversion Curve Equations (from Alternative Route to Project Road based on the Cost Ratio).

Diversion Curve Equation

These equations will facilitate estimation of diverted traffic (Car, Bus, Truck) based on Ratio of Cost of travel between the proposed and existing facility. The value less than unity will signify higher diversion percentage, while higher values than unity signify higher travel cost on proposed facility compared to existing facility and hence lower diversion of traffic to the new facility.

The trucks and buses have similar equations because both are built on same platform and have similar engines unlike in the developed world where buses and trucks have different engine configuration. In absence of any credible equation differentiating the buses and trucks, the equation presented below is utilized. The equation is presented in **Table 4.13.**

TABLE 4.13 DIVERSION CURVE EQUATION

Vehicle	Cost Ratio (CR) Interval	Equations
Car	<= 0.634	%Div = 98.750 - (CR/0.634) * 8.125
	0.634 <= CR <= 1.465	%Div = 90.625 - ((CR-0.634)/0.831) * 84.375
	1.465 <= CR <= 2.0	%Div = 6.25 - ((CR-1.465)/0.535) * 5.25
Truck & Bus	<= 0.750	%Div = 100 - ((CR/0.75) * 5)
	0.750 <= CR <= 1.250	%Div = 95 - ((CR-0.75)/0.5) * 90
	1.250 <= CR <= 2.0	%Div = ((2-CR)/0.75) * 5
Source:	*Expressway System Planning Study – Likely Diversion of Traffic Task (I) study,*	
	by Wilbur Smith and Associates under Technical Assistance programme, funded by ADB for MOST.	
Diversion % from cost equations is in the direction of the numerator of the CR		
ie. If CR = Alternative Road/Project Road, then the Diversion % is from Project Road towards Alternative		

The basic input for the equations is presented below.

Link Node Map

The link node map is a graphical representation of the road network in the PIA and shows the nodes and links with their description on physical map. The details are presented on the map. The Link Node Map is presented in **Figure 4.1.**

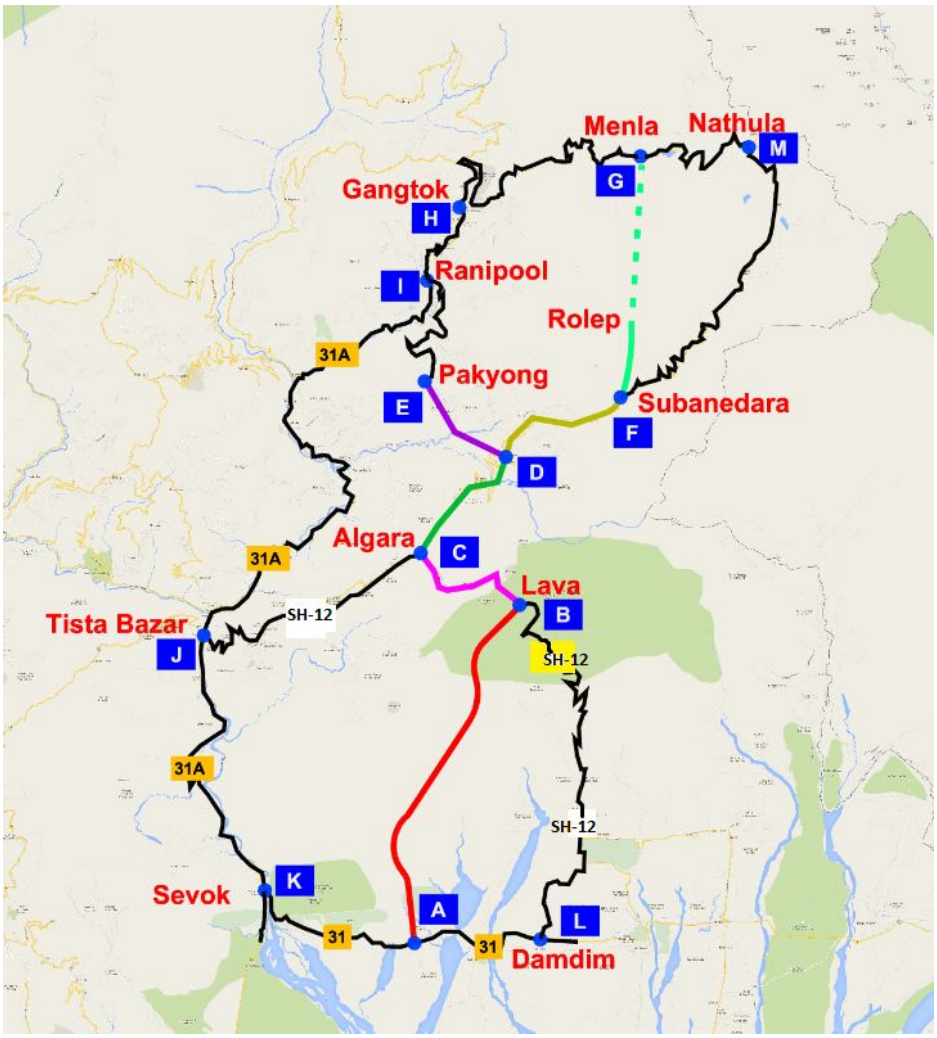


FIGURE 4.1 LINK NODE MAP

Link Nodes Characteristics

The road network is classified in terms of Links and Nodes. The important intersection in the network is termed as nodes while the road linking these nodes is called Links. The physical characteristics of each link i.e. length, carriageway width, configuration etc. The details of road network in the PIA are presented in **Table 4.14**.

TABLE 4.14 LINK NODE CHARACTERISTICS

S No	Node	Section	Road Name	Length (in Kms)	Toll (Y/N)	Lane
1	K-J	Sevoke-Kalimpong (Tista Bridge)	NH-31A	30	N	2 Lane

2	J-I	Kalimpong (Tista Bridge) – Ranipool	NH-31A	50	N	2 Lane
3	J-C	Kalimpong (Tista Bridge) – Algarah	SH-12	32	N	1.5 Lane
4	I-H	Ranipool - Gangtok	NH-31A	12	N	1.5 Lane
5	H-G	Gangtok - Menla	JawarLal Nehru Marg	30	N	1.5 Lane
6	G-M	Menla - Nathula	JawarLal Nehru Marg	20	N	1.5 Lane
7	M-F	Nathula - Rongli	ReshiRhenock Road	75	N	1.5 Lane
8	F-D	Rongli - Rhenok	ReshiRhenock Road (Project Road)	15	Y	2 Lane
9	F-G	Rongli - Menla	New Road (Project Road)	25	Y	2 Lane
10	D-E	Rhenok - Pakyong	New Road (Project Road)	25	Y	2 Lane
11	E-I	Pakyong - Ranipool	RangpoRorathan Road	20	N	1 Lane
12	D-C	Rhenok - Alagarah	PedongReshi Road (Project Road)	25	Y	2 Lane
13	C-B	Algarah - Lava	SH-12 (Project Road)	15	Y	2 Lane
14	B-L	Lava - Damdim	SH-12	52	N	1.5 Lane
15	L-A	Damdim - Bagrakot	NH-31 Jaigaon Road	10	N	2 Lane
16	B-A	Bagrakot - Lava	New Road (Project Road)	35	Y	2 Lane
17	A-K	Bagrakot - Sevoke	NH-31 Jaigaon Road	15	N	2 Lane

Diverted Traffic along Project Road

The consultant has estimate diverted traffic based on the above described stages. The results shows that the higher traffic diversions are on Section AB-BC and CD at 1082 PCU's after the construction of road link. The lowest traffic diversions are on the FG section of project road. The details of road network in the PIA are presented in **Table 4.15**.

TABLE 4.15 DIVERTED TRAFFIC ALONG PROPOSED ROAD

Proposed Road	Car	Mini Bus	Bus	Two Wheeler	LCV	Truck	Total Veh.	Total PCU
PCU Value	1	1.5	3	0.5	1.5	3		
Potential Divertible from Route KJIH	1104	55	4	31	210	366	**1770**	**2627**
Divertible % from Route-KJIH	5.27	3.14	3.30	5.47	3.10	3.44		
Diverted Traffic on Stretch-ABCDE	**58**	**2**	**0**	**2**	**7**	**13**	**81**	**109**
Potential Divertible from Route KJCDF	710	25	2	40	165	222	**1164**	**1687**
Divertible % from Route-KJCDF	50.46	48.95	50.96	51.02	49.08	53.51		
Diverted Traffic on Stretch-ABCDF	**358**	**12**	**1**	**20**	**81**	**119**	**592**	**868**
Potential Divertible from Route LAKJIH	38	0	0	5	6	15	**64**	**95**
Divertible % from Route-LAKJIH	33.05	20.34	23.85	34.31	19.94	27.20		
Diverted Traffic on Stretch-ABCDE	**13**	**0**	**0**	**2**	**1**	**4**	**20**	**27**
Potential Divertible from Route LAKJCDF	8	0	0	0	6	9	**23**	**44**

Divertible % from Route-LAKJCDF	74.77	92.11	94.02	75.23	92.34	95.06		
Diverted Traffic on Stretch-ABCDF	**6**	**0**	**0**	**0**	**6**	**9**	**20**	**40**
Potential Divertible from Route KJIHG	27	5	1	5	3	9	**50**	**72**
Divertible % from Route-KJIHG	49.91	47.39	51.06	52.32	47.25	55.54		
Diverted Traffic on Stretch-ABCDFG	**13**	**2**	**1**	**3**	**1**	**5**	**25**	**37**
ADT On Stretch - AB-BC-CD	**448**	**16**	**2**	**26**	**96**	**149**	**737**	**1082**
ADT On Stretch - DE	**378**	**15**	**2**	**23**	**88**	**132**	**637**	**945**
ADT On Stretch - DF	**71**	**2**	**0**	**3**	**8**	**17**	**100**	**137**
ADT On Stretch - FG	**13**	**2**	**1**	**3**	**1**	**5**	**25**	**37**
SCF	**0.99**	**0.92**	**0.92**	**0.99**	**0.92**	**0.92**		
AADT On Stretch - AB-BC-CD	**444**	**15**	**2**	**26**	**88**	**137**	**712**	**1027**
AADT On Stretch - DE	**374**	**13**	**1**	**23**	**81**	**122**	**614**	**896**
AADT On Stretch - DF	**70**	**2**	**0**	**3**	**7**	**15**	**97**	**131**
AADT On Stretch - FG	**13**	**2**	**0**	**3**	**1**	**5**	**24**	**35**

Source: Consultant Estimates

4.15.10 DIVERTED TRAFFIC FORECAST

TABLE 4.16 TRAFFIC FORECAST ALONG PROJECT ROAD (DIVERTED+ INDUCED TRAFFIC)

ALONG AB-BC-CD SECTION

Year	Car	Mini Bus	Bus	Two Wheeler	LCV	Truck	Veh.	PCU
2015	444	15	2	26	88	137	**712**	**1027**
2016	487	16	2	28	96	150	**779**	**1124**
2017	560	18	2	32	109	171	**892**	**1285**
2018	612	19	2	35	119	186	**973**	**1400**
2019	669	21	2	38	129	202	**1061**	**1525**
2020	732	22	2	41	140	220	**1157**	**1661**
2021	800	24	2	44	152	239	**1262**	**1810**
2022	872	25	3	48	165	259	**1371**	**1964**
2023	950	27	3	52	178	280	**1489**	**2132**
2024	1034	29	3	56	193	303	**1618**	**2314**
2025	1127	31	3	60	209	329	**1758**	**2511**
2026	1227	33	3	65	226	356	**1910**	**2726**
2027	1332	35	4	70	243	384	**2068**	**2949**
2028	1446	37	4	75	263	415	**2240**	**3190**
2029	1570	40	4	81	283	448	**2426**	**3451**
2030	1705	42	4	87	306	484	**2627**	**3733**
2031	1850	45	5	93	330	522	**2845**	**4039**
2032	2002	48	5	100	355	562	**3071**	**4356**
2033	2167	51	5	107	381	605	**3316**	**4699**

2034	2345	54	5	115	410	651	**3580**	**5068**
2035	2538	57	6	123	441	701	**3866**	**5467**
2036	2746	61	6	132	474	754	**4174**	**5897**
2037	2964	64	7	141	509	810	**4495**	**6343**
2038	3198	68	7	151	546	869	**4840**	**6824**
2039	3451	72	7	162	586	933	**5211**	**7340**
2040	3724	77	8	173	628	1002	**5612**	**7897**
2041	4019	81	8	185	674	1075	**6043**	**8495**

Source: Consultant Estimates

TABLE 4.17 TRAFFIC FORECAST ALONG PROJECT ROAD (DIVERTED +INDUCED TRAFFIC)

ALONG D-E SECTION

Year	Car	Mini Bus	Bus	Two Wheeler	LCV	Truck	Veh.	PCU
2015	374	13	1	23	81	122	**614**	**896**
2016	411	14	2	25	88	133	**672**	**980**
2017	471	16	2	28	101	152	**770**	**1121**
2018	516	17	2	30	109	165	**839**	**1221**
2019	564	19	2	33	119	179	**915**	**1330**
2020	616	20	2	36	129	195	**998**	**1448**
2021	674	21	2	39	140	212	**1088**	**1578**
2022	734	23	2	42	151	230	**1182**	**1712**
2023	800	24	3	45	164	249	**1284**	**1858**
2024	871	26	3	48	177	269	**1395**	**2017**
2025	949	28	3	52	192	292	**1516**	**2189**
2026	1034	29	3	56	208	316	**1646**	**2375**
2027	1122	31	3	61	224	341	**1783**	**2569**
2028	1218	33	3	65	241	368	**1930**	**2779**
2029	1323	36	4	70	260	398	**2090**	**3006**
2030	1436	38	4	75	281	429	**2263**	**3252**
2031	1559	40	4	81	303	464	**2451**	**3518**
2032	1687	43	4	87	326	499	**2646**	**3794**
2033	1825	45	5	93	351	537	**2857**	**4092**
2034	1975	48	5	100	377	578	**3084**	**4413**
2035	2138	51	5	107	406	622	**3329**	**4760**
2036	2313	54	6	115	436	670	**3595**	**5134**
2037	2496	58	6	123	468	719	**3870**	**5522**
2038	2694	61	6	132	502	772	**4167**	**5940**
2039	2907	65	7	141	539	829	**4487**	**6389**
2040	3137	68	7	151	578	890	**4831**	**6872**
2041	3386	73	8	161	620	955	**5201**	**7392**

Source: Consultant Estimates

TABLE 4.18 TRAFFIC FORECAST ALONG PROJECT ROAD (DIVERTED +INDUCED TRAFFIC)

ALONG D-F SECTION

Year	Car	Mini Bus	Bus	Two Wheeler	LCV	Truck	Veh.	PCU
2015	70	2	0	3	7	15	**97**	**131**
2016	77	2	0	4	8	17	**107**	**143**
2017	88	2	0	4	9	19	**122**	**164**
2018	96	2	0	5	10	21	**134**	**179**
2019	106	2	0	5	10	23	**146**	**195**
2020	115	2	0	5	11	25	**159**	**213**
2021	126	3	0	6	12	27	**174**	**232**
2022	137	3	0	6	13	29	**189**	**252**
2023	150	3	0	7	14	31	**205**	**273**
2024	163	3	0	7	16	34	**223**	**297**
2025	178	3	0	8	17	37	**242**	**323**
2026	194	3	0	8	18	40	**264**	**350**
2027	210	4	0	9	20	43	**286**	**379**
2028	228	4	0	10	21	46	**309**	**411**
2029	248	4	0	10	23	50	**335**	**445**
2030	269	4	0	11	25	54	**363**	**481**
2031	292	5	0	12	27	58	**394**	**521**
2032	316	5	0	13	29	63	**425**	**562**
2033	342	5	0	14	31	68	**460**	**607**
2034	370	6	0	15	33	73	**497**	**655**
2035	400	6	0	16	36	78	**536**	**707**
2036	433	6	0	17	38	84	**580**	**763**
2037	467	7	1	18	41	91	**624**	**821**
2038	504	7	1	19	44	97	**673**	**884**
2039	544	8	1	21	47	104	**725**	**952**
2040	587	8	1	22	51	112	**781**	**1024**
2041	634	9	1	24	54	120	**841**	**1103**

Source: Consultant Estimates

TABLE 4.19 TRAFFIC FORECAST ALONG PROJECT ROAD (DIVERTED +INDUCED TRAFFIC) ALONG F-G SECTION

Year	Car	Mini Bus	Bus	Two Wheeler	LCV	Truck	Veh.	PCU
2015	13	2	0	3	1	5	**24**	**35**
2016	15	2	1	3	1	5	**27**	**38**
2017	17	3	1	3	2	6	**31**	**44**
2018	18	3	1	3	2	6	**33**	**47**
2019	20	3	1	4	2	7	**36**	**52**
2020	22	3	1	4	2	7	**39**	**56**
2021	24	3	1	4	2	8	**43**	**61**
2022	26	4	1	5	2	9	**47**	**66**
2023	29	4	1	5	3	9	**50**	**72**
2024	31	4	1	6	3	10	**55**	**78**

2025	34	4	1	6	3	11	**59**	**84**
2026	37	5	1	6	3	12	**64**	**91**
2027	40	5	1	7	4	13	**70**	**98**
2028	43	5	1	7	4	14	**75**	**106**
2029	47	6	1	8	4	15	**81**	**115**
2030	51	6	1	9	5	16	**88**	**124**
2031	56	7	1	9	5	18	**95**	**134**
2032	60	7	1	10	5	19	**103**	**144**
2033	65	7	2	11	6	20	**111**	**156**
2034	70	8	2	11	6	22	**119**	**168**
2035	76	8	2	12	7	24	**129**	**180**
2036	83	9	2	13	7	25	**139**	**194**
2037	89	9	2	14	8	27	**149**	**209**
2038	96	10	2	15	8	29	**160**	**224**
2039	104	10	2	16	9	31	**172**	**241**
2040	112	11	2	17	9	34	**185**	**259**
2041	121	12	3	18	10	36	**199**	**278**

Source: Consultant Estimates

4.15.11 CAPACITY ANALYSIS

The consultant have carried out capacity analysis based on IRC:64-1990 “Guideline for Capacity of Roads in Rural Areas” (Table-4).

The above mentioned IRC standard stipulates that the Design Service Volume is 35,000 PCU per day for 4 lane road without paved shoulder at LOS– B and the capacities can be increased by 15 % by upgrading the roads with paved shoulder. The project road is predominantly hilly terrain therefore the capacity analysis done using DSV of Hilly Road.

The Design Service Volume and Capacity Standard for a 2/ 4 lane road based on IRC is presented in **Table 4.20**.

TABLE 4.20 DESIGN SERVICE VOLUME AND CAPACITY STANDARD FOR 2/4 LANE ROAD

Road Type	Design Service Volume (PCU/ Day)			Ultimate Capacity
	LOS 'B'	LOS 'C'	LOS 'D'	LOS 'E'
	50%	70%	85%	100%
2-Lane Roads without Paved Shoulders	5000	7000	8500	10000
2-Lane Roads with Paved Shoulders	5750	8050	9775	11500
4-Lane Roads without Paved Shoulders	11500	16100	19550	23000
4-Lane Roads with Paved Shoulders	13225	18515	22482.5	26450

Source: IRC:64-1990

The consultant has carried out the capacity analysis for 2 lane road without paved shoulder. The capacity analysis is presented in **Table 4.21**.

TABLE 4.21CAPACITY ANALYSIS OF PROJECT ROAD

Year	Section AB-BC-CD		Section DE		Section DF		Section FG	
	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)	Volume (PCU)	Level of Service (LOS)
2015	1027	LOS 'B'	896	LOS 'B'	131	LOS 'B'	35	LOS 'B'
2016	1124	LOS 'B'	980	LOS 'B'	143	LOS 'B'	38	LOS 'B'
2017	1285	LOS 'B'	1121	LOS 'B'	164	LOS 'B'	44	LOS 'B'
2018	1400	LOS 'B'	1221	LOS 'B'	179	LOS 'B'	47	LOS 'B'
2019	1525	LOS 'B'	1330	LOS 'B'	195	LOS 'B'	52	LOS 'B'
2020	1661	LOS 'B'	1448	LOS 'B'	213	LOS 'B'	56	LOS 'B'
2021	1810	LOS 'B'	1578	LOS 'B'	232	LOS 'B'	61	LOS 'B'
2022	1964	LOS 'B'	1712	LOS 'B'	252	LOS 'B'	66	LOS 'B'
2023	2132	LOS 'B'	1858	LOS 'B'	273	LOS 'B'	72	LOS 'B'
2024	2314	LOS 'B'	2017	LOS 'B'	297	LOS 'B'	78	LOS 'B'
2025	2511	LOS 'B'	2189	LOS 'B'	323	LOS 'B'	84	LOS 'B'
2026	2726	LOS 'B'	2375	LOS 'B'	350	LOS 'B'	91	LOS 'B'
2027	2949	LOS 'B'	2569	LOS 'B'	379	LOS 'B'	98	LOS 'B'
2028	3190	LOS 'B'	2779	LOS 'B'	411	LOS 'B'	106	LOS 'B'
2029	3451	LOS 'B'	3006	LOS 'B'	445	LOS 'B'	115	LOS 'B'
2030	3733	LOS 'B'	3252	LOS 'B'	481	LOS 'B'	124	LOS 'B'
2031	4039	LOS 'B'	3518	LOS 'B'	521	LOS 'B'	134	LOS 'B'
2032	4356	LOS 'B'	3794	LOS 'B'	562	LOS 'B'	144	LOS 'B'
2033	4699	LOS 'B'	4092	LOS 'B'	607	LOS 'B'	156	LOS 'B'
2034	5068	LOS 'C'	4413	LOS 'B'	655	LOS 'B'	168	LOS 'B'
2035	5467	LOS 'C'	4760	LOS 'B'	707	LOS 'B'	180	LOS 'B'
2036	5897	LOS 'C'	5134	LOS 'C'	763	LOS 'B'	194	LOS 'B'
2037	6343	LOS 'C'	5522	LOS 'C'	821	LOS 'B'	209	LOS 'B'
2038	6824	LOS 'C'	5940	LOS 'C'	884	LOS 'B'	224	LOS 'B'
2039	7340	LOS 'D'	6389	LOS 'C'	952	LOS 'B'	241	LOS 'B'
2040	7897	LOS 'D'	6872	LOS 'C'	1024	LOS 'B'	259	LOS 'B'
2041	8495	LOS 'D'	7392	LOS 'D'	1103	LOS 'B'	278	LOS 'B'

Source: Consultant Estimates

Conclusion

This analysis suggest that the project road will have smooth traffic flow at LOS 'C' up to the horizon year 2040. Only in the year 2040, the LOS will drop this year, the road could be upgraded by adding a paved shoulder.

