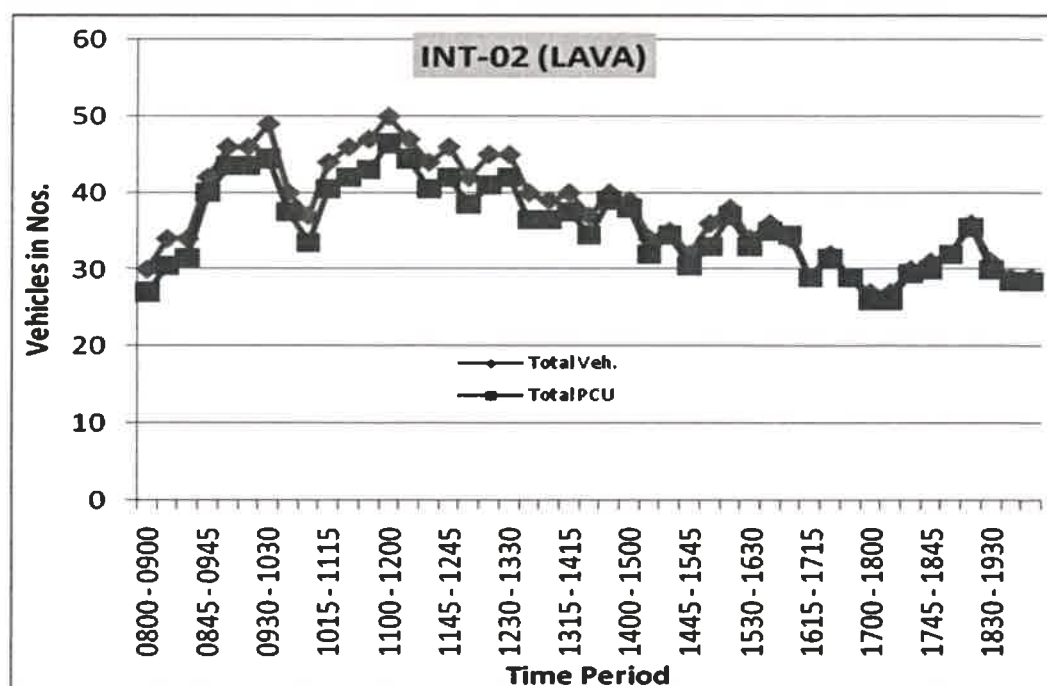
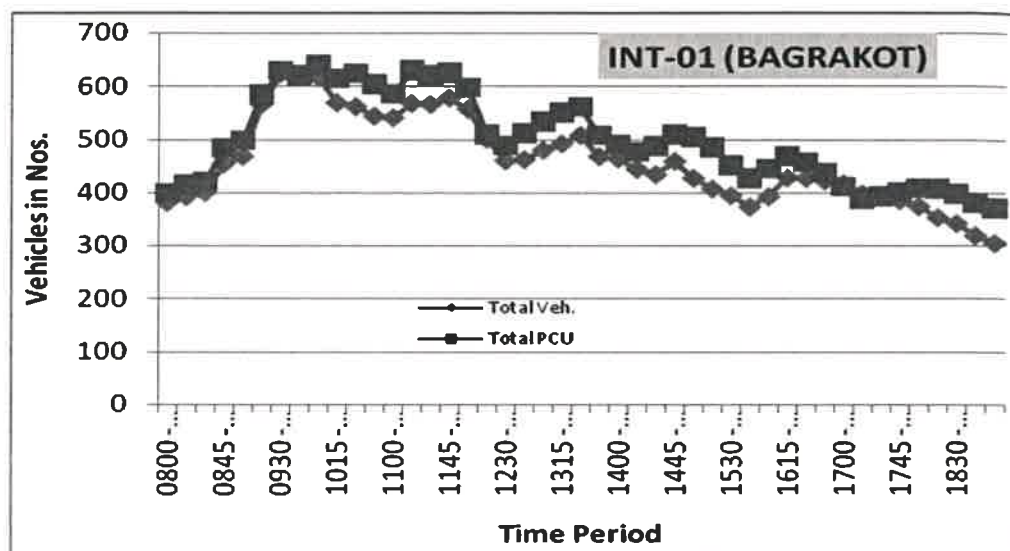
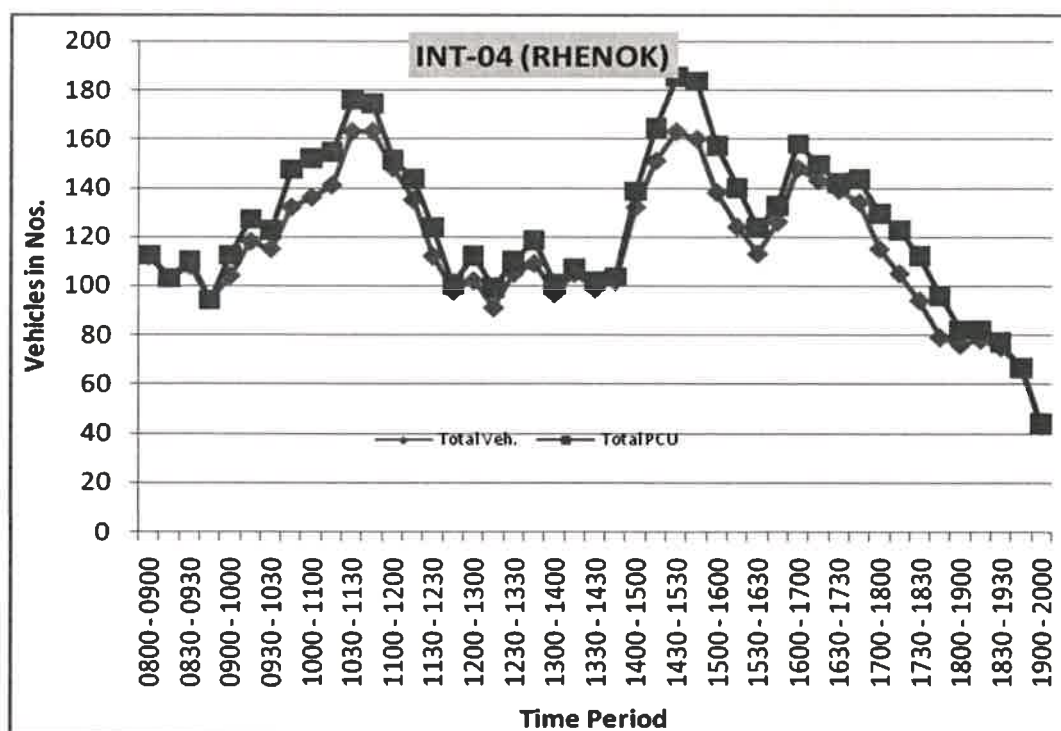
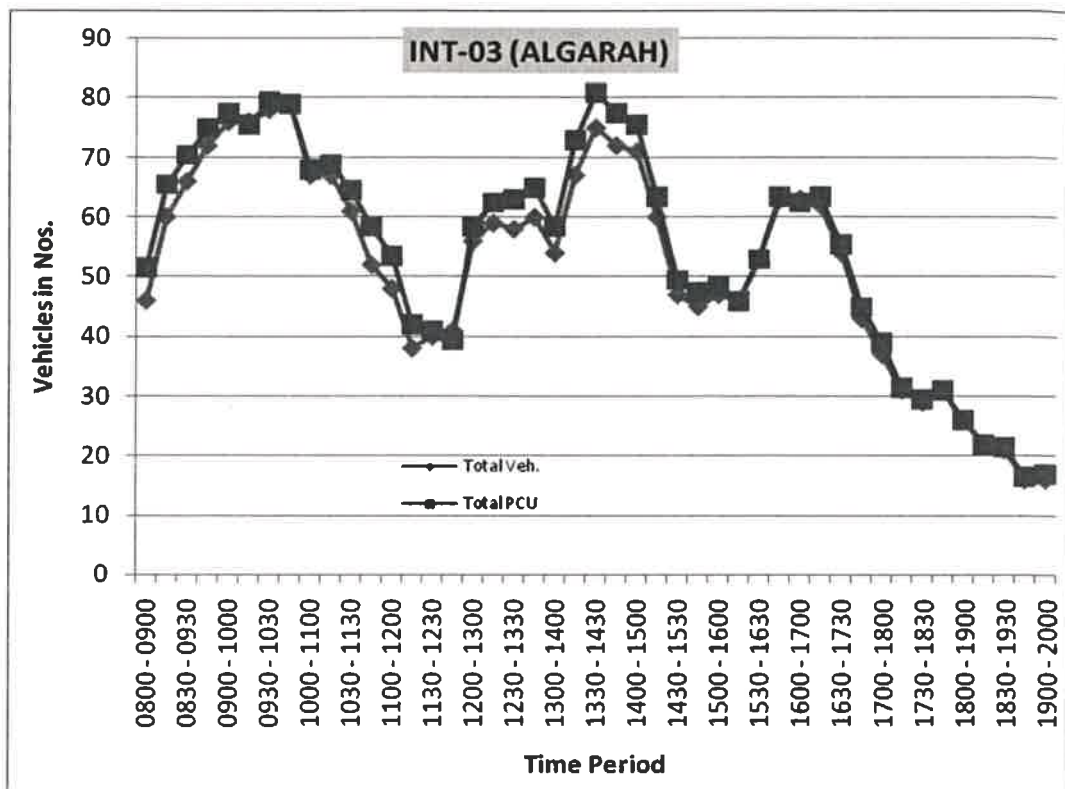


4.10.3 Hourly Variation of Traffic at Study Intersection

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.





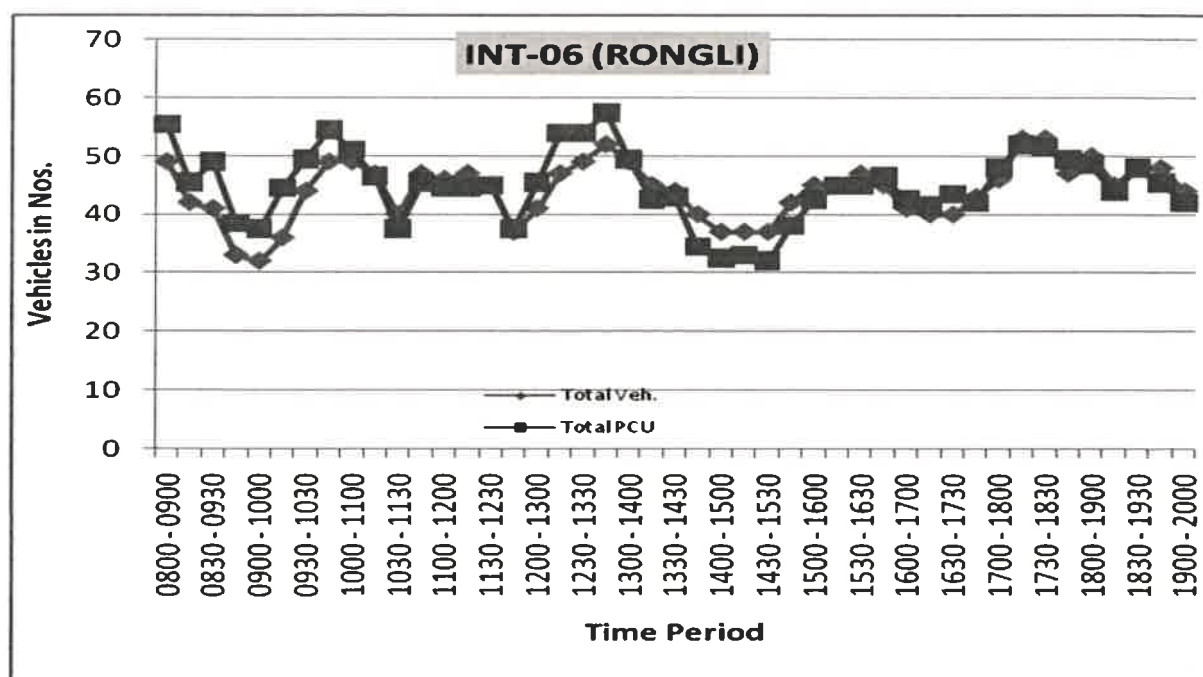
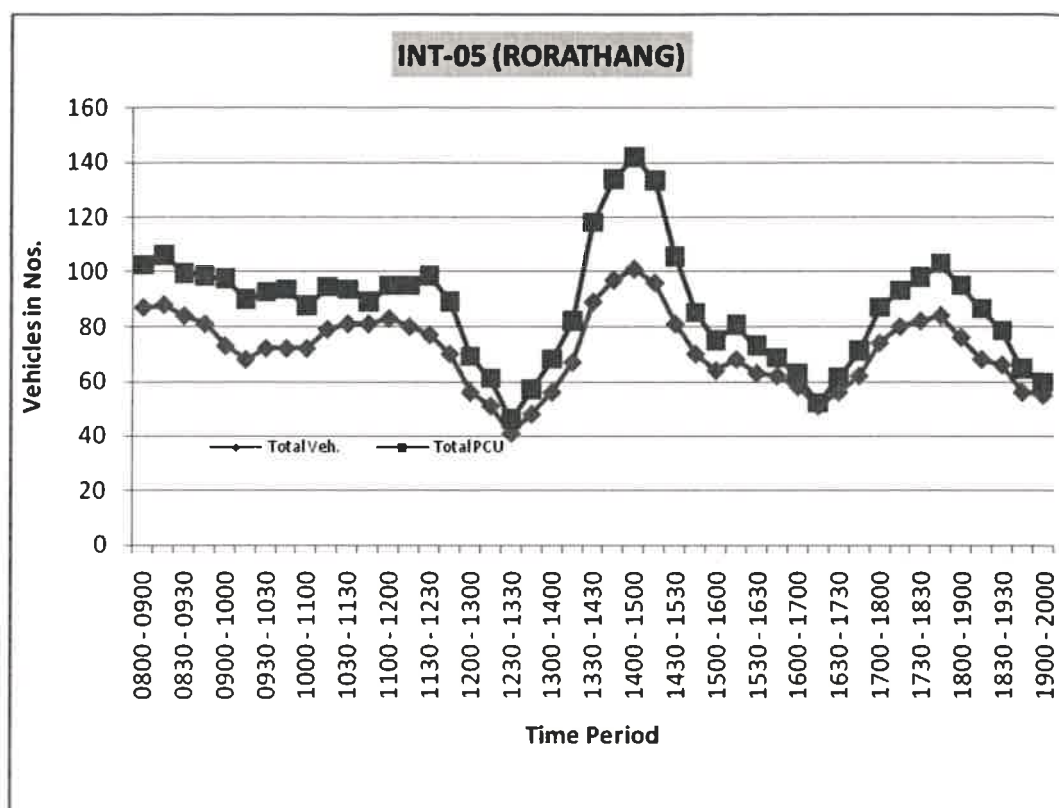


