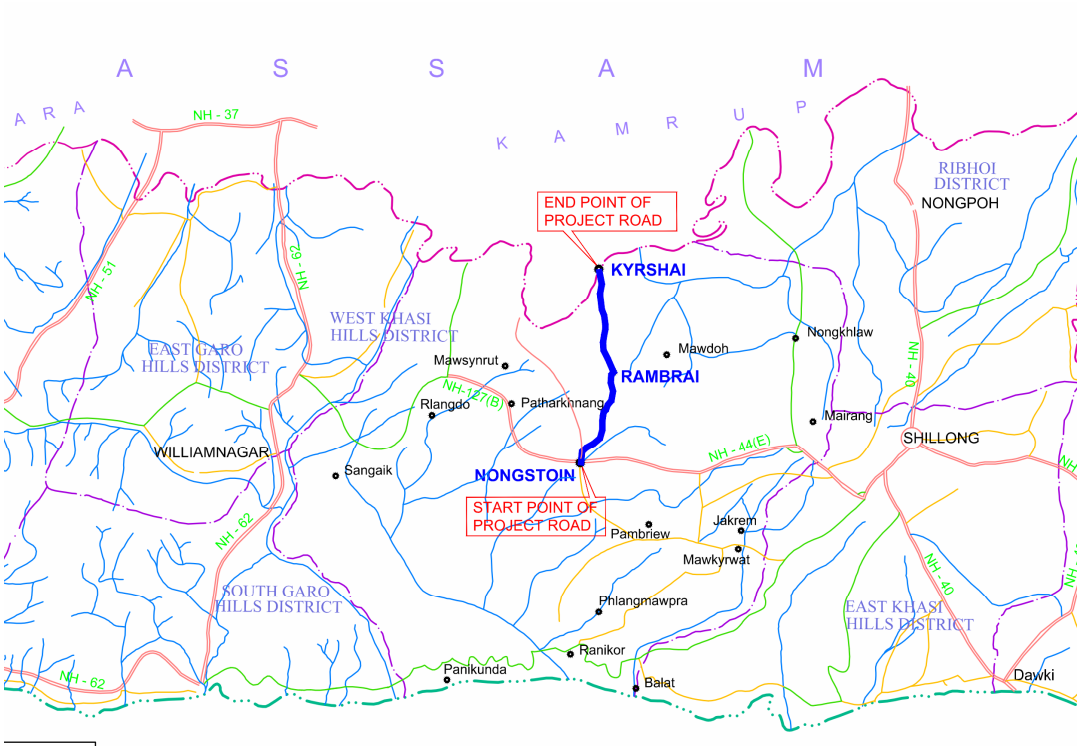
NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

Consultancy Services for Detailed Engineering / Detailed Project Preparation for Upgradation of Road Nongstoin-Rambrai-Kyrshai road up to Meghalaya-Assam Border to 2-Lane under SARDP-NE "Phase-A" in the state of Meghalaya



DETAILED PROJECT REPORT

Volume – I (Main Report)

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EXECUTIVE SUMMARY

0.1 Project Background

Nongstoin – Rambrai – Kyrshai Road is an important link of Meghalaya with neighbouring Assam and rest of the country. The road from Nongstoin to Rambrai(20 Km approx) is a single lane surfaced road and the condition of road is fair to poor. The curves are sharp and the average road width is 5.5 m and carriageway width is 3.75m. After Rambrai, there is a katcha road upto Mawthir (14 Km approx) and thereafter no road exists except for a jungle track. Geometrics of existing katcha road and jungle track are very poor having sharp curves and steep gradients.

0.2 Project Location

The project road lies in West Khasi Hills District & starts from Design Chainage 0+335 which is a newly proposed T junction with NH 44E near Nongstoin and after traversing a length of about 73 Km, the project road ends within the Kyrshai town.

As per the directions of NHIDCL the consultant has divided the project into three Packages as per the table below

Table 1: Package Detail

Package No.	From(Km)	To (Km)	Length(Km)
1	0+335	34+039	33.704
2	35+155	53+500	18.345
3	53+500	72+863	19.363
Total	**0+335**	**72+863**	**71.412**

0.3 Existing Carriageway & Pavement

The road from Nongstoin to Rambrai (20 Km approximately) is a single lane surfaced road. The condition of road from Nongstoin to Rambrai is fair to poor. The curves are sharp and narrow. After Rambrai, there is a katcha road for a distance of 14 km upto Mawthir, thereafter no road exists except for a jungle track. Geometrics of existing Katcha road and jungle track are very poor having sharp curves and steep gradients. The average roadway width is 5.50 m and carriageway 3.75 m.

0.4 Existing Project details

In general, pavement condition is poor along the project road. At few places there is

no existing road available.

a) **Terrain :** Hilly terrain

b) **Lane Configuration:** single lane upto Rambrai

c) **Pavement Condition**: Fair to Poor

d) **Existing ROW**: Roadway width is varying from 5.5m to 5.8m.

e) **Junctions / Intersections:**

There are 13 major / minor junctions on the project road. Detail of junctions is shown in table below.

Table 2: Junctions

S. No.	Location of intersection (km)	Type of intersection	Other features
1	0+335	T	Intersection with NH-44E(Starting point of alignment
2	0+450	Y	Cross road leading to Nongstoin town
3	0+800	T	Village Road
4	4+100	T	Village Road
5	5+400	+	Intersection with NH-44E bypass
6	8+610	T	Village Road
7	8+800	T	Village Road
8	10+330	T	Village Road
9	15+950	T	Village Road
10	17+250	T	Village Road
11	17+740	T	Village Road
12	18+650	T	Village Road
13	72+525	T	Connect to Kyrshai Village via Bridge

f) **Settlements :**

Followings are the list of settlement along the project road.

Table 3: Village/Town list

S.No.	Name of Village	Design Chainage
1	Nongstoin	0+000
2	Tiehsaw	0+800
3	Mawrusyiar	2+840
4	Steplanghir	6+480
5	Mawlich	10+000
6	Domjri	12+330
7	Mawphansyiar	12+625
8	Mawthwrgmarwei	15+480
9	Mawrang	15+970

S.No.	Name of Village	Design Chainage
10	Rambrai	17+000
11	Nongkroh	18+530
12	Mawthaw	18+910
13	Lawdibah	19+288
14	Sohmynthar	24+155
15	Mawthir	26+330
16	Nongkyllang	34+220
17	Mawdiangkper	37+910
18	Patharphalang	44+425
19	Mawpong	50+201
20	Kyrshai	68+550

g) Project Road Constraints

Based on the ground study, reconnaissance & survey and the data collected the consultant have gained appreciation of the technical and project management problems and have insight of the challenge areas of the project. The general appreciation of the thrust areas are described in the following paragraph.

I. From Nongstoin to Rambrai, existing surface road has poor geometrics at many locations.

II. From Rambrai to Kyrshai, there is an existing Katcha track for a distance of 14 kms and there after jungle tracks exists. This stretch of the road passes through steep gradient and there are very poor geometrics on the existing track with steep gradients. It is not possible to follow the existing alignment after Rambrai (km 21) due to steep gradient (10-15%) at many locations.