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5.0 Economic Analysis

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. It is therefore important that decisions about investments in roads are made on objective judgments and therefore, Economic appraisal has been carried out for each traffic homogenous section of entire Project road.

The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the project is worthy of investment keeping in view the benefits to the society. The Proposal for project road i.e Bagrakot to Kafer through rehabilitation and upgrading the road with 2 Lanes with Paved shoulders as per RFP of NHAI. In order to assess the benefits accrued to the society, both the options of 'Existing' and 'Proposed' have to be compared. For this purpose, the entire existing Road has been considered along with its proposed maintenance and improvement proposals.

5.1 Economic Analysis Approach

The economic evaluation has been carried out within the broad framework of social cost benefit analysis. The objective is to determine the best improvement scheme out of several proposals, which will lead to minimizing total transport costs and maximizing benefits to the road users.

The benefits accruing to society from the proposed improvement are mainly reduced vehicle operating cost, reduced travel time cost and reduced accident costs. Total transport costs comprise of two basic components as shown in **Table 5.1**.

Table 5.1: Total Transport Costs

Road Supplier Costs	Road User Costs
Construction Costs	Vehicle Operating Costs (VOC) both MT & NMT
Maintenance Costs	Travel Time Costs
Replacement Costs: Costs of Environmental Impact Mitigation Measures, Costs of Rehabilitation and Resettlement (R&R) measures	

These costs are generated using HDM – IV for every year of the analysis period (cost-benefit stream) from which economic indicator parameters that essential for viability of project namely Net Present Value (NPV), Economic Rate of Return (EIRR) and Benefit Cost Ratio (B/C) are the final economic outputs.

NPV is the present value of Net Benefits (NB) during the project period. EIRR is the discount rate at which the NPV of the Net Benefit (NB) is zero. Net Benefit is the cumulative sum of the difference between yearly benefit and yearly costs incurred after discounting.

$$NB = \sum_{n=1}^{M} (Benefit(n) - Cost(n))$$

Savings from vehicle emission reduction and less energy consumption due to improved facility are also important economic savings which are possible to calculate but these quantities are not converted to economic cost inside the software. So these benefits are not included.

The appraisal period (including the construction period) has been taken as 30 years after which a residual value of investment is assumed as 20%.

5.2 Project Economic Evaluation using HDM - 4

Economic evaluation for Bagrakot to Kafer road is carried out by consideration of two alternatives In HDM – 4.

5.2.1 Alternative 1: Existing

For without project consideration, project road will carry existing traffic on it without any improvement and maintenance in present condition that means No treatment is given to existing road for improving its capacity augmentation, functional and structural pavement quality and geometry standards.

5.2.2 Alternative 2: Proposed

For with project consideration, Project road is rehabilitated and upgraded as 2 lanes with paved shoulders. In this alternative, project road improvements are made by improving its geometry through realignments, providing bypasses and rehabilitation to existing pavement though reconstruction and strengthening.

5.3 Project Cost and Scheduling

The existing project road is 14.230 km long and passes through Bagrakot, Kafer towns. Therefore, Project road is proposed to undertake work of widening, strengthening and rehabilitation to facilitate the proposed road. The Project road is divided into 1 homogeneous section based on the Pavement improvements and homogeneous traffic sections. Accordingly, economic analysis of the project road is being carried out in 1 homogeneous section as follows:

Table 5.2: Section Details

Homogeneous Section	Existing Chainage		Improvement
	From	To	
Bagrakot to Kafer	24+940	39+170	2 lane Paved Shoulder

The project road with existing carriageway width of 3.5 to 5.5 m is proposed for 2 lanes paved shoulders facility which satisfies the project and traffic requirement.

The Economic analysis was carried out for 30year benefit period (2016-2046). For performing economic evaluation, a 'project' is formulated in which comparison is made between two scenarios namely (1) Existing and (2) Proposed.

5.3.1 Capital Cost

Project costs have been worked out and given in Chapter-7. For economic evaluation base costs have been taken as factor cost of civil works and other cost related to land acquisition social environmental and utility relocations that mean Capital cost is the total construction cost of civil works for the project improvement.

The construction cost for each homogeneous section is tabulated in **Table 5.3** for the year 2018 at which Project will start to implement. Therefore, the project cost of present year is increased with 5 % inflation rate for two successive years. The construction cost of project will be utilised in two phases i.e. 50 % in first year and 50 % in second year as construction period of 2 years.

The cost estimate for each section has been calculated separately based on the quantities worked out for major items of work to be executed in the project on the basis of preliminary engineering design of roads, structures and the adopted rates. A conversion factor of 0.90 has been used to convert financial cost into economic costs.

The economic cost for each package is as under:

Table 5.3: Total Project Cost

Homogeneous Section	Civil Works Cost Per km (Cr)	Economical Cost per km(Cr)
Bagrakot to Kafer	13.55	9.21

5.3.2 Maintenance Cost

For Two lanes with Paved shoulder road

Routine maintenance cost - Rs. 1.5 lac per km per year
Periodic maintenance cost - Rs 4500000 per km (50mm BC)

5.4 Project Benefits

Project Benefits mainly occurs due to Reduction in Vehicle operating cost and travel time savings.

The vehicle operating cost (VOC) components are

- Fuel
- Lubricants
- Tyres
- Spare Parts
- Maintenance Labour
- Wages of Crew
- Fixed costs including overheads, administration, interest on borrowed capital
- Depreciations
- Travel time cost

5.4.1 Vehicle Fleet

5.4.1.1 Fleet Utilization

Fleet utilization data adopted for the analysis is based on the findings of Road User Cost study in 2001, IRC SP: 30-2009. The adopted values are summarized as shown in table below.

Table 5.4: Life Norms for Vehicles

Particulars	Km Driven	Life, Year	Working Hour	Passenger
2 Axle Truck	90000	12	1950	-
Multi Axle Truck	75000	12	2100	-
3 Axle Truck	75000	12	2100	-
LCV	45500	10	1050	-
Bus/Mini Bus	125000	10	2400	45
Car / Jeep / Van	87500	10	1750	5
Two Wheeler	28800	10	636	1.5

5.4.2 Vehicle Resources

5.4.2.1 Vehicle and Tyre Cost

Economic costs of vehicle and tyre are derived from the market survey in West Bengal. Ex-Show Room Price for each category of vehicle have been collected and elements of taxes, duties, freight, dealer's margin and incentives as applicable have been removed to arrive at the economic costs. The adopted economic costs are summarized as presented in table below.

Table 5.5: Prices of Vehicles

Category	Vehicle(Rs.)	Tyre(Rs.)
2 Axle Truck	900000	7075
3 Axle and Multi Axle Truck	1000000	7075
LCV	500000	3500
Bus	850000	7500
Car / Jeep / Van	450000	2250
Two Wheeler	41000	750

5.4.2.2 Fuel & Lubricant

Economic Prices fuel and lubricant are arrived based on ratio of WPI for all commodities of March 2015 with respected to March 2009 and applying that ratio to search out actual value**.**

Table 5.6: Economic Cost of Fuel & Lubricants

Item	Price/ litre as per SP 30:2009	WPI Ratio	Present Cost/ litre
Petrol	18.55	1.54	28.567
Diesel	18.2	1.54	28.028
Lubricants	56.7	1.54	87.318

5.4.2.3 Maintenance Labour and Crew Wages

Adopted values for Maintenance Labour and Crew Wages are based on the enquiries made by the Consultant with transport operators and workshops in and around the project Road. The adopted values are summarized vide in table below.

Table 5.7: Labour and Crew Wages

(Cost in Rs. per hour)

Category	Maint. Labour	Crew Wage
Truck	100	75
3 Axle and Multi Axle Truck	100	90
LCV	100	45
Bus	125	115
Car / Jeep / Van	60	25
Two Wheeler	40	-

5.4.2.4 Annual Overhead

Recommendations of the "Study for Updating Road User Cost Data: 2001"and IRC SP: 30-2009 are considered to arrive at annual overhead cost per vehicle and are summarised in table below:

Table 5.8 : Annual Overheads

Category	Annual Overhead Cost (Rs.)
2 Axle Truck	192500
3 Axle and Multi Axle Truck	258000
LCV	128000
Bus	155000
Car / Jeep / Van	80000
Two Wheeler	6624

5.4.2.5 Annual Interest

An Economic Interest Rate of 12% has been adopted for the analysis.

5.4.2.6 Time Value of Passengers

Time Value of Passenger (Work Trips and Non Work Trips) is arrived based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP:30 -2009)". The values of 2009 are upgraded by considering Whole Sale Price Index Ratio for the year 2009 and 2015. Non work time value of passenger is considered 15% and work time value of passenger is considered 85 % of time value of passengers as suggested in IRC SP:30 -2009 ". The adopted values are summarized as given in table below.

Table 5.9: Time Value of Passengers

Mode of Travel	Unit	2 Wheeler	Car/ Taxi	Bus
Travel time Value RUCS-March 2009	Rs/Hour	62.5	32.0	39.5
WPI Ratio 2014/2015	-	1.156	1.156	1.156
Travel time Value RUCS-august2010	Rs/Hour	31.0	61.0	39.0

Eq. Non-work Time Value in 2010	Rs./Hour	5.5	10.8	6.8

5.4.2.7 Time Value of Cargo

Average value of commodity is based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP: 30 - 2009)". Equivalent cost of commodity in 2010-2011 is determined using the WPI ratio (1.156 over 2009). Average payload for each category of freight vehicles is based on axle load survey. Time-delay cost is estimated with an economic interest rate of 12% and economic conversion factor of 0.90 and provided in table below:

Table 5.10: Time Value of Cargo

Vehicle Category	Average Payload (Tonnes)	Average Running Time (hour/Year)	Time-delay Cost (Rs./Hr)
2Axle Truck	15	1950	32.00
3 Axle and Multi Axle Truck	17	2100	55.00
LCV	8.25	1050	19.0

5.4.3 HDM Traffic

Following category of fast moving and slow moving vehicles are considered for carrying out HDM 4 Analysis.

- 2 Axle Truck
- 3 Axle Truck
- Multi Axle Truck
- LCV
- Bus
- Mini Bus
- Car / Jeep / Van
- Two Wheeler

As HDM-4 does not include 3 Wheeler and Agricultural Tractor Categories of Vehicle therefore these categories are not considered in the analysis. Percentage compositions of assigned traffic in AADT on the project road as on year 2015 and adopted for the analysis for the Project road are summarized as given in table below.

Table 5.11: Composition of Motorized Traffic assigned on Project road (MT) (%)

Section ID	2 Wheeler	Passenger Car+Jeep	Bus	LCV	2-Axle	3-Axle and Multi Axle	AADT (PCU No.)
RP	18	676	0	11	16	0	981

Adopted traffic growth rates as per traffic analysis is Presented in **Table 5.12.** .

Table 5.12: Traffic growth Rate of Motorized Traffic assigned on Project road (MT) (%)

Year	2 Wheeler	Passenger Car+Jeep	Bus	LCV	2-Axle	3-Axle and Multi Axle
2015-2018	5.0	5.0	5.0	5.0	5.0	5.0
2018-2023	5.0	5.0	5.0	5.0	5.0	5.0
2023-2028	5.0	5.0	5.0	5.0	5.0	5.0
2028-2033	5.0	5.0	5.0	5.0	5.0	5.0
2033-2038	5.0	5.0	5.0	5.0	5.0	5.0
2038-2043	5.0	5.0	5.0	5.0	5.0	5.0
2043-2048	5.0	5.0	5.0	5.0	5.0	5.0

5.5 Economics Internal Rate of Return

Economic Analysis has been carried out for construction option discussed above. Variables considered in for economic analysis of the project are volatile and depend on various factors. In general, in case of economic analysis is also recommended that analysis period should not be long as it may lead to erroneous results.

However, in order to be able to draw the conclusions on common platform Economic Analysis have also been carried out for 20 years of analysis period. The summary of Economic internal rate of return (EIRR) worked out, for construction option based on life cycle cost analysis is presented below.

Economic Analysis was carried out following the methodology and input data discussed in the preceding paragraphs of this chapter using HDM-4 software.

HDM-4 outputs on Annual Discounted Net Benefit Streams with time savings is presented vide **.**

HDM-4 output on Benefit Cost Ratios is presented vide.

The Economic Analysis Summary with time savings (By Alternative) is presented vide **Annexure 5.1.**

The EIRR and NPV at 12% discount rate for each construction package as worked out with and without benefits due to travel time savings are summarized as under:

Table 5.13: Results of Economic Analysis

Homogeneous Sections	Option	Net Economic Benefit (NPV @ 12%)	Economic Internal Rate of Return (12 %)
Bagrakot to Kafer	With time saving	2332.6	13.06

5.6 Sensitivity Analysis

The Sensitivity analysis has been carried out in order to study the viability of the project against the uncertainties in traffic forecasting and the possible variations of project cost due to unforeseen reasons. The sensitivity analysis has been performed with following situations.

S1: Base cost plus 15% and Base Benefits

S2: Base cost and Base Benefits minus 15%

S3: Base cost plus 15% and Base Benefits minus 15%

The analysis has been done by changing the cost and benefit streams independently as well as in combination. The end results of this study have been summarised below:

Table 5.14: Results of Sensitivity Analysis

Option	Economic Internal Rate of Return (%)		
	S1	S2	S3
With time saving	14.0	14.7	13.06

5.7 Conclusion

The project road is economically viable for proposed improvement as it yields more than 12% return (assumed interest rate for the analysis). The proposed improvement is also viable for various sensitivity alternatives.

****

6 SOCIAL IMPACT ASSESSMENT REPORT

1. PROJECT DESCRIPTION

6.1 Background

National Highways & Infrastructure Development Corporation Limited (Ministry of Road Transport & Highways) has decided to upgrade the entire single and intermediate lane sections of National Highways to two lane/two lane with paved shoulder and /or strengthening of various sections of National Highways. The work would be taken up for up gradation on corridor concept. Therefore, corridors include strengthening (in adjoining stretches) in addition to widening to 2 lane / 4 lane with paved shoulder standards in order to have a better facility in a long continuous stretch.

In pursuance of the above, SA Infrastructure Consultants Pvt. Ltd. Noida (UP) has been appointed as Consultants to carry out the Feasibility Study and Final Feasibility Report for Consultancy for preparation of feasibility report cum preliminary Design for Alternative highway to Gangtok in Sikkim via Bagrakot – Chuikhim – Nimbong – Kafer – Bakhim – Algarah – Rhenock in the state of West Bengal and from Rhenock – Rorathang – Pakyong along with spur from Aritar – Rolep – Menla in the state of Sikkim. The Agreement was signed and the commencement of services commenced w.e.f from 08-10-2014 with the reference of NHIDCL letter no. NHIDCL/Tech/WB/FRCPD/Sikkim/2014/444/5726 dated 08-10-2014.

6.2 Objective of the Project

The main objectives of Social Analysis and Design are to improve decision making and to ensure that the highway improvement options under consideration are socially sound, sustainable and contribute to the development of social development goals. The main objectives of the Resettlement Action Plan are to provide for resettlement policy framework and includes comprehensive mitigation measures to ensure that the affected and displaced persons are appropriately resettled and rehabilitated i.e. to improve their livelihoods and standards of living or at least to restore them, in real terms. The Social Impact Assessment involves undertaking full baseline information

6.3 Scope of Work

The scope of work comprises the following main tasks, comprising main elements:

- Prepare in accordance with guidelines of the Government, a draft Resettlement and Land Acquisition Plan.
- Prepare area specific social assessments to support development of a locally relevant approach to resettlement which provides benefits to people in the Project's area of influence, which include socio- economic conditions, social service infrastructure and social institutions and organization, in accordance with the Government policies and guidelines;
- These social assessment should include gender and local ethnic aspects;
- Provide recommendations and action plan for the Contractor to undertake, at the detailed design stage, a full census and inventory of lost assets (household, shops and agricultural and other lands, or access to current income-generating activities, including impacts caused by permanent or temporary acquisition) of affected people and a baseline socioeconomic survey of the affected population. Determine the scope and magnitude of likely resettlement and land acquisition effects, and list likely losses of households, agricultural lands, business and income opportunities, as well as affected communal assets and public building;
- In consultation with local stakeholders, government and the Authority, develop an entitlement matrix, on the basis of the consultations, socio-economic surveys and inventories of losses that will determine the amount of compensation in accordance with the guidelines and policies of the Government;
- Prepare the plans with full stakeholder participation, including the Government and the Authority, Consult with affected persons and community based organizations to ensure that all affected persons have been fully informed of their entitlements through the consultative processes initiated by the Government and the Authority. Ensure that communities and displaced persons understand the project, its impacts and the responsibilities of the parties, and
- Analyse and confirm the following aspects that will apply to land acquisition and resettlement in the project area: (i) laws and regulations, including local practices; (ii) budgetary processes for involuntary resettlement and land acquisition, (iii) schedules for these activities that are coordinated with construction schedule; and (iv) administrative arrangements and requirements.

6.4 Project Road (Package No. IVD)

The project road 717-A from Km. 0.000 to 97.442 (section Bagrakot to Reshi Border) starts from Bagrakot with the junction of NH-31 and ends at Reshi Bridge with with Sikkim Border at km. 92.800. This project has been divided into two homogenous section i.e. Package No. IV and Package No. V. Package-IV starts from Bagrakot to Kafer (km. 0.000 to km. 40.000) and Package-V starts from Kafer to Rishi Border (km. 39.800 to km. 92.800). The project package is the part of Jalpaiguri District and Darjeeling District in the state of West Bengal.

The key map of Project Road is given in **Fig 1.**

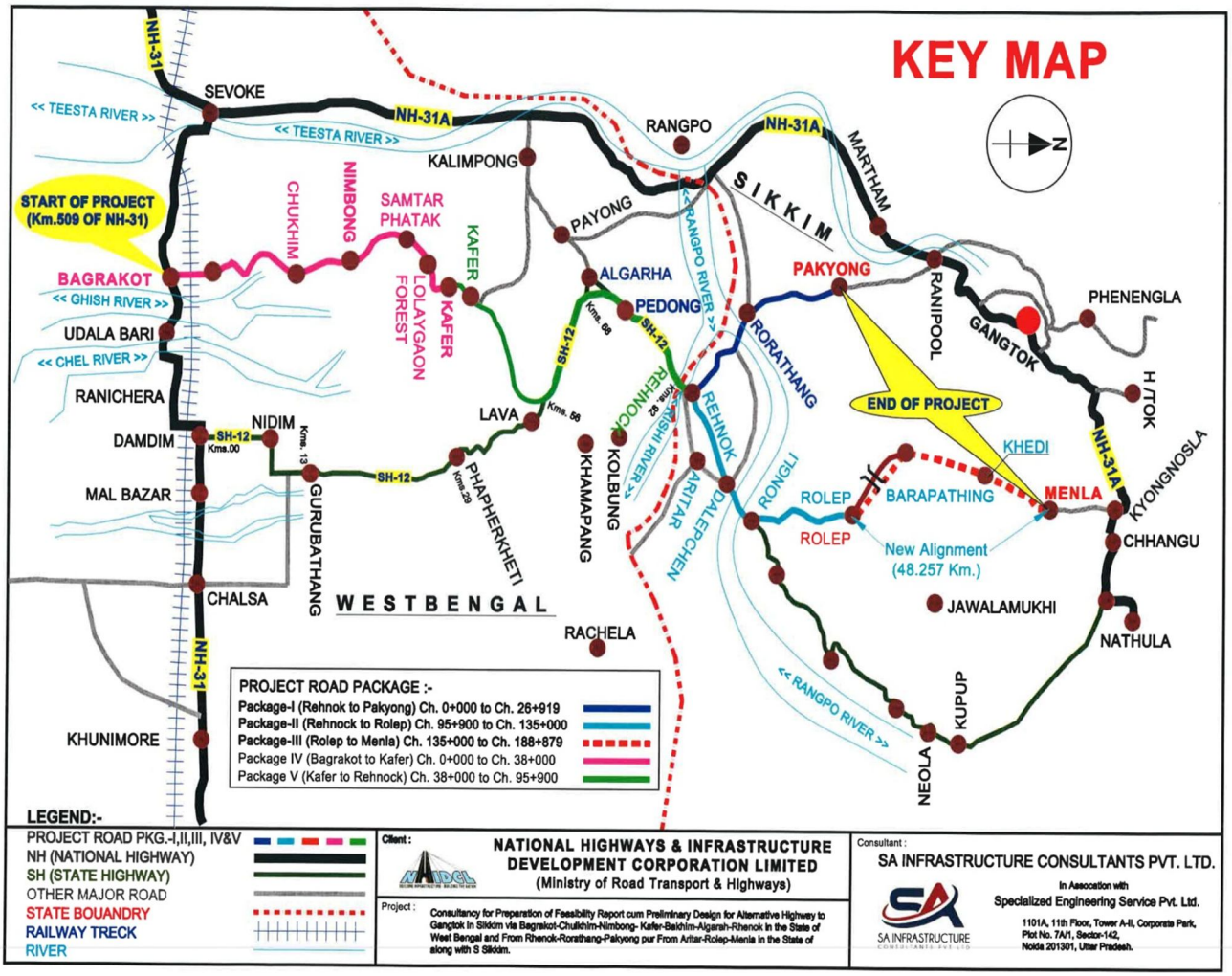


Fig 1.1

6.4.1 Habitation along the project

The entire proposed project road is located in the state of West Bengal. The project road

has significant influence on West Bengal State and particular in Darjeeling District and Jalpaiguri District. Maximum part of the project stretch is passing through Darjeeling District and the very first three kilometer of the stretch is part of Jalpaiguri District. The major part of the project stretch about 28 km is passing through forest land and about 12km it crossing through the habitations or revenue land namely Bagrakot of Jalpaiguri district, Nabagon, Pabrintar and Nimbong of Darjeeling district. The details of the habitation along the project road is presented in table: 1

Table1: Villages and Districts under the project Road

District	Block	Village	From	To
Jalpaiguri	**Mal**	**Bagrakot Tea Garden**	**0.000**	**3.200**
Darjeeling	**Kalimpong-I**	**Forest Land**	**3.200**	**19.200**
		NabgaonKhasmahal	**19.200**	**23.800**
		PabrintarKhasmahal	**22.500**	**25.400**
		NimbongKhasmahal	**25.400**	**28+600**
		Forest Land	**28+600**	**40+000**

6.4.2 Project Road Characteristics

The most of the existing road has a single lane of 3.75m carriageway except some curve locations where extra widening is provided and 2.75km length from start of the project is intermediate lane of 5.5m carriageway. The surface of the carriageway is bituminous for most of the stretch and gravel for remaining stretch.