FIGURE 4.9 HOURLY VARIATION OF TRAFFIC AT STUDY INTERSECTION

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	-	

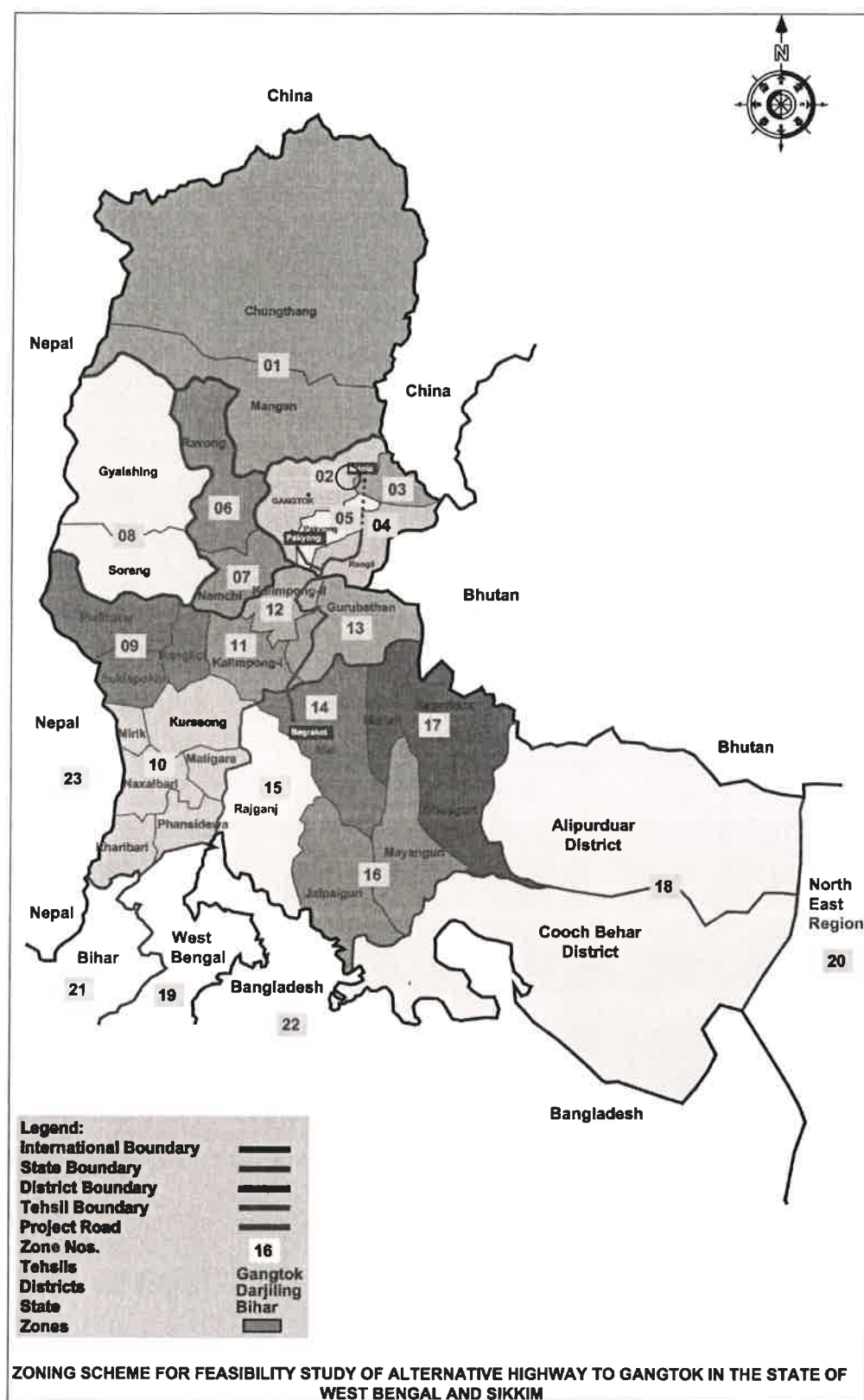


FIGURE 4.10 ZONING SCHEME (IMMEDIATE INFLUENCE AREA)

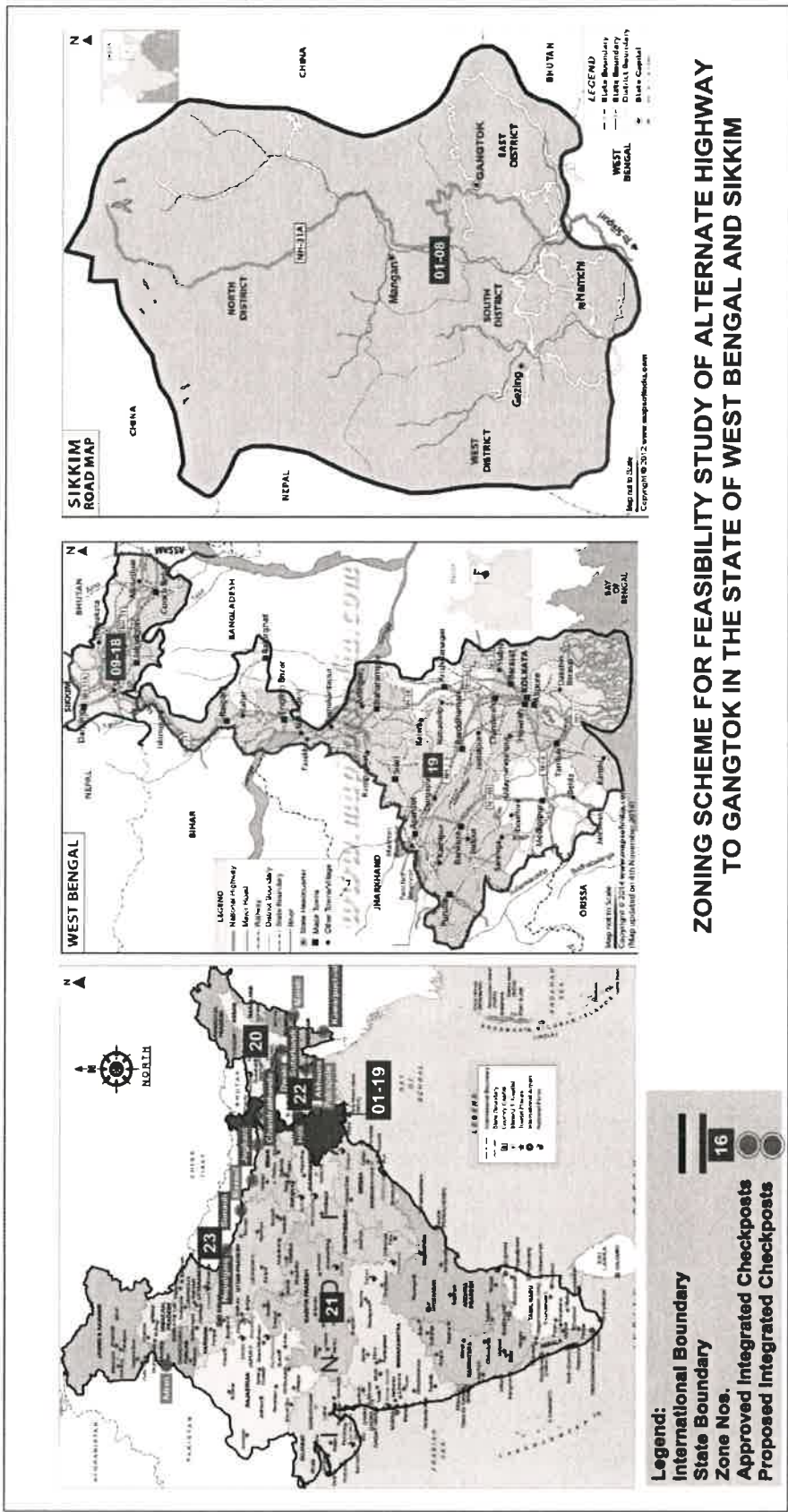


FIGURE 4.11 ZONING SCHEME (BROAD INFLUENCE AREA)

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%

Revised Final Feasibility Report : TRAFFIC SURVEY AND ANALYSIS

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 Siliguri to Sikkim is high as 3.08 while only 0.45 average VDF in the direction of travel from Sikkim to Siliguri. The reason for the high VDF in one direction of travel that most of the trucks load commodities from Siliguri 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 Siliguri to Sikkim. The details are presented in **Table 4.20**.

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

MODE	Siliguri-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**.

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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

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4.15.5 REGISTERED 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 at 8.6%. The average growth rate of 2-wheelers is 6%. The details are presented in **Table 4.4**.

TABLE 4.4 REGISTERED VEHICLES OF SIKKIM

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 RESULTS OF 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

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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 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 SENSITIVITY 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,

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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

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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:

- 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.
- 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)
- Calculate total generalized cost = RUC+Toll for each competing route.
- 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	$\%Div = 98.750 - (CR/0.634) * 8.125$
	$0.634 \leq CR \leq 1.465$	$\%Div = 90.625 - ((CR-0.634)/0.831) * 84.375$
	$1.465 \leq CR \leq 2.0$	$\%Div = 6.25 - ((CR-1.465)/0.535) * 5.25$
Truck & Bus	≤ 0.750	$\%Div = 100 - ((CR/0.75) * 5)$
	$0.750 \leq CR \leq 1.250$	$\%Div = 95 - ((CR-0.75)/0.5) * 90$
	$1.250 \leq CR \leq 2.0$	$\%Div = ((2-CR)/0.75) * 5$
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**.

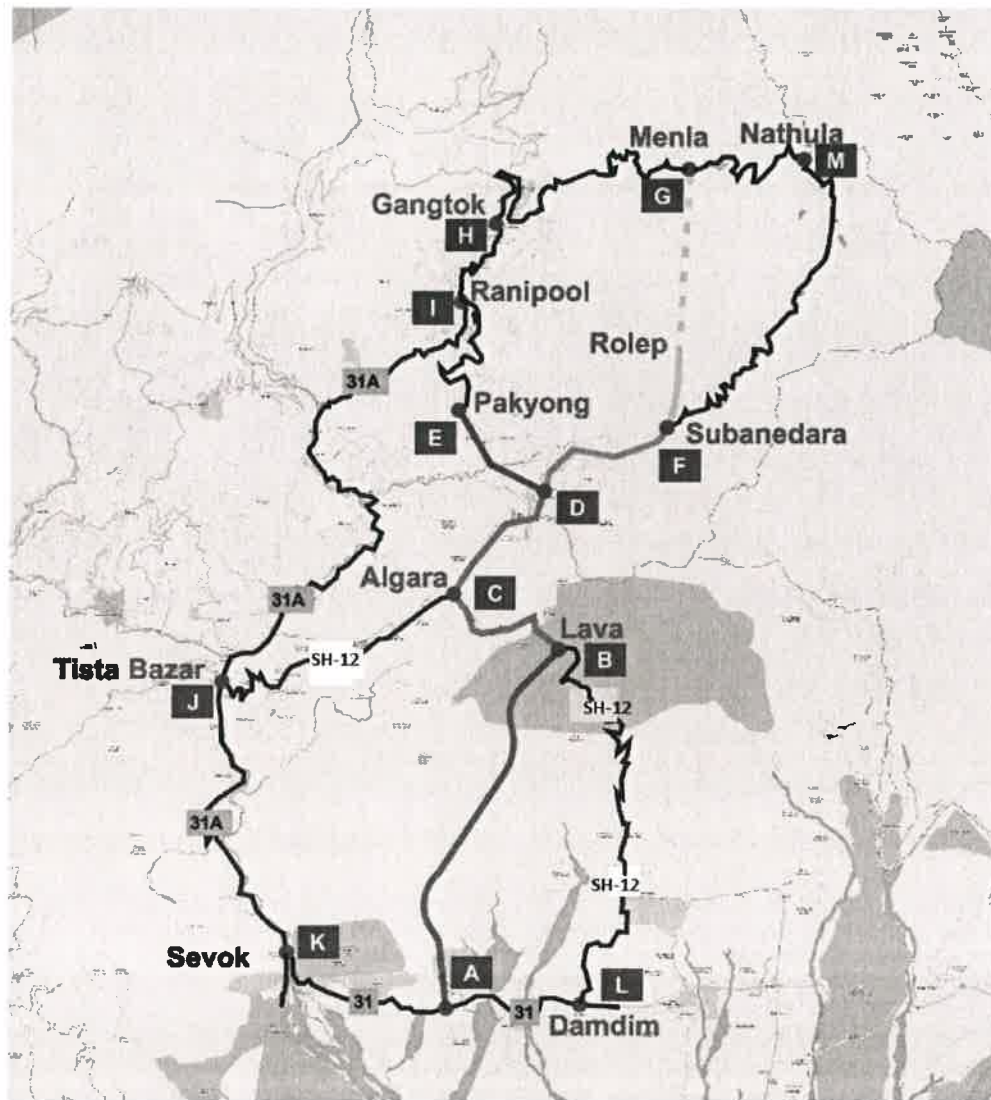


FIGURE 4.1 LINK NODE MAP

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

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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 - Algarah	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
<i>PCU Value</i>	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

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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

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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

Project: 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.

Revised Final Feasibility Report : TRAFFIC SURVEY AND ANALYSIS

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

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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

Project: 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.

Revised Final Feasibility Report : TRAFFIC SURVEY AND ANALYSIS

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.

CHAPTER - 5

ECONOMIC ANALYSIS

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.

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

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 through reconstruction and strengthening.

5.3 Project Cost and Scheduling

The existing project road is 38.900 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	0/000	38/900	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

Feasibility Report : ECONOMICS ANALYSIS

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	15.97	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

Feasibility Report : ECONOMICS ANALYSIS

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.

Feasibility Report : ECONOMICS ANALYSIS

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

Feasibility Report : ECONOMICS ANALYSIS

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

Feasibility Report : ECONOMICS ANALYSIS

Year	2 Wheeler	Passenger Car+Jeep	Bus	LCV	2-Axle	3-Axle and Multi Axle
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.

CHAPTER - 6

SOCIAL IMPACT ASSESSMENT

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:

Feasibility Report : SOCIAL IMPACT ASSESSMENT

- 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.

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6.4 Project Road (Package No. IV)

The project road 717-A from Km. 0.000 to 92.800 (section Bagrakot to Reshi Border) starts from Bagrakot with the junction of NH-31 and ends at Reshi Bridge 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.