III. Hill slope is stable varying from 10 degree to 80 degree.

IV. There is built-up area at few locations along the project road, widening of existing road would require demolition of existing houses at few locations.

0.5 Proposals for the project road:

a) Proposed Cross section :

Description of Typical cross section used in project roads, are given below:

TCS - 1: 2 Lane Carriageway for New Construction (One side hill).
TCS - 2: 2 Lane Carriageway for New Construction (Box Cut section)
TCS - 3: 2 Lane Carriageway for widening (One side Hill)
TCS - 4: 2 Lane Carriageway for widening (Box Cut section)

TCS - 5: 2 Lane Carriageway for Built-up section

Total road width	:	12.00 meter
Carriageway	:	7.000 m
Earthen Shoulder Hill side	:	2.5m
Earthen Shoulder Valley side	:	2.5m

For details, refer to drawing volume.

b) Alignment Proposals

As alignment passes through hilly terrain, there are sharp curves and steep gradient on existing alignment. Curve improvements have been proposed between Nongstoin and Rambrai (first 20km). From Rambrai to Kyrshai, there is an existing Katcha track for a distance of 14 kms and there after jungle tracks exists, having very sharp curves and steep gradients. Gradients go up to 10-12% at some locations. It is not possible to follow the existing katcha and jungle track after Rambrai. New alignment has been proposed after km 21 to provide good geometrics. New alignment is more or less near to existing alignment (Katcha Track).

c) Design Speed

In general, Project road has been designed for a speed more than 40kmph but at few locations, 30kmph speed has been provided in unavoidable circumstances due to steep terrain & sharp curves. Proposed Vertical gradient is not exceeding 6% along the project road.

d) Vertical Gradient

Proposed Vertical gradient is not exceeding 6% along the project road.

e) Culverts

There are 133 culverts existing along, out of which 111 are stone slabs, 6 are slab culverts, 3 wooden culverts and 13 pipe culverts. The structural conditions of culverts are generally poor to very poor. Most of the culverts are fully or partially choked. Consultant has proposed 349 culverts for new/reconstruction on the project road and all of them are box culverts.

f) Bridges

There are 5 existing bridges on the project road. All the bridges are wooden/timber constructed, hence are to be reconstructed. There are 7 new bridge proposed.

Table 5: Bridge Details

Sl No	Existing Chainage (km)	Design Chainage (km)	Span Arrangement	Proposal	Type
1		0+410	1x24	New Construction	RCC Girder
2	6+755	6+500	1x 14	Reconstruction	RCC Girder
3	7+925	7+600	1x 8	Reconstruction	RCC Slab
4	13+122	12+340	1x 14	Reconstruction	RCC Girder
5	16+420	15+495	1 x 10	Reconstruction	RCC Slab
6	19+910	18+890	3x14	New Construction	PSC Girder
7	-	41+100	2x14	New construction	RCC Girder
8	-	60+600	1X8	New construction	RCC Slab
9	-	64+540	1X8	New construction	RCC Slab
10	-	67+770	1X14	New construction	RCC Girder
11	-	69+460	1X10	New construction	RCC Slab
12	-	72+664	4X32	New construction	PSC Girder

g) Drainage system including surface and subsurface drains for the Project Highway shall be provided.

S.no	Type of Drain	Length (Km)
1	V-Shape Line Drain	69.675
2	RCC-Cover Drain	2.975
	Total Length	72.65

h) Bus stop/shelter

At 26 locations bus bay/bus stop have been proposed on both sides.

Table 6: Bus stop locations

Sl No	Chainage	Side	Sl No	Chainage	Side
1	0+550	RHS	14	0+650	LHS
2	1+180	RHS	15	1+220	LHS
3	4+660	RHS	16	4+600	LHS
4	9+000	RHS	17	8+750	LHS
5	11+450	RHS	18	11+500	LHS
6	15+550	RHS	19	15+575	LHS
7	17+300	RHS	20	17+350	LHS
8	17+750	RHS	21	17+725	LHS
9	29+250	RHS	22	29+200	LHS
10	37+850	RHS	23	37+800	LHS
11	42+050	RHS	24	42+000	LHS
12	63+250	RHS	25	63+200	LHS
13	69+550	RHS	26	69+500	LHS

i) Traffic Projection & Capacity Analysis

As per traffic projection there is requirement for 2 lane road in year 2024. Consultant has proposed widening/new construction of project road to 2 lane configuration.

Table 7 : Table Projection

Year	Car	3-Wheeler including Auto Rickshaw	Two Wheeler	Mini bus	Standard Bus	LCV(Passenger)	2-axle Truck	3-axle Truck	Multi-axle Truck Articulated	Agri. Tractor with Trailer	Pedal Cycle	Total Fast Moving Vehicles	Total Slow Moving Vehicles	Total Vehicles	PCU(Fast Moving)	PCU(Slow Moving)	Total PCU
2013	1008	79	81	11	0	92	122	18	0	6	1	1417	1	1418	1729	1	1730
2014	1058	83	85	12	0	97	128	19	0	6	1	1488	1	1489	1815	1	1816
2015	1111	87	89	12	0	101	135	20	0	7	1	1562	1	1563	1906	1	1907
2016	1167	91	94	13	0	107	141	21	0	7	1	1640	1	1642	2002	1	2002
2017	1225	96	98	13	0	112	148	22	0	7	1	1722	1	1724	2102	1	2102
2018	1286	101	103	14	0	117	156	23	0	8	1	1808	1	1810	2207	1	2207
2019	1351	106	109	15	0	123	163	24	0	8	1	1899	1	1900	2317	1	2318
Construction Period of 2.5 Years																	
2020	1418	111	114	15	0	129	172	25	0	8	1	1994	1	1995	2433	1	2434
2021	1489	117	120	16	0	136	180	27	0	9	1	2094	1	2095	2555	1	2555
2022	1564	123	126	17	0	143	189	28	0	9	2	2198	2	2200	2682	1	2683
Diverted traffic after construction of road																	
Diverted traffic	782	61	63	9	0	71	95	14	0	5	1	1099	1	1100	1341	0	1342
Total Traffic	**2346**	**184**	**188**	**26**	**0**	**214**	**284**	**42**	**0**	**14**	**2**	**3297**	**2**	**3300**	**4023**	**1**	**4025**

j) Pavement Design

Flexible pavement shall be adopted for Project Highway. Pavement has been designed for 20 years for 10 MSA and 8% CBR. The crust details are as under

Table 8: Pavement layer thickness details

Type	Pavement Thickness
BC	40
WMM	150
CTSB	200

k) Retaining wall and Breast wall

Retaining wall are to be provided on the outer edges of the roadway where the valley/river/nala/ edge exist. The minimum length of the retaining wall to be provided is as per the table below

Retaining Wall

Location(Km)	Length (m)	Average Height (m)
5+660	20	2
5+740	20	2
5+760	20	2
5+840	20	4
18+880	20	2
18+900	20	2
44+720	20	5
52+220	20	3
64500	60	2
72600	100	3
Approaches of culverts (appx.)*	2000	4