The condition of the pavement is generally poor with lots of ruts, raveling or potholing and patching.

Table.2: Existing Road Characteristeics

Existing Chainage		Carriageway Width(m)	Surface Type	Shoulder Width	Shoulder Type	Terrain /Type
Start	End					
24+940	39+170	3.5 - 5	BT	0.5-1	ER	Hilly

6.4.3 Road Junctions

. There are no major junction and 6 minor junctions in the entire stretch.

Table 3: Details of Major Junction

Sr. No.	Chainage	Type	Link	Direction
Nil				

Table 4: Details of Minor Junction

Sl. No.	Design Chainage	Type of Intersection	Direction	Type of Road	Going To
			Left/Right	ER/BT/CC	
1	24+960	Y	Left	-	Gyasok Village
2	25+300	Y	Right	ER	Babangoan Village
3	26+120	Y	Left	ER	Nimbong Khasmahal
4	30+140	T	Right	BT	Pemling
5	30+400	Y	Left	BT	Kalimpong
6	38+830	T	Left	CC	Kafer Village

6.4.4 Existing Bridge & Cross Drainage Structures

There are 2 no. of Viaduct, 13 slab culverts, 54 Causeway and no ROB on the project road section.

Table 5: Summary of Existing Bridges and Culverts

S. No	Type	Nos.
1	**Major Bridges**	**0**
2	**Minor Bridges**	**0**
3	Viaduct	2
4	Pipe Culverts	0
5	**Slab Culverts**	**13**
6	**Causeway**	**54**
	Total	67

6.4.5 Benefits envisaged from the project road:

Following are the expected benefits due to the improvement in the project road:

- Better level of service in terms of **improved riding quality** and **smooth traffic flow.**
- 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.
- **Enhanced connectivity** between **rural & urban population** which will **benefit** the all sections of the society like **general population, petty business, farmers,** etc.
- **Improved access** to higher **education facilities & modern health facilities**.
- **Strengthening of both rural & urban economies** which in turn will improve economic scenario of the state and country.
- Improved road connectivity helps in **better implementation and management**

of government schemes.

- Being the part of **old silk route and tourist place**, it helps to induce economy and **generate employment opportunities**.
- **Overall improvement of the region.**

6.5 Project Area

Project area is part Himalayan Mountain and almost falls in hilly region of Darjeeling District. Only first three kilometer is the part of Jalpaiguri District. The hill area is formed of comparatively recent rock structure that has a direct bearing on landslides. Heavy monsoon precipitation contributes to the landslides. Soils of Darjeeling hill areas are extremely varied, depending on elevation, degree of slope, vegetative cover and geolology.

This Himalayan region is the source of natural resources for the population residing in the hills. As human population expands in the hills, forests are being depleted for the extension of agricultural lands, introduction of new settlements, roadways, etc. The growing changes coming in the wake of urbanization and industrialization leave deep impressions on the hill ecosystem.

The economy of the project area depends on tea production, horticulture, agriculture, forestry and tourism. The major portions of the forests are today found at elevations of 2000 meters and above. The area in between 1000–2000 meters is cleared either for tea plantation or cultivation. Evergreen forest is found in the project stretch. Lish and Gish are the important rivers of the project.

6.6 Identification of Villages and Towns

As part of project preparation, Social Screening Survey was conducted of the project road. Along the project road section there are many villages and a few built up locations. The survey identified villages and the built up section abutting the project road section. A total of 4 revenue villages abutting the project road have been identified. Bagrakot, Sansidara, Babot and Nimbong are the locations where some habitations can be seen. Names of revenue villages along the project road alignment and are likely to be impacted by the proposed road is presented in **table 2**.

Table 6 – Details of Revenue Villages

District	Tehsil	Village
Jalpaiguri	Mal	Bagrakot Tea Garden
Darjeeling	Kalimpong-I	NabgaonKhasmahal
		PabrintarKhasmahal
		NimbongKhasmahal

2. OBJECTIVES AND STUDY METHODOLOGY

2.1 Objectives

The overall objective of the study is to assess the adverse impacts of the project road on property and life of people and also prepare a time bound action plan to assist the project affected persons (PAPs) in getting their entitlements (compensation - for affected land, structure and other properties and assets and R&R assistance) to enable them in improving or at least restoring their living standards and income earning capacity.

The specific objectives of the study are as under:

- Collect information using suitable tools regarding project impacts;
- Differentiate the properties and assets likely to be affected by type of ownership and construction, etc;
- Assess the extent of loss of properties (land, structure and others) of individual as well as that of community and loss of livelihood;
- Conduct meaningful consultations with likely PAPs, community and other stakeholders;
- Establish a baseline profile of population, social structure, employment, sources of income, access to social services and facilities, etc.

The various activities that have been carried out as part of the study are summarized as under:

2.2 Collection of Right of Way (ROW) Data

RoW information was collected from the PWD Offices of concerned districts as one of the first activities of the study. This helped broadly in assessing the potential impacts in view of

proposed widening and strengthening. Availability of RoW information was helpful in broadly understanding the extent of encroachments particularly, in settlements and market places.

2.3 Properties and Assets likely to be Affected

Structures and other properties likely to be affected within the corridor of impact were identified even most part of the project traverses through barren and agricultural land by following the proposed alignment plan. Any structure (residential, commercial, small business units, etc) and CPRs that fell within the proposed ROW (corridor of impact) either partially or fully were considered as likely affected structures. Approximate dimension of structures falling within the limits (COI) were measured. Simultaneously, names of owners/possessors of structures, associated with the likely affected structures and properties were also noted. The information on likely affected structures and other properties were recorded in a format. Data generated from this activity have been used to assess the project impacts.

2.4 Census and Socio Economic Survey

Census and socio-economic survey was conducted for each structures and properties. The survey was carried out by using a Census and Socio-economic survey questionnaire (**Annexure-I**). This survey was conducted to generate baseline information on socio-economic conditions of the PAPs and also to assess the extent of impacts due to proposed upgrading of project road.

Census and socio-economic survey was conducted by engaging a team of surveyors recruited locally. The survey was conducted under the overall supervision of Social Development Specialist. It was conducted amongst all the project affected households and business units within the corridor of impact. The survey was administered to head of the household; preferably otherwise an adult member of the household was requested to provide the response.

The socio-economic questionnaire was developed keeping in view the aims and objectives and baseline data needed for assessing the socio-economic conditions of project affected persons with specific concern to vulnerable sections of the society (SC, ST, Women Headed Household etc) for monitoring the status of project affected persons during and after the implementation of project. The socio-economic questionnaire

covered data generation on demography, education, occupation, sources of income, land holding, ownership of dwelling and other properties and their views on the project.

2.5 Consultations

Consultations with potential project affected persons, local people and government officials were held during social screening survey and census and socio-economic surveys. Efforts were made to involve village heads, representatives of various government departments including Revenue Department, PWD, Forest Department, representative of religious and community structures likely to be affected. Besides, road side group consultations and individual consultations were held at several places during the field survey work. Output of the consultations was shared with the design team of the consultant for integrating the social concerns wherever feasible. The main objective of consultations were to promote public understanding and find out meaningful solutions of developmental problems such as local needs and problems, loss of livelihoods, impact on religious structures, alternatives, etc.

3. SOCIO-ECONOMIC PROFILING OF THE PROJECT AREA

As mentioned above, the project road passes through the boundaries of 4 villages Social profile of the villages is presented in **table 8**. SC constitutes about 6.89% of the total population. It is less than equal to 10% of the total population. It is significant in Bagrakot Tea Garden i.e. 10.59% of the village population and 2.14% of the village population in NimbangKhasmahal but the SC population is insignificant in NabgaonKhasmahal and PabrintarKhasmahalshere it is less than 1%. ST population is present in all project affected villages and it constitutes 33.98% of the total population. In PabrintarKhasmahal it is more than half of the village population (53.79%) and about 40% of the village population is in NimbongKhasmahal village.

Literacy is one of the important indicators of measurement of development. Literacy level among the potential project affected persons is important as it provides a basis to understand their educational level and thereby form a base for skill development in the event of loss of livelihood. From the data provided in table 5, it may be seen that overall literacy rate is about 67.29% which is very less as compared to the literacy rate of West Bengal (74.04%). The literacy rate of Jalpaiguri and Darjeeling stand at 73.21% and

79.56% respectively. The literacy rate of Darjeeling District is higher than the literacy rate of Bihar.Data on literacy rates is presented in **table 5**.

Table 7 – Literacy rates segregated by sex (Census 2011)

State/District	Literacy Rate (%)
West Bengal	74.04
Jalpaiguri	73.21
Darjeeling	79.56
Project Affected Villages	**67.29**

Summary of relevant data of villages through which the project road passes as per Census 2011 is presented in **table 8**. As per Census 2011, the total population of all the villages together is 16332. Female constitutes 49.52% of the total population. There are 8088females for 8244males and hence the sex ratio works out to be 981. In other words, there are 981 females per 1000 males.

Table 8 – Social -Economic Profile of Villages

Village	**Population**	**Male (%)**	**Female (%)**	**SC (%)**	**ST (%)**	**Literacy (%)**	**Male Literacy (%)**	**Female Literacy (%)**	**Worker (%)**	**Non Worker (%)**
Bagrakot Tea Garden	9971	49.21	50.79	10.59	29.22	68.98	77.34	60.88	40.47	59.53
NimbongKhasmahal	2659	51.45	48.55	0.90	40.17	62.47	67.76	56.86	55.55	44.45
NobgaonKhasmahal	1681	52.94	47.06	2.14	28.61	67.64	72.81	61.82	56.69	43.31

ParingarKhas mahal	2021	53.39	46.61	0.49	53.79	65.02	71.27	57.86	54.97	45.03
Total	**16332**	**50.48**	**49.52**	**6.89**	**33.98**	**67.29**	**74.47**	**59.98**	**46.49**	**53.61**

Source: Census 2011

Percentage of workers engaged in different activities indicates the nature of employment available in the area is presented in **table 8**above. It has been obtained from the Census of India, 2011. 46.49% of the total population has been identified as workers. Non workers constitute about 53.61% of the total population indicating high dependency ratio. Data reveals that people are primarily engaged in agriculture and cultivation and petty shop business. The maximum population surrounding Bagrakot are agricultural labour and are involved in tea garden. The proposed Bagrakot bypass starts from tea garden. The project is the part of tourist places and the petty shop is another occupation of local residents. The improvement of project will enhance their business and number of tourist. Census data on respective villages is provided as **Annex-II.**

4. Proposed Improvements

Following is a summary of the recommended design standards proposed to be adopted for the project road other than service road and intersections:

Table 9: Design Standard for Proposed Improvement

(i)	Design Speed (Km/hr)		
	Hilly Terrain	:	60 (Ruling), 40(Minimum)
(ii)	Level of Service	:	B
(iii)	Roadway Widths (m)	:	11m for 2-lanes with paved shoulders areas)
(iv)	Roadway Elements		
		:	Carriageway • 2-lane- 2X3.5m= 7.0m • 2x1.5m (Paved shoulder)=3.0m • 1X1.0m Earthen Shoulder on valley side
(v)	Camber		Carriageway/Paved Shoulder- 2.50% Unpaved Shoulder- 3.50%
(vi)	Right of Way		24m for bypasses
(vii)	Embankment/ Cutting Slope		In filling- 1V: 2 H In cutting- 1V:1H

(viii)	Stopping Sight Distance		90m for design speed of 60 Km /hr 45 m for design speed of 40km/hr
	Intermediate sight distance		180m for design speed of 60 Km/hr 90 m for design speed of 40 Km /hr
	Overtaking sight distance		340m for design speed of 60 Km/hr 165 m for design speed of 40 Km /hr
(ix)	Super-elevation		Maximum 7% Desirable Minimum 5%
(x)	Radii for Horizontal Curves		Ruling Minimum 150 M Absolute minimum 75 m
(xi)	Ruling Gradient		2.5%
(xii)	Minimum K- factor		
	Summit Curve		26.7 for design speed of 60 km/hr 15 for Design speed of 50 km/hr
	Valley Curve		15 for Design speed of 60 km/hr 10 for Design speed of 50 km/hr
(xiii)	Bridge Clearance		
	Vehicular underpass		5.5 m
	Cattle and Pedestrian		3.0m
(xiv)	Design Flood Frequency		
	Bridges		100 years

	Sewers and Ditches		60 years
(xv)	Minimum Drainage Channel Width		0.60 m

Proposed cross-sections along with widening schedule is shown in **Table 10** below

Table 10: Proposed Improvement Proposal

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
1	26+100	26+430	330	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	VI
2	26+430	26+960	530	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
3	26+960	27+200	240	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
4	27+200	27+720	520	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
5	27+720	27+840	120	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
6	27+840	28+000	160	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
7	28+000	28+540	540	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
8	28+540	29+980	1440	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
9	29+980	30+010	30	Elevated Structure (including box abutment length)	VIII

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
10	30+010	30+180	170	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
11	30+180	31+040	860	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
12	31+040	31+150	110	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
13	31+150	31+320	170	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
14	31+320	31+440	120	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
15	31+440	31+600	160	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
16	31+600	31+740	140	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
17	31+740	32+560	820	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
18	32+560	32+660	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
19	32+660	33+480	820	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
20	33+480	33+560	80	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
21	33+560	33+700	140	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
22	33+700	33+800	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
23	33+800	34+000	200	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
24	34+000	34+180	180	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
25	34+180	34+280	100	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
26	34+280	34+380	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
27	34+380	34+880	500	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
28	34+880	34+900	20	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
29	34+900	34+960	60	Elevated Structure (including box abutment length)	VIII
30	34+960	35+360	400	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
31	35+360	35+440	80	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
32	35+440	35+900	460	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
33	35+900	35+980	80	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
34	35+980	36+600	620	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley	III

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
				section)	
35	36+600	37+270	670	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
36	37+270	39+500	2230	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
37	39+500	40+000	500	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
	Total Length		**13900**		

Table 11: Details of TCS

TCS No.	Description	Total Length (m)
1	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	3110
2	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	3150
3	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	2160
4	Two lane with Paved shoulder Realignment (One Side Hill, One side Valley section)	1840
5	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	2880
6	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	330

TCS No.	Description	Total Length (m)
7	Two lane with Paved shoulder Realignment (Both Side Hill section)	340
8	Elevated Structure (including box abutment length)	90
	Total	**13900**

5. MINIMIZING ADVERSE IMPACTS

As part of the project preparation, social screening survey was carried out by the consultant during the m/o June 2016**.** The study involved reconnaissance survey, identification of constraints along the road (congested locations, common property resources, and other social concerns), collection of RoW, assessment of the magnitude of social impact, typology of structures, extent of land acquisition, consultations, etc.

A reconnaissance survey was conducted which contained identification of congested locations and analysis of alternatives, consultations covering issues and concerns of people, assessments of impacts on structures and other structures, common property resources, additional land required for the project and estimated budget for resettlement and rehabilitation. As per the survey about 200 residential and commercial structures were affected by widening of existing road. A large number of petty shop business were affected in Bagrakot, Barbot and Nimbong habitations. Structures likely to be affected constitute pucca and semi-pucca structures.. Besides above mentioned residential and commercial structures, 2 community properties were also identified along the project road which comprised church and the statue of Lord Buddha,

Table 17: Summary of Cost of Project Road

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
A	**ROAD WORKS**					
1	Site Clearance					

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
					8,394,023.40	0.839
2	Excavation	Cum			310,067,710.40	31.007
3	Earthwork Filling	Cum			8,944,156.95	0.894
4	Sub Grade	Cum			26,497,121.14	2.650
5	CTSB	Cum			150,492,715.82	15.049
6	BSM	Cum			147,499,418.14	14.750
7	Prime Coat	Sqm			4,131,275.39	0.413
8	Tack Coat	Sqm			3,098,456.54	0.310
9	BC	Cum			76,889,920.52	7.689
B	**BRIDGES and STRUCTURES**					
1	Culverts	No.	68		157,215,992.18	15.72
C	**SLOPE STRUCTURES**					
1	Elevated Structure	No.	2		98,971,984.78	9.90
2	Retaining Wall	Rnm	1540		118,645,861.64	11.86

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
3	Breast Wall	Rnm	11600		225,110,134.76	22.51
D	**JUNCTIONS**					
1	Minor Junctions	No	6.0		40,794,385.50	4.08
E	**DRAIN & PROTECTION WORK**					
1	Drainage Works	Km			81,585,127.87	8.16
2	Parapet Wall	Km	10.92		26,535,600.00	2.65
3	Other Protetive Works				381,817,800.00	38.18
F	**LAY BYES**					
1	Bus Shelter	Nos	4.0	1,500,000	6,000,000.00	0.60
G	**OTHER MISCELLANEOUS ITEMS**					
1	Miscellaneous Items	Total			1,893,900.00	0.19
2	Traffic Signs, Marking and Road Appurtenances	Total			6,614,661.51	0.66
3	Reflective Road Studs	Nos	3060			

SI.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
					2,553,019.20	0.26
	TOTAL CIVIL COST				**1883753265.73**	**188.375**
	COST PER KM (LENGTH = 13.900 KM) IN CRORES ...					**13.55**

7.0 Improvement Proposals and Design

7.1 General

This chapter describes the various improvement proposals and their necessities to upgrade the existing carriageway facility of project road into two lane with paved shoulder in accordance to the Indian standard configuration and design standards proposed for the project road. These improvement proposals are based on the findings of various engineering features carried out on the project roads such as Traffic Survey and Analysis, Inventory Data and Pavement Investigations.

The improvement proposals for proposed widening include the provisions for the following major items:

a) Curvature Improvement
b) Realignment
c) Widening Proposal
d) Proposed Pavement Design & Overlay Design
e) Bridge and Cross Drainage Structures
f) Traffic Control and Safety Measures

7.2 Design Standards

7.1.1 Summary

Following is a summary of the recommended design standards proposed to be adopted for the project road other than service road and intersections:

(i)	Design Speed (Km/hr)		
	Hilly Terrain	:	60 (Ruling), 40(Minimum)
(ii)	Level of Service	:	B
(iii)	Roadway Widths (m)	:	11m for 2-lanes with paved shoulders areas)
(iv)	Roadway Elements		
		:	Carriageway • 2-lane- 2X3.5m Paved Shoulder • 2-lane with PSS- 2x1.5m Unpaved Shoulder • 2 lane -1X1.0m
(v)	Camber		Carriageway/Paved Shoulder- 2.50% Unpaved Shoulder- 3.50%
(vi)	Right of Way		24m for bypasses
(vii)	Embankment/ Cutting Slope		In filling- 1V: 2 H In cutting- 1V:1H

(viii)	Stopping Sight Distance		90m for design speed of 60 Km /hr 45 m for design speed of 40km/hr
	Intermediate sight distance		180m for design speed of 60 Km/hr 90 m for design speed of 40 Km /hr
	Overtaking sight distance		340m for design speed of 60 Km/hr 165 m for design speed of 40 Km /hr
(ix)	Super-elevation		Maximum 7% Desirable Minimum 5%
(x)	Radii for Horizontal Curves		Ruling Minimum 150 M Absolute minimum 75 m
(xi)	Ruling Gradient		2.5%
(xii)	Minimum K- factor		
	Summit Curve		26.7 for design speed of 60 km/hr 15 for Design speed of 50 km/hr
	Valley Curve		15 for Design speed of 60 km/hr 10 for Design speed of 50 km/hr
(xiii)	Bridge Clearance		
	Vehicular underpass		5.5 m
	Cattle and Pedestrian		3.0m
(xiv)	Design Flood Frequency		
	Bridges		100 years
	Sewers and Ditches		60 years
(xv)	Minimum Drainage Channel Width		0.60

7.1.2 Road Functional Classification

NHIDCL Government of India has seceded to upgrade some of the single lane / intermediate lane National Highways to at least two lane with paved shoulder. The work would be taken up for up-gradation on corridor concept. Therefore, corridors include strengthening (in adjoining reaches) in addition to widening to two lane/two lane with paved shoulder standards in order to have a better facility in a long continuous stretch.
Thus the NHIDCL requires to rehabilitation and up gradation of the project road to two lanes or four lanes with paved shoulder configuration and or its strengthening & widening.