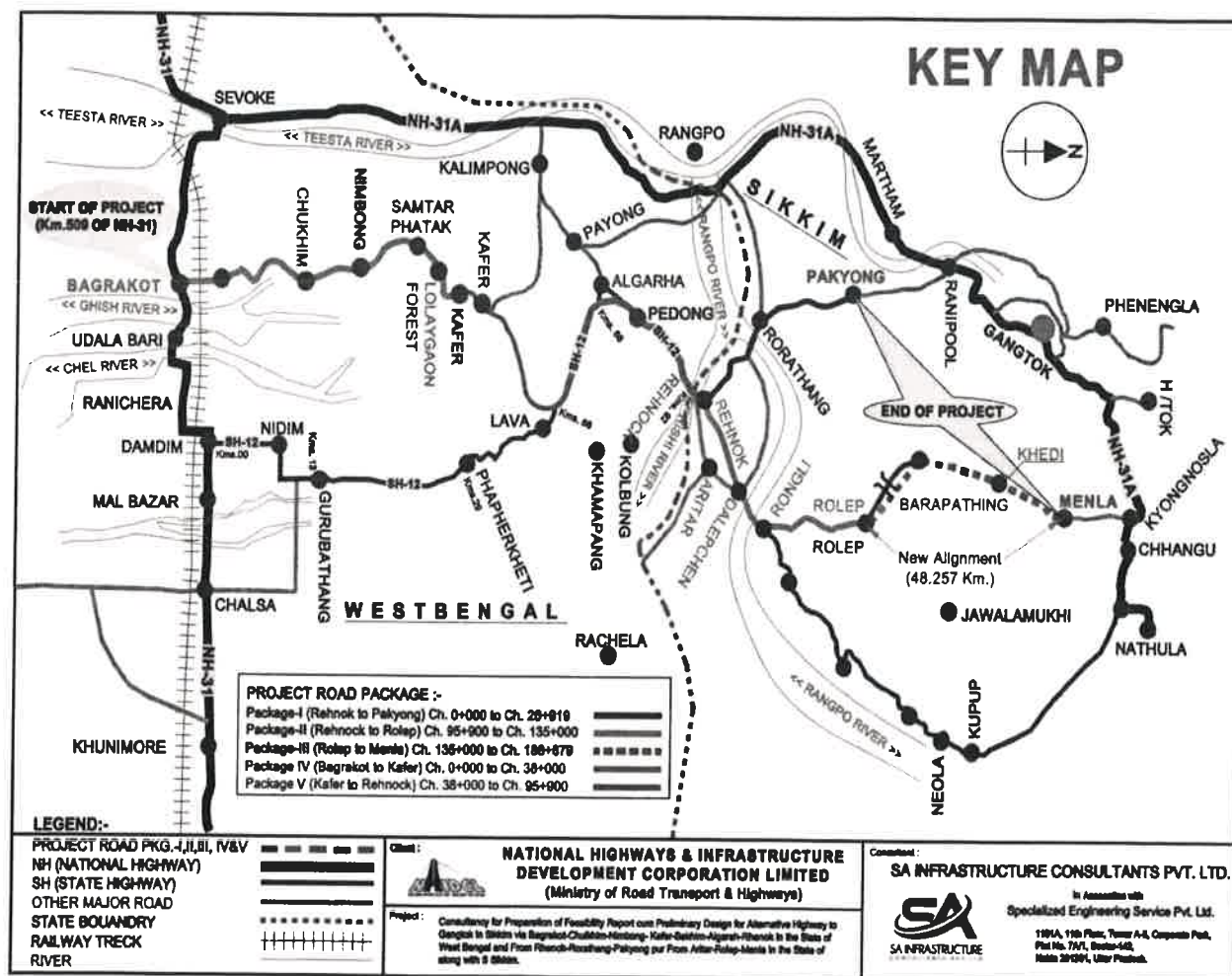


Fig 1.1

6.4.1 Habitation along the project

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

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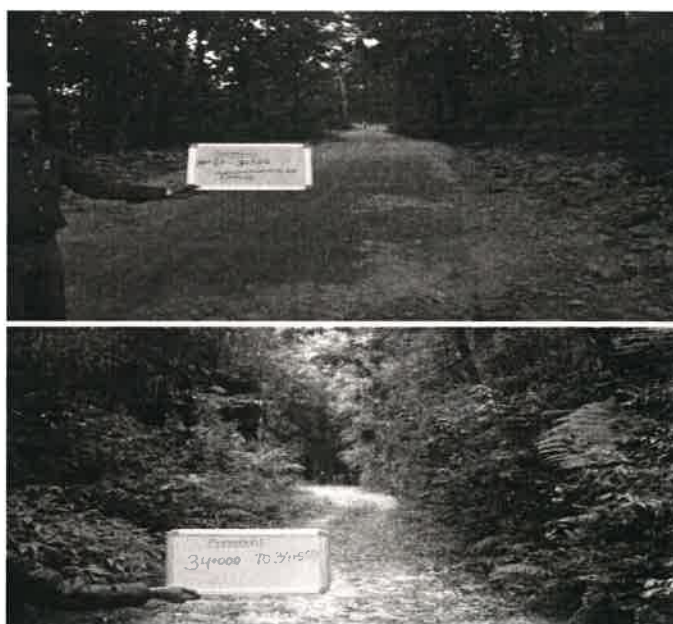
has significant influence on West Bengal State and particular in Darjeeling District and Jalpaiguri District. Maximum part of the project stretch is passing through Darjeeling District and the very first three kilometer of the stretch is part of Jalpaiguri District. The major part of the project stretch 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.



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

Table.2: Existing Road Characteristics

Existing Chainage		Carriageway Width(m)	Surface Type	Shoulder Width	Shoulder Type	Terrain /Type
Start	End					
0+000	38+900	3.5 - 5	BT	0.5-1	ER	Hilly

6.4.3 Road Junctions

. There are 1 major junction and 16 minor junctions in the entire stretch. The major junction is at starting point with NH-31 in Bagrakot.

Table 3: Details of Major Junction

Sr. No.	Chainage	Type	Link	Direction
1	0+000	T	Bagrakot	RHS & LHS

Table 4: Details of Minor Junction

SL. No.	Existing Chainage	Design Chainage	Type of intersection	Direction	Type of Road	Going to
				Left/Right	E/BT/C	
1	-	2+000	Y	Left		Tea garden
2	-	2+220	Y	Left & Right		Tea garden
3	-	2+600	Y	Left & Right		Tea garden
4	12+600	13+560	Y	Right	E	Yalbong Village
5	15+510	16+610	Y	Left		Chuikhim Village

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6	15+920	16+980	Y	Left	E	Chuikhim Village
7	21+730	23+130	y	Right	E	Lungret Village
8	24+340	25+500	Y	Right	BT	Ghantidara Village
9	24+960	26+120	Y	Left		Gyasok Village
10	25+300	26+440	Y	Right	E	Babangoan Village
11	26+120	27+220	Y	Left	R	Home
12	30+140	31+060	T	Right	BT	Pemlin
13	30+400	31+320	Y	Left	BT	Kalimpong
14	38+250	39+200	Y	Right	E	Forest Park

6.4.4 Existing Bridge & Cross Drainage Structures

There are 2 minor bridges, 56 slab culverts, 98 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	2
3	Pipe Culverts	0
4	Slab Culverts	56
5	Causeway	98
Total		158

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

Feasibility Report : SOCIAL IMPACT ASSESSMENT

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 geology.

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.

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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;

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- 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

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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 PabrintarKhasmahal where 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

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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 8088 females for 8244 males and hence the sex ratio works out to be 981. In other words, there are 981 females per 1000 males.

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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
NimbongKhas mahal	2659	51.45	48.55	0.90	40.17	62.47	67.76	56.86	55.55	44.45
NobgaonKhas mahal	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**.

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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/ Granular Shoulder areas)
(iv)	Roadway Elements	
		: Carriageway <ul style="list-style-type: none"> • 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

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(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

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	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 (Km)	Type of Cross Section	TCS
	From (Km)	To (Km)			
1	0	0.4	0.4	Type of Cross Section of 4-lane divided highway with raised median	4
2	0.4	3.8	3.4	Type of Cross Section of 2-lane with paved shoulder (Open country-plain/rolling terrain)	3
3	3.8	3.86	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
4	3.86	3.915	0.055	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
5	3.915	3.97	0.055	Two lane with paved shoulder Raised portion(Hill section)	1
6	3.97	4.34	0.37	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
7	4.34	4.4	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
8	4.4	4.69	0.29	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
9	4.69	4.725	0.035	Two lane with paved shoulder Raised portion(Hill section)	1
10	4.725	4.86	0.135	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
11	4.86	4.89	0.03	Two lane with paved shoulder Raised portion(Hill section)	1
12	4.89	5.05	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : SOCIAL IMPACT ASSESSMENT

13	5.05	5.13	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
14	5.13	5.23	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
15	5.23	5.4	0.17	Two lane with paved shoulder Raised portion(Hill section)	1
16	5.4	5.59	0.19	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
17	5.59	5.66	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
18	5.66	5.79	0.13	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
19	5.79	6.14	0.35	Two lane with paved shoulder Raised portion(Hill section)	1
20	6.14	6.27	0.13	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
21	6.27	6.38	0.11	Two lane with paved shoulder Raised portion(Hill section)	1
22	6.38	6.52	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
23	6.52	6.58	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
24	6.58	7.16	0.58	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
25	7.16	7.28	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
26	7.28	7.36	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
27	7.36	7.44	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
28	7.44	8.12	0.68	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
29	8.12	8.18	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
30	8.18	8.26	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
31	8.26	8.46	0.2	Two lane with paved shoulder Raised portion(Hill section)	1

Feasibility Report : SOCIAL IMPACT ASSESSMENT

32	8.46	8.52	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
33	8.52	8.62	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
34	8.62	8.68	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
35	8.68	9.22	0.54	Two lane with paved shoulder Raised portion(Hill section)	1
36	9.22	9.26	0.04	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
37	9.26	9.4	0.14	Two lane with paved shoulder Raised portion(Hill section)	1
38	9.4	9.5	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
39	9.5	10.02	0.52	Two lane with paved shoulder Raised portion(Hill section)	1
40	10.02	10.24	0.22	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
41	10.24	10.34	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
42	10.34	10.55	0.21	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
43	10.55	10.62	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
44	10.62	10.82	0.2	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
45	10.82	10.91	0.09	Two lane with paved shoulder Raised portion(Hill section)	1
46	10.91	11	0.09	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
47	11	11.09	0.09	Two lane with paved shoulder Raised portion(Hill section)	1
48	11.09	11.14	0.05	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
49	11.14	11.94	0.8	Two lane with paved shoulder Raised portion(Hill section)	1
50	11.94	12.08	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : SOCIAL IMPACT ASSESSMENT

51	12.08	12.2	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
52	12.2	12.28	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
53	12.28	12.36	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
54	12.36	12.5	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
55	12.5	12.57	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
56	12.57	12.62	0.05	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
57	12.62	12.82	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
58	12.82	12.96	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
59	12.96	13.16	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
60	13.16	13.3	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
61	13.3	13.84	0.54	Two lane with paved shoulder Raised portion(Hill section)	1
62	13.84	13.98	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
63	13.98	14.1	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
64	14.1	14.2	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
65	14.2	14.72	0.52	Two lane with paved shoulder Raised portion(Hill section)	1
66	14.72	14.91	0.19	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
67	14.91	14.98	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
68	14.98	15.14	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
69	15.14	16.44	1.3	Two lane with paved shoulder Raised portion(Hill section)	1

Feasibility Report : SOCIAL IMPACT ASSESSMENT

70	16.44	16.58	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
71	16.58	16.9	0.32	Two lane with paved shoulder Raised portion(Hill section)	1
72	16.9	17.04	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
73	17.04	17.12	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
74	17.12	17.34	0.22	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
75	17.34	17.42	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
76	17.42	17.6	0.18	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
77	17.6	17.8	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
78	17.8	17.94	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
79	17.94	18	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
80	18	18.27	0.27	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
81	18.27	18.36	0.09	Two lane with paved shoulder Raised portion(Hill section)	1
82	18.36	18.5	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
83	18.5	18.82	0.32	Two lane with paved shoulder Raised portion(Hill section)	1
84	18.82	18.93	0.11	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
85	18.93	19.34	0.41	Two lane with paved shoulder Raised portion(Hill section)	1
86	19.34	19.74	0.4	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
87	19.74	19.86	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
88	19.86	20.14	0.28	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : SOCIAL IMPACT ASSESSMENT

89	20.14	20.24	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
90	20.24	20.4	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
91	20.4	20.46	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
92	20.46	20.52	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
93	20.52	20.66	0.14	Two lane with paved shoulder Raised portion(Hill section)	1
94	20.66	20.72	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
95	20.72	20.84	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
96	20.84	21.46	0.62	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
97	21.46	22.58	1.12	Two lane with paved shoulder Raised portion(Hill section)	1
98	22.58	22.8	0.22	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
99	22.8	23.52	0.72	Two lane with paved shoulder Raised portion(Hill section)	1
100	23.52	23.78	0.26	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
101	23.78	23.98	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
102	23.98	24.14	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
103	24.14	24.2	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
104	24.2	24.4	0.2	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
105	24.4	24.7	0.3	Two lane with paved shoulder Raised portion(Hill section)	1
106	24.7	25.04	0.34	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
107	25.04	25.2	0.16	Two lane with paved shoulder Raised portion(Hill section)	1

Feasibility Report : SOCIAL IMPACT ASSESSMENT

108	25.2	25.4	0.2	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
109	25.4	26.96	1.56	Two lane with paved shoulder Raised portion(Hill section)	1
110	26.96	27.2	0.24	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
111	27.2	27.72	0.52	Two lane with paved shoulder Raised portion(Hill section)	1
112	27.72	27.84	0.12	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
113	27.84	28	0.16	Two lane with paved shoulder Raised portion(Hill section)	1
114	28	28.54	0.54	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
115	28.54	30.07	1.53	Two lane with paved shoulder Raised portion(Hill section)	1
116	30.07	30.18	0.11	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
117	30.18	31.04	0.86	Two lane with paved shoulder Raised portion(Hill section)	1
118	31.04	31.15	0.11	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
119	31.15	31.32	0.17	Two lane with paved shoulder Raised portion(Hill section)	1
120	31.32	31.44	0.12	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
121	31.44	31.6	0.16	Two lane with paved shoulder Raised portion(Hill section)	1
122	31.6	31.74	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
123	31.74	32.56	0.82	Two lane with paved shoulder Raised portion(Hill section)	1
124	32.56	32.66	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
125	32.66	33.48	0.82	Two lane with paved shoulder Raised portion(Hill section)	1
126	33.48	33.56	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : SOCIAL IMPACT ASSESSMENT

127	33.56	33.7	0.14	Two lane with paved shoulder Raised portion(Hill section)	1
128	33.7	33.8	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
129	33.8	34	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
130	34	34.18	0.18	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
131	34.18	34.28	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
132	34.28	34.38	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
133	34.38	34.88	0.5	Two lane with paved shoulder Raised portion(Hill section)	1
134	34.88	35.02	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
135	35.02	35.36	0.34	Two lane with paved shoulder Raised portion(Hill section)	1
136	35.36	35.44	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
137	35.44	35.9	0.46	Two lane with paved shoulder Raised portion(Hill section)	1
138	35.9	35.98	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
139	35.98	39.54	3.56	Two lane with paved shoulder Raised portion(Hill section)	1
140	39.54	39.64	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
141	39.64	39.88	0.24	Two lane with paved shoulder Raised portion(Hill section)	1
142	39.88	39.96	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
143	39.96	40	0.04	Two lane with paved shoulder Raised portion(Hill section)	1

TCS ON ROB APPROACH AND RAMP

Sr. No.	Proposed Chainage	Length	Section	TCS
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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		

Table 11: Details of TCS

Sr. No.	Detail	TCS	Length (m)	Length (Km)
1	Two Lane with Paved Shoulder Raised Portion (Hill Section)	I	24050	24.05
2	Two Lane with Paved Shoulder Raised Portion (Hill Section) in new alignment	II	12150	12.15
3	Type of Cross Section of 2-lane bypass (Open country-plain/rolling terrain)	III	3400	3.4
4	Type of Cross Section of 4-lane highway (Open country-plain/rolling terrain)	IV	400	0.4

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.