Location(Km)	Length (m)	Average Height (m)
Total length (m)	2320	

Breast Wall

Chainage	Side	Length	Total length	Height
2680	2	20	40	3
2900	2	20	40	3
3060	1	20	20	3
3180	1	20	20	3
3320	1	60	60	3
6080	1	20	20	5
6600	1	20	20	3
7500	2	20	40	3
7540	2	20	40	3
7780	2	20	40	3
7800	2	20	40	3
8460	1	20	20	3
8480	1	20	20	3
8500	1	20	20	3
8520	1	20	20	3
9300	1	20	20	5
9320	1	20	20	5
9540	1	20	20	4
9600	1	20	20	5
9620	1	20	20	5
10520	2	20	40	5
10540	2	20	40	5
10560	2	20	40	5
10580	2	20	40	5
11520	1	20	20	3
11540	1	20	20	3
11560	1	20	20	3
11660	1	20	20	6
11680	1	20	20	6
11700	1	20	20	6
12200	1	20	20	4
12220	1	20	20	4
12520	1	20	20	5
12540	1	20	20	5
12560	1	20	20	5
12960	1	20	20	3
13080	1	20	20	6
13100	1	20	20	6
14140	1	20	20	3
14160	1	20	20	3
14180	1	20	20	3
14780	1	20	20	6

Chainage	Side	Length	Total length	Height
14800	1	20	20	6
14820	1	20	20	6
16580	1	20	20	4
16600	1	20	20	4
16620	1	20	20	4
19580	1	20	20	3
22500	1	20	20	5
22520	1	20	20	5
22540	1	20	20	**5**
24560	1	20	20	4
24580	1	20	20	4
24600	1	20	20	4
26800	1	20	20	**6**
26820	1	20	20	**6**
26840	1	20	20	6
26860	1	20	20	6
26880	1	20	20	6
26900	1	20	20	6
26920	1	20	20	6
26940	1	20	20	6
26960	1	20	20	6
27260	1	20	20	3
27280	1	20	20	3
27920	1	20	20	**6**
27940	1	20	20	6
27960	1	20	20	6
27980	1	20	20	6
28000	1	20	20	6
28020	1	20	20	6
28040	1	20	20	6
28060	1	20	20	6
39760	1	20	20	2
41320	1	20	20	3.5
41340	2	20	40	4.5
41360	2	20	40	4.5
41380	2	20	40	4.5
41400	2	20	40	4.5
41420	2	20	40	4.5
41440	2	20	40	4.5
41460	2	20	40	4.5
41480	2	20	40	4.5
41500	2	20	40	4.5
41520	2	20	40	4.5
41540	2	20	40	4.5
41560	2	20	40	4.5
41580	2	20	40	4.5
42620	1	20	20	3.5
42640	1	20	20	3.5
42660	1	20	20	3.5

Chainage	Side	Length	Total length	Height
42680	1	20	20	3.5
42700	1	20	20	3.5
42720	1	20	20	3.5
42740	1	20	20	3.5
42760	1	20	20	3.5
42780	1	20	20	3.5
42800	1	20	20	3.5
42820	1	20	20	3.5
42840	1	20	20	3.5
42860	1	20	20	3.5
42880	1	20	20	3.5
42900	1	20	20	3.5
42920	1	20	20	3.5
43420	1	20	20	2
43440	1	20	20	2
43460	1	20	20	2
43480	1	20	20	2
43500	1	20	20	2
44240	1	20	20	2
44260	1	20	20	2
44280	1	20	20	2
44300	1	20	20	2
44320	1	20	20	2
44340	1	20	20	2
44360	1	20	20	2
44380	1	20	20	2
44400	1	20	20	2
50460	1	20	20	4
50480	1	20	20	4
50500	1	20	20	4
50520	1	20	20	4
50540	1	20	20	4
50560	1	20	20	4
50580	1	20	20	4
50600	1	20	20	4
53280	1	20	20	2
53300	1	20	20	2
53320	1	20	20	2
53340	1	20	20	2
53360	1	20	20	2
53380	1	20	20	2
59740	1	20	20	3.5
64740	1	20	20	4
68860	1	20	20	5
68880	1	20	20	5
68900	1	20	20	5

Chainage	Side	Length	Total length	Height
68920	1	20	20	5
68940	1	20	20	5
68960	1	20	20	5

l) Status of Land Acquisition

i) Package 1

Description	Qty./Status
Total Land Required	84 Ha
Land Available	11.01 Ha
Land to be acquired	72.99 Ha

ii) Package 2

Description	Qty./Status
Total Land Required	55.01 Ha
Land Available	0.0 Ha
Land to be acquired	55.01 Ha

ii) Package 3

Description	Qty./Status
Total Land Required	58.07 Ha
Land Available	0.0 Ha
Land to be acquired	58.07 Ha

0.6 Preliminary Cost Estimate

Package1 (Km 0+335 to Km 34+039)

As per preliminary cost estimate, construction cost of Package-1 is 218.54 cr (6.48cr. Per Km). The Abstract of project cost is presented in Table 9 below

Table 9: Cost Estimates (Package-1)

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	SITE CLEARANCE	3,510,426	
2	EARTHWORKS	876,195,481	
3	SUB-BASE AND BASE COURSES	526,515,485	
4	BITUMINOUS COURSES	141,027,089	
5	CROSS DRAINAGE WORKS	337,563,189	
6	NEW BRIDGES, ROBS AND UNDERPASSES	112,998,562	
7	DRAINAGE AND PROTECTIVE WORKS	314,744,514	
8	TRAFFIC SIGNS, MARKINGS AND ROAD APPURTENANCES	134,200,047	
9	MISCELLANEOUS	854,460	
A	**Construction Cost (Rates adopted from current October'2019 SOR for National Highway Circle, Meghalaya are inclusive of GST @12% (1 to 9)**	**2,447,609,253**	7.262 cr. Per km
	Cost of GST @ 12%	**262,243,849**	
B	**Construction Cost (Excluding GST)**	**2,185,365,404**	6.484 cr. Per km
	Cost Inflation for the year 2020-21 @ 4.3% based on WPI on B	**93,970,712**	
C	**Estimated Civil Cost/ Cost Put upto Tender**	**2,279,336,117**	6.763 cr. Per km
	Addition of GST @12% of C	273,520,334	
	Contingencies at 2.8% of C	63,821,411	
	Agency charges @ 3% on C	68,380,084	
	O&M cost for Ist five years after construction @ 2.5% of C	56,983,403	
	Supervision @ 3% on C	68,380,084	
	Price Escalation @ 5% per year for 1.5 year on C	170,950,209	
D	**TOTAL PROJECT COST**	**2,981,371,641**	8.846 cr. Per km
1	UTILITY SHIFTING COST	33,206,472	
2	LAND ACQUISITION	712,770,117	
E	**TOTAL NONCIVIL COST (1+2)**	**745,976,589**	2.213 cr. Per km
F	**TOTAL PROJECT COST (D+E)**	**3,727,348,230**	11.059 cr. Per km