7.1.3 Geometric Design

7.1.3.1 General

Geometric design of a highway is the process whereby the layout of the road in specific terrain is designed to meet the needs of the road users keeping in view the road function, type and volume of traffic, potential traffic hazards and safety as well as convenience of the road users. The principal areas of control for fulfilment of this objective are- the horizontal alignment, vertical alignment and the road cross-section.

The Consultants have referred to the latest IRC publications and MOSRT&H circulars regarding design standards for National Highways in India. After careful review of all

available data and requirements of the project road the proposed Design Standards for adoption on the project road have been recommended.

7.1.3.2 Design Speed

The project road passes through hilly terrain. For geometric design of the highway, design speed is used as an index which links road function, traffic flow and terrain. An appropriate design speed should correspond to general topography and adjacent land use. The speed selected for design should also cater to travel needs and behaviour of the road users. Mountainous highways are normally designed for speed of 60 km/hr, however depending on terrain and whether the design is for new alignment or reconstruction of an existing facility, the design speed is determined to the site requirement.

The ruling design speed corresponding to the type of terrain as per IRC: SP: 73-2018, AASHTO 2004 and TAC (1999) are as follows:

Table 6.1: Design Speed Standards

Terrain	Ruling Design Speed (km/h)		
	IRC	AASHTO	TAC (1999)
Plain	100	100	100
Hill	60	60	60

Assuming a diverse mix of traffic on the project roads, a ruling design speed of 60 km/h and minimum design sped of 40km/hr for hilly terrain is proposed for the project road.

7.1.3.3 Levels of Service (LOS)

The Level of Service (LOS) characterizes the operating conditions on the roadway in terms of traffic performance measures related to speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience. The levels of service range from level-of-service A (least congested) to level-of-service F (most congested). The Highways Capacity Manual (HCM) provides the following levels of service definitions:

Table 6.2: Standards for Level of Service

Level of Service (LOS)	General Operating Conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Considering the importance of the highway, whereas Level of Service (LOS) 'B' is desirable and level of service up to LOS-'C' may be acceptable.

7.1.3.4 Cross Sectional Elements

Adequate roadway width will be provided for the requisite number of traffic lanes besides the shoulders and a central median dividing the traffic flow directions.

As specified in the IRC :SP:73-2018 in general, standard lane width shall be 3.5m for project highway. Based on a comparative review of international standards and safety, the values proposed to be adopted for the roadway elements by the Consultants for the project highway are as follows:

a) Roadway Width for Two lane Highways

Table 6.3A: Road Cross Section

Item	Two-Lane with Paved Shoulder
Carriageways	2X3.5m
Paved shoulder	2X1.5 m
Unpaved shoulder Plain terrain	1X1m
Total Roadway width Hilly terrain	11m

* Exclusive of parapets and side drains

b) Lane Width

Lane width has a significant influence on the safety and comfort of the road. The capacity of a roadway is marked by affected by the lane width. In general, safety increases with wider lanes up to a width of about 3.7 m. The lane width as per IRC:SP 73: 2018 is 3.5 m. recommended lane widths for this type of facility are 3.6 m and 3.7 m respectively for design speed of 100 km/h.

Experience shows that operating speed normally remains less than the design speed because of the partially access controlled facility and the other ambient conditions. Based on this assumption a 3.5 m lane width is proposed. This also concurs with other National Highways in India currently under construction.

c) Shoulders

Shoulders are a critical element of the roadway cross section. Shoulders provide recovery area for errant vehicles; a refuge for stopped or disabled vehicles; and access for emergency and maintenance vehicles. Shoulders can also provide an opportunity to improve sight distance through cut sections.

According to IRC:SP 73-2018 for two lane highways the normal shoulder width shall be 1.5m paved and 1m earthen shoulder on either side for hilly terrain.

d) Pavement Camber (Cross fall)

IRC :SP 73 2018 recommends the following camber for various surface types:

Table 6.4: Provision for Cross Fall

Category of surface	Annual Low rainfall (less than 1500 mm)	Annual High rainfall (more than 1500 mm)
Bituminous	2.5%	2.5%
Cement Concrete	2.0%	2.0%
Metal/Gravel	2.5%	3.0%
Earth	3.0%	4.0%

Considering of bituminous surfacing (bituminous concrete) the Consultants propose to provide a camber of 2.5 % for the main carriageway as well as paved shoulders and 3.5 % for the unpaved shoulder.

e) Land Width (Right of Way)

The IRC:SP 73-2018 has specified following land width values or Right-of Way for National Highways

Table 6.5: Provision for ROW

Right of Way (m)	Hilly Terrain	
	Range	Normal
Open Areas	24-30	24
Built-up Areas	13-14	13.5

It may be noted that the provisions stipulated above corresponds to the carriageway configuration of Two lane Highway.
The Consultants therefore, propose 24 m ROW in hilly for two lane section. In built up areas the ROW will depend on the adjacent land strip available for development.

f) Embankment Slopes

The slope of embankment is linked with its height. In accordance with the Manual for Safety in Road Design (MoRT&H publication), the following are proposed to be adopted:

Ht of embankment 4.5 m and above	2 H : 1V with crash barriers
Ht of embankment 3 m to 4.5 m	2.5 H : 1 V
Ht of embankment 1.5 m to 3 m	3 H : 1 V
Ht of embankment less than 1.5 m	4 H : 1 V

As per IRC: SP: 73-2018 the side slopes for embankment shall not be steeper than 2H:1V unless soil is retained by suitable soil retaining structure. The side slopes of cutting shall be provided in accordance with the nature of soil encountered. The slope shall be stable for type of strata. Where required, benching including use of slope stability measures like pitching, breast wall, etc. shall be adopted to make the slopes stable and safe.
The Consultants propose to provide slopes of 2H:1V in Fill sections. Cut slopes are proposed as 1H: 1V in general however, these sections will be specifically analyzed for stability before adopting this slope or steeper slopes.

7.1.3.5 Horizontal Alignment

a) General

For balance in highway design, all geometrical elements should be determined for consistent operation under the design speed in general. A horizontal alignment should be as smooth and consistent as possible with the surrounding topography. To achieve that, an appropriate blending with the natural contours is preferable to the one with long tangents through the terrain.

b) Sight Distances

Visibility is an important requirement for the safety of travel on roads. For this it is necessary that sight distance of adequate length is available in different situations, to permit drivers enough time and distance to control their vehicles so that chances of accidents are minimized. Sight distance is a direct function of the design speed. On divided highways the design should correspond to Stopping Sight Distance, which is the clear distance ahead needed by a driver to bring his vehicle to a stop before meeting a stationary object in his path. On two-lane roads, normally intermediate sight distance should be available throughout for design purposed. In stretches where even intermediate sight distance is not available, safe stopping site distance should be provided with traffic signs depicting “Overhead Prohibited” at all such locations.
Sight distance corresponding to various design speeds are given below.

Table 6.6A: Sight distance for various Speeds

Design Speed Km/h	IRC SP 73:2018		
	Stopping Sight Distance (m)	Intermediate Sight Distance (m)	Overtaking Sight Distance (m)
40	45	90	165
60	90	180	340
80	120	240	470
100	180	360	640

Safe stopping distances corresponding to various design speeds are given below:

Table 6.6B: Stopping Sight Distance Criteria

Design Speed Km/h	Safe Stopping Sight Distance (m)		
	IRC SP 73:2018	AASHTO (2001)	TAC (1999)
50	60	65	55 - 65
80	120	130	113 - 140
100	180	185	152 – 205

It is desirable to design the highway for more liberal values for operational convenience. An appropriate allowance would be considered to take care of the effect of adverse incidents. The value recommended by IRC & guidelines are proposed to be adopted in design.

c) Horizontal Curve

The minimum horizontal curve radius is the limiting values of curvature for a given design speed and is determined based on from the maximum rate of super elevation and the side friction factor. As per the IRC: SP:73 – 2018 the minimum ruling radii of Horizontal curve for National Highways corresponding to different terrain conditions are as follows:

Table 6.7 : Horizontal Radii Criteria

Type of Terrain	Minimum Radii of Horizontal Curve	
	Desirable Minimum	Absolute Minimum
Mountainous & steep	150	75

Absolute minimum and ruling minimum radii correspond to the minimum design speed and the ruling design speeds respectively.

On new roads, horizontal curves are designed with liberal radius provision that blends well the overall geometry and topography. However, for locations with constraints and to make use of available roadway, it is proposed to keep minimum radius in accordance with the IRC recommendations.

Table 6.8: Adopted Horizontal Radii

Speed (km/h)	Absolute Minimum Radius (m)
100	400
80	250
65	155
50	90

d) Transition (Spiral) Curves

The purpose of a transition (spiral) curve is to provide a smooth and aesthetically pleasing transition from a tangent and a circular curve. In addition the transition curves provide the necessary length for attainment of super-elevation runoff.

The IRC: 73-2018 and IRC :38-1988 design standards suggest 130 m, 90 m,80m and 75 m transition curve lengths for circular curves of radii 400 m, 250 (design speeds of 100 km/hr, 80 km/). The AASHTO (2001) design guidelines specify transition curve lengths of 72 m, 65 m and 50 m; and the TAC (1999) design guidelines recommend transition curve lengths of 80 m, 80 m and 50 m for curve radii of 440 m, 250 m, 90 m (design speeds of 100 km/hr, 80 km/hr and 50 km/hr) respectively.

It is proposed to adopt transition curve lengths of 130 m, 90 m, 80 m and 75 m for design speeds of 100 km/hr, 80 km/hr, 65 km/hr and 50 km/hr respectively at their minimum recommended moves.

e) Extra Width of Pavement and Roadways

Since the project road is of two lane categories extra widening is necessary on curves having radius less than 300 m. to counter balance mechanical and psychological disorder of the vehicle. Extra widening is achieved by increasing the width at a uniform rate along the curve. On curve having no transition, widening is achieved in same way as super elevation i.e. two third is being attained on the straight section before start of the curve and one third on the curve. In hill roads and on curves without transitions extra widening is provided on inner side of the curve. As per IRC: SP: 73-2018, the extra widening shall be increased as follows:

Table 6.9: Extra width of Pavement and Roadway

Radius of Curve	Extra Width
75-100m	0.9m
101-300m	0.6m

The value and guide lines recommended by IRC are proposed to be adopted in design.

f) Super-elevation

The limiting value of the super-elevation on the project road in both plain rolling terrain is proposed to be 7% as per IRC: 73 -1980.

7.1.3.6 Service Road Standards

It may not be possible to provide service roads at every built up area to facilitate the through traffic. However if feasible service roads will be provided at specific locations for segregation of local traffic from the through traffic using the project highway at locations like grade separation, Vehicular underpasses etc.

Following values are proposed to be adopted for service roads wherever applicable:

Design speed	:	40km/h
Cross fall	:	2.5 %

Horizontal Curve radius	:	30-60 m
Gradient	:	5 %
Width of carriageway	:	minimum 5.5m at VUP 7.0m at Grade Separator
Sidewalk/Foot path/drain /Shoulder /Separator	:	minimum 1.5m (either side) at VUP 2.0m (either side) at Grade Separator
Roadway Width	:	minimum 8.5m at VUP 11m at Grade Separator

7.1.3.7 Vertical Alignment

a) General

The vertical alignment should produce a smooth longitudinal profile consistent with standard of the road and of the terrain. Wherever possible horizontal and vertical curvature should be so combined that the safety and operational efficiency of the road is enhanced.

b) Gradients

The IRC: SP: 73-2018 propose ruling vertical grades of 2.5% for hilly terrains;. However, for the project road, the following standard is proposed.

Table 6.10 : Vertical Gradient

Terrain	Ruling (%)	Limiting (%)
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

c) Vertical Curves

As per IRC: 73-1980 design standards, the minimum lengths of vertical curves are 60 m and 50 m for design speeds of 100 km/h and 80 km/h respectively. At complex locations such as interchanges and major intersections the minimum lengths of vertical curves should be designed for safe decision sight distance. The length of a vertical curve is calculated using the following equation:

$L = K \times A$,

Where L = Length of vertical curve in metres;
K = Coefficient, a measure of the flatness of a vertical curve; and
A = Algebraic difference of grade lines (%)

Summit or Crest Curves

According to AASHTO (2001) design guidelines, the minimum K values for stopping sight distance requirements are 52, 26 and 7 for design speeds of 100 km/hr, 80 km/h and 50 km/hr respectively.

According to TAC (1999) design guidelines, the minimum K valves for stopping sight distance requirements are 45 to 80, 24 to 36 and 6 to 16 for design speeds of 100 km/hr, 80 km/hr and 50 km/hr respectively.

The Consultants propose minimum summit curve K values of 75, 35, 20 and 15 for design speeds of 100 km/hr, 80 km/hr, 65km/hr and 50 km/hr respectively.

Valley or Sag Curves

The minimum K values for valley or sag curves, in accordance with AASHTO (2001) design guidelines are 45, 30 and 13 for design speeds of 100 km/hr, 80 km/hr and 50 km/hr respectively. The minimum K values for valley or sag curves, in accordance with TAC (1999) design guidelines are 37 to 50, 25 to 32 and 7 to 16 for design speeds of 100 km/hr, 80 km/hr and 50 km/hr respectively.

The Consultants propose minimum sag curve K values of 42, 30, 20 and 15 for design speeds of 100 km/hr, 80 km/hr, 65km/hr and 50 km/hr respectively.

7.1.4 Design Standards for Structures

The design of new structures shall be based on the following materials and loading-

7.1.4.1 Materials

Concrete Grade

The minimum Grade of concrete in various elements shall be as under for moderate conditions of exposure:

	Major Bridge	***Minor Bridge/Culvert***
All PCC	M 25	M 15
All RCC	M 30	M 25
All PSC	M 35	-

Reinforcement Steel

- High yield strength deformed bar/TMT shall be of grade Fe-415/Fe-500
- Mild steel bar shall be of grade Fe-240

7.1.4.2 Seismic Zone

The project road is located in a seismic zone III. It is proposed to design the bridges for seismic forces as mentioned in modified clause 222 of IRC: 6-2000.

7.1.4.3 Pre-Stressing System

Following pre -stressing system may be adopted as a general system.

a) System (Post tensioning)	:	12T13/19T13 multi pull strand system of "Freyssinet" or "ISMALCCL" or equivalent
b) Cables (Post tensioning)	:	12T13/19T13 with strands of 12.7mm nominal dia.
c) High Tensile Steel (for both post/pre tensioning)		
Strands	:	Nominal 12.7 mm dia 7 ply low relaxation Strands conforming to class 2 of IS:14268-95
Area	:	98.7 sq.mm per strand (nominal cross section area)
Ultimate load	:	183.71 KN per strand
Modulus of Elasticity	:	1.95E05 Mpa
d) Sheathing (Post tensioning)	:	75mmOD/90mmOD Bright metal corrugated flexible sheathing for 12T13/19T13 cables respectively.
e) Friction Coefficient (Post tensioning)		0.25/radian
f) Wobble Coefficient (Post tensioning)		0.0046/m
g) Anchorage Slip (Post tensioning)		6mm average

h) Loss of force due to relaxation	:	2.5% at 0.7 UTS after 1000 hrs. The final relaxation Values for design shall be 3.0 times the 1000hr. value as per cl 11.4 of IRC: 18-1985.

7.1.4.4 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: 226.

7.1.4.5 Bearings

Reinforced elastomeric bearings shall be proposed for short span simply supported superstructures. Elastomeric bearings shall be designed as per IRC: 83 (Part II & III) and shall conform to Cl.2005 of MOSRT&H Specifications for Road & Bridges Works (4th Revision). RCC solid slab superstructures of culverts and minor bridges shall directly rest on pier/abutment caps with a tar paper in bearing.

Pot fixed/Pot PTFE sliding/ metallic bearings shall be proposed for long span simply supported superstructures and continuous superstructures. The loads and forces on the bearings shall be calculated to enable the manufacturer to design these bearings and these shall conform to Cl. 2006 of MOSR&TH Specifications for Road & Bridges Works(4th Revision).

7.1.4.6 Expansion Joints

The following types of Expansion Joints shall be adopted:

Filler type expansion joints shall be proposed for minor bridges with solid slab superstructures having span lengths not exceeding 10 meters. These type of joints shall conform to Cl. 2605 of MOST's Specifications for Road & Bridge Works (4th Revision).

Single Strip seal expansion joints shall be proposed for superstructures having movements up 80mm. (± 40mm).

The strip seal joints shall conform to Cl. 2607 of MOST's Specification for Road and Bridges works (4th Revision).

7.1.4.7 Loads

Dead Loads

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

Pre-stressed Concrete	:	2.5t/m3
Reinforced Concrete	:	2.4t/m3
Plain Cement Concrete	:	2.2 to 2.3 t/m3
Structural Steel	:	7.85t/m3
Dry Density of Soil	:	2.00 t/m3
Saturated Density of Soil	:	1.0 t/m3

Superimposed Dead Loads

Wearing coat	:	Bituminous Concrete with total weight of 2.2 t/m3

In addition Footpath / Kerb as well as Crash barriers, wherever feasible and provided are also considered as SIDL

Carriage way Live Load

Bridge Live load	:	One lane of IRC 70R or 2-Lane of Class-A whichever produces worst effect
Footpath Live Load	:	Footpath LL, wherever feasible are also considered as SIDL

The impact factor shall be as per Cl. 211 of IRC:6 for the relevant load combinations.

Longitudinal Forces

The following effects shall be considered for calculating the longitudinal forces in the design.

Braking forces as per the provision of Cl. 214 of IRC: 6-2000

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 Cl. 214.5 of IRC:6 by assuming stiff supports.

Centrifugal Forces

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

C = W*V2/127R,

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 metres.

The centrifugal force shall be considered to act at 1.20m above the formation level of the bridge in the transverse direction. No impact value on carriageway live load shall be considered for calculating the centrifugal force.

Water Current Forces

The effect of water current forces shall be calculated in accordance with clause number 213 of IRC: 6-2000 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.

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.

Earth Pressure

Horizontal forces due to earth pressure shall be calculated as per the provision of Cl. 217 of IRC:6 assuming the following soil properties:

Type of soil assumed for backfilling	:	Dry Density of 2.0 t/cu.m and Submerged Density of 1.0t/cu.m

Angle of Internal friction	: ø = 30 degree
Angle of Wall Friction	: δ =20 degree
Coefficient of Friction μ at base	: tan(2/3ø), where ø is the angle of internal friction of substrata immediately under the foundation.

Live Load surcharge shall be considered as equivalent to 1.2m height of earth fill in case of abutments and equivalent to 0.6m height of earth fill in case of return/wing walls.

Wind Forces

Structures shall be designed for wind effects as stipulated as Cl. 212 of the IRC:6. The Wind force shall be considered in the following two ways. The design shall be governed by the one producing the worst effect.

- ✓ Full wind forces at right angle to the superstructure
- ✓ 65% of wind force as calculated in (i) above acting perpendicular to the superstructure and 35% acting in the traffic direction.

7.1.4.8 Seismic Effect

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

Feq	=	Ah X (Dead Load + Appropriate Live Load)
Where, Ah	=	Horizontal seismic co-efficient = (Z/2) X (Sa/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 IV. 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.

7.1.4.9 Temperature Range

The bridge structure/components i. e bearings and expansion joints shall be designed for a temperature variation of ± 25 degree centigrade considering extreme climate.

The super structure shall be designed for effects of distribution of temperature across the deck depth as per stipulations of BD 37/88 suitably modified for the surfacing thickness.

7.1.4.10 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 Cl.605.2 of IRC: 22-1986.

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

7.1.4.11 Differential Settlement Effects

Differential Settlement effects for continuous superstructure units shall be appropriately assessed for each structure. However in any case of differential settlement of ± 12 mm shall be accounted for in the design.
The differential settlement effects in continuous superstructures shall be accounted for under following conditions:

- ✓ A minimum of 12mm differential settlement of supports with half value of 'E'.
- ✓ To simulate the bearing replacement conditions, a 12mm differential uplift with full value of 'E' shall be considered but without any live load on the superstructure.

7.1.4.12 Buoyancy

100% buoyancy shall be considered while checking stability of foundations irrespective of their resting on soil/weathered rock/or hard rock. However, maximum base pressure shall 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.

7.1.4.13 Load Combination

All members shall be designed to safely sustain the most 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 Cl. 202 of IRC:6 and Cl.706 of IRC:78.
In addition, the stability of a bridge resting on neoprene/pot bearings shall be checked under one span dislodged condition. The load case shall be checked with seismic/wind load combinations.