Feasibility Report : SOCIAL IMPACT ASSESSMENT

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,

Alternatives were explored to minimize the adverse impacts of the proposed intervention as far as possible. Some of the specific measures adopted for minimizing the adverse impact are as under:

- Concentric widening has been proposed in as far as possible. Impacts on land in open sections of project road were minimized by adopting the principle of actual land requirements from one point to another point to fit in the requisite cross section instead of having a uniform land width throughout the road stretch.
- Bypasses have been proposed at three locations namely, **Bagrakot, Barbot and Nimbong**. A very large number of structures were likely to be affected at these locations. Bypasses have been provided for these places in order to minimize the impacts though resulting in impacts on 4.04 ha of lands i.e., 12% of the total additional land requirements (33.5 ha of private land). There was demand for bypass at these locations and they were also in consultations with local people and project authority. The land width for bypasses has been fixed as 24m.

The proposed alignment has been finalized after satisfying the following considerations:

- Good Geometry
- Availability of Land
- Minimum constraints
- Minimum Rehabilitation and Resettlement
- Minimum Land Acquisition
- Minimum damage to the existing environment

Feasibility Report : SOCIAL IMPACT ASSESSMENT

- Avoiding swamp lands/ water bodies such as ponds/ tanks

The major features, like details of important crossing points of the alignment option-I are discussed below in Table.

Table 12: Details of Alignment Option - I

Sr. No.	Design Chainage (Km+m)	Description of Existing Land mark	Remarks
1	0+000	Bagrakot (West Bengal)	Start point of project
2	0+100	Existing Level Crossing	Proposed ROB
3	0+000	Start of Bypass	Bagrakot Bypass
4	3+800	End of Bypass	Bagrakot Bypass
5	17+000	Village	Chukhim
6	24+700	Start of Bypass	Barbot Bypass
7	25+100	End of Bypass	Barbot Bypass
8	28+200	Start of Bypass	Nimbong Bypass
9	28+500	End of Bypass	Nimbong Bypass
10	40+000	End of Pkg IV	

Salient Features – Alignment Option-I

The salient features of the Alignment Option-I are given in Table below:

Table 13: Salient Features of the Proposed Alignment Option-I

Sr. No.	Factors		Remarks
1	Highway, Traffic Services	Length of Proposed Alignment (km)	40.000 km
		Service to Road users	Good Speed, Safety
		Land	Passes mostly through Existing

Feasibility Report : SOCIAL IMPACT ASSESSMENT

Sr. No.	Factors	Remarks	
			Alignment
		Network Connectivity	Connects all the major existing Habitants
		Traffic decongestion	The proposed road will not decongest the traffic
2	Availability of land	Available ROW from Km 0 to Km 2.9 is 14-16 m. Km 3 to Km 38 is 3-7 m	Extra land required for realignment, Bypass and hair pin bands location,
2	Social and Environmental	Rehabilitation/ Resettlement	Minimum R&R is required
		Water and Air Quality	Minor Impact
		Protection of Flora and Fauna	Minor loss of Agricultural land and minimum forest land is required
3	Land use	Impact on Commercial activity	No commercial activities noted along the proposed alignment, hence no effect
4	CD works	Grade Separator/ ROB/ Major & Minor Bridges	ROB+LOOP – 1 No's Flyover – 0 No's Grade Separator – 0 No's Underpass – 0 No's Cattlepass– 0 No's Major Bridge – 0 No's Minor Bridge–4 No's

Feasibility Report : SOCIAL IMPACT ASSESSMENT

Sr. No.		Factors	Remarks
		Culverts	Total 172 No's of minor CD structures are required
5	Approximate Cost	Construction Cost	674.58 Cr Approx
		Savings in Cost	Cheaper other than options

Alignment Option-II

The project alignment starts from Bagrakot (West Bengal) at Ch 0+000 and ends at Kafer (Ch 39+000). Office Memorandum of Ministry of Environment & Forests (FC division) Government of India, F.No. 11-122/2011-FC. Recommendation of MOEF that it is fortuitous that there exists an alternative route that not only minimizes damage to the natural heritage of the country, while serving the important requirement of defence. The existing road is less damaging and preserves the natural heritage of the country and viable also from the construction and safety point of view. It is therefore recommended that the Bagrakot – Chuikhim – Nimbong – Kafer – Bakhim – Algarah – Rhenok route be taken up as the alternate route to Sikkim.

We did not consider Bagrakot, Barbot and Nimbong bypass in this option.

The major features, like details of important crossing points of the alignment option – II are discussed below in table below.

Table 14: Details of Alignment Option-II

Sr. No.	Design Chainage (Km+m)	Description of Existing Land mark	Remarks
1	0+000	Bagrakot (West Bengal)	Start point of project
2	0+100	Existing Level Crossing	Proposed ROB
3	2+500	Village	Bagrakot Village
4	17+000	Village	Chuikhim

Feasibility Report : SOCIAL IMPACT ASSESSMENT

Sr. No.	Design Chainage (Km+m)	Description of Existing Land mark	Remarks
5	20+900	Village	Navgaon
6	23+200	Village	Sansidara
7	24+800	Village	Barbot
8	28+300	Village	Nimbong
9	39+000	End of Pkg IV	

Salient Features – Alignment Option-II

The salient features of the Alignment Option-II are given below in table below.

Table 15: Salient Features of the Proposed Alignment Option-II

Sr. No.	Factors		Remarks
1	Highway, Traffic Services	Length of Proposed Alignment (km)	39
		Service to Road users	Good Speed, Safety
		Land	Alignment passes mainly through agricultural land.
		Network Connectivity	Passing through Bagrakot, Chuikhim, Navgaon, Sansidara, Barbot, Nimbong, Kafer
		Traffic decongestion	The proposed road will congest the traffic.
2	Social and Environmental	Rehabilitation/ Resettlement	Maximum R&R will be needed since the existing Habitation is affecting in the proposed alignment
		Water and Air Quality	Major Impact

Feasibility Report : SOCIAL IMPACT ASSESSMENT

Sr. No.	Factors		Remarks
		Protection of Flora and Fauna	Loss of Forest land
3	Land use	Impact on Commercial activity	Petty Business will be affected in habitations
4	CD works	Grade Separator/ ROB/ Major & Minor Bridges	ROB – 1 No's Flyover – 0 No's Grade Separator – 1 No's Elevated Structure- 1.3 Km Underpass – 0 No's Cattlepass– 0 No's Major Bridge – 1 No's Minor Bridge–3 No's
		Box and Pipe Culverts	Total 168 No's of minor CD structures are required
5	Approximate Cost	Construction Cost	722 Cr Approx + Cost of elevated structure (Appx. 140 Cr) in case LA not possible due to dense habitation
		Savings in Cost	Fuel and time consumes more compared to previous alternative and R & R is more.

Merits and Demerits of Alignment Options I and II

The merits and demerits of all alignment options were studied in detail to arrive at recommended alignment option. The details of the same are presented in table below.

Table 16: Merits and Demerits of Alignment Options I and II

Comparison of proposed 2 Alternative of Package IV (Bagrakot -Kafer)

Feasibility Report : SOCIAL IMPACT ASSESSMENT

S.No.	Description	Option I	Option II
1	Take off Existing Km	Bagrakot	Bagrakot
2	End of Existing Km	Kafer	Kafer
3	Route Alignment	Bagrakot, Barbot and Nimbong bypass	Bagrakot, Barbot and Nimbong without bypass
4	Length of proposed project stretch	40.000	39.000
5	Existing Alignment followed	24.05	39
6	New Alignment	15.95	0.00
7	Terrain	Hilly	Hilly
8	Speed	40kmph	40 kmph
9	Geometrics	Hair pin Bend - 54 Nos	70
10	Features	Bagrakot, Barbot and Nimbong bypass	Passing through Existing Road
11	Villages Enroute	Passing through Bagrakot, Chukhim, Navgaon, Sansidara, Barbot, Nimbong, Kafer	Passing through Bagrakot, Chukhim, Navgaon, Sansidara, Barbot, Nimbong, Kafer
12	LA	Km 0 to Km 2.9 is 10-12 m. Km 3 to Km 38 is 3-7 m Extra land is required for Bypass and Hair Pin Bend.	Km 0 to Km 2.9 is 10-12 m. Km 3 to Km 38 is 3 -7 m Extra land is required for Hair Pin Bend.
13	No. of Structures	1ROB+GS+LOOP +4 Minor Bridge	1ROB +1GS+3 Minor Bridge+Elevated structure(1.3km in Bagrakot Habitation)
14	Area required for LA	37 ha is required for: (i) proposed Bagrakot, Barbot,	22 ha is required for widening of existing

Feasibility Report : SOCIAL IMPACT ASSESSMENT

	hectares	Nimbong Bypasses (ii) improvement of Hair Pin Bend and (iii) widening of existing road	road and improvement of Hair Pin Bend
15	Approximate cost of L.A.	60 Cr (37 Ha @ 50 Lac/ha)	36 Cr (22 Ha @ 50Lac/ha)
16	Approx R & R Cost	1.00Cr (Appx. 23 Structure to be Affected)	11.50Cr (Appx. 197 Structure to be Affected)
16	Approximate cost of Structures	58.29 Cr	193 Cr (Cost of elevated structure (Appx. 140 Cr) in case LA not possible due to dense habitation)
17	Approximate Civil cost of Roads @15.97 Cr per km	674.58	Rs 722 Cr
18	Approximate Total Civil cost of including LA+US+FC	953.47 Cr	984 Cr
19	Recommended Option	Yes	No

Finalization of Alignment Option

Looking to all above alignment options merits and demerits; consultant recommended the alignment **Option-I**, which was also the outcome from the detailed discussions with NHIDCL.

Table 17: Summary of Cost of Project Road

Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)	Page Number
ROAD WORKS						
Site Clearance				6,528,322.19	0.653	
Excavation	Cum					

Project: 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.

Feasibility Report : SOCIAL IMPACT ASSESSMENT

				537,779,045.09	53.778	
Earthwork Filling	Cum			237,362,901.58	23.736	
Loosening & Recompacting	Cum			10,099,969.20	1.010	
Sub Grade	Cum			61,410,952.00	6.141	
GSB	Cum			205,925,594.56	20.593	
WMM	Cum			216,906,415.00	21.691	
Prime Coat	Sqm			11,358,703.20	1.136	
Tack Coat	Sqm			8,737,464.00	0.874	
DBM / Profile Corrective Course	Cum			377,965,722.48	37.797	
BC	Cum			195,594,562.00	19.559	

BRIDGES and STRUCTURES						
Minor Bridges	No.	4		68,449,470.79	6.84	
ROB+Viaduct(Loop)	No.	1		161,064,684.84	16.11	
Culverts Pipe/Slab/Box	No.	172	2054288.89	353,337,688.22	35.33	

SLOPE STRUCTURES						
Reinforced Slope Structure	No./m			2,247,621,379.49	224.76	
RE Wall				275,673,390.00	27.57	
Retaining and Breast Wall				1,198,231,184.53	119.82	

JUNCTIONS						
Major Junctions	No	1.00		5,874,125.00	0.59	
Minor Junctions	No	14.00		33,380,585.00	3.34	

Project: 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.

Feasibility Report : SOCIAL IMPACT ASSESSMENT

DRAIN & PROTECTION WORK						
Drainage Works	Km	6.80		238,927,569.33	23.89	
Metal Crash Barrier	Km	9.25		40,768,718.00	4.08	
Other Protective Works				160,949,457.90	16.09	
LAY BAYS						
Bus Bays	Nos	16.00	1,547,988.76	24,767,820.13	2.48	
Truck Lay Bays	Nos	1.00	10,371,454.35	10,371,454.35	1.04	
OTHER MISCELLANEOUS ITEMS						
Footpath and Separators				2,752,400.00	0.28	
Miscellaneous Items	Total			16,326,640.00	1.63	
Traffic Signs, Marking and Road Appurtenances	Total			20,757,623.05	2.08	
Reflective Road Studs	Nos	20278		16,918,007.23	1.69	
TOTAL CIVIL COST				6745841849.16	674.58	
40 Km for Project length and 2.24km for ROB Approach Loop & NH-31 widening at ROB Locations						
COST PER KM (LENGTH = 42.24 KM) IN CRORES ...					15.97	

Recommendation

Proposal of Option-I has been considered for future traffic growth, less rehabilitation and resettlement and various developments activities.

CHAPTER - 7

IMPROVEMENT PROPOSAL & DESIGN

6.0 Improvement Proposals and Design

6.1 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

6.2 Design Standards

6.2.1 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/ Granular Shoulder 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

(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

6.2.2 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.

6.2.3 Geometric Design

6.2.3.1 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

6.2.3.2 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: 73-2015, 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 speed of 40km/hr for hilly terrain is proposed for the project road.

6.2.3.3 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.

6.2.3.4 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:73-2015 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:

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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: 2015 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 73-2015 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 2015 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 73-2015 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

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Built-up Areas	13-14	13.5
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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: 73-2015 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.

6.2.3.5 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Table 6.6A: Sight distance for various Speeds

Design Speed Km/h	IRC SP 73:2015		
	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 73:2015	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 – 2015 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

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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: 73-2015 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/hr). 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: 73-2015, 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.