0.6.1 Package - 2 (Km 35+155 to Km 53+500)

As per preliminary cost estimate, construction cost of Package-2 is 120.29 cr (6.56cr. Per Km). The Abstract of project cost is presented in Table 10 below

Table 10: Cost Estimates (Package-2)

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	SITE CLEARANCE	1,947,902	
2	EARTHWORKS	580,056,904	
3	SUB-BASE AND BASE COURSES	291,437,796	
4	BITUMINOUS COURSES	76,163,502	
5	CROSS DRAINAGE WORKS	146,554,030	
6	NEW BRIDGES, ROBS AND UNDERPASSES	27,925,338	
7	DRAINAGE AND PROTECTIVE WORKS	146,562,731	
8	TRAFFIC SIGNS, MARKINGS AND ROAD APPURTENANCES	58,385,421	
9	MISCELLANEOUS	18,189,880	
A	**Construction Cost (Rates adopted from current October'2019 SOR for National Highway Circle, Meghalaya are inclusive of GST @12% (1 to 9)**	**1,347,223,504**	7.344 cr. Per km
	Cost of GST @ 12%	**144,345,375**	
B	**Construction Cost (Excluding GST)**	**1,202,878,129**	6.557 cr. Per km
	Cost Inflation for the year 2020-21 @ 4.3% based on WPI on B	**51,723,760**	
C	**Estimated Civil Cost/ Cost Put upto Tender**	**1,254,601,888**	6.839 cr. Per km
	Addition of GST @12% of C	150,552,227	
	Contingencies at 2.8% of C	35,128,853	
	Agency charges @ 3% on C	37,638,057	
	O&M cost for Ist five years after construction @ 2.5% of C	31,365,047	
	Supervision @ 3% on C	37,638,057	
	Price Escalation @ 5% per year for 1.5 year on C	94,095,142	
D	**TOTAL PROJECT COST**	**1,641,019,270**	8.945 cr. Per km

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	UTILITY SHIFTING COST	623,711	
2	LAND ACQUISITION	202,896,149	
E	**TOTAL NONCIVIL COST (1+2)**	**203,519,860**	1.109 cr. Per km
F	**TOTAL PROJECT COST (D+E)**	**1,844,539,129**	10.055 cr. Per km

0.6.2 Package - 3 (Km 53+500 to Km 72+863)

As per preliminary cost estimate, construction cost of Package-3 is 137.76 cr (7.115cr. Per Km). The Abstract of project cost is presented in Table 11 below

Table 11: Cost Estimates (Package-3)

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	SITE CLEARANCE	2,053,194	
2	EARTHWORKS	700,739,856	
3	SUB-BASE AND BASE COURSES	306,739,754	
4	BITUMINOUS COURSES	80,692,271	
5	CROSS DRAINAGE WORKS	147,645,794	
6	NEW BRIDGES, ROBS AND UNDERPASSES	183,650,504	
7	DRAINAGE AND PROTECTIVE WORKS	58,878,819	
8	TRAFFIC SIGNS, MARKINGS AND ROAD APPURTENANCES	62,307,174	
9	MISCELLANEOUS	189,880	
A	**Construction Cost (Rates adopted from current October'2019 SOR for National Highway Circle, Meghalaya are inclusive of GST @12% (1 to 9)**	**1,542,897,246**	7.968 cr. Per km
	Cost of GST @ 12%	**165,310,419**	
B	**Construction Cost (Excluding GST)**	**1,377,586,827**	7.115 cr. Per km
	Cost Inflation for the year 2020-21 @ 4.3% based on WPI on B	**59,236,234**	
C	**Estimated Civil Cost/ Cost Put upto Tender**	**1,436,823,060**	7.42 cr. Per km
	Addition of GST @12% of C	172,418,767	
	Contingencies at 2.8% of C	40,231,046	

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
	Agency charges @ 3% on C	43,104,692	
	O&M cost for Ist five years after construction @ 2.5% of C	35,920,577	
	Supervision @ 3% on C	43,104,692	
	Price Escalation @ 5% per year for 1.5 year on C	107,761,730	
D	**TOTAL PROJECT COST**	**1,879,364,563**	9.706 cr. Per km
1	UTILITY SHIFTING COST	658,322	
2	LAND ACQUISITION	214,155,253	
E	**TOTAL NONCIVIL COST (1+2)**	**214,813,575**	1.109 cr. Per km
F	**TOTAL PROJECT COST (D+E)**	**2,094,178,138**	10.815 cr. Per km

0.7 Conclusion and Recommendation

1. As per traffic projection, 2 Lane with earthen shoulders has been proposed for the project road
2. From Nongstoin to Rambrai, existing alignment has been followed except for small realignments/ curve improvement.
3. After Rambrai, new alignment has been proposed.
4. Total Construction cost for the project road is Rs.476.59 crores for the year 2019-20.

CHAPTER - 1

INTRODUCTION

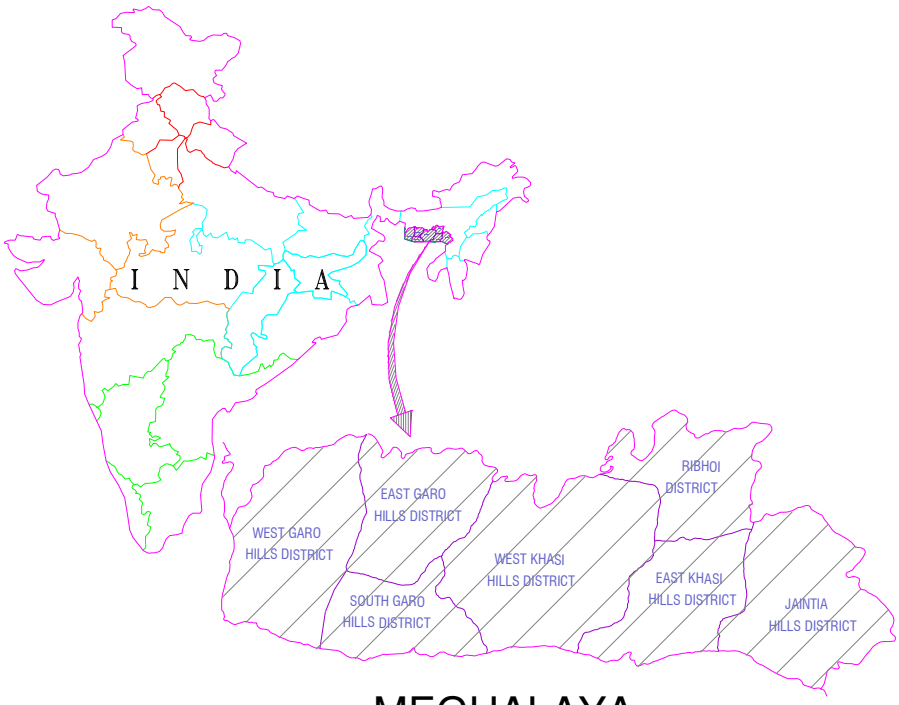
1.1 GENERAL

Transport plays a vital role in the economic and social development of a country. The demand for inter-city freight transport in India is expected to double every 12 years while the demand for passenger transport is expected to double every eight or nine years. Since 1950, the system of State Highways has expanded over eight-fold. This rapid expansion of road network was made possible through speedy access to available resources for construction of single or intermediate lane state and district roads, with thin and structurally deficient pavements. As a result the arterial road system has become grossly congested with poor pavement condition. We are faced with many capacity related problems as traffic on arterial routes is growing at 10-12% per annum. With such high growth of traffic, congestion becomes inevitable and loss due to accidents also increases. Additional capacity has to be created by widening the roads to multi-lane standards and/or by strengthening the existing pavement crust. As per the letter vide 12027/60/2006NER/NH-10 (Pt-file) dated 18.02.2010 received from the ministry, the Govt. of India in the ministry of Road Transport & Highways, New Delhi has included this road under Phase-'A' of SARDP-NE.