7.1.4.14 Design Criteria of Culverts

The culverts shall be designed as per relevant IRC codes and special publications. The following IRC codes have been adopted for design of culverts:

IRC : 5-2015	General Features of Design;
IRC : 6-2014	Loads & Stresses;
IRC : 21-2000	Cement Concrete Plain & Reinforced;
IRC : 40-2002	Brick, Stone & Block Masonry;
IRC:SP:13 2004	Guidelines for the Design of Small Bridges and Culverts;

7.1.4.15 Codes to be adopted for Design

Various codes of practices which shall be used for the design of culverts and bridges are mentioned below:

IRC Standards

1) IRC:5-2015 : Standard Specifications and Code of Practice for Road Bridges, Section I- General Features of Design (Seventh Revision)
2) IRC:6-2014 : Standard Specifications and Code of Practice for Road Bridges, Section II- Loads and Stresses (Fourth Revision)
3) IRC:7-1971 : Recommended Practice for Numbering Bridges and Culverts (First Revision)
4) IRC:22-2015: Standard Specifications and Code of Practice for Road Bridges Section VI – Composite Construction (Limit States Design) (Second Revision)
5) IRC:24-2010: Standard Specifications and Code of Practice for Road Bridges Section IV – Brick, Stone and Block Masonry (Second Revision)
6) IRC:40-2002: Standard Specifications and Code of Practice for Road Bridges Section V – Steel Road Bridges (Second Revision)
7) IRC: 45-1972: Recommendations for Estimating the Resistance of Soil Below the maximum scour Level in the Design of Well Foundations of Bridges.
8) IRC:54-1974: Lateral and Vertical Clearances at Underpasses for Vehicular Traffic
9) IRC:78-2014 : Standard Specifications and Code of Practice for Road Bridges Section VII – Foundation and Substructure (Second Revision)
10) IRC:83-2015 : Standard Specifications and Code of Practice for Road Bridges Section IX – Bearings, Part I: Metallic Bearings (First Revision)
11) IRC:83-2015 : Standard Specifications and Code of Practice for Road Bridges Section IX – Bearings, Part II: Elastomeric Bearings
12) IRC:83-2015 : Standard Specifications and Code of Practice for Road Bridges Section IX – Bearings, Part III: POT,POT-CUM-PTFE,PIN and Metallic Guide Bearings
13) IRC:89-1997: Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)
14) IRC:112-2011 Code of Practice for Concrete Road Bridges

IRC-SP

15) IRC: SP: 33-1989: Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures.
16) IRC:SP:48-1998 : Hill Road Manual
17) IRC:SP: 13-2004 : Guidelines for the Design of Small Bridges and Culverts(First Revision)
18) IRC: SP: 18-1978: Manual for Highway Bridge Maintenance Inspection.
19) IRC:SP: 35-1990: Guidelines for Inspection and Maintenance of Bridges.
20) IRC:SP: 40-1993: Guidelines on Techniques for Strengthening and Rehabilitation of Bridges
21) IRC:SP: 47-1998 : Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete)
22) IRC: SP:51-2015 : Guidelines for Load Testing of Bridges.
23) IRC: SP:73-2018 : Manual of Standards and Specifications for 2-lanning of State Highways on BOT Basis

British standards, in absence of Indian standards

24) BS 5400-PartIX (For design of POT/POT-PTFE Bearings)

MORT&H Specifications

25) The specifications for road and bridges works of Ministry of Road Transport & Highways (latest editions) published by Indian Road congress shall be used for materials to be used for construction of bridge.
26) MOSRT&H standards plans for single, double and triple cell box culverts with and without earth cushion.
27) Standard Drawings for Road Bridges RCC Solid Slab Superstructure (22.5 skew) for spans 4m to 10m

Indian Standards

28) IS:456-2000: Plain and Reinforced Concrete (Fourth Revision)
29) IS:2502-1963
30) IS: 808
31) IS: 2062/8500

7.2 Widening Scheme

In order to meet future traffic requirement the existing carriageway is proposed to upgrade to achieve high speed of travel with comfort and safety. Concentric widening scheme is followed to minimise land acquisition issues and to ensure maximum utilisation of existing carriageway.

7.2.3 Typical Cross-sections

Proposed cross-sections along with widening schedule is shown in **Table 6.11** below and (**Annexure 6.5**).

Table 6.11: Proposed Improvement Proposal

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
1	26+100	26+430	330	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	VI
2	26+430	26+960	530	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
3	26+960	27+200	240	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
4	27+200	27+720	520	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
5	27+720	27+840	120	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
6	27+840	28+000	160	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
7	28+000	28+540	540	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
8	28+540	29+980	1440	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
9	29+980	30+010	30	Elevated Structure (including box abutment length)	VIII
10	30+010	30+180	170	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
11	30+180	31+040	860	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
12	31+040	31+150	110	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
13	31+150	31+320	170	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
14	31+320	31+440	120	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
15	31+440	31+600	160	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
16	31+600	31+740	140	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
17	31+740	32+560	820	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
18	32+560	32+660	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
19	32+660	33+480	820	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
20	33+480	33+560	80	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
21	33+560	33+700	140	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
22	33+700	33+800	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV

Sr. No.	Proposed Chainage		Length in (m)	Type of Cross Section	TCS No.
	From (Km)	To (Km)			
23	33+800	34+000	200	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
24	34+000	34+180	180	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
25	34+180	34+280	100	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
26	34+280	34+380	100	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
27	34+380	34+880	500	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
28	34+880	34+900	20	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
29	34+900	34+960	60	Elevated Structure (including box abutment length)	VIII
30	34+960	35+360	400	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
31	35+360	35+440	80	Two lane with paved shoulder Realignment (Both Side Hill section)	VII
32	35+440	35+900	460	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
33	35+900	35+980	80	Two lane with paved shoulder Realignment (One Side Hill, One side Valley section)	IV
34	35+980	36+600	620	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	III
35	36+600	37+270	670	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	V
36	37+270	39+500	2230	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	II
37	39+500	40+000	500	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	I
	Total Length		**13900**		

TCS ON ROB APPROACH AND RAMP

Sr. No.	Proposed Chainage		Length	Section	TCS
	From (Km)	To (Km)	in (Km)		
1	A+0.000	A+0.300	0.3	On ROB Approach	4
2	A+0.300	A+0.800	0.5	Ramp A-A	4A
3	B+0.300	B+0.700	0.4	Ramp B-B	4A
4	C+610.360	C+611.400	1.04	On NH-31	5
	Total		**2.24**		

Details of TCS

TCS No.	Description	Total Length (m)
1	Two lane with Paved shoulder Concentric Widening (One Side Hill, One side Valley section)	3110
2	Two lane with Paved shoulder Eccentric Left Widening (One Side Hill, One side Valley section)	3150
3	Two lane with Paved shoulder Eccentric Right Widening (One Side Hill, One side Valley section)	2160
4	Two lane with Paved shoulder Realignment (One Side Hill, One side Valley section)	1840
5	Two lane with Paved shoulder Concentric Widening (Both Side Hill section)	2880
6	Two lane with Paved shoulder Concentric Widening (Both Side Valley section)	330
7	Two lane with Paved shoulder Realignment (Both Side Hill section)	340
8	Elevated Structure (including box abutment length)	90
	Total	**13900**

Culverts

Overall width of all culverts shall be equal to the roadway width of the approaches.

Reconstruction of Existing Culverts:

The existing culverts at the following locations shall be reconstructed as new culverts:

Sl. No.	Existing Chainage (Km)	Type of Culvert	Existing No. of Spans with Span Length x Vertical Clearance (In m)	Recommendation	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (In m)
1	25+083	Cause way		Reconstruction	26+220	RCC Slab	1x3
2	25+544	Cause way		Reconstruction	26+660	RCC Slab	1x3
3	25+776	RCC Slab	1X2	Reconstruction	26+900	RCC Slab	1X3

Sl. No.	Existing Chainage (Km)	Type of Culvert	Existing No. of Spans with Span Length x Vertical Clearance (In m)	Recommendation	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (In m)
4	25+977	RCC Slab	1X2	Reconstruction	27+060	RCC Slab	1X3
5	26+103	RCC Slab	1X3	Reconstruction	27+180	RCC Slab	1X3
6	26+231	RCC Slab	1X1.5	Reconstruction	27+280	RCC Slab	1X3
7	26+460	RCC Slab	1X2	Reconstruction	27+480	RCC Slab	1X3
8	26+642	Causeway		Reconstruction	27+620	RCC Slab	1X3
9	26+774	Causeway		Reconstruction	27+920	RCC Slab	1X3
10	27+380	RCC Slab	1X2	Reconstruction	28+340	RCC Slab	1X3
11	27+728	Causeway		Reconstruction	28+680	RCC Slab	1X3
12	28+613	Causeway		Reconstruction	29+550	RCC Slab	1X3
13	28+715	Causeway		Reconstruction	29+650	RCC Slab	1X3
14	28+883	RCC Slab	1X2.8	Reconstruction	29+810	RCC Slab	1X3
15	29+221	RCC Slab	1X2	Reconstruction	30+160	RCC Slab	1X3
16	29+543	RCC Slab	1X2	Reconstruction	30+480	RCC Slab	1X3
17	29+774	RCC Slab	1X2.2	Reconstruction	30+700	RCC Slab	1X3
18	29+985	RCC Slab	1X3.1	Reconstruction	30+890	RCC Slab	2X3
19	30+025	Causeway		Reconstruction	30+920	RCC Slab	1X3
20	30+150	Causeway		Reconstruction	31+060	RCC Slab	1X3
21	30+250	Causeway		Reconstruction	31+175	RCC Slab	1X3
22	30+300	RCC Slab	1X3	Reconstruction	31+220	RCC Slab	1X3
23	30+508	Causeway		Reconstruction	31+450	RCC Slab	1X3
24	30+790	Causeway		Reconstruction	31+760	RCC Slab	1X3
25	30+814	Causeway		Reconstruction	31+805	RCC Slab	1X3
26	30+853	Causeway		Reconstruction	31+850	RCC Slab	1X3
27	31+016	Causeway		Reconstruction	31+960	RCC Slab	1X3
28	31+159	Causeway		Reconstruction	32+090	RCC Slab	1X3
29	31+194	Causeway		Reconstruction	32+140	RCC Slab	1X3
30	31+313	Causeway		Reconstruction	32+260	RCC Slab	1X3
31	31+424	Causeway		Reconstruction	32+360	RCC Slab	1X3
32	31+992	Causeway		Reconstruction	32+920	RCC Slab	1X3
33	32+214	Causeway		Reconstruction	33+140	RCC Slab	1X3
34	32+381	Causeway		Reconstruction	33+300	RCC Slab	1X3
35	32+483	Causeway		Reconstruction	33+400	RCC Slab	1X3
36	32+596	Causeway		Reconstruction	33+515	RCC Slab	1X3
37	33+000	Causeway		Reconstruction	33+930	RCC Slab	1X3
38	33+187	Causeway		Reconstruction	34+160	RCC Slab	1X3
39	33+427	Causeway		Reconstruction	34+390	RCC Slab	1X3
40	33+769	Causeway		Reconstruction	34+715	RCC Slab	1X3
41	33+856	Causeway		Reconstruction	34+800	RCC Slab	1X3

Sl. No.	Existing Chainage (Km)	Type of Culvert	Existing No. of Spans with Span Length x Vertical Clearance (In m)	Recommendation	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length (In m)
42	34+099	Causeway		Reconstruction	35+080	RCC Slab	1X3
43	34+244	Causeway		Reconstruction	35+240	RCC Slab	1X3
44	34+487	Causeway		Reconstruction	35+460	RCC Slab	1X3
45	34+582	Causeway		Reconstruction	35+560	RCC Slab	1X3
46	34+591	Causeway		Reconstruction	35+575	RCC Slab	1X3
47	34+798	Causeway		Reconstruction	35+780	RCC Slab	1X3
48	34+904	Causeway		Reconstruction	35+900	RCC Slab	1X3
49	35+132	Causeway		Reconstruction	36+095	RCC Slab	1X3
50	35+185	Causeway		Reconstruction	36+145	RCC Slab	1X3
51	35+337	Causeway		Reconstruction	36+295	RCC Slab	1X3
52	35+456	Causeway		Reconstruction	36+410	RCC Slab	1X3
53	35+521	Causeway		Reconstruction	36+475	RCC Slab	1X3
54	35+670	RCC Slab	1X2	Reconstruction	36+625	RCC Slab	1X3
55	35+819	Causeway		Reconstruction	36+800	RCC Slab	1X3
56	35+929	Causeway		Reconstruction	36+900	RCC Slab	1X3
57	36+150	Causeway		Reconstruction	37+120	RCC Slab	1X3
58	36+218	Causeway		Reconstruction	37+180	RCC Slab	1X3
59	36+280	Causeway		Reconstruction	37+240	RCC Slab	1X3
60	36+377	Causeway		Reconstruction	37+340	RCC Slab	1X3
61	36+835	Causeway		Reconstruction	37+760	RCC Slab	1X3
62	37+377	Causeway		Reconstruction	38+295	RCC Slab	1X3
63	38+022	Causeway		Reconstruction	38+940	RCC Slab	1X3
64	38+222	Causeway		Reconstruction	39+100	RCC Slab	1X3
65	38+483	Causeway		Reconstruction	39+360	RCC Slab	1X3
66	38+585	Causeway		Reconstruction	39+460	RCC Slab	1X3
67	39+085	Causeway		Reconstruction	39+960	RCC Slab	1X3

Additional New culverts shall be constructed as per Particulars given in the table below:

Sl. No.	Design Chainage (Km)	Type of Culvert	No. of Spans with Span Length(In m)
1	29+110	RCC SLAB	1X3

Viaducts

a. The following Viaducts shall be reconstructed:

Sl. No.	Start Chainage	End Chainage	Span Arrangement up to Expansion joint (m)	Type	Width of Carriageway (m)	Length (m)
1	29+980	30+010	2X15	Voided Slab	9	30
2	34+900	34+960	4X20	Voided Slab	9	60
					Total Length	**90**

5.1.1 Additional New Bridges

a. New major bridge at the following locations on the project highway shall be constructed. GADs for the new bridges are attached in the drawings folder:

Sr. No.	Location		Span Arrangement	Total length (m)	Remarks
	Existing Chainage (Km)	Design Chainage (Km)			
NIL					

b. New minor bridges at the following locations on the project highway shall be constructed. GADs for the new bridges are attached in the drawings folder:

Sr. No.	Location		Span Arrangement	Total length (m)	Remarks
	Existing Chainage (Km)	Design Chainage (Km)			
Nil					

Road Over-Bridges and Loop section combined

Road over-bridges (road over railway line) and loop shall be provided at the following level crossings, as per manual:

Sl. No.	Location of Level crossing (Chainage km)	Length of bridge (m)	Type of structure	remarks
Nil				

Truck Lay-byes

Truck lay byes shall be provided at the following locations for a capacity of minimum 10 trucks at each location.

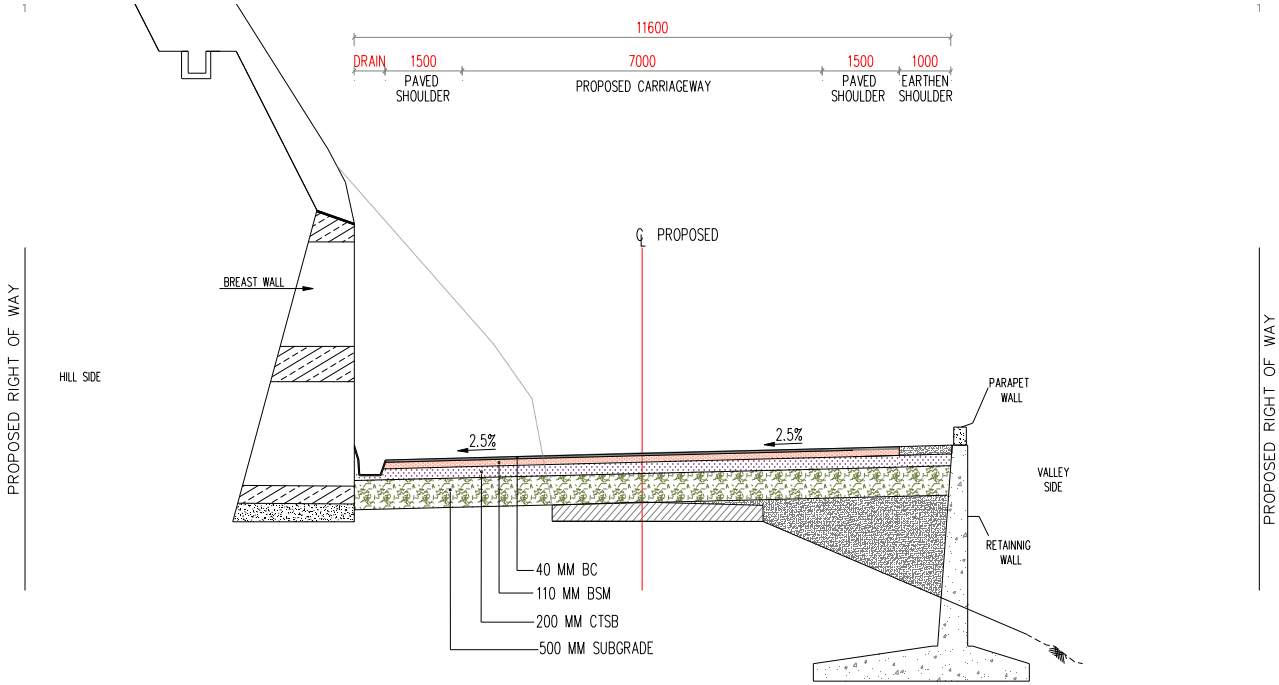
Sr. No.	Proposed Ch.
Nil	

Bus Shelter

Bus Shelter shall be provided at locations given below:

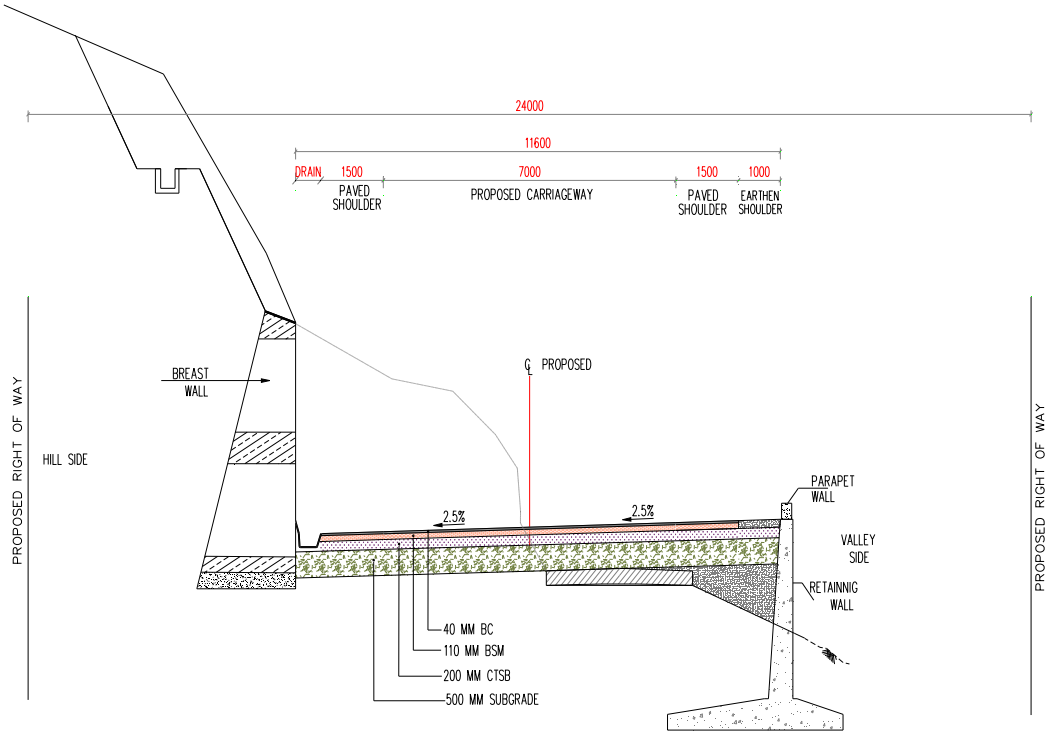
Sl. No.	Design Chainage	Sides
1	26+500	Right
2	27+300	Left
3	30+600	Left
4	39+500	Left

TCS-I



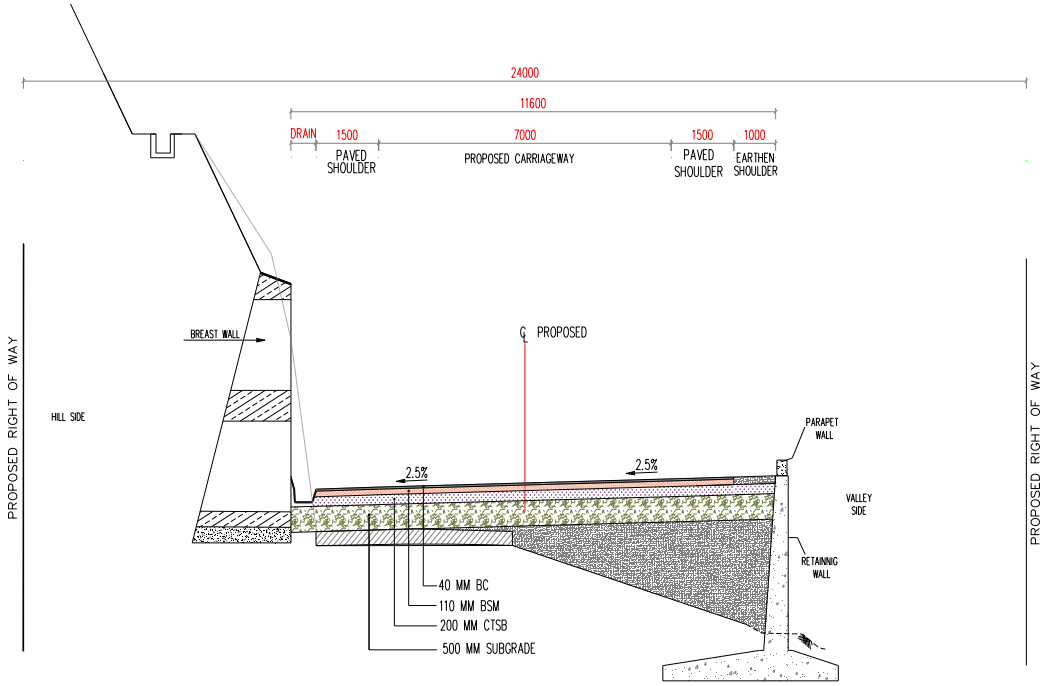
TCS-I
Two Lane With Paved Shoulder Concentric Widening (One Side Hill One Side Valley Section)