6.2.3.6 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 %

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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

6.2.3.7 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: 73-2015 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.2.4 Design Standards for Structures

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

6.2.4.1 Materials

Concrete Grade

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

	<u>Major Bridge</u>	<u>Minor Bridge/Culvert</u>
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

6.2.4.2 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.

6.2.4.3 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

6.2.4.4 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.

6.2.4.5 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).

6.2.4.6 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. (± 40 mm).

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

6.2.4.7 Loads

Dead Loads

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

Pre-stressed Concrete	:	2.5t/m ³
Reinforced Concrete	:	2.4t/m ³
Plain Cement Concrete	:	2.2 to 2.3 t/m ³
Structural Steel	:	7.85t/m ³
Dry Density of Soil	:	2.00 t/m ³
Saturated Density of Soil	:	1.0 t/m ³

Superimposed Dead Loads

Wearing coat	:	Bituminous Concrete with total weight of 2.2 t/m ³
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In addition Footpath / Kerb as well as Crash barriers, wherever feasible and provided are also considered as SIDL

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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-

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

Where C = Centrifugal force acting normal to the traffic.

W = Carriageway Live Load

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

R = Radius of curvature in 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 : $\phi = 30$ degree

Angle of Wall Friction : $\delta = 20$ degree

Coefficient of Friction μ at base : $\tan(2/3\phi)$, where ϕ 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.2.4.8 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 = $(Z/2) \times (Sa/g)/(R/I)$
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.

6.2.4.9 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.

6.2.4.10 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.

6.2.4.11 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'.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

- ✓ 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.

6.2.4.12 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.

6.2.4.13 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.

6.2.4.14 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;

6.2.4.15 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

- 6) Section IV – Brick, Stone and Block Masonry (Second Revision)
IRC:40-2002: Standard Specifications and Code of Practice for Road Bridges
- 7) Section V – Steel Road Bridges (Second Revision)
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:73-2015 : 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Indian Standards

- 28) IS:456-2000: Plain and Reinforced Concrete (Fourth Revision)
- 29) IS:2502-1963
- 30) IS: 808
- 31) IS: 2062/8500

6.3 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.

6.3.1 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 (Km)	Type of Cross Section	TCS
	From (Km)	To (Km)			
1	0	0.4	0.4	Type of Cross Section of 4-lane divided highway with raised median	4
2	0.4	3.8	3.4	Type of Cross Section of 2-lane with paved shoulder (Open country-plain/rolling terrain)	3
3	3.8	3.86	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
4	3.86	3.915	0.055	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
5	3.915	3.97	0.055	Two lane with paved shoulder Raised portion(Hill section)	1
6	3.97	4.34	0.37	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
7	4.34	4.4	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
8	4.4	4.69	0.29	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
9	4.69	4.725	0.035	Two lane with paved shoulder Raised portion(Hill section)	1
10	4.725	4.86	0.135	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
11	4.86	4.89	0.03	Two lane with paved shoulder Raised portion(Hill section)	1
12	4.89	5.05	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
13	5.05	5.13	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
14	5.13	5.23	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
15	5.23	5.4	0.17	Two lane with paved shoulder Raised portion(Hill section)	1
16	5.4	5.59	0.19	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

17	5.59	5.66	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
18	5.66	5.79	0.13	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
19	5.79	6.14	0.35	Two lane with paved shoulder Raised portion(Hill section)	1
20	6.14	6.27	0.13	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
21	6.27	6.38	0.11	Two lane with paved shoulder Raised portion(Hill section)	1
22	6.38	6.52	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
23	6.52	6.58	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
24	6.58	7.16	0.58	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
25	7.16	7.28	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
26	7.28	7.36	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
27	7.36	7.44	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
28	7.44	8.12	0.68	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
29	8.12	8.18	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
30	8.18	8.26	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
31	8.26	8.46	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
32	8.46	8.52	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
33	8.52	8.62	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
34	8.62	8.68	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
35	8.68	9.22	0.54	Two lane with paved shoulder Raised portion(Hill section)	1
36	9.22	9.26	0.04	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
37	9.26	9.4	0.14	Two lane with paved shoulder Raised portion(Hill section)	1
38	9.4	9.5	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
39	9.5	10.02	0.52	Two lane with paved shoulder Raised portion(Hill section)	1
40	10.02	10.24	0.22	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
41	10.24	10.34	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
42	10.34	10.55	0.21	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
43	10.55	10.62	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
44	10.62	10.82	0.2	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
45	10.82	10.91	0.09	Two lane with paved shoulder Raised portion(Hill section)	1
46	10.91	11	0.09	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
47	11	11.09	0.09	Two lane with paved shoulder Raised portion(Hill section)	1
48	11.09	11.14	0.05	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

49	11.14	11.94	0.8	Two lane with paved shoulder Raised portion(Hill section)	1
50	11.94	12.08	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
51	12.08	12.2	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
52	12.2	12.28	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
53	12.28	12.36	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
54	12.36	12.5	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
55	12.5	12.57	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
56	12.57	12.62	0.05	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
57	12.62	12.82	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
58	12.82	12.96	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
59	12.96	13.16	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
60	13.16	13.3	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
61	13.3	13.84	0.54	Two lane with paved shoulder Raised portion(Hill section)	1
62	13.84	13.98	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
63	13.98	14.1	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
64	14.1	14.2	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
65	14.2	14.72	0.52	Two lane with paved shoulder Raised portion(Hill section)	1
66	14.72	14.91	0.19	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
67	14.91	14.98	0.07	Two lane with paved shoulder Raised portion(Hill section)	1
68	14.98	15.14	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
69	15.14	16.44	1.3	Two lane with paved shoulder Raised portion(Hill section)	1
70	16.44	16.58	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
71	16.58	16.9	0.32	Two lane with paved shoulder Raised portion(Hill section)	1
72	16.9	17.04	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
73	17.04	17.12	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
74	17.12	17.34	0.22	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
75	17.34	17.42	0.08	Two lane with paved shoulder Raised portion(Hill section)	1
76	17.42	17.6	0.18	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
77	17.6	17.8	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
78	17.8	17.94	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
79	17.94	18	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
80	18	18.27	0.27	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

81	18.27	18.36	0.09	Two lane with paved shoulder Raised portion(Hill section)	1
82	18.36	18.5	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
83	18.5	18.82	0.32	Two lane with paved shoulder Raised portion(Hill section)	1
84	18.82	18.93	0.11	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
85	18.93	19.34	0.41	Two lane with paved shoulder Raised portion(Hill section)	1
86	19.34	19.74	0.4	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
87	19.74	19.86	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
88	19.86	20.14	0.28	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
89	20.14	20.24	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
90	20.24	20.4	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
91	20.4	20.46	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
92	20.46	20.52	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
93	20.52	20.66	0.14	Two lane with paved shoulder Raised portion(Hill section)	1
94	20.66	20.72	0.06	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
95	20.72	20.84	0.12	Two lane with paved shoulder Raised portion(Hill section)	1
96	20.84	21.46	0.62	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
97	21.46	22.58	1.12	Two lane with paved shoulder Raised portion(Hill section)	1
98	22.58	22.8	0.22	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
99	22.8	23.52	0.72	Two lane with paved shoulder Raised portion(Hill section)	1
100	23.52	23.78	0.26	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
101	23.78	23.98	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
102	23.98	24.14	0.16	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
103	24.14	24.2	0.06	Two lane with paved shoulder Raised portion(Hill section)	1
104	24.2	24.4	0.2	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
105	24.4	24.7	0.3	Two lane with paved shoulder Raised portion(Hill section)	1
106	24.7	25.04	0.34	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
107	25.04	25.2	0.16	Two lane with paved shoulder Raised portion(Hill section)	1
108	25.2	25.4	0.2	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
109	25.4	26.96	1.56	Two lane with paved shoulder Raised portion(Hill section)	1
110	26.96	27.2	0.24	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
111	27.2	27.72	0.52	Two lane with paved shoulder Raised portion(Hill section)	1
112	27.72	27.84	0.12	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

113	27.84	28	0.16	Two lane with paved shoulder Raised portion(Hill section)	1
114	28	28.54	0.54	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
115	28.54	30.07	1.53	Two lane with paved shoulder Raised portion(Hill section)	1
116	30.07	30.18	0.11	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
117	30.18	31.04	0.86	Two lane with paved shoulder Raised portion(Hill section)	1
118	31.04	31.15	0.11	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
119	31.15	31.32	0.17	Two lane with paved shoulder Raised portion(Hill section)	1
120	31.32	31.44	0.12	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
121	31.44	31.6	0.16	Two lane with paved shoulder Raised portion(Hill section)	1
122	31.6	31.74	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
123	31.74	32.56	0.82	Two lane with paved shoulder Raised portion(Hill section)	1
124	32.56	32.66	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
125	32.66	33.48	0.82	Two lane with paved shoulder Raised portion(Hill section)	1
126	33.48	33.56	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
127	33.56	33.7	0.14	Two lane with paved shoulder Raised portion(Hill section)	1
128	33.7	33.8	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
129	33.8	34	0.2	Two lane with paved shoulder Raised portion(Hill section)	1
130	34	34.18	0.18	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
131	34.18	34.28	0.1	Two lane with paved shoulder Raised portion(Hill section)	1
132	34.28	34.38	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
133	34.38	34.88	0.5	Two lane with paved shoulder Raised portion(Hill section)	1
134	34.88	35.02	0.14	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
135	35.02	35.36	0.34	Two lane with paved shoulder Raised portion(Hill section)	1
136	35.36	35.44	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
137	35.44	35.9	0.46	Two lane with paved shoulder Raised portion(Hill section)	1
138	35.9	35.98	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
139	35.98	39.54	3.56	Two lane with paved shoulder Raised portion(Hill section)	1
140	39.54	39.64	0.1	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
141	39.64	39.88	0.24	Two lane with paved shoulder Raised portion(Hill section)	1
142	39.88	39.96	0.08	Two lane with paved shoulder Raised portion(Hill section), New Alignment	2
143	39.96	40	0.04	Two lane with paved shoulder Raised portion(Hill section)	1

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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

Sr. No.	Detail	TCS	Length (m)	Length (Km)
1	Two Lane with Paved Shoulder Raised Portion (Hill Section)	I	24050	24.05
2	Two Lane with Paved Shoulder Raised Portion (Hill Section) in new alignment	II	12150	12.15
3	Type of Cross Section of 2-lane bypass (Open country-plain/rolling terrain)	III	3400	3.4
4	Type of Cross Section of 4-lane highway (Open country-plain/rolling terrain)	IV	400	0.4

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	3+685	RCC SLAB	1X3.25	Reconstruction	3+997	RCC SLAB	2X3
2	4+010	RCC SLAB	1X3.25	Reconstruction	4+430	RCC SLAB	2X3
3	4+617	RCC SLAB	1X3	Reconstruction	5+080	RCC SLAB	1X3
4	4+652	RCC SLAB	1X3	Reconstruction	5+150	RCC SLAB	1X3
5	4+800	RCC SLAB	1X1.5	Reconstruction	5+280	RCC SLAB	1X3
6	4+860	RCC SLAB	1X3	Reconstruction	5+340	RCC SLAB	1X3
7	4+956	RCC SLAB	1X2	Reconstruction	5+440	RCC SLAB	2X3

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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)
8	5+372	RCC SLAB	1X2	Reconstruction	5+850	RCC SLAB	1X3
9	5+452	RCC SLAB	1X1.5	Reconstruction	5+920	RCC SLAB	1X3
10	5+836	RCC SLAB	1X1.5	Reconstruction	6+280	RCC SLAB	1X3
11	7+120	RCC SLAB	1X1.5	Reconstruction	8+520	RCC SLAB	1X3
12	7+366	Causeway	-	Reconstruction	8+750	RCC SLAB	1X3
13	7+665	RCC SLAB	1X1	Reconstruction	9+040	RCC SLAB	1X3
14	7+950	Causeway	-	Reconstruction	9+280	RCC SLAB	1X3
15	8+230	Causeway	-	Reconstruction	9+540	RCC SLAB	1X3
16	8+288	Causeway	-	Reconstruction	9+620	RCC SLAB	1X3
17	8+457	Causeway	-	Reconstruction	9+780	RCC SLAB	1X3
18	8+532	Causeway	-	Reconstruction	9+870	RCC SLAB	1X3
19	8+612	RCC SLAB	1X1	Reconstruction	9+930	RCC SLAB	2X3
20	8+655	Causeway	-	Reconstruction	9+980	RCC SLAB	1X3
21	8+764	Causeway		Reconstruction	10+060	RCC SLAB	1X3
22	8+988	Causeway		Reconstruction	10+280	RCC SLAB	1X3
23	9+027	Causeway		Reconstruction	10+300	RCC SLAB	1X3
24	9+180	Causeway		Reconstruction	10+420	RCC SLAB	1X3
25	9+290	RCC SLAB	1X3	Reconstruction	10+480	RCC SLAB	1X3
26	9+326	RCC SLAB	1X2.1	Reconstruction	10+520	RCC SLAB	1X3
27	9+440	RCC SLAB	1X3.1	Reconstruction	10+585	RCC SLAB	2X3
28	9+480	Causeway		Reconstruction	10+670	RCC SLAB	1X3
29	9+600	Causeway		Reconstruction	10+760	RCC SLAB	1X3
30	9+780	Causeway		Reconstruction	10+900	RCC SLAB	1X3
31	9+983	RCC SLAB	1X2	Reconstruction	11+000	RCC SLAB	1X3
32	10+046	RCC SLAB	1X2.1	Reconstruction	11+140	RCC SLAB	1X3
33	10+209	Causeway		Reconstruction	11+280	RCC SLAB	1X3
34	10+261	Causeway		Reconstruction	11+350	RCC SLAB	1X3
35	10+386	Causeway		Reconstruction	11+480	RCC SLAB	1X3
36	10+419	Causeway		Reconstruction	11+500	RCC SLAB	1X3
37	11+018	Causeway		Reconstruction	12+090	RCC SLAB	1X3
38	11+120	RCC SLAB	1X2	Reconstruction	12+225	RCC SLAB	1X3
39	11+524	Causeway		Reconstruction	12+585	RCC SLAB	1X3
40	11+822	Causeway		Reconstruction	12+850	RCC SLAB	1X3
41	11+950	Causeway		Reconstruction	12+950	RCC SLAB	1X3
42	12+050	Causeway		Reconstruction	13+120	RCC SLAB	1X3
43	12+486	Causeway		Reconstruction	13+450	RCC SLAB	1X3
44	12+626	Causeway		Reconstruction	13+620	RCC SLAB	1X3