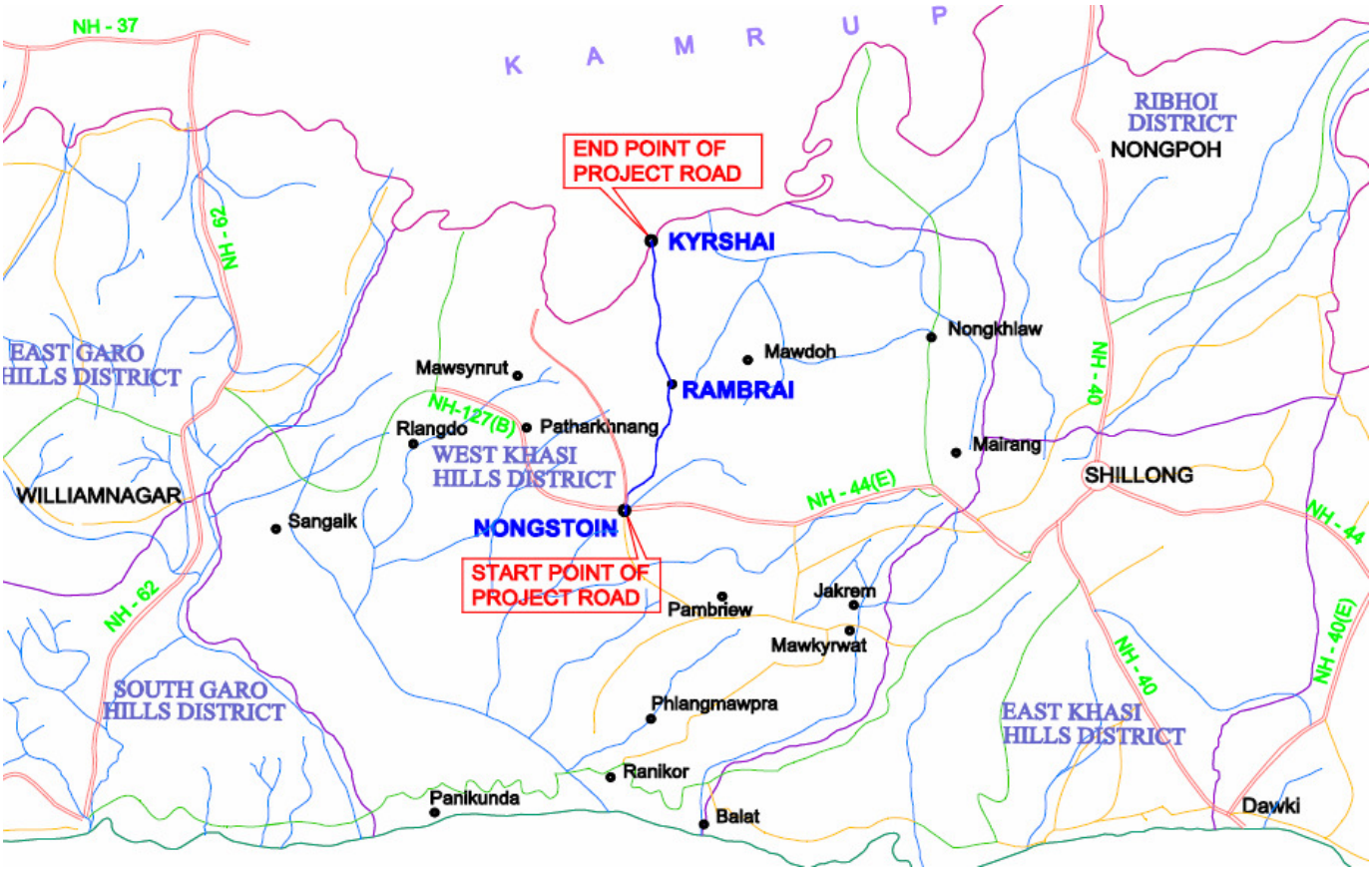
1.2 PROJECT BACKGROUND

Nongstoin – Rambrai – Kyrshai Road is an important link of Meghalaya with neighbouring Assam and rest of the country. The road from Nongstoin to Rambrai(20 Km approx) is a single lane surfaced road and the condition of road is fair to poor. The curves are sharp and the average road width is 5.5 m and carriageway width is 3.75m. After Rambrai, there is a katcha road upto Mawthir (14 Km approx) and thereafter no road exists except for a jungle track. Geometrics of existing katcha road and jungle track are very poor having sharp curves and steep gradients.

The project road indicated in Fig: 1.1



MEGHALAYA



The Government of Meghalaya, Public Works Department, Meghalaya called for consultancy assignment for preparation of Detailed Project Report which should expressively give all the requirements for development of the project and its facilities as well as to assess the financial requirements in a clear and

practicable manner. The consultancy assignment has been awarded to Holtec Consulting Private Limited, Gurgaon for preparation of Detailed Project Report for upgradation of the project Highway.

1.3 Salient Features of the Consultancy Assignment

• Name of the Project	Detailed Engineering / Detailed Project Preparation for Upgradation of Nongstoin – Rambrai – Kyrshai road upto Meghalaya – Assam Border to 2-lane under SARDP-NE "Phase-A" in Meghalaya.
• Name of Employer	Chief Engineer (NH), PWD (Roads) Government of Meghalaya,
• Name of Consultant	Holtec Consulting Private Limited, Gurgaon, Haryana
• Contract Award	Agreement dated 23 January 2012
• Work Order	PW/CE/SARDP/12/2010/30 23 JAN 2012
• Consultant's Services	Preparation of Detailed Project Report

1.4 Objective of the Assignment

The objective of the consultancy services is to prepare a detailed project report covering widening of existing highway to 2-lane standards, which shall, inter-alia, include construction of bypasses/re-alignments, construction/reconstruction of bridges, Grade separators and cross drainage structures, retaining walls, breast walls, provision of road safety measures.

- Survey and Investigations.
- Detailed Engineering Design and Project Report.
- Economics Analysis.
- Contract Packaging and Implementation Schedules.
- Computerized inventory and digitized maps.

We will demonstrate the efficacy of coordinated effort of the Department and the Consultant for achieving high quality project.