TCS-II



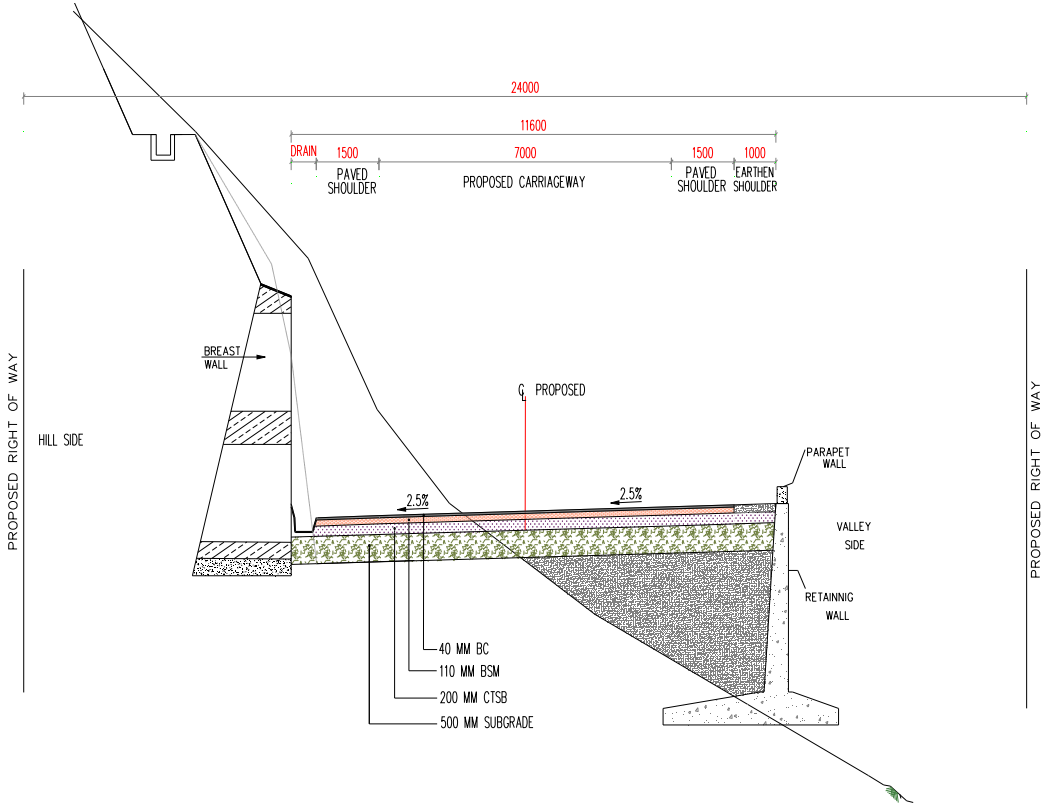
TCS-III
Two Lane With Paved Shoulder Eccentric Left Side Widening (One Side Hill One Side Valley Section)

TCS-III



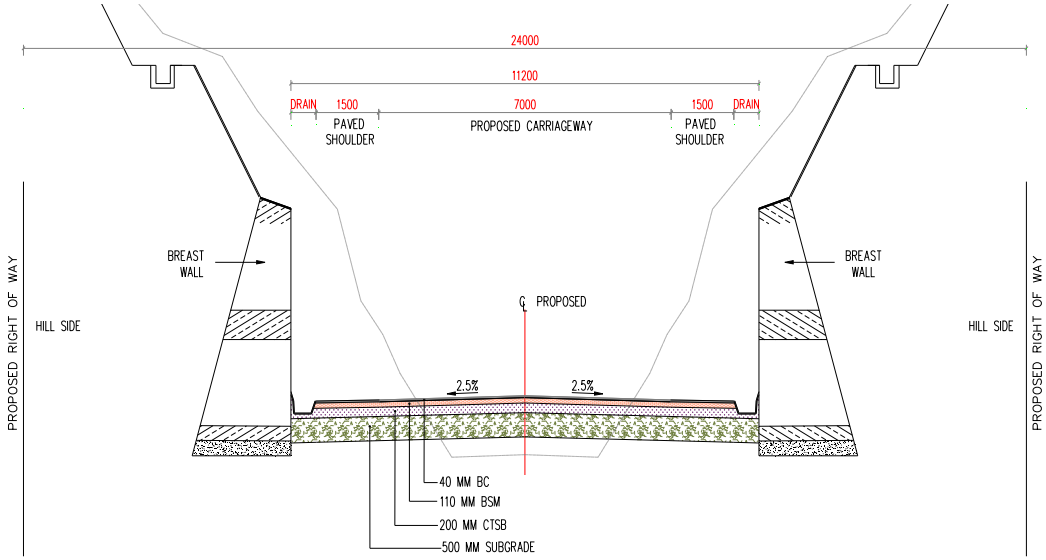
TCS-III
Two Lane With Paved Should Eccentric Right Widening (One Side Hill One Side Valley Section)

TCS-IV



TCS-IV
Two Lane With Paved Shoulder (One Side Hill One Side Valley Section)
(Re-Alignment)

TCS-V

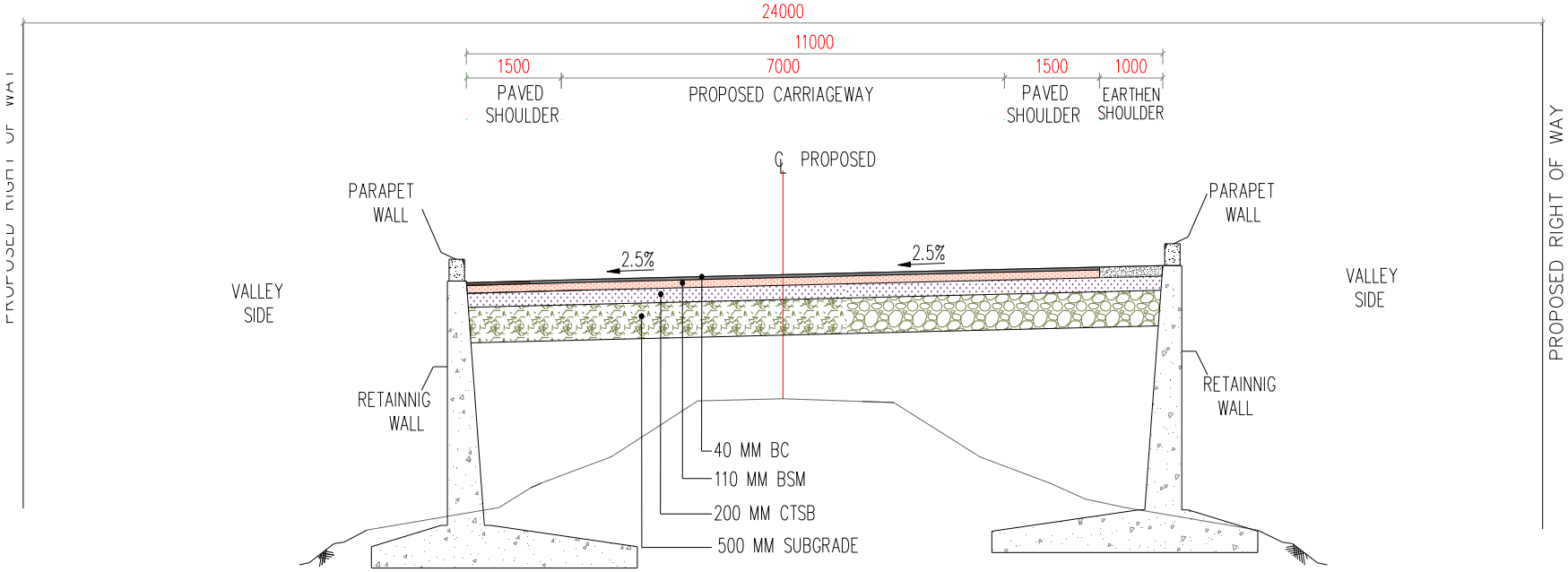


TCS-V
Two Lane With Paved Shoulder Raised Portion(Both Side Hill Section)

Note:-

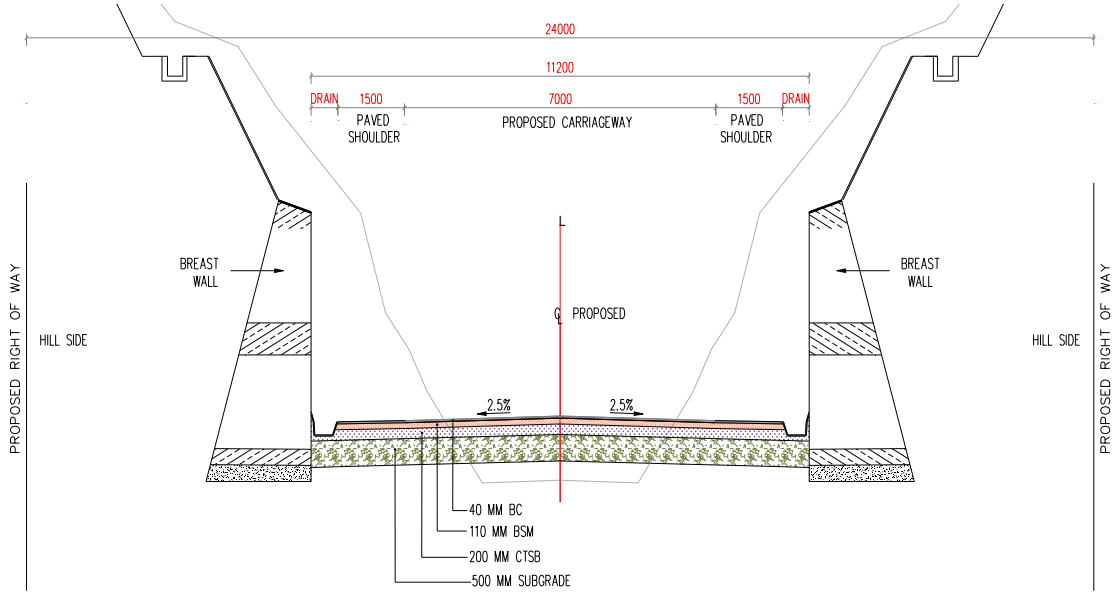
Hill cutting slope should not exceed 6°,
1.5m benching to be provided at every 1m height.

TCS-VI



TCS-VI
Two Lane With Paved Shoulder (Both Side Valley Section)

TCS-VII

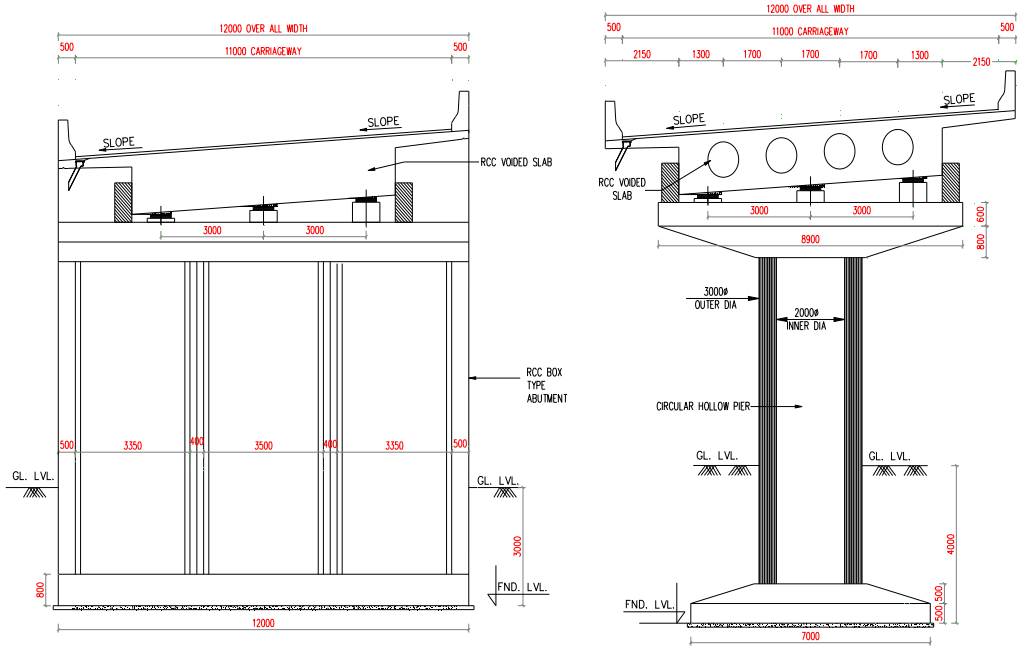


TCS-VII
Two Lane With Paved Shoulder Realignment (Both Side Hill Section)

Notes:-

Hill cutting slope should not exceed 6°,
1.5m benching to be provided at every 1m height.

TCS-VIII



TCS-VIII
TYPICAL CROSS SECTION FOR ELEVATED STRUCTURE

7.3 Requirement of Options

This part of chapter describes brief about the existing alignment, alignment options with their Evaluation matrix and their necessities to upgrade the existing carriageway facility of project road into 2-lane paved carriageway in accordance to the Indian standard configuration. These improvement proposals are based on the findings from various Engineering features carried out on the project roads such as reconnaissance survey, future traffic requirement, Inventory Data and Pavement Investigation.

Summary of Cost of Project Road

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
A	**ROAD WORKS**					
1	Site Clearance				8,394,023.40	0.839
2	Excavation	Cum			310,067,710.40	31.007
3	Earthwork Filling	Cum			8,944,156.95	0.894
4	Sub Grade	Cum			26,497,121.14	2.650
5	CTSB	Cum			150,492,715.82	15.049
6	BSM	Cum			147,499,418.14	14.750
7	Prime Coat	Sqm			4,131,275.39	0.413
8	Tack Coat	Sqm			3,098,456.54	0.310
9	BC	Cum			76,889,920.52	7.689
B	**BRIDGES and STRUCTURES**					
1	Culverts	No.	68		157,215,992.18	15.72
C	**SLOPE STRUCTURES**					
1	Elevated Structure	No.	2		98,971,984.78	9.90
2	Retaining Wall	Rnm	1540		118,645,861.64	11.86
3	Breast Wall	Rnm	11600		225,110,134.76	22.51
D	**JUNCTIONS**					
1	Minor Junctions	No	6.0			

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)
					40,794,385.50	4.08
E	**DRAIN & PROTECTION WORK**					
1	Drainage Works	Km			81,585,127.87	8.16
2	Parapet Wall	Km	10.92		26,535,600.00	2.65
3	Other Protetive Works				381,817,800.00	38.18
F	**LAY BYES**					
1	Bus Shelter	Nos	4.0	1,500,000	6,000,000.00	0.60
G	**OTHER MISCELLANEOUS ITEMS**					
1	Miscellaneous Items	Total			1,893,900.00	0.19
2	Traffic Signs, Marking and Road Appurtenances	Total			6,614,661.51	0.66
3	Reflective Road Studs	Nos	3060		2,553,019.20	0.26
	TOTAL CIVIL COST				**1883753265.73**	**188.375**
	COST PER KM (LENGTH = 13.900 KM) IN CRORES ...					**13.55**

7.5 Geometric Improvement Design

As per the IRC: SP: 73-2018 the project highway should be design with 60km/hr ruling speed and minimum speed of 40km/hr for hilly terrain. Existing geometry of the project highway has been improved to achieve the minimum design speed of 60km/hr except with following locations which are proposed as "Speed Restriction Zone" and improved with design speed of 40km/hr to 45 km/hr to utilise existing bridges, bridges under construction, to reduce land acquisitions and R&R in the project. The speed at Hair pin bend is considered 20-30 km/hr.

7.6 Improvement of Bridges

The following approach and methodology for the finalization of designs and drawings for the existing and proposed bridge structures are proposed.

7.6.1 General

- ✓ Review of Past records like Studies, Reports and Data's.
- ✓ Data relevant to bridges shall also be collected from the PWD (NH) and irrigation departments of West Bengal. The following data will generally be looked to the extent available:
- ✓ Hydrological and geo-technical reports of the existing CD structures.
- ✓ Complete 'as built' drawings of existing two lane bridges along with their design calculations, if available.
- ✓ Details of repair/rehabilitation, if any, carried out for the existing Single lane bridges.
- ✓ Nature and extent of damage observed during floods to any of the existing two lane bridges.
- ✓ Utility services to be carried over the bridges.
- ✓ Any other engineering data found suitable for the detailed engineering of proposed bridge structures.

This Chapter covers the various methodologies and design criteria, Codal provisions for proposed Bridges.

Following are the grades of construction material proposed for the project

Foundation

Concrete Grade: M35 for Bridges & Culverts
Reinforcement : HYSD of grade Fe500

Abutment / Abutment Cap and Pier / Pier Cap

Concrete Grade: M35 for Bridges with RCC Substructure and Foundation
Reinforcement : HYSD of grade Fe500

Superstructure

Concrete Grade: M35 for RCC girders
: M45 for PSC precast girders
: M35 for Bridge decks over girders
: M35 for RCC solid slabs
: M35 for RCC solid slab of Slab Culverts
Reinforcement : HYSD of grade Fe500

Structural Steel : Grade E250 (Fe410 W B grade) (For ROB)

Crash Barrier

Concrete Grade: M40
Reinforcement : HYSD steel of grade Fe500

Approach Slab

Concrete Grade: M30
Reinforcement : HYSD steel of grade Fe500

Clear Cover to any Reinforcement is followed as below

Foundation : 75 mm
Substructure : 50 mm
Superstructure : 40 mm

Bearings

- For Span 6.00 - 10.00 m, Tar paper bearings shall be adopted for slab superstructure.
- For Span 10.00 – 20.00 m, Elastomeric Bearing for RCC solid slab, RCC girder superstructure.
- For Larger span, POT / PTFE bearing for RCC / PSC girder superstructure.

Expansion Joints

Compression seal for slab superstructure and strip seal for girder superstructure.

Wearing Coat

- Cross –drainage structure: 40 mm thick bituminous concrete overlaid with 16 mm thick mastic asphalt.
- Minor and Major Bridges: 40 mm thick bituminous concrete overlaid with 25 mm thick mastic asphalt.

Approaches

RCC Return or Retaining wall for Culverts and Bridges & Reinforced earth wall for ROB to be adopted for the approaches.

Drainage Provisions.

Drainage spouts shall be placed not greater than 10. 00 m centre to centre. Down take pipes will be provided to dispose the water.

Margins in Material (FOS)

All critical sections shall be checked for stresses under various load combinations. A suitable margin (preferably 8-10%) shall be there between maximum stress and allowable stress in concrete as well as reinforcement in the final design.

Conceptual Guidelines for Structure

Following guidelines will be followed in design and construction of structures:

- The existing structures will be widened or extended to match the new road cross sections.
- For Major and Minor bridges in urban or rural areas, open median shall be provided with minimum 3.50 m clear gap between two crash barriers of bridges.
- New Bridges will be planned without affecting the foundations of adjacent existing bridges, if any.
- All new / reconstructed pipe culverts will constitute minimum 1.20 m diameter size pipes that confirm to NP4 specifications. The existing 0.90 m or more diameter pipe culverts will be extended to new carriageway with the same diameter or 1.20 m diameter pipes. In case where the culverts are hydraulically inadequate, shall be replaced by RCC Box / RCC Slab culvert of adequate size.
- Rehabilitation of substructure / superstructure of the existing Bridges which are proposed to be retained, including, but not limited to, replacement of bearings, expansion joints, pitching, bed protection, provision of crash barrier and railings, shall be done by the Concessionaire in accordance with - the Concession Agreement.

Relevant Codes Followed for Design of Structures

List of IRC Codes

The list of IRC codes for the design of various all types of structures are as follows.

- IRC: 5-2015 - Standard Specifications & code of Practice for Road Bridges. Section-I General features of Design (8th revision)
- IRC: 6-2014 - Standard Specifications & code of Practice for Road Bridges. Section-II Loads and Stresses (5th revision)
- IRC: 7-1971 - Recommended Practice for numbering Bridges and culverts (1st revision)
- IRC: 112-2011 - Standard Specifications & code of Practice for Road Bridges
- IRC: 24-2010 - Standard Specifications & code of Practice for Road Bridges. Section-V Steel Road bridges (1st revision)
- IRC: 78-2014 - Standard Specification & code of Practice for Road Bridges. Section-VII Foundations and Substructure (2nd revision)
- IRC: 83-2011 - Standard Specifications & code of Practice for Road Bridges. Section-IX Bearings Part II- Elastomeric Bearings

- IRC: 83-2002 - Standard Specifications & code of Practice for Road Bridges. Section-IX Bearings Part III- POT/PTFE, PIN and METALLIC GUIDED Bearings

- IRC: 89-2010 - Guidelines for Design & Construction of River training & Control works for Road Bridges (1st revision).

List of IRC-SP Codes

- IRC: SP: 13-2004 - Guidelines for the Design of Small Bridges and Culverts

- IRC: SP: 35-1990 - Inspection and maintenance of Bridges

- IRC: SP: 40-1993 - Guidelines on Strengthening and Rehabilitation of Bridges

- IRC: SP: 84-2014 – Manual of Specifications and Standards for Four Laning of Highways through public private partnership

Ministry of Surface Transport Publications

MORT&H Specifications for Road and Bridge Works, 2013 (Fifth Revision Existing structures on the project road have been classified in six categories based on the reconnaissance survey.

(a) Culverts

Structures having an overall length up to 6.0m shall be treated as culverts. Most of the culverts have no protection works.

(b) Minor Bridges

Structures having a length between inner face of dirt walls more than 6.0m and up to 60.0m shall be treated as minor bridges. These bridges on project roads are of reinforced concrete solid slab, structural steel trusses/ girder and RCC T- beam girders type. Minor bridges seen during the site visit have spans varying from 8.0m to 50.0 m with R&R masonry wall type abutments and stone masonry/plain cement concrete wall type piers. The protection works around abutments are either damaged or not existing.

(c) Major Bridges

Structures having a length of more than 60.0m shall be called major bridges. There is no existing major bridge on the project road.

(d) Rail Road Bridges

ROB/RUB shall be provided on all railway level crossings, unless otherwise specified as per IRC: SP: 73-2015.