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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)
45	12+760	Causeway		Reconstruction	13+740	RCC SLAB	1X3
46	12+960	Causeway		Reconstruction	13+920	RCC SLAB	1X3
47	13+231	RCC SLAB	1X4.5	Reconstruction	14+220	RCC SLAB	2X3
48	14+310	Causeway		Reconstruction	15+400	RCC SLAB	1X3
49	14+633	Causeway		Reconstruction	15+730	RCC SLAB	1X3
50	14+783	RCC SLAB	1X4	Reconstruction	15+860	RCC SLAB	2X3
51	14+922	RCC SLAB	1X2	Reconstruction	15+970	RCC SLAB	1X3
52	14+940	RCC SLAB	1X2	Reconstruction	16+020	RCC SLAB	1X3
53	14+973	RCC SLAB	1X2	Reconstruction	16+050	RCC SLAB	1X3
54	15+105	Causeway		Reconstruction	16+190	RCC SLAB	1X3
55	15+261	Causeway		Reconstruction	16+350	RCC SLAB	1X3
56	15+470	Causeway		Reconstruction	16+580	RCC SLAB	1X3
57	15+775	Causeway		Reconstruction	16+880	RCC SLAB	1X3
58	16+020	Causeway		Reconstruction	17+100	RCC SLAB	1X3
59	16+796	RCC SLAB	1X2	Reconstruction	18+040	RCC SLAB	1X3
60	16+911	RCC SLAB	1X1.5	Reconstruction	18+100	RCC SLAB	1X3
61	17+500	Causeway		Reconstruction	18+720	RCC SLAB	1X3
62	17+890	Causeway		Reconstruction	19+100	RCC SLAB	1X3
63	18+222	Causeway		Reconstruction	19+400	RCC SLAB	1X3
64	18+407	RCC SLAB	1X1.5	Reconstruction	19+560	RCC SLAB	1X3
65	18+413	RCC SLAB	1X1.5	Reconstruction	19+580	RCC SLAB	1X3
66	20+360	Causeway		Reconstruction	21+860	RCC SLAB	1X3
67	20+861	RCC SLAB	1X1.7	Reconstruction	22+320	RCC SLAB	1X3
68	21+321	RCC SLAB	1X0.3	Reconstruction	22+720	RCC SLAB	1X3
69	21+400	Causeway		Reconstruction	22+780	RCC SLAB	1X3
70	21+525	RCC SLAB	1X1.35	Reconstruction	22+900	RCC SLAB	1X3
71	21+902	RCC SLAB	1X1.5	Reconstruction	23+280	RCC SLAB	1X3
72	22+540	Causeway		Reconstruction	23+880	RCC SLAB	1X3
73	22+692	RCC SLAB	1X1.5	Reconstruction	23+990	RCC SLAB	1X3
74	22+980	Causeway		Reconstruction	24+260	RCC SLAB	1X3
75	23+055	Causeway		Reconstruction	24+400	RCC SLAB	1X3
76	23+263	RCC SLAB	1X2	Reconstruction	24+590	RCC SLAB	1X3
77	23+876	Causeway		Reconstruction	25+020	RCC SLAB	1X3
78	24+165	Causeway		Reconstruction	25+320	RCC SLAB	1X3
79	24+220	Causeway		Reconstruction	25+400	RCC SLAB	1X3
80	24+824	RCC SLAB	1X2	Reconstruction	25+980	RCC SLAB	1X3
81	25+083	Causeway		Reconstruction	26+220	RCC SLAB	1X3

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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)
82	25+544	Causeway		Reconstruction	26+660	RCC SLAB	1X3
83	25+776	RCC SLAB	1X2	Reconstruction	26+900	RCC SLAB	1X3
84	25+977	RCC SLAB	1X2	Reconstruction	27+060	RCC SLAB	1X3
85	26+103	RCC SLAB	1X2	Reconstruction	27+180	RCC SLAB	1X3
86	26+231	RCC SLAB	1X1.5	Reconstruction	27+280	RCC SLAB	1X3
87	26+460	RCC SLAB	1X2	Reconstruction	27+480	RCC SLAB	1X3
88	26+642	Causeway		Reconstruction	27+620	RCC SLAB	1X3
89	26+774	Causeway		Reconstruction	27+920	RCC SLAB	1X3
90	27+380	RCC SLAB	1X2	Reconstruction	28+340	RCC SLAB	1X3
91	27+728	Causeway		Reconstruction	28+680	RCC SLAB	1X3
92	28+613	Causeway		Reconstruction	29+550	RCC SLAB	1X3
93	28+715	Causeway		Reconstruction	29+650	RCC SLAB	1X3
94	28+883	RCC SLAB	1X2.8	Reconstruction	29+810	RCC SLAB	1X3
95	29+078	RCC SLAB	1X2	Reconstruction	30+000	RCC SLAB	1X3
96	29+221	RCC SLAB	1X2	Reconstruction	30+160	RCC SLAB	1X3
97	29+543	RCC SLAB	1X2	Reconstruction	30+480	RCC SLAB	1X3
98	29+774	RCC SLAB	1X2.2	Reconstruction	30+700	RCC SLAB	1X3
99	29+985	RCC SLAB	1X3.1	Reconstruction	30+890	RCC SLAB	2X3
100	30+025	Causeway		Reconstruction	30+920	RCC SLAB	1X3
101	30+150	Causeway		Reconstruction	31+060	RCC SLAB	1X3
102	30+250	Causeway		Reconstruction	31+175	RCC SLAB	1X3
103	30+300	RCC SLAB	1X3	Reconstruction	31+220	RCC SLAB	1X3
104	30+508	Causeway		Reconstruction	31+450	RCC SLAB	1X3
105	30+790	Causeway		Reconstruction	31+760	RCC SLAB	1X3
106	30+814	Causeway		Reconstruction	31+805	RCC SLAB	1X3
107	30+853	Causeway		Reconstruction	31+850	RCC SLAB	1X3
108	31+016	Causeway		Reconstruction	31+960	RCC SLAB	1X3
109	31+159	Causeway		Reconstruction	32+090	RCC SLAB	1X3
110	31+194	Causeway		Reconstruction	32+140	RCC SLAB	1X3
111	31+313	Causeway		Reconstruction	32+260	RCC SLAB	1X3
112	31+424	Causeway		Reconstruction	32+360	RCC SLAB	1X3
113	31+992	Causeway		Reconstruction	32+920	RCC SLAB	1X3
114	32+214	Causeway		Reconstruction	33+140	RCC SLAB	1X3
115	32+381	Causeway		Reconstruction	33+300	RCC SLAB	1X3
116	32+483	Causeway		Reconstruction	33+400	RCC SLAB	1X3
117	32+596	Causeway		Reconstruction	33+515	RCC SLAB	1X3
118	33+000	Causeway		Reconstruction	33+930	RCC SLAB	1X3

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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)
119	33+187	Causeway		Reconstruction	34+160	RCC SLAB	1X3
120	33+427	Causeway		Reconstruction	34+390	RCC SLAB	1X3
121	33+769	Causeway		Reconstruction	34+715	RCC SLAB	1X3
122	33+856	Causeway		Reconstruction	34+800	RCC SLAB	1X3
123	34+099	Causeway		Reconstruction	35+080	RCC SLAB	1X3
124	34+244	Causeway		Reconstruction	35+240	RCC SLAB	1X3
125	34+487	Causeway		Reconstruction	35+460	RCC SLAB	1X3
126	34+582	Causeway		Reconstruction	35+560	RCC SLAB	1X3
127	34+591	Causeway		Reconstruction	35+575	RCC SLAB	1X3
128	34+798	Causeway		Reconstruction	35+780	RCC SLAB	1X3
129	34+904	Causeway		Reconstruction	35+900	RCC SLAB	1X3
130	35+132	Causeway		Reconstruction	36+095	RCC SLAB	1X3
131	35+185	Causeway		Reconstruction	36+145	RCC SLAB	1X3
132	35+337	Causeway		Reconstruction	36+295	RCC SLAB	1X3
133	35+456	Causeway		Reconstruction	36+410	RCC SLAB	1X3
134	35+521	Causeway		Reconstruction	36+475	RCC SLAB	1X3
135	35+670	RCC SLAB	1X2	Reconstruction	36+625	RCC SLAB	1X3
136	35+819	Causeway		Reconstruction	36+800	RCC SLAB	1X3
137	35+929	Causeway		Reconstruction	36+900	RCC SLAB	1X3
138	36+150	Causeway		Reconstruction	37+120	RCC SLAB	1X3
139	36+218	Causeway		Reconstruction	37+180	RCC SLAB	1X3
140	36+280	Causeway		Reconstruction	37+240	RCC SLAB	1X3
141	36+377	Causeway		Reconstruction	37+340	RCC SLAB	1X3
142	36+835	Causeway		Reconstruction	37+760	RCC SLAB	1X3
143	37+377	Causeway		Reconstruction	38+295	RCC SLAB	1X3
144	38+222	Causeway		Reconstruction	39+100	RCC SLAB	1X3
145	38+483	Causeway		Reconstruction	39+360	RCC SLAB	1X3
146	38+585	Causeway		Reconstruction	39+460	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	1+264	RCC SLAB	1X3

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2	2+247	RCC SLAB	1X3
3	2+807	RCC SLAB	1X3
4	3+342	RCC SLAB	1X3
5	3+778	RCC SLAB	1X3
6	3+818	RCC SLAB	1X3
7	4+104	RCC SLAB	1X3
8	4+680	RCC SLAB	1X3
9	4+780	RCC SLAB	1X3
10	7+480	RCC SLAB	1X3
11	7+800	RCC SLAB	1X3
12	14+580	RCC SLAB	1X3
13	15+100	RCC SLAB	1X3
14	15+550	RCC SLAB	1X3
15	16+460	RCC SLAB	1X3
16	17+000	RCC SLAB	1X3
17	17+200	RCC SLAB	1X3
18	17+480	RCC SLAB	1X3
19	17+900	RCC SLAB	1X3
20	18+340	RCC SLAB	1X3
21	18+840	RCC SLAB	1X3
22	19+700	RCC SLAB	1X3
23	21+100	RCC SLAB	1X3
24	22+680	RCC SLAB	1X3
25	29+110	RCC SLAB	1X3
26	34+920	RCC SLAB	1X3

Bridges

a. The following Minor bridges shall be reconstructed:

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
1	13+441	14+367	1x20	1x10	RCC Slab	Precast RCC Girder
2	14+200	15+305	1X20	2x5.2	RCC Slab	Precast RCC Girder

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:

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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)			
1	-	1+382	1x10	10	New Construction
2	-	3+585	1x40	40	New Construction

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
1	0+020	(1X25)+(1X45.4)+(1X40.5)+(2X25)	PSC, RDSO(Steel)	ROB+LOOP

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.
1.	22+000

Bus Bays

Bus Bays shall be provided at locations given below:

Sl. No.	Existing Chainage	Design Chainage	Sides
1	-	1+600	Both sides
2	-	3+400	Both sides
3	15+750	16+860	Both sides
4	18+760	20+000	Both sides

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Sl. No.	Existing Chainage	Design Chainage	Sides
5	20+040	21+520	Both sides
6	23+680	24+900	Both sides
7	17+640	28+600	Both sides
8	39+020	39+900	Both sides

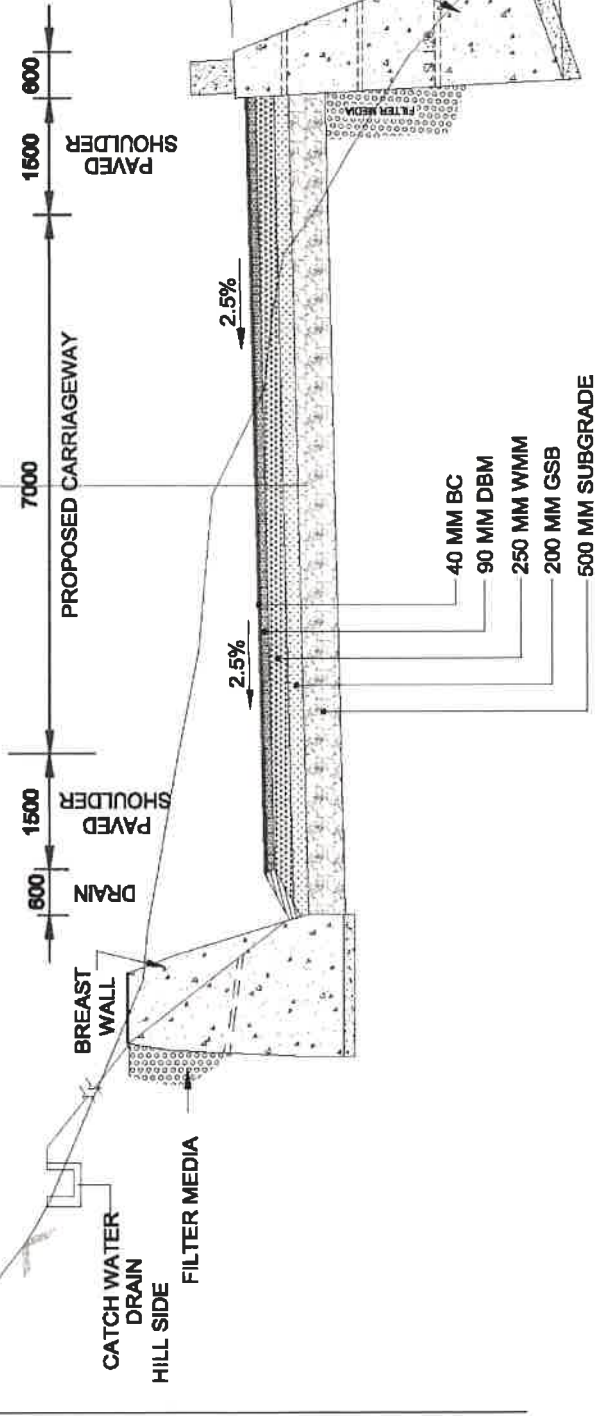


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TCS-II

24000

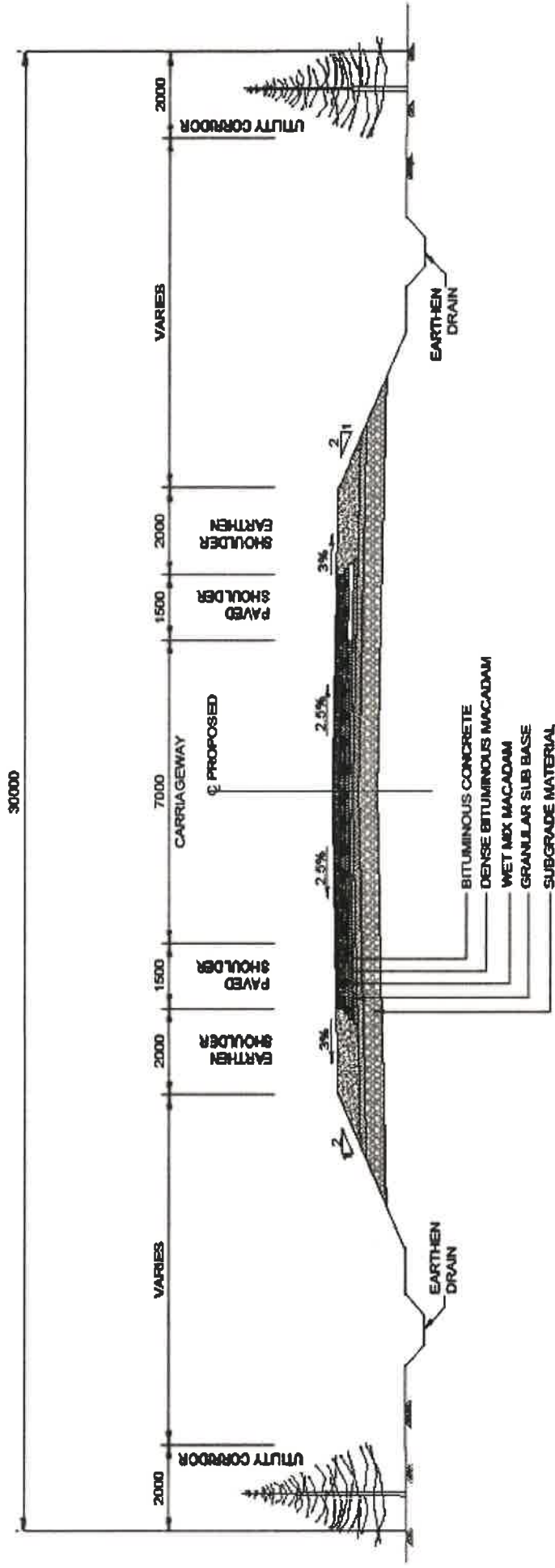
Q PROPOSED



TCS 2
Two Lane With Paved Shoulder Raised Portion(Hill Section)
(New Alignment)