1.5 Scope of Services

These are specified in the TOR and are summarized as under:

- Strip plan.
- Alignment Plan showing proposals for realignment

- Need/ Justification of Bypass
- Need/ Justification for replacement of level crossing by ROB
- Sitting of bridge & type of bridge
- Hydraulic Analysis.
- Road Inventory
- Bridge Inventory
- Typical cross section of Existing/proposed road pavement
- Topographic Survey.
- Traffic Survey and Assessment.
- Material investigations.
- Pavement investigations.
- Identification of homogeneous Sections and junctions.
- GAD of bridges & culverts.
- Phasing and prioritization economic analysis.
- Provision of lay bye, Parking, Bus Stop and road safety appurtenances.
- Estimation of quantities and project cost.

1.6 Project Stage

- Stage – 1 : Inception Report.
- Stage – 2 : Draft Report
- Stage – 3 : Final Report

The Final Detailed Project Report (DPR) was submitted on 08 July 2016 and the Final DPR after incorporation client's observations is submitted herewith.

1.7 Reporting Structure of Final Report

This Final Report is submitted in response to Clause 8. (ii) of the Terms of Reference (TOR). The report brings out the project description, Engineering survey, methodology, alignment study etc. A broad conceptualization of the project essentially based on study of available secondary data/reports and a detailed reconnaissance survey is also provided. The report also makes

proposals on issues requiring discussions with client and their decisions necessary for detailing of the project.

Final Report is presented in four volumes.

Volume I : Main Report

Volume II : Cost Estimate

Volume III : Technical Schedules

Volume IV : Drawings

CHAPTER: 2

PROJECT ROAD DESCRIPTION

2.1 GENERAL

The Govt of India and Govt of Meghalaya have decided to take up the development of the Nongstoin – Rambrai – Kyrshai Road to 2 lane configuration under SARDP-NE Phase-'A'. The project road location is in the state of Meghalaya. This road is a vital link with neighboring Assam state and rest of the country.

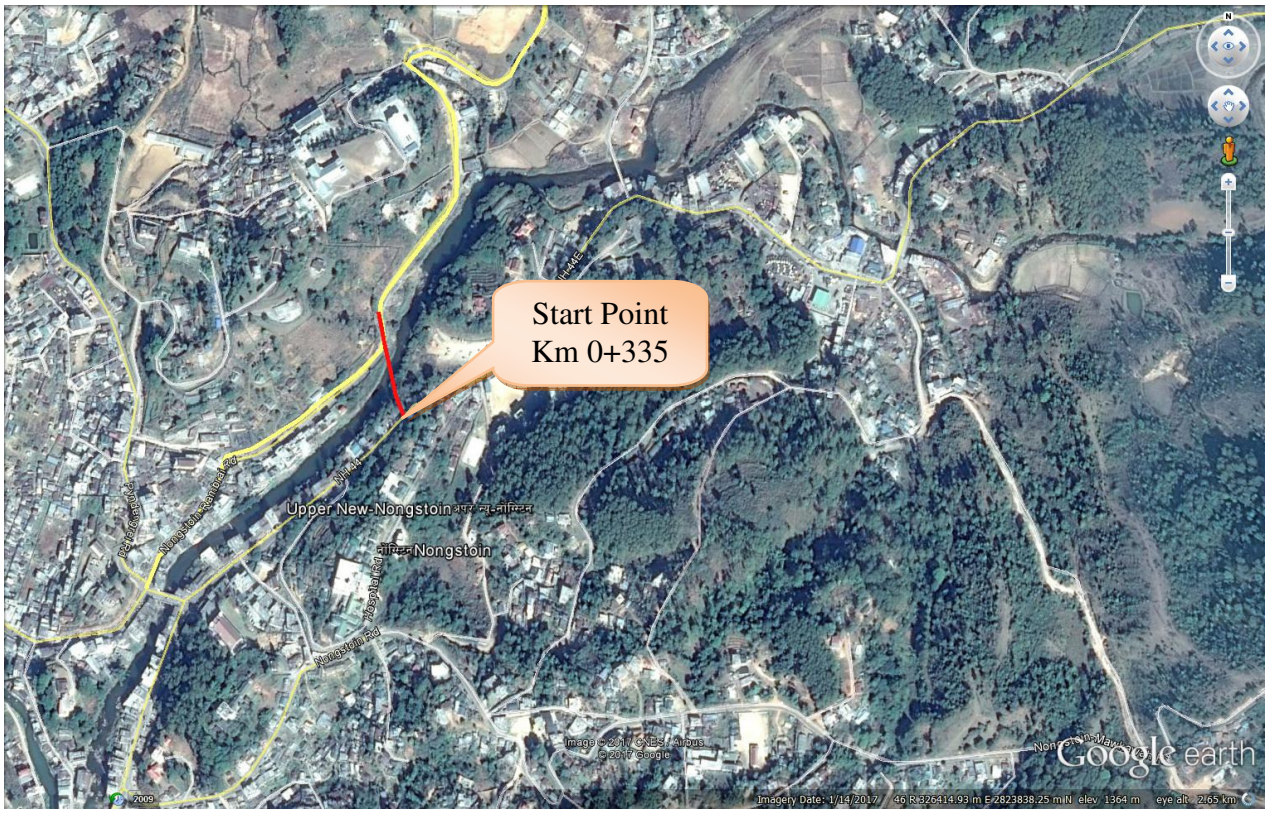
2.2 PROJECT LOCATION

The project road lies in West Khasi Hills District & starts from Design Chainage 0+335 which is a newly proposed T junction with NH 44E near Nongstoin and after traversing a length of about 73 Km, the project road ends within the Kyrshai town.

Latitude & Longitude of start & end points are shown below:

Location	Latitude (N)	Longitude (E)
Start Point of Project Road	25°31'17.51"	91°16'11.47"
End Point of Project Road	25°50'20.52"	91°20'23.12"

Start point and end point of project road is shown below:



Starting Point of Project Road

End Point of Project Road

2.3 GEOGRAPHY

Meghalaya is one of the Seven Sister States of India. The state of Meghalaya consists mainly of Archean rock formations. These rock formations contain rich deposits of valuable minerals like coal, limestone, uranium and sillimanite.

Meghalaya has many rivers. Most of these are rain fed and seasonal. The important rivers in the Garo Hills region are Daring, Sanda, Bandra, Bhogai, Dareng, Simsang, Nitai and the Bhupai. In the central and eastern sections of the plateau, the important rivers are Umkhri, Digaru, Umiam, Kynchiang (Jadukata), Mawpa, Umiam or Barapani, Myngot and Myntdu. In the southern Khasi Hills region, these rivers have created deep gorges and several beautiful waterfalls.

The elevation of the plateau ranges between 150 m to 1961 m. The central part of the plateau comprising the Khasi Hills has the highest elevations, followed by the eastern section comprising the Jaintia Hills region. The highest point in Meghalaya is Shillong Peak, which is a prominent IAF station in the Khasi Hills overlooking the city of Shillong. It has an altitude of 1961 m. The Garo Hills region in the western section of the plateau is nearly plain. The highest point in the Garo Hills is Nokrek Peak with an altitude of 1515 m.