(e) Cause Ways

These structures on the project road are generally of flush type without vents. The structure comprises a concrete topping on the road base at the stream crossings, extending over the complete length of the waterway with protection wall on both sides. At

many of the causeway locations, discharge passes occasionally only during the rains and during flash-flood. The overall conditions of causeways are unsatisfactory.

7.6.2 Proposed Re-construction of Existing Cross Drainage Structures

Project road mainly consists of bridges, culverts and causeways. Most of the culverts are in good condition and are not choked. The number of existing culverts, which could be retained, shall be known after finalization of culvert inventory and condition survey. The existing culverts, which are in good conditions but does not have sufficient / adequate width for 2-lane, shall be widened. Damaged causeways will be proposed for reconstruction.

7.6.3 Proposed Re-construction of Existing Bridges

It is found based on the site visit most of the bridges are in fair to good condition but inadequate width. The detailed condition survey of the existing bridges is carried out to ascertain their conditions. The existing bridges with adequate carriageway width for a two lane bridge will be retained with some rehabilitation work. At few Placing overtopping is observed and CD structures are proposed to be reconstructed.

7.6.4 Type of Proposed Bridges

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

- Structural steel girders/trusses
- Reinforced concrete pre-cast bridges
- Pre-cast Post tensioned concrete bridges
- RCC Box type structures where SBC is less

Following type of sub-structures will be most suitable for bridges:

- RCC abutment and pier for bridges
- PCC abutment and pier for culverts

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 metres

Submersible Structures

Submersible Bridges and Causeway are highly suitable where the floods are flash and do not interrupt the traffic for long period.

These are normally built on non-erodible bed rock with protective pitching or apron.

Though submersible bridges are cheap compared to high level bridges, they need greater maintenance for approaches if there is considerable spread of water. Design of hand rails,

impact of floating debris and the hydrodynamic effect of the water acting over the whole bridges also required to design submersible Bridges. These have to be considered along with the buoyancy in design.

7.6.5 Improvement Proposal of Existing and Proposal of New CD Structure

There are fifteen existing minor bridges in the project road. During inventory and Condition survey, it was found that few bridges are submerged and poor condition and also some bridges are insufficient width. Based on hydraulics, few bridges are overtopped and converted to high level bridges. The Brief detail of existing structures has been given different improvement proposals below table:

Summary of Structures

Sl. No.	DESCRIPTION	No. Of Structures	REMARKS
1	**HUME PIPE CULVERTS**		
(i)	Retaining & Widening	0	**-**
(ii)	Dismantling & Reconstruction Pipe Culvert With Box Culvert	0	-
(iii)	New Proposals	0	-
(iv)	Abandoned	0	
2	**SLAB CULVERTS**		
(i)	Retaining & Widening	0	-
(ii)	Dismantling & Reconstruction	13	-
(iii)	New Proposals	01	-
(iv)	Abandoned	0	
3	**BOX CULVERTS**		
(i)	Retaining & Widening	0	-
(ii)	Dismantling & Reconstruction	0	-
(iii)	New Proposals	0	-
(iv)	Abandoned	0	
4	**CAUSEWAY**		
(i)	Retaining & Widening	0	-
(ii)	Dismantling & Reconstruction	54	
(iii)	New Proposals	0	
(iv)	Abandoned	0	-
5	**MINOR BRIDGES**		
(i)	Retained	0	-

Sl. No.	DESCRIPTION	No. Of Structures	REMARKS
(ii)	Dismantling & Reconstruction	0	-
(iii)	Abandoned	0	
(iv)	New proposals	0	-
6	**MAJOR BRIDGES**		
(i)	Retained	0	
(ii)	New proposal	0	
(iii)	Flyovers	0	
(iv)	New proposal	0	-
8	**Viaduct**		
(i)	To be Widened	0	-
(ii)	New Proposals	2	

7.7 Widening / Improvement of Culverts

There are many scuppers on the project roads and these serve the purpose of cross-drainage works. These are made of course rubble dry masonry abutments. The top of the abutments is corbelled with a few layers of stones till the gap between the abutments is sufficiently reduced, when a stone slab is laid on the top. Hand-packed stones are placed on the top and also for the return walls of the scuppers. Retaining walls in course rubble dry masonry have commonly been provided on both ends of the scuppers. It has been observed that the scuppers on the project road are performing satisfactorily and many of damaged/poor condition scuppers are under construction.

7.7.1 Formation Width for New Bridges and Culverts

The formation width of structures shall be proposed to be maintained as full formation width of road section.

7.8 Drainage Design

A good drainage system is vital for the safety and longer life of any structure. This is more relevant in the case of highways. Proper drainage of road surface, pavement and the foundation layers is basic requirement for maintaining the structural soundness and functional efficiency of a road. Pavement structure including subgrade must be protected from any ingress of water. For this purpose, the following conditions have to be ensured:

- Interception of the surface runoff;
- Keeping the water flow duration on the pavement to a minimum;
- Saving the pavement structure from stagnation of water;
- Efficient dispersal and disposal of water; and
- Quick disposal of sub-surface water away from the pavement.

Design for drainage is proposed to be carried out in accordance with the provision contained in IRC: SP 42-2014 and IRC: SP 50 -2013.

7.8.1 Hydrological Design Methodology

For the calculation of discharge of the stream by Area-Velocity method, topographical survey including levelling surveys have been carried out across and along the water courses to determine the cross-section and the slope. A number of cross-sections have been taken at regular intervals on both upstream and downstream side of the structure, including one at the proposed location of the structure in accordance with IRC specifications.

The following assumptions have been made for peak discharge calculation:

For locations where water spreads over the banks, the cross-sections were extended up to the HFL, in order to calculate the effective cross-section of flow.

The longitudinal section to determine the bed slope have been taken following the channel course extending on both the upstream and the downstream sides of the structure. Caution is taken by following the curved flow line for longitudinal gradient, rather than a straight line.

Assessment of Peak Discharge

The peak discharge is calculated by the following method for cross section on the upstream and the downstream sections.

Area – Velocity Method (Kutter's constant)

$Q = A \times V$

$V = C \times \sqrt{(R \times S)}$

Where, Q = the discharge in cumecs;
A = Area of the cross section in sq. m.
V = Velocity in m/sec;
R = Hydraulic mean depth in m. = A / P;
P = Wetted perimeter of the stream in m.
C = Kutter's constant which is given by
S = Bed slope of the stream; and
N = Co-efficient of rougosity which depends upon the roughness of the stream

The Design Discharge had been taken as the maximum of discharges at different cross sections. Which will have 10% variations with one another.

Hydraulic Analysis for Design HFL

HFL is fixed at the bridge location by local enquiry, then line parallel the bed slope line is drawn at this HFL, from this line HFL at different cross sections are found.

Afflux Calculation

When the waterway area of the opening of a bridge is less than the unobstructed natural waterway area of the stream, i.e. when bridge contracts the stream, afflux occurs. The afflux will be calculated using Orifice formula as given below: -

$$Q=C_0 \times \sqrt{2g}\ L\ Dd \times \sqrt{\{h+ (1+e)\ (U^2/2g)\}}$$

Where, h = Afflux in meters;
Q = Discharge
U = velocity
L = Linear waterway
Dd = Depth at D/S side
W = width of River
C_o and 'e' = Orifice formula co-efficient is taken from graph

Scour Depth Calculation

To provide an adequate margin of safety for design of foundation, a further increase by 30% has been made over the design discharge as per IRC: 78-2000, to calculate mean scour depth.

By IRC: 5-1998 / IRC: 78-2000

As per IRC: 5-1998 or IRC: 78-2000, the mean depth of scour below the highest flood level, DSM, will be given by the following equation:

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

Where, D_b = the discharge in cumecs per meter width and Ksf = Silt Factor.

The value of 'D_b' shall be the total design discharge divided by the theoretical effective linear waterway between abutments.

For most of the bridges, the silt factor, K_{sf}, has been calculated as per guidelines given in IRC-78: 2014since most of the bridges are Ghat section the bed material composes of pebbles and course sand for which silt factor assumed as 4.

Maximum Depth of Scour for Design of Foundation

The maximum depth of scour below the Highest Flood Level (HFL) for the design of piers (dsmp) and abutments (dsma), having individual foundations without any floor protection are as follows:

In the vicinity of pier: $dsmp = 2 \times D_{sm}$
In the vicinity of abutment: $dsma = 1.27 \times D_{sm}$

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^3/s	Minimum Clearance in m
up to 0.30	0.15
Above 0.3 and up to 3.0	0.45
Above 3.0 and up to 30	0.6
Above 30 and up to 300	0.9
Above 300 and up to 3000	1.2
Above 3000	1.5

7.8.2 Design Storm Calculation

The design of drainage system involves – (a) calculating the total discharge that the system will require to drain off and (b) fixing the slope and dimensions of the drain to have adequate capacity to carry the discharge and afford maintenance.

(a) Hydrological Design

Hydrological study is an important step prior to the design of road drainage system. Such analysis is necessary to determine the magnitude of flow and the duration for which it would last. Hydrological data required for design includes drainage area map, water shed delineation, arrow indicating direction of flow, outfalls, ditches, other surface drainage facilities, ground surface conditions, rainfall and flood frequencies.

To estimate the amount of runoff requiring disposal at given instant, information regarding rainfall intensities within the catchment area and the frequency with which this precipitation to assess peak run-off is essential. The 'Rational Method' is universally accepted empirical

formula relating rainfall to run-off and is applicable to small catchment areas not exceeding 50 sqkm. The discharge is calculated by,

Q = 0.028 P A Ic

Where;

Q = Discharge (Peak run-off) in cum/ sec

P = Coefficient of run-off for the catchment characteristics

A = Area of catchment in Hectares

Ic = Critical intensity of rainfall in cm per hour for the selected frequency and for duration equal to the time of concentration

Coefficient of run-off 'P' for a given area is not constant but depends on a large number of factors such as porosity of soil, type of ground cover, catchment area, slope and initial state of wetness and duration of storm. For specific site conditions, the following values of 'P' given in IRC: SP 42-1994, 'Guidelines on Road Drainage' have been adopted.

Table 6.13 : Values of Coefficient of Run-off

Sr. No.	Description of Surface	Coefficient of Run-off (P)
1.	Steep bare rock and water tight pavement surface	0.90
2.	Steep rock with some vegetative cover	0.80
3.	Plateau areas with light vegetative cover	0.70
4.	Bare stiff clayey soils (impervious soils)	0.60
5.	Stiff clayey soils with vegetative cover with uneven paved road surface	0.50
6.	Loam lightly cultivated or covered and macadam or gravel road	0.40
7.	Loam largely cultivated or turfed	0.30
8.	Sandy soil, light growth, parks, gardens, lawns and meadows	0.20
9.	Sandy soil covered with heavy bush or wooded/ forested areas	0.10

The primary component in designing storm water drains is the design storm i.e. rainfall value of specified duration and return period. For the project road a return period of 25 years is considered to be adequate. As the extent of drainage system for the project road is small, even an intense rainfall of short duration may cause heavy outflows. The storm duration chosen for design purposes is equal to time of concentration. It has two components- (a) entry time and (b) time of flow. Because of lack of data for small duration peak rainfall for small catchments in project influence area, the following equation has been used to estimate the rainfall intensity for the shorter durations:

$$i = \frac{F(T+1)}{T(t+1)}$$

where,

i= Intensity of rainfall within a shorter period of 't' hrs within a storm

F= Total rainfall in a storm in cm falling in duration of storm of 'T' hrs

t= Smaller time interval in hrs within the storm duration in 'T' hrs

For the purpose of design storm, one hour maps available from Directorate of Hydrology (small catchments), Central Water and Commission, New Delhi have been used. 1-hr rainfall for return period of 25 years for the project influence area has been taken as 100 mm.

(b) Design of Drain Section

For uniform flow in open channels, the basic relationships are expressed by the Manning's Formula:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

Where,
Q= discharge in cum/sec
n= Manning's roughness coefficient
R= hydraulic radius in m which is flow cross section divided by wetted perimeter
S= energy slope of the channel which is roughly taken as slope of drain bed
A= Area of flow cross section in sqm

In design, the flow is assumed to be sub-critical. The slope and velocity are kept below the critical level. If design depth is less than critical depth, the section is to be redesigned to avoid critical flow situation.

To simplify the analysis the following energy slopes have been considered for the site specific conditions:

- For longitudinal median drain : 1 in 200
- For lateral median drain and intersection drainage system : 1 in 285
- For side drains in urban areas : 1 in 200
- For side drains in plain terrain : 1 in 100

7.8.3 Hydraulic Design and Resizing of Existing Culverts

Culverts like Slab culverts and Pipe culverts are predominant along the existing alignment. But they are neither sufficient in number not in terms of vent height at few locations. Hence as per Hydraulic designs per SP13:2004, re-sizing of culverts are proposed.

7.8.4 Slope Stabilisation and Protection Works

Erosion prevention is one of the major factors in design, construction and maintenance of highways. The most direct application of erosion control occurs in drainage design and in the writing of specifications for landscaping and slope planting. Erosion is minimized largely by the use of flat side slopes, rounded and blended with natural terrain; serrated cut slopes; drainage channels designed with due regard to width, depth, slopes, alignment, and protective treatment; inlets located and spaced with erosion control in mind; prevention of erosion at culvert outlets; proper facilities for groundwater interception; dikes, berms, and other protective devices to trap sediment at strategic locations; and protective ground covers and planting.

7.8.4.1 Treatment of High Embankment

High embankment will be site specifically designed considering the quality of the available material, prevalent moisture condition and associated pore water pressure, bearing capacity of the founding strata and the requirement of any preloading etc. Stone pitching/gabion walls are proposed at these locations.

7.8.4.2 Reinforced Earth Wall

Reinforced earth walls have been proposed for the urban locations where there is a constraint on Land width to retained the earth embankment upto 6.0m height .For more than 6.0m height retaining wall has been proposed instead of reinforced earth wall as per the IRC stipulations. Generally, approaches to underpasses / flyovers/ROBs, in heavily built-up areas have been proposed with reinforced earth technology. Apart from the benefit of reduction in roadway, reinforced earth wall offers greater reliability and wider application because its system is self draining, more flexible, aesthetically pleasing and Eco-friendly solution permitting the growth of vegetation and maintaining the existing environment.

7.8.5 Design Methods for Widening of Culverts

Longitudinal drains are designed in such a way that drains merges either at invert level of culverts or at bridge. Also all culverts are proposed to be widened or reconstructed with full formation width of road. Project alignment is 2lane with paved shoulder hence full formation width will be 11.0m.

7.8.6 Design Methods for Widening of Bridges

Longitudinal drains are designed in such a way that drains merges either at invert level of culverts or at bridge. Also all bridges are proposed to be widened or reconstructed 11.0m width without foot path and 16m width footpath which is more than full formation width of road i.e. 14.0m for 2 lanes.

7.8.7 Designs for Road Side Drainage

Presence of a good drainage system is essential. It is therefore necessary to perform a detailed survey of the existing drainage system, the adjoining terrain and its slope, and recommendations for new drainage system or modification to existing drainage system.

Some basic principles have been adopted in order to meet IRC standards.

The surface water from the carriageway, the paved shoulders, the embankment slopes and the adjoining land must be effectively drained off without allowing it to percolate into the sub-grade.

The drains must have sufficient capacity and adequate longitudinal slope to drain away the entire collected surface water to the nearest natural surface stream, river or nallah.

No roadside drains are proposed where the longitudinal water bodies are present parallel to the road. In the project alignment, the following types of drains will have to be proposed:

- Unlined Open Drain in rural section
- Lined Drain in urban areas

- Chute Drains

The hydraulic adequacy of the drains shall be checked as per IRC SP-42 "Guidelines on Road Drainage". The design return period for the drains shall be taken as 25 years for median drains, chute drains, urban drains and other important drainage systems while the 2 years shall be taken as rural drainage system.

The rain water from the right of way of the road is ultimately required to be transported away before it can cause nuisance or damage. First of all, water has to be transported over the surface. This aspect has been well looked after by providing adequate cross-slope and compatible longitudinal profile. After running over the surface, most of the runoff is collected in the covered / open drain along the road. Open drains are preferred over covered ones as these are easier to maintain and allow removal of silt and other solids easily. Also, for a given cross section open drains can carry much larger discharge particularly in flood conditions where drain is surcharged.

7.8.7.1 Unlined Open Drain in Rural Section

In rural areas where embankment height is less than 1.5m, open unlined toe drains and 1V: 2H side slope have been proposed near ROW on both sides of the road as per guidelines given IRC SP-42.

7.8.7.2 Lined Drain in Urban Areas

In urban areas, water will flow across separators through cross cuts of size 150 cm x 150 cm top covered by precast slab in RCC M 20 grade provided at an interval of 10 m. This will also facilitate crossings near building lines/built up areas. However, an attempt has been made to minimize such locations as low level maintenance of covered drain is envisaged in post-construction phase. The design runoff has been considered not only from the road but also from the adjoining building lines.

7.8.7.3 Chute Drains

When the height of the embankment is more than 3.0m, the possibility of erosion of embankment slopes and shoulders increases. In such cases longitudinal kerbed drains at edge of roadway are provided to channelise the flow and are led down by lined chute drains. And these chute drains are ultimately discharged into roadside drains.

7.8.7.4 Drainage at Intersections

Any stagnation of water at intersections would reduce the capacity of junction resulting in queuing up of traffic. The level of junction has been kept higher than the cross roads so that water can reach the main drainage system which is along the main carriageway. No covered drain will be provided as these are likely to be choked due to sweepings from the road during the dry season. The side drain will have to be extended along the cross roads till the appropriate out-fall. In extreme cases, pipe drain will have to be proposed across the cross road to maintain the continuity of the drainage network if out-fall is not possible near-by due to site conditions.

7.8.7.5 Drainage at Bridge

In case of bridges across a river, the main water is to be discharged into river bed through drainage spouts as per IRC standards. Properly designed filter media is to be provided behind abutment / earth retaining structures along with weep hole arrangement at 1.0 m interval to drain out the percolated water.

On approach portion longitudinal drains will have to be provided at the edges of roadway as kerb channel cum ditch drain. Kerb channel will be 55 cm wide having 6% slope and ditch will be of size 50 cm x 45 cm. Kerb channel will have RCC grating at 4.5 m interval to guide water into ditch. In initial stretch smaller depth, say 30 cm, can be adopted which then can be increased progressively to achieve 45 cm depth at the end of ramp.

7.9 Road Markings, Signs and Other Safety Devices

7.9.1 Road Markings

Road markings will be made for center and edge lines using reflective thermoplastic paints. Appropriate road markings will also be provided at junctions and crossings.

7.9.2 Road Signs

Road signs are to place according to IRC: 67-2012. The signs are to be placed on embankment so that extreme edge of sign would be 2.0m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines there in.

7.9.3 Safety Barrier

Traffic barriers are protective devices that are placed between traffic and a potential hazard off the roadway, with the intention of reducing the severity of a collision when an errant vehicle leaves the travelled portion of the roadway. Barriers are to be provided at high embankments, sharp curves and bridge approaches. The barrier is to be located at the edge of paved shoulders.

7.10 Miscellaneous Requirements

7.10.1 Proposal for Truck Lay byes

As per the detailed field surveys and reconnaissance, truck lay bye/ Parking cum rest areas are no need to provide.

Table 6.14: Truck lay byes

Sr. No.	Existing Chainage	Proposed Chainage
Nil		

7.11 Pavement Design

The project road envisages two-laning with earthen shoulder and upgrading of the existing pavement to carry the anticipated traffic over the design period. This would involve:

i) Construction of new pavement for widened and realigned/new alignment.
ii) Strengthening and rehabilitation of the existing pavements.

The Flexible pavement is proposed for the entire length of project road. The overlay for the existing flexible pavement is designed for the flexible option only. The applicable IRC Guidelines would be used for this purpose, but using other internationally accepted design method(s) to ensure that the recommended design is the most appropriate one would further check the design.

15 years Design life of the flexible pavement of National Highway is considered for which the pavement component of base and sub-base is designed. Bituminous layers are designed for a shorter period adopting stage construction technique. At the end of design life of bituminous layer, strengthening of bituminous layer to cater for the future traffic can be worked out based on deflection survey. On the other hand, a concrete pavement is usually designed for a longer period of up to 30 years. The design traffic loadings for these design periods have been computed from axle-load surveys.

A brief explanation of the design methods, and the assumptions and parameters used are given in the following Sections.

7.11.1 Traffic or Cumulative Equivalent Single Axle Loads

The project road is used by all types of vehicle with different loading and different axle configuration. For pavement design it is very necessary that all kinds of loads converted to a single common axle load hence using equivalent factor. The equivalent axle load factor (EALF) is based on a procedure of converting the number of repetitions of a given load into an equivalent number of repetitions of 8.16 tonne single axle load. The EALF based on fatigue cracking is different from that based on permanent deformation. The use of a single value for both modes of failure is approximate, at best. The most widely used method for determining the EALF is that which uses the empirical equations developed from the AASHTO Road Test, according to which the damage caused increases as the fourth power of the load. For example, a 10.2 tonne axle load would result in EALF of $(10.2/8.16)^4 = 2.5$. Thus, an increase of 25 % in the axle load would result in 2.5 times more damage. This fact becomes even more significant in India where overloading is a norm. The fourth power relationship is internationally accepted and is used for design.

Equivalent single axle loads (ESALs) depends upon:

i) initial traffic
ii) traffic growth (r)
iii) directional split of the traffic or directional distribution factor (DDF)
iv) number of lanes or lane distribution factor (LDF)
v) axle load spectrum or vehicle damage factor (VDF)

Traffic surveys and subsequent analyses were carried out to determine the above parameters.