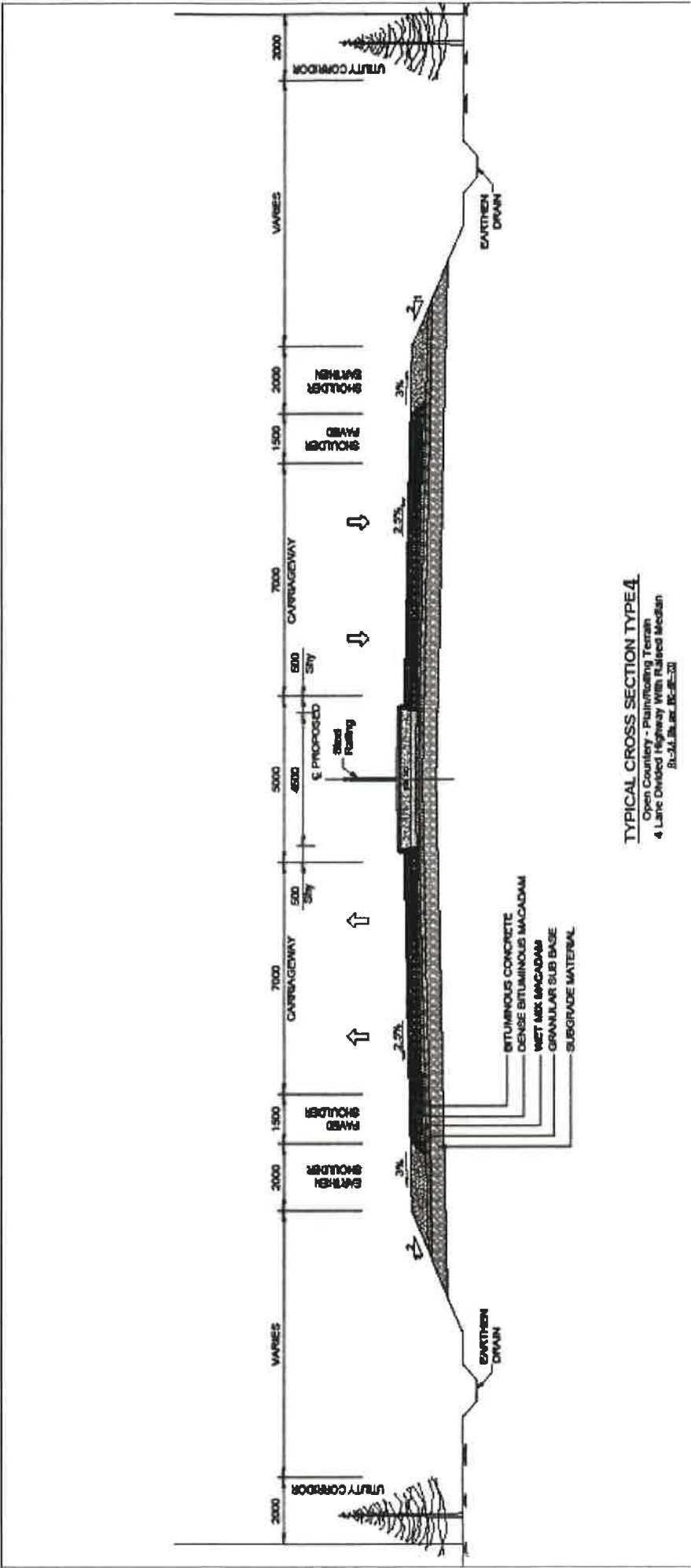
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TCS-III



TCS 3 Two Lane with Paved Shoulder (Open Country-Plain/Rolling Terrain)

TCS-IV



Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

6.4 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. There are two options were worked out for Bagrakot to Kafer.

6.5 Alignment Report

6.5.10 Alignment Option-I for package-IV (Recommended)

The project alignment starts from Bagrakot (West Bengal) at Ch 0+000 and ends at Kafer (Ch 40+000). Office Memorandum of Ministry of Environment & Forests (FC division) Government of India, F.No. 11-122/2011-FC. Recommendation of MOEF that it is fortuitous that there exists an alternative route that not only minimizes damage to the natural heritage of the country, while serving the important requirement of defence. The existing road is less damaging and preserves the natural heritage of the country and viable also from the construction and safety point of view. It is therefore recommended that the Bagrakot – Chuikhim – Nimbong – Kafer – Bakhim – Algarah – Rhenok route be taken up as the alternate route to Sikkim.

We considered Bagrakot, Barbot and Nimbong bypass in this option.

The proposed alignment has been finalized after satisfying the following considerations:

- Good Geometry
- Availability of Land
- Minimum constraints
- Minimum Rehabilitation and Resettlement
- Minimum Land Acquisition
- Minimum damage to the existing environment
- Avoiding swamp lands/ water bodies such as ponds/ tanks

The major features, like details of important crossing points of the alignment option-I are discussed below in Table.

Table 6.5: Details of Alignment Option - I

Sr. No.	Design Chainage (Km+m)	Description of Existing Land mark	Remarks
1	0+000	Bagrakot (West Bengal)	Start point of project
2	0+100	Existing Level Crossing	Proposed ROB
3	0+000	Start of Bypass	Bagrakot Bypass
4	3+800	End of Bypass	Bagrakot Bypass
5	17+000	Village	Chukhim
6	24+700	Start of Bypass	Barbot Bypass
7	25+100	End of Bypass	Barbot Bypass

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Sr. No.	Design Chainage (Km+m)	Description of Existing Land mark	Remarks
8	28+200	Start of Bypass	Nimbong Bypass
9	28+500	End of Bypass	Nimbong Bypass
10	39+982	End of Pkg IV	

6.5.11 Salient Features – Alignment Option-I

The salient features of the Alignment Option-I are given in Table below:

Table 6.6: Salient Features of the Proposed Alignment Option-I

Sr. No.	Factors		Remarks
1	Highway, Traffic Services	Length of Proposed Alignment (km)	40.00 km
		Service to Road users	Good Speed, Safety
		Land	Passes mostly through Existing Alignment
		Network Connectivity	Connects all the major existing Habitants
		Traffic decongestion	The proposed road will not decongest the traffic
2	Availability of land	Available ROW from Km 0 to Km 2.9 is 14-16 m. Km 3 to Km 38 is 3-7 m	Extra land required for realignment, Bypass and hair pin bands location,
2	Social and Environmental	Rehabilitation/ Resettlement	Minimum R&R is required
		Water and Air Quality	Minor Impact
		Protection of Flora and Fauna	Minor loss of Agricultural land and minimum forest land is required
3	Land use	Impact on Commercial activity	No commercial activities noted along the proposed alignment, hence no effect
4	CD works	Grade Separator/ ROB/ Major & Minor Bridges	ROB+FLYOVER & LOOP – 1 No's Grade Separator – 0 No's Underpass – 0 No's Cattlepass – 0 No's Major Bridge – 0 No's Minor Bridge – 4 No's
		Culverts	Total 172 No's of minor CD structures are required
5	Approximate Cost	Construction Cost	674.58 Cr Approx
		Savings in Cost	Cheaper other than options

6.5.15 Alignment Option-II

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

The project alignment starts from Bagrakot (West Bengal) at Ch 0+000 and ends at Kafer (Ch 39+000). Office Memorandum of Ministry of Environment & Forests (FC division) Government of India, F.No. 11-122/2011-FC. Recommendation of MOEF that it is fortuitous that there exists an alternative route that not only minimizes damage to the natural heritage of the country, while serving the important requirement of defence. The existing road is less damaging and preserves the natural heritage of the country and viable also from the construction and safety point of view. It is therefore recommended that the Bagrakot – Chuikhim – Nimbong – Kafer – Bakhim – Algarah – Rhenok route be taken up as the alternate route to Sikkim.

We did not consider Bagrakot, Barbot and Nimbong bypass in this option.

The major features, like details of important crossing points of the alignment option – II are discussed below in table below.

Table 6.7: Details of Alignment Option-II

Sr. No.	Design Chainage (Km+m)	Description of Existing Land mark	Remarks
1	0+000	Bagrakot (West Bengal)	Start point of project
2	0+100	Existing Level Crossing	Proposed ROB
3	2+500	Village	Bagrakot Village
4	17+000	Village	Chukhim
5	20+900	Village	Navgaon
6	23+200	Village	Sansidara
7	24+800	Village	Barbot
8	28+300	Village	Nimbong
9	39+000	End of Pkg IV	

6.5.15 Salient Features – Alignment Option-II

The salient features of the Alignment Option–II are given below in table below.

Table 6.8: Salient Features of the Proposed Alignment Option-II

Sr. No.	Factors		Remarks
1	Highway, Traffic Services	Length of Proposed Alignment (km)	39
		Service to Road users	Good Speed, Safety
		Land	Alignment passes mainly through agricultural land.
		Network Connectivity	Passing through Bagrakot,

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Sr. No.	Factors		Remarks
			Chukhim, Navgaon, Sansidara, Barbot, Nimbong, Kafer
		Traffic decongestion	The proposed road will congest the traffic.
2	Social and Environmental	Rehabilitation/ Resettlement	Maximum R&R will we needed since the existing Habitation is affecting in the proposed alignment
		Water and Air Quality	Major Impact
		Protection of Flora and Fauna	Loss of Forest land
3	Land use	Impact on Commercial activity	Petty Business will be affected in habitations
4	CD works	Grade Separator/ ROB/ Major & Minor Bridges	ROB – 1 No's Flyover – 0 No's Grade Separator – 1 No's Elevated Structure- 1.3 Km Underpass – 0 No's Cattlepass– 0 No's Major Bridge – 1 No's Minor Bridge–3 No's
		Box and Pipe Culverts	Total 168 No's of minor CD structures are required
5	Approximate Cost	Construction Cost	Total cost is Appx. 722 Cr (582 Cr Approx + Cost of elevated structure (Appx. 140 Cr) in case LA not possible due to dense habitation
		Savings in Cost	Fuel and time consumes more compared to previous alternative and R & R is more.

6.5.15 Merits and Demerits of Alignment Options I and II

The merits and demerits of all alignment options were studied in detail to arrive at recommended alignment option. The details of the same are presented in table below.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Table 6.10: Merits and Demerits of Alignment Options I and II

Comparison of proposed 2 Alternative of Package IV (Bagrakot -Kafer)			
S.No.	Description	Option I	Option II
1	Take off Existing Km	Bagrakot	Bagrakot
2	End of Existing Km	Kafer	Kafer
3	Route Alignment	Bagrakot, Barbot and Nimbong bypass	Bagrakot, Barbot and Nimbong without bypass
4	Length of proposed project stretch	40.00	39.000
5	Existing Alignment followed	24.05	39
6	New Alignment	15.95	0.00
7	Terrain	Hilly	Hilly
8	Speed	40kmph	40 kmph
9	Geometrics	Hair pin Bend - 54 Nos	70
10	Features	Bagrakot, Barbot and Nimbong bypass	Passing through Existing Road
11	Villages Enroute	Passing through Bagrakot, Chukhim, Navgaon, Sansidara, Barbot, Nimbong, Kafer	Passing through Bagrakot, Chukhim, Navgaon, Sansidara, Barbot, Nimbong, Kafer
12	LA	Km 0 to Km 2.9 is 10-12 m. Km 3 to Km 38 is 3-7 m Extra land is required for Bypass and Hair Pin Bend.	Km 0 to Km 2.9 is 10-12 m. Km 3 to Km 38 is 3 -7 m Extra land is required for Hair Pin Bend.
13	No. of Structures	1ROB+GS+LOOP +4 Minor Bridge	1ROB +1GS+3 Minor Bridge Elevated structure(1.3km in Bagrakot Habitation)
14	Area required for LA hectares	37 ha is required for: (i) proposed Bagrakot, Barbot, Nimbong Bypasses (ii) improvement of Hair Pin Bend and (iii) widening of existing road	22 ha is required for widening of existing road and improvement of Hair Pin Bend

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

Comparison of proposed 2 Alternative of Package IV (Bagrakot -Kafer)			
S.No.	Description	Option I	Option II
15	Approximate cost of L.A.	60 Cr (37 Ha @ 50 Lac/ha)	36 Cr (22 Ha @ 50Lac/ha)
16	Approx R & R Cost	1.00Cr (Appx. 23 Structure to be Affected)	11.50Cr (Appx. 197 Structure to be Affected)
16	Approximate cost of Structures (ROB+FLYOVER+LOOP+MINOR BRIDGE+CULVERTS)	58.29Cr	193 Cr (Cost of elevated structure (Appx. 140 Cr) in case LA not possible due to dense habitation)
17	Approximate Civil cost of Roads @15.97 Cr per km	674.58 cr	Rs 722 Cr
18	Approximate Total Civil cost of including LA+US+FC	953.47 Cr	984 Cr
19	Recommended Option	Yes	No

6.5.15 Finalization of Alignment Option

Looking to all above alignment options merits and demerits; consultant recommended the alignment **Option-I**, which was also the outcome from the detailed discussions with NHIDCL.