The West Khasi Hills district is the largest district in the state with a geographical area of 5,247 square kilometres (2,026 sq mi). The district was carved out of Khasi Hills District on 28 October 1976. The district headquarters are located at Nongstoin.

2.4 CLIMATE

Meghalaya is directly influenced by the South-West Monsoon and the northeast winter wind. Mostly seasons of Meghalaya are: Spring - March and April, Summer (Monsoon) - May to September, Autumn -October and November and Winter - December to February.

The Monsoon usually starts by the third week of May and continues right to the end of September and sometimes well into the middle of October. Maximum rainfall occurs over the southern slopes of the Khasi Hills, i.e over the Sohra and the Mawsynram platform, which receives the heaviest rainfall in the world. The average rainfall in the State is 12,000 mm.

Total rainfall of Nongstoin is 3480.80mm in 139 rainy days in year 2012. April is the hottest month when the maximum temperature is 33^{o} C and mean maximum is 22^{o} C sub-zero winter temperatures are common.

2.5 TERRAIN & SOIL CONDITIONS

Project road passes through hilly terrain. The hills are of recent origin with rocky areas comprising of soft and hard rocks. Hill slope is varying from 10 degree to 80 degree. General geology of area is Rocky & SMB (soil mixed with boulders).

S/no	Sector	Terrain	Classification of Hills
1.	Nongstoin to Rambrai km 0.000 to km 19.20	Hilly	SMB – 60%, SR – 20% and HR – 20%
2.	Rambrai to Kyrshai Km 19.20 to km 72.863	Hilly and steep	SMB – 60%, SR- 15% and HR- 25%

2.6 TOWNS & VILLAGES

The following table provides a complete list of towns and villages along the project road:

Table: 2.1 List of Villages and Town

S.No.	Name of Village	Design Chainage
1	Nongstoin	0+000
2	Tiehsaw	0+800
3	Mawrusyiar	2+840
4	Steplanghir	6+480
5	Mawlich	10+000
6	Domjri	12+330
7	Mawphansyiar	12+625
8	Mawthwrgmarwei	15+480
9	Mawrang	15+970
10	Rambrai	17+000
11	Nongkroh	18+530
12	Mawthaw	18+910
13	Lawdibah	19+288
14	Sohmynthar	24+155
15	Mawthir	26+330
16	Nongkyllang	34+220
17	Mawdiangkper	37+910
18	Patharphalang	44+425
19	Mawpong	50+201
20	Kyrshai	68+550

2.7 JUNCTIONS

The following table provides a complete list of junctions along the project road:

Table: 2.2 List of Junctions

Sl No	Chainage	Junction Type	Remarks
1	0+000	+	Rambarai-Nongstoin-Shilong-Tura
2	0+800	T	Church Road
3	1+223	T	Village Road
4	1+322	T	Village Road
5	2+070	T	Village Road
6	2+200	T	Village Road
7	2+335	T	Village Road
8	3+270	T	Village Road
9	4+300	T	Village Road
10	5+600	+	NH Bypass Shillong – Nongstoin – Tura Road
11	8+600	T	Village Road
12	8+800	T	Village Road
13	8+900	⊤	Village Road
14	9+200	T	Village Road
15	9+350	T	Village Road
16	10+300	T	Village Road
17	10+800	T	Village Road
18	14+300	T	Village Road
19	16+000	T	Village Road
20	16+900	T	Village Road
21	17+140	T	Village Road
22	17+350	T	Village Road
23	17+670	T	Nongstoin Rambrai Road
24	18+250	T	Village Road
25	18+600	T	Rambrai Nongriat Road
26	18+740	T	Village Road
27	18+600	T	Rambrai Nongriat Road
28	19+670	T	Village Road

2.8 PRELIMINARY ASSESSMENT OF PROJECT ROAD

2.8.1 Existing Carriageway & Pavement

The start point of Project is at NH-44 E. The road from Nongstoin to Rambrai (20 Km approximately) is a single lane surfaced road. The road from Nongstoin to Rambrai(20 Km approx) is a single lane surfaced road and the condition of road is fair to poor. The curves are sharp and the average road width is 5.5 m and carriageway width is 3.75m. After Rambrai, there is a katcha road upto Mawthir (14 Km approx) and thereafter no road exists except for a jungle track. Geometrics of existing katcha road and jungle track are very poor having sharp curves and steep gradients.

The existing saddles are required to be raised and balancing culverts are required to be provided at these locations.

2.8.2 Existing ROW

Roadway width is varying from 5.5m to 5.8m.The existing ROW is not defined on the ground.

2.8.3 **Existing Alignment Geometrics :** There are sharp curves and steep gradient along the project road.

2.8.4 Existing Bridges

There are 5 existing minor bridges on the project road. From Rambrai to Kyrshai section only river bed exists, but there is no existing structure there. The type of superstructures for existing minor bridges is of steel girder with timber deck slab type except one with RCC girder, resting on open Foundation. The substructures are of PCC type. The condition of existing minor bridges is fair to poor. Water way of minor bridge is adequate. A summary of the existing bridges are as given in table 2.3.

Table 2.3 Details of Existing Structures

S. No.	Existing Chainage (Km)	Span Arrangement (m)	Average Vertical Clearance (m)	Type of Bridges			Carriage way width (m)	Total width (m)
				Super Structure	Sub Structure	Foundation		
1	6+755	1x12	4.3	Timber decking	Cement concrete	Open	4.3	4.6
2	7+925	1x6.00	4.60	Steel Girder with Timber Decking	Cement concrete	Open	3.80	4.00
3	13+122	1x11.75	6.70	Steel Girder with RCC Decking	Cement concrete	Open	3.60	3.90
4	16+420	1x9.3	3.60	Steel Girder with Timber Decking	Cement concrete	Open	3.2	3.6
5	19+910	1x36.20	8.20	Steel Girder with RCC	Cement concrete	Open	3.9	4.3

2.8.5 Culverts

There are 133 culverts existing along, out of which 111 are stone slabs, 6 are slab culverts, 3 wooden culverts and 13 pipe culverts. The structural conditions of culverts are generally poor to very poor. Most of the culverts are fully or partially choked.

The overall width of the culverts is 3 to 7m. The pipe culverts are generally with 1 row of 0.90 to 1.0 m dia. Slab culvert span varies from 0.5 to 2.0m.

2.8.6 Existing Level Crossing / ROBs / RUBs

No railway line crosses the project road.

2.8.7 Project Road Constraints

Based on the ground study, reconnaissance & survey and the data collected the consultant have gained appreciation of the technical and project management problems and have insight of the challenge areas of the project. The general appreciation of the thrust areas are described in the following paragraph.

i. From Nongstoin to Rambrai, existing surface road has poor geometrics at few locations.

ii. From Rambrai to Kyrshai, there is an existing Katcha track for a distance of 14 kms and there after jungle track exists. This stretch of the road passes through steep gradient and there are very poor geometrics on the existing track with steep gradients. It is not possible to follow the existing alignment after Rambrai (km 21) due to steep gradient (10-15%) at many locations .

iii. Hill slope is stable varying from 10 degree to 80 degree.

iv. There is built-up area at few locations along the project road, widening of existing road would require demolition of existing houses at few locations.