From the axle-load survey, VDF for each type of vehicle can be determined. The cumulative ESAL is calculated using the following equations:

$$\text{ESAL} = \sum_{i=1}^{i=j} \text{Initial Traffic} \times 365 \times \frac{(1+r)^n - 1}{r} \times \text{Lane Factor} \times \text{DDF} \times \text{VDF}$$

The equivalent single axle loads (ESALs) have been calculated assuming that the project road will be opened to traffic in the year 2018. Design ESAL in Millions i.e. MSA for project road is presented as below:

Table 6.15: Summary of MSA

Section		Existing Chainage		Design MSA (2015-2032)
From	To	From	To	
Start of project	End of Project	24+940	39+170	25

For pavement design of project road, the above MSA values have been adopted. Pavement thickness is a function of log MSA, therefore, at high MSA values the change in pavement thickness is rather minor compared to the change in the MSA value.

7.11.2 Flexible Pavement Design

Flexible pavement design methods may be broadly divided into three categories

- Empirical or semi-empirical design methods based on experience with the performance of pavement with similar traffic, pavement structure, sub-grade and climatic conditions. These are the most commonly used methods. The examples of such methods are IRC 37-2012.
- The second category consists of design methods in which layer thickness are determined as a result of experimental road tests. These methods, such as AASHTO, and Asphalt Institute Methods, have a more rational basis for pavement design, and are widely used at abroad.
- The third and the most recently developed methods are called analytical or mechanistic design, which compute the stresses and strains in each layer and adjust the layer thickness so that these are kept within the predetermined limits. These limits are established based on field and laboratory testing to ensure that the pavement does not fail during its design life. The examples of mechanistic design are CHEVRON, BISAR and ELSYM and IRC 37-2012.

No single design method is perfect. All have some shortcomings. The mechanistic methods come closest to simulating the pavement behaviour but these require extensive field and laboratory testing of these pavement design methods, the ones considered to be appropriate for use on this project are:

a) IRC 37-2012 Guidelines for the Design of Flexible Pavements, IRC 81-1997
b) AASHTO Guide for the Design of Pavements Structures
c)

7.11.3 Overlay Design

There are several design methods in use to determine the thickness of flexible overlay required. The most common procedures are:

- Based on deflection testing; and
- Effective thickness procedure

Each of these methods is essentially empirical in nature and liable to give different results. Therefore, it is important that a consistent methodology backed by experience and sound engineering judgment be used. Both methods, however, are widely used.
However as the design covered in IRC 81-1997 is based on R-6 and R-56 – research work by MOST, this method has been adopted for arriving the overlay thickness for the existing carriage way.

7.11.4 Shoulder

As per AASHTO, “as shoulder is the portion of the roadway contiguous with the travelled way for accommodation of stopped vehicles, for emergency use and for lateral support of sub-base, base and surface course." There should be continuous paved shoulder on both the right and the left side of all freeways facilities and the usable paved width of the shoulder should be between 10ft (3.048m) to 12ft (3.658m).
The factors affecting shoulder design are similar to those of mainline pavement design. The major difference is the amount of traffic. Traffic volume on shoulders is lower than on a mainline and much difficult to predict.
Three types of traffic may be considered in shoulder design:

- Encroaching traffic
- Parking traffic, and
- Regular traffic

Regular traffic is considered only if the use of shoulder as an additional lane for peak hour or detoured traffic is anticipated. If there is no regular traffic, the sum of encroaching and parking traffic is used to design the inner edge of shoulder adjacent to the mainline; while parking traffic is used to design the outer edge of shoulder. When there is a paved shoulder and no lateral obstruction within the shoulder area, trucks using the outer traffic lane tend to encroach on the shoulder. The percentage of parking traffic should be added to the encroaching traffic because any truck must encroach to park on the shoulder. It is a common practice to design mainline and shoulder pavements a single unit.

7.11.5 Drainage

Design methods that develop pavement cross-sections on the assumption that the controlling factors are stress, strain, deformation and fatigue under repeated wheel loads, and ignore the effects of wheel load on water trapped in the pavement structure are a recipe for “designed to fail” pavement design. The trapped water in the pavement structure under the wheel loads generates pore pressures which drastically reduce the bearing capacity or strength of the granular layer and erodes the base and sub-base material, resulting in damage which may cause premature failure of the pavement.

To ensure adequate internal drainage of the pavement a full width of bottom most granular layer is proposed in the case of new flexible pavement, and a drainage layer under the rigid pavement has been provided.

7.11.6 Flexible Pavement Structural Design for New Construction

7.11.6.1 Recommended Pavement Design

Granular sub base should be laid in up to formation width. Similarly, a dense bituminous macadam thickness is proposed as per IRC design, would be most appropriate, and does not affect either design drastically. The recommended pavement design on project road, therefore, should consist of layer composition as per **Table 6.16**

Table 6.16: Recommended New Pavement Design

Crust Composition For New Pavement as per IRC 37 - 2012									
Homogeneous Section	Chainage		CBR	MSA	Crust			S.Grade	Total Thickness
	From	To			BC	BSM	CTSB		
1	26+100	40+000	9	25	40	110	200	500	**850**

7.12 Retaining Structures

7.12.1 Retaining Wall & Breast Wall

After detailed survey and design it is found that there are various places where retaining wall & breast wall is required, that's why we have proposed retaining wall & breast wall of different heights depending upon the filling & cutting required. Table given below shows the summary of length with respect to height of retaining wall & breast wall.

Table 8.17: Retaining wall & Breast wall length

SL. No.	Length of Retaining Wall (m)	Length of Breast Wall (m)
1	1540	11600

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8.0 Cost Estimate

8.1 Introduction and Assumptions

Detailed cost estimate for Bagrakot to Kafer Section from km 26.100 to km 40.000 Pkg-IVD has been finalised based on the improvements proposed under Chapter – 6. The detailed estimate is worked out based on the quantities calculated for the items of work to be executed in the project and also rates derived after detail analysis and as contained in the government Basic schedule of Rates.

Following assumptions have been made for calculating quantities, rate analysis and cost estimate.

a) It is assumed that suitable water would be available for construction purpose within reasonable lead and hence no separate haulage / rate has been considered for this purpose.
b) Establishment of good hygienic labour camp is deemed to be included in adopted rates and hence no separate provision has been made.
c) Establishment of field laboratory for conducting basic tests on soils, construction material and for quality control is also deemed to be included in adopted rates.
d) For road work, bituminous construction, bridge work and CD work, basic lead of 5 km is considered for all completed items and thereafter additional lead component has been considered.
e) All sundries, contractor profit, and other overhead charges are deemed to be included in the derived rates. Items required for adhering to safety standards during construction and maintenance phases mentioned in O&M standards are also deemed to be considered.
f) Mechanised construction using Hot mix batching plant, pavers, concrete batching plant etc has been assumed while working out the rates.

8.2 Adoption of Unit Rates

The cost estimate of the project road as presented in the DFR is based on the final development proposals and priced at latest schedule of rates of PWD West Bengal 2019-20.

The cost estimate has been done with the consideration that the full proposed length of the road will be constructed in one construction package.

For arriving at unit rates at Feasibility stage, it has been assumed that the specifications generally conform to the provisions made in "**Specifications for Road and Bridge Works (Vth Edition)**" of **MORT&H**.

To develop a thorough understanding of the prevailing construction rates the Consultant have reviewed Basic Schedule of Rates (BSR) published by Public Works Department, West Bengal year 2019-20.

Based on the Following Rates:

As per the WB PWD SOR 2019-20 & Sikkim PWD SOR 2012(duly updated to 2019-20 with escalation on WPI at 12.06% per year)
As per the Market Rate -Current market rates have been taken for cement, Steel and IOCL website rates for Bitumen

8.3 Bill of Quantities for Civil Works

The quantities of major items of works have been worked out based on the preliminary highway design, inventory, condition surveys, and other pavement investigations data. The pavement quantities have been worked out based the geometrics and cross sections, pavement design done based on traffic and laboratory investigations.

Site Clearance:
The area considered for Site Clearance is the area within the proposed Right of Way minus the existing carriageway area.

Earth Works:

This item provides for roadway excavation, earthwork in embankment, subgrade and shoulders including disposal of surplus earth and unsuitable material. The earth work quantities like roadway in embankment have been computed based on the data collected during inventory survey. The quantity for cutting in deep section is computed and further classified as cutting in ordinary rock or cutting by open/ controlled blasting in hard rock. The earthwork quantities are based on our site surveys and highway design. Sub-grade having a CBR > 10% will be taken from borrows area.

Sub-base, Base, Surface Courses:

These provide for the items of GSB and WMM for the main carriageway. The quantities for road pavement, base, sub-base etc. for main carriageway have been calculated through applicable cross sectional template developed in excel software. A provision for cross-fall correction layer has been made for existing carriageway and its quantity has been worked out.

Bituminous Works:

Flexible pavement has been considered for the project road. Bituminous works provide for all items of bituminous courses and surfacing. Quantities for the pavement component are based on the pavement designs proposed in **Chapter 6**.

Culverts:

The estimation of quantities for culverts was based on site inventory condition survey and study of require hydraulics. The detailed recommendations are given in **Chapter 6**. The quantities for structures have been calculated based on detailed General Arrangement

Drawings (GAD) and other associated drawings using STAAD software and in-house software.

Bridges and structures:

The cost for bridges has been worked out based on the quantities derived from GAD prepared.

Junctions Improvement:

This item includes quantities of kerbs, railings, median etc. The cost for junctions also includes the cost for 'at grade' junctions, which need improvement along the highway.

Traffic Signs and Markings:

Proper traffic signs were planned at required locations along the project corridor. It is reviewed considering the traffic and pedestrian safety. The number of traffic signs shall be adequate and modified if required. Centre line and edge markings required from safety point of view were considered in the quantity estimate. RCC Guard posts, double sided metal beam barrier and pedestrian steel guards have been considered at appropriate locations.

Drainage and Protection works:

Provision under this sub-head has been made for surface, subsurface and roadside drains, drainage chutes in cement concrete and stone pitching at outfalls/escapes for drainage. This covers for unlined, open lined and covered drains. The quantities for drainage, protection of embankment & protection against tank bund and river training works are computed based on typical drain drawings and tentative drainage plan.

Miscellaneous Items:

A lump sum amount has been provided for project house, furniture and equipment required for project maintenance, parking, footpath, electrifications, and roadside amenities. In addition to these, traffic control and diversion, bus-stops and cross utility ducts have also been provided.

Utility Shifting

Broad provision is made in the cost estimate for raising and or shifting high-tension lines, electric supply lines, telephone lines, water pipe lines and other utilities.

Table 7.1: Description of Bills for Cost Estimate

Major Heading	Item of Works
Site Clearance	• Clearing and Grubbing • Dismantling of existing structures/km stones/ pavement/ road signs • Cutting of Trees and Removal of stumps • Scarifying existing bituminous surface • Dismantling

Major Heading	Item of Works
Earth work	• Earthwork in excavation for Ordinary soil / soft rock / hard rock • Embankment construction with material from borrow area • Embankment construction with material from road cutting • Sub grade and Shoulder construction • Turfing
Non-Bituminous Courses	• Granular sub-base • Wet mix macadam • Footpath
Bituminous Course	• Prime coat • Tack coat • Bituminous Macadam as Profile Corrective Course • Dense Bituminous Macadam • Semi dense bitumen macadam • Bituminous Concrete
Cement Concrete Pavement	• Dry Lean Concrete • Pavement Quality Concrete
Bridge and Cross Drainage Structures	• Earthwork in excavation for Ordinary soil / soft rock / hard rock • Concrete work in foundation, substructure and superstructure • CR masonry work in foundation and substructure • Slab culvert (widening / new construction / repair / on cross road) • Pipe culvert (widening / new construction / repair / on cross road/ duct for utility crossing) • Major/Minor Bridge (widening / new construction / repair) • RCC bore pile and pile cap • Load test of Pile • Reinforcement in foundation, substructure and superstructure • HT Steel • Steel liner • Bearing - PTFE, Tar paper, elastomeric • Expansion joint - Strip seal, Pre-moulded filler • Asphaltic Wearing coat • Cement paint to exposed concrete • PMC mortar & epoxy bonding coat to concrete • Stone pitching in slope and apron • NP-4 Pipe for culvert
Drainage and Protection works	• Unlined drain • Covered lined drain • Chute Drain • Pitching • Reinforced Earth Structure • Stone pitching • Inspection Chamber/ Catch pits • Filter media • Reinforced Earth Structure
Road side Furniture	• Km. stone / Boundary stone • Road signs • Pavement markings • Road signage

Major Heading	Item of Works
	• Crash Barrier • Road stud • Railing • Fencing • Kerb
Maintenance	• Diversion • Routine Maintenance
Electrical Works	• Streetlight in Urban area • Lighting at toll plaza • Lighting at Truck Lay byes • Lighting at Intersections
Miscellaneous Items	• Road side Barriers
Way side amenities	• Utility duct • Bus shelter • Tree plantation
Toll Plaza	• Toll Booth • Barrier Gate • Canopy • Administrative Building
HTMS	• Highway Traffic Management System

8.4 Costing for Safety Devices

The safety devices have been proposed based on criteria given in Chapter 8 – Improvement Proposal. Cost for safety devices like crash barrier, road signs and markings, delineators, kerbs, etc. have been derived in Bill of Road side Furniture.

8.5 Land Acquisition Cost

Area of land acquisition has been derived based on the actual area calculation from the plan drawing which is difference of proposed ROW and existing ROW. The land acquisition cost have been derived cost estimate summary.

8.5 Cost of R&R

A tentative R & R cost (i.e. cost for acquisition of structures, resettlement site development, transitional allowance, staff training, and institutional arrangement & strengthening etc,) is expected to be about Rs. 1 Crores.

8.6 Cost of Environmental Mitigation Plan

A tentative EMP cost for implementing of various mitigation measures on different items is about Rs. 5.0 Crores.

8.7 Total Cost Estimate

The Abstract and Detailed cost estimate is presented and summarised in **Table 9.1.**

Table 7.1: Cost of Civil Works

Section	Proposed Length (km)	Base Cost In Crores
Bagrakot to Kafer Section (km 26.100 to km 40.000)	13.900	188.375

Table 9.1: Abstract of Cost Estimate

SL.NO	ITEMS	UNIT	LENGTH (IN KM)	RATE (IN RS.)	AMOUNT (IN RS.)	AMOUNT (IN CR.)
A	**ROAD WORKS**					
1	SITE CLEARANCE				8,394,023.40	0.839
2	EXCAVATION	CUM			310,067,710.40	31.007
3	EARTHWORK FILLING	CUM			8,944,156.95	0.894
4	SUB GRADE	CUM			26,497,121.14	2.650
5	CTSB	CUM			150,492,715.82	15.049
6	BSM	CUM			147,499,418.14	14.750
7	PRIME COAT	SQM			4,131,275.39	0.413
8	TACK COAT	SQM			3,098,456.54	0.310
9	BC	CUM			76,889,920.52	7.689
B	**BRIDGES AND STRUCTURES**					
1	CULVERTS	NO.	68		157,215,992.18	15.72
C	**SLOPE STRUCTURES**					
1	ELEVATED STRUCTURE	NO.	2		98,971,984.78	9.90
2	RETAINING WALL	RNM	1540		118,645,861.64	11.86
3	BREAST WALL	RNM	11600		225,110,134.76	22.51
D	**JUNCTIONS**					
1	MINOR JUNCTIONS	NO	6.0			

SL.NO	ITEMS	UNIT	LENGTH (IN KM)	RATE (IN RS.)	AMOUNT (IN RS.)	AMOUNT (IN CR.)
					40,794,385.50	4.08
E	**DRAIN & PROTECTION WORK**					
1	DRAINAGE WORKS	KM			81,585,127.87	8.16
2	PARAPET WALL	KM	10.92		26,535,600.00	2.65
3	OTHER PROTETIVE WORKS				381,817,800.00	38.18
F	**LAY BYES**					
1	BUS SHELTER	NOS	4.0	1,500,000	6,000,000.00	0.60
G	**OTHER MISCELLANEOUS ITEMS**					
1	MISCELLANEOUS ITEMS	TOTAL			1,893,900.00	0.19
2	TRAFFIC SIGNS, MARKING AND ROAD APPURTENANCES	TOTAL			6,614,661.51	0.66
3	REFLECTIVE ROAD STUDS	NOS	3060		2,553,019.20	0.26
	TOTAL CIVIL COST				**1883753265.73**	**188.375**
	COST PER KM (LENGTH = 13.900 KM) IN CRORES ...					**13.55**

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Conclusion and Recommendations

9.1 General

Given the needs of the project to adequately address the concerns of the local population and latest IRC guidelines, the project has been conceived with the provision of underpasses, Railway over Bridges, service roads and wayside amenities completely integrated into the project wherever required. Looking at the peculiarity of soaring prices around the highways for which the widening works are in progress, the aspect of acquisition of wider land strip or formation of bypass has been examined wherever feasible.

9.2 Project Clearances

Following clearances are required before the commencement of construction work. Out of these, few are critical and need to be obtained immediately to avoid the time lag at later date.

Table 8.1: Project Clearances

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
1	The EIA Notification, 14th September 2006 and subsequent amendments	Identifies "(i) New National Highways; and (ii) Expansion of National Highways greater than 30 Km involving additional right of way greater than 20m involving land acquisition" under (item 7 (f) of schedule) as one of the projects requiring prior clearance.	Not required	New National Highway NH - 717A (Category of project - A)	MoEF&CC
2	Notification for use of Fly ash, 3rd November 2009	Reuse fly ash discharged from Thermal Power Station to minimise land use for dispersal and minimise borrow area material. The onus shall lie with the implementing authority to use fly ash unless it is not feasible as per IRC.	NO	If Projects within power 500 km of plant will cover under this notification (SO 1396 (E). 25 March 2015	MoEF&CC, SPCB
3	The Water (Prevention and Control of Pollution) Act,	Central and State Pollution Control Board to establish/enforce	NO	Consent required if ground water is being used	CPCB /SPCB

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
	1974	water quality and effluent standards, monitor water quality, prosecute offenders, and issue licenses for construction/operation of certain facilities.		for consent purpose	
4	Noise Pollution (Regulation And Control) Act, 1990	Standards for noise emission for various land uses	Yes	construction machineries and vehicles to conform to the standards for construction	State pollution control board
5	Forest (Conservation) Act, 1980	Conservation and definition of forest areas. Diversion of forest land follows the process as laid by the act	Yes	For diversion of forest land for road construction	State forest department, MoEF&CC
6	Coastal Regulatory Zone Notification, 2011	Protect and manage coastal areas	No	The project area is not within designated coastal zone	MoEF&CC, State forest department,
7	Wild Life Protection Act, 1972	Protection of wild life in sanctuaries and National Park	NO		
8	Ancient Monuments and Archaeological sites and Remains Act 1958	To protect and conserve cultural and historical remains found.	No	For world heritage sites and monuments	Archaeological Survey of India, Dept. of Archaeology
9	The Motor Vehicle Act. 1988	Empowers State Transport Authority to enforce standards for vehicular pollution. From August 1997 the "Pollution Under Control Certificate is issued to reduce vehicular emissions.	Yes	All vehicles used for construction will need to comply with the provisions of this act.	State Motor Vehicles Department
10	The Explosives Act (& Rules) 1884 (1983)	Sets out the regulations as to regards the use of explosives and	Yes	If new quarrying operation is started by the	Chief Controller of Explosives

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
		precautionary measures while blasting & quarrying.		concessionaire / contractor	
11	Public Liability And Insurance Act,1991	Protection to the general public from accidents due to hazardous materials	Yes	Hazardous materials shall be used for road construction	Project Implementation Unit/ Contractor
12	Hazardous Wastes (Management and Handling) Rules, 1989	Protection to the general public against improper handling and disposal of hazardous wastes	Yes	Hazardous wastes shall be generated due to activities like of maintenance and repair work on vehicles	CPCB/SPCB
13	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Protection against chemical accident while handling any hazardous chemicals resulting	Yes	Handling of hazardous (flammable, toxic and explosive) chemicals during road construction	District & Local Crisis Group headed by the DM and SDM
14	Mines and Minerals (Regulation and Development) Act, 1957 as amended in 1972	Permission of Mining of aggregates and sand	Yes	Permission of Sand Mining from river bed & aggregates	Department of Mining for state and central level
15	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Employing Labour / Workers	Yes	Employing Labour/ workers	District labour Commissioner

9.3 Recommendations

- Based on the lane capacity analysis results, the project road requires 2 lanes with Paved shoulder for capacity augmentation and efficient movement of traffic up to project common concession period of 15 years i.e. horizon year 2033.

- The project road can be improved without causing significant adverse environmental impacts to the natural, social, economic or cultural environments.
- Ribbon development is observed on the project road near Pedong town. To segregate local traffic and traffic travelling on national highway and also considering the future traffic projections, the raised footpath cum drain is proposed.
- The process of land acquisition has to be initialised immediately after the approval of the alignment, to expedite construction of bypass and widening sections.
- The project can be constructed within 24 months period with strategic planning and through one construction package. The construction work may begin from April 2020. The estimated basic cost is give below table (Amount in Crores)

Section	Proposed Length (km)	Base Cost In Cr
Bagrakot to Kafer (26+100 to 40+000)	13+900	188.375

- On the basis of preliminary analysis, nature of impacts and observations of the various affected groups due to project, it is concluded that the proposed National Highway can be developed without causing significant adverse environmental impacts to the natural, social, economic agricultural environment of the study area, assuming the mitigation measures identified in EIA report will be incorporated into design and implementation stage. The important points are:
- Appropriate mitigation measures as suggested in environmental assessment report shall be incorporated. Construction of National Highway in the state of West Bengal is not expected to result in any significant adverse environmental impacts. Forest clearance will be applicable for diverting reserved and protected forest for road construction. All the necessary clearances will be required from concern departments at different stage of the project implementation
- The project road is economically viable for proposed improvement as it yields more than 12% return (assumed interest rate for the analysis). The proposed improvement is also viable for various sensitivity alternatives.

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