Summary of Cost of Project Road

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

ABSTRACT OF COST ESTIMATE

Note 1 : Basis of Cost Estimate : Rate Analysis as per WB SOR 2015-16 with 5% Escalation, Machinery rates from Sikkim SOR 2012 with 20% Escalation (for 4 years) and Major material rates from Market as on Feb 2017.

Note 2 : Two Landslides found in the alignment at Ch 9+230 and Ch 25+820. The cost estimate doesn't include protection measures for these landslides.

Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)	Page Number
A	ROAD WORKS						
1	Site Clearance				6,528,322.19	0.653	18
2	Excavation	Cum			537,779,045.09	53.778	18
3	Earthwork Filling	Cum			237,362,901.58	23.736	18
4	Loosening & Recompacting	Cum			10,099,969.20	1.010	18
5	Sub Grade	Cum			61,410,952.00	6.141	18
6	GSB	Cum			205,925,594.56	20.593	19
7	WMM	Cum			216,906,415.00	21.691	19
8	Prime Coat	Sqm			11,358,703.20	1.136	19
9	Tack Coat	Sqm			8,737,464.00	0.874	19
10	DBM / Profile Corrective Course	Cum			377,965,722.48	37.797	19
11	BC	Cum			195,594,562.00	19.559	19
B	BRIDGES and STRUCTURES						
1	Minor Bridges	No.	4		68,449,470.79	6.84	25
2	ROB+Viaduct(Loop)	No.	1		161,064,684.84	16.11	26
3	Culverts Pipe/Slab/Box	No.	172	2054288.89	353,337,688.22	35.33	27
C	SLOPE STRUCTURES						
1	Reinforced Slope Structure	No./m			2,247,621,379.49	224.76	29
2	RE Wall				275,673,390.00	27.57	36
3	Retaining and Breast Wall				1,198,231,184.53	119.82	37-38
D	JUNCTIONS						
1	Major Junctions	No	1.00		5,874,125.00	0.59	11
2	Minor Junctions	No	14.00		33,380,585.00	3.34	11
E	DRAIN & PROTECTION WORK						
1	Drainage Works	Km	6.80		238,927,569.33	23.89	20
2	Metal Crash Barrier	Km	9.25		40,768,718.00	4.08	20
3	Other Protetive Works				160,949,457.90	16.09	20
F	LAY BYES						
1	Bus Bays	Nos	16.00	1,547,988.76	24,767,820.13	2.48	39
3	Truck Lay Bays	Nos	1.00	10,371,454.35	10,371,454.35	1.04	42
G	OTHER MISCELLANEOUS ITEMS						
1	Footpath and Separators				2,752,400.00	0.28	19
2	Miscellaneous Items	Total			16,326,640.00	1.63	22
3	Traffic Signs, Marking and Road Appurtenances	Total			20,757,623.05	2.08	21
4	Reflective Road Studs	Nos	20278		16,918,007.23	1.69	21
TOTAL CIVIL COST					6745841849.16	674.58	
40 Km for Project length and 2.24km for ROB Approach Loop & NH-31 widening at ROB Locations							
COST PER KM (LENGTH = 42.24 KM) IN CRORES ...						15.97	

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

6.5.1 Recommendation

Proposal of a Option-I has been considered for future traffic growth and various developments activities.

6.5 Geometric Improvement Design

As per the IRC: SP: 73-2015 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.

6.6 Improvement of Bridges

The following approach and methodology for the finalization of designs and drawings for the existing and proposed bridge structures are proposed.

6.6.1 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

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: 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

- 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).

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

- (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.

6.6.2 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.

6.6.3 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.

6.6.4 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.6.5 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

SI. 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	56	-

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

SI. No.	DESCRIPTION	No. Of Structures	REMARKS
(iii)	New Proposals	26	-
(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	98	
(iii)	New Proposals	0	
(iv)	Abandoned	0	-
5	MINOR BRIDGES		
(i)	Retained	0	-
(ii)	Dismantling & Reconstruction	2	-
(iii)	Abandoned	0	
(iv)	New proposals	2	-
6	MAJOR BRIDGES		
(i)	Retained	0	
(ii)	New proposal	0	
(iii)	Flyovers	0	
(iv)	New proposal	0	-
8	ROAD OVER BRIDGES+LOOP		
(i)	To be Widened	0	-
(ii)	New Proposals	1	

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

6.7 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.

6.7.1 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.

6.8 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.

6.8.1 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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 roughness 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: -

$$Q = C_o \times \sqrt{2g} L D_d \times \sqrt{\{h + (1+e) (U^2/2g)\}}$$

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:

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

$$s_m = 1.34 \times (D_b^2 / K_{sf})^{1/3}$$

Where, D_b = the discharge in cumecs per meter width and K_{sf} = 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: 2014 since most of the bridges are Ghat section the bed material composes of pebbles and coarse 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

6.8.2 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,

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

$$Q = 0.028 P A I_c$$

Where;

Q = Discharge (Peak run-off) in cum/ sec

P = Coefficient of run-off for the catchment characteristics

A = Area of catchment in Hectares

I_c = 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

(b) Design of Drain Section

For uniform flow in open channels, the basic relationships are expressed by the Manning's Formula:

$$Q = \frac{1}{n} AR^{2/3} S^{1/2}$$

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

6.8.3 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.

6.8.4 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.

6.8.4.1 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

6.8.4.2 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.

6.8.5 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.

6.8.6 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.

6.8.7 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.

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.8.7.1 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.

6.8.7.2 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.

6.8.7.3 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.

6.8.7.4 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.

6.8.7.5 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.9 Road Markings, Signs and Other Safety Devices

6.9.1 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.

6.9.2 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.

6.9.3 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.

6.10 Miscellaneous Requirements

6.10.1 Proposal for Truck Lay byes

As per the detailed field surveys and reconnaissance, truck lay bye/ Parking cum rest areas are proposed at the following one location.

Table 6.14 : Truck lay byes

Sr. No.	Existing Chainage	Proposed Chainage
1	Near Navgaon 20+450 to 20+580	Near Navgaon 21+940 to 22+060

6.11 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:

- Construction of new pavement for widened and realigned/new alignment.
- 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.11.1 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:

- initial traffic
- traffic growth (r)
- directional split of the traffic or directional distribution factor (DDF)
- number of lanes or lane distribution factor (LDF)
- 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:

$$ESAL = \sum_{i=1}^{i=n} \text{Initial Traffic} \times 365 \times \frac{(1+r)^n - 1}{r} \times \text{Lane Factor} \times \text{DDF} \times \text{VDF}$$

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	0+000	38+900	25

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.11.2 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

6.11.3 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.

6.11.4 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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.

6.11.5 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.

6.11.6 Flexible Pavement Structural Design for New Construction

6.11.6.1 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	DBM	WMM	GSB		
1	0+000	39+978	9	25	40	90	250	200	500	1080

6.12 Retaining Structures

6.12.1 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

Feasibility Report : IMPROVEMENT PROPOSAL AND DESIGN

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	9730	30410

6.12.2 Reinforced Slope Structure & Slope Protection

Reinforced Slope Structure shall be used as a retaining structure for proposed widening of the Valley Side for those locations wherever requisite design width is sufficiently available to lay the soil reinforcing element of the Reinforced Slope Structure with minimal excavation and disturbance to the existing valley slope and the traffic running on top of it.

Description	Retaining Wall RESS (m)
Length	1660

Description	Retaining Wall RECS (m)
Length	2740

Description	Slope Protection on both sides (m)
Length	2005

Description	Slope Protection on single sides (m)
Length	1320

CHAPTER - 8

COST ESTIMATE

7.0 Cost Estimate

7.1 Introduction and Assumptions

Detailed cost estimate for Bagrakot to Kafer(Km 40.000) 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.

7.2 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 2015-16. The price have been escalated to arrive at 2016-17 price.

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 2015-16.

Based on the Following Rates:

As per the WB PWD SOR 2015-16& Sikkim PWD SOR 2012(duly updated to 2015-16 with escalation on WPI at 3.05% per year)

As per the Market Rate -Current market rates have been taken for cement, Steel and IOCL website rates for Bitumen

7.3 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	<ul style="list-style-type: none">• Clearing and Grubbing• Dismantling of existing structures/km stones/ pavement/ road signs• Cutting of Trees and Removal of stumps• Scarifying existing bituminous surface• Dismantling
Earth work	<ul style="list-style-type: none">• 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

Project: 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.

Feasibility Report : COST ESTIMATE

Major Heading	Item of Works
	<ul style="list-style-type: none"> • Turfing
Non-Bituminous Courses	<ul style="list-style-type: none"> • Granular sub-base • Wet mix macadam • Footpath
Bituminous Course	<ul style="list-style-type: none"> • Prime coat • Tack coat • Bituminous Macadam as Profile Corrective Course • Dense Bituminous Macadam • Semi dense bitumen macadam • Bituminous Concrete
Cement Concrete Pavement	<ul style="list-style-type: none"> • Dry Lean Concrete • Pavement Quality Concrete
Bridge and Cross Drainage Structures	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Km. stone / Boundary stone • Road signs • Pavement markings • Road signage • Crash Barrier • Road stud • Railing • Fencing • Kerb
Maintenance	<ul style="list-style-type: none"> • Diversion

Major Heading	Item of Works
	<ul style="list-style-type: none"> • Routine Maintenance
Electrical Works	<ul style="list-style-type: none"> • Streetlight in Urban area • Lighting at toll plaza • Lighting at Truck Lay byes • Lighting at Intersections
Miscellaneous Items	<ul style="list-style-type: none"> • Road side Barriers
Way side amenities	<ul style="list-style-type: none"> • Utility duct • Bus shelter • Tree plantation
Toll Plaza	<ul style="list-style-type: none"> • Toll Booth • Barrier Gate • Canopy • Administrative Building
HTMS	<ul style="list-style-type: none"> • Highway Traffic Management System

7.4 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.

7.5 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.

7.6 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.

7.7 Cost of Environmental Mitigation Plan

A tentative EMP cost for implementing of various mitigation measures on different items is about Rs. 5.0 Crores.

7.8 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	40.000	674.58

Project: 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.
Feasibility Report : COST ESTIMATE

Table 9.1: Abstract of Cost Estimate

ABSTRACT OF COST ESTIMATE

Note 1 : Basis of Cost Estimate : Rate Analysis as per WB SOR 2015-16 with 5% Escalation, Machinery rates from Sikkim SOR 2012 with 20% Escalation (for 4 years) and Major material rates from Market as on Feb 2017.							
Note 2 : Two Landslides found in the alignment at Ch 9+230 and Ch 25+820. The cost estimate doesn't include protection measures for these landslides.							
Sl.NO	Items	Unit	Length (in Km)	Rate (in Rs.)	Amount (in Rs.)	Amount (in Cr.)	Page Number
A	ROAD WORKS						
1	Site Clearance				6,528,322.19	0.653	18
2	Excavation	Cum			537,779,045.09	53.778	18
3	Earthwork Filling	Cum			237,362,901.58	23.736	18
4	Loosening & Recompacting	Cum			10,099,969.20	1.010	18
5	Sub Grade	Cum			61,410,952.00	6.141	18
6	GSB	Cum			205,925,594.56	20.593	19
7	WMM	Cum			216,906,415.00	21.691	19
8	Prime Coat	Sqm			11,358,703.20	1.136	19
9	Tack Coat	Sqm			8,737,464.00	0.874	19
10	DBM / Profile Corrective Course	Cum			377,965,722.48	37.797	19
11	BC	Cum			195,594,562.00	19.559	19
B	BRIDGES and STRUCTURES						
1	Minor Bridges	No.	4		68,449,470.79	6.84	25
2	ROB+Viaduct(Loop)	No.	1		161,064,684.84	16.11	26
3	Culverts Pipe/Slab/Box	No.	172	2054288.89	353,337,688.22	35.33	27
C	SLOPE STRUCTURES						
1	Reinforced Slope Structure	No./m			2,247,621,379.49	224.76	29
2	RE Wall				275,673,390.00	27.57	36
3	Retaining and Breast Wall				1,198,231,184.53	119.82	37-38
D	JUNCTIONS						
1	Major Junctions	No	1.00		5,874,125.00	0.59	11
2	Minor Junctions	No	14.00		33,380,585.00	3.34	11
E	DRAIN & PROTECTION WORK						
1	Drainage Works	Km	6.80		238,927,569.33	23.89	20
2	Metal Crash Barrier	Km	9.25		40,768,718.00	4.08	20
3	Other Protetive Works				160,949,457.90	16.09	20
F	LAY BYES						
1	Bus Bays	Nos	16.00	1,547,988.76	24,767,820.13	2.48	39
3	Truck Lay Bays	Nos	1.00	10,371,454.35	10,371,454.35	1.04	42
G	OTHER MISCELLANEOUS ITEMS						
1	Footpath and Separators				2,752,400.00	0.28	19
2	Miscellaneous Items	Total			16,326,640.00	1.63	22
3	Traffic Signs, Marking and Road Appurtenances	Total			20,757,623.05	2.08	21
4	Reflective Road Studs	Nos	20278		16,918,007.23	1.69	21
TOTAL CIVIL COST					6745841849.16	674.58	
40 Km for Project length and 2.24km for ROB Approach Loop & NH-31 widening at ROB Locations							
COST PER KM (LENGTH = 42.24 KM) IN CRORES ...						15.97	

CHAPTER - 9

CONCLUSION & RECOMMENDATION

Feasibility Report : CONCLUSION AND RECOMMENDATIONS

Conclusion and Recommendations

8.1 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.

8.2 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, 1974	Central and State Pollution Control Board to establish/enforce water quality and	NO	Consent required if ground water is being used for consent	CPCB /SPCB

Project: 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.

Feasibility Report : CONCLUSION AND RECOMMENDATIONS

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
		effluent standards, monitor water quality, prosecute offenders, and issue licenses for construction/operation of certain facilities.		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 precautionary measures while	Yes	If new quarrying operation is started by the concessionaire / contractor	Chief Controller of Explosives

Project: 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.

Feasibility Report : CONCLUSION AND RECOMMENDATIONS

Sl. No.	Law/ Regulation/ Guidelines	Relevance	Applicable Yes / No	Reason for Application	Implementing / Responsible Agency
		blasting & quarrying.			
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

8.3 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 November 2016. The estimated basic cost is give below table (Amount in Crores)

Section	Proposed Length (km)	Base Cost In Cr
Bagrakot to Kafer (0+000 to 40+00)	40+000	674.58

- 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.