CHAPTER: 3

SOCIO ECONOMIC PROFILE

3.1 Socio-Economic Profile of Project Influence Area

Meghalaya is a state in north-east India. As of 2011, the state has a population of 2,9,66,889 and is the 23rd most populous in the country. Meghalaya covers an area of approximately 300 kilometres in length and about 100 kilometres in breadth. This state is bounded to the south by the People's Republic of Bangladesh and the north by India's Assam. The capital is Shillong, known as the "Scotland of the East" and has a population of 143,007.

About one-third of the state is forested. The Meghalaya subtropical forests ecoregion encompasses the state; its mountain forests are distinct from the lowland tropical forests to the north and south. The forests are notable for their biodiversity of mammals, birds, and plants. It was previously part of Assam, but on 21 January 1972, the districts of Khasi, Garo and Jaintia hills became the new state of Meghalaya.

Meghalaya has predominantly an agrarian economy. The important crops are potatoes, rice, maize, pineapples, bananas, etc. The service sector is made up of real estate and insurance companies. The state has become a hub of illegal mining activity. Meghalaya's gross state domestic product for 2004 was estimated at $1.6 billion in current prices.

Shillong, the capital of the state, is a popular hill station. There are several falls in and around Shillong. Shillong Peak, also known as the "abode of the gods" is the highest in the state.

The West Khasi Hills district was carved out of the erestwhile Khasi Hills district, which was dividied into West and East Khasi Hills districts on 28 October 1976.

The district headquarters is located at Nongstoin. The district occupies an area of 5247km²

The Langshiang Falls is located 24 kilometres (15 mi) from Nongstoin.

3.2 Meghalaya Population 2011

As per details from Census 2011, Meghalaya has population of 29.67 Lakhs, an increase from figure of 23.19 Lakh in 2001 census. Total population of Meghalaya as per 2011 census is 2,966,889 of which male and female are 1,491,832 and 1,475,057 respectively. In 2001, total population was 2,318,822 in which males were 1,176,087 while females were 1,142,735.

3.2.1 Population Growth Rate in Meghalaya

The total population growth in this decade was 27.95 percent while in previous decade it

was 29.94 percent. The population of Meghalaya forms 0.25 percent of India in 2011. In 2001, the figure was 0.23 percent.

3.2.2 Literacy Rate in Meghalaya

Literacy rate in Meghalaya has seen upward trend and is 74.43 percent as per 2011 population census. Of that, male literacy stands at 75.95 percent while female literacy is at 71.88 percent. In 2001, literacy rate in Meghalaya stood at 62.56 percent of which male and female were 71.18 percent and 50.43 percent literate respectively.

In actual numbers, total literates in Meghalaya stands at 1,785,005 of which males were 913,879 and females were 871,126.

3.2.3 Population Density of Meghalaya

Total area of Meghalaya is 22,429 sq. km. Density of Meghalaya is 132 per sq km which is lower than national average 382 per sq km. In 2001, density of Meghalaya was 103 per sq km, while nation average in 2001 was 324 per sq km.

3.2.4 Sex Ratio of Meghalaya

Sex Ratio in Meghalaya is 989 i.e. for each 1000 male, which is below national average of 940 as per census 2011. In 2001, the sex ratio of female was 975 per 1000 males in Meghalaya.

Description	**2011**	**2001**
Approximate Population	**29.67 Lakhs**	**23.19 Lakh**
Actual Population	**2,966,889**	**2,318,822**
Male	1,491,832	1,176,087
Female	1,475,057	1,142,735
Population Growth	**27.95%**	**29.94%**
Percantage of total Population	0.25%	0.23%
Sex Ratio	**989**	**975**
Child Sex Ratio	970	932
Density/km2	**132**	**103**
Density/mi2	343	268
Area km2	**22,429**	**22,429**
Area mi2	8,660	8,660
Total Child Population (0-6 Age)	**568,536**	**467,979**
Male Population (0-6 Age)	288,646	237,215
Female Population (0-6 Age)	279,890	230,764

Literacy	**74.43 %**	**62.56 %**
Male Literacy	75.95 %	71.18 %
Female Literacy	71.88 %	50.43 %
Total Literate	**1,785,005**	**1,157,875**

3.2.5 Urban Population of Meghalaya

Out of total population of Meghalaya, 20.07% people live in urban regions. The total figure of population living in urban areas is 595,450 of which 297,572 are males and while remaining 297,878 are females. The urban population in the last 10 years has increased by 20.07 percent.

Sex Ratio in urban regions of Meghalaya was 1001 females per 1000 males. For child (0-6) sex ratio the figure for urban region stood at 954 girls per 1000 boys. Total children (0-6 age) living in urban areas of Meghalaya were 77,944. Of total population in urban region, 13.09 % were children (0-6).

Average Literacy rate in Meghalaya for Urban regions was 90.79 percent in which males were 92.46% literate while female literacy stood at 89.24%. Total literates in urban region of Meghalaya were 469,851.

3.2.6 Rural Population of Meghalaya

Of the total population of Meghalaya state, around 79.93 percent live in the villages of rural areas. In actual numbers, males and females were 1,194,260 and 1,177,179 respectively. Total population of rural areas of Meghalaya state was 2,371,439. The population growth rate recorded for this decade (2001-2011) was 79.93%.

In rural regions of Meghalaya state, female sex ratio per 1000 males was 986 while same for the child (0-6 age) was 972 girls per 1000 boys. In Meghalaya, 490,592 children (0-6) live in rural areas. Child population forms 20.69 percent of total rural population.

In rural areas of Meghalaya, literacy rate for males and female stood at 71.46 % and 67.15 %. Average literacy rate in Meghalaya for rural areas was 69.92 percent. Total literates in rural areas were 1,315,154

Description	Rural	Urban
Population (%)	**79.93 %**	**20.07 %**
Total Population	**2,371,439**	**595,450**
Male Population	1,194,260	297,572

Description	Rural	Urban
Female Population	1,177,179	297,878
Population Growth	**27.17 %**	**31.12 %**
Sex Ratio	**986**	**1001**
Child Sex Ratio (0-6)	972	954
Child Population (0-6)	**490,592**	**77,944**
Child Percentage (0-6)	20.69 %	13.09 %
Literates	**1,315,154**	**469,851**
Average Literacy	**69.92 %**	**90.79 %**
Male Literacy	71.46 %	92.46 %
Female Literacy	67.15 %	89.24 %

3.3 Profile of West Khasi Hill District

Demographic details of West Khasi Hill district of Meghalaya are as given below:

3.3.1 District Population

In 2011, West Khasi Hills had population of 383,461 of which male and female were 193,715 and 189,746 respectively. In 2001 census, West Khasi Hills had a population of 296,049 of which males were 150,419 and remaining 145,630 were females. West Khasi Hills District population constituted 12.92 percent of total Maharashtra population. In 2001 census, this figure for West Khasi Hills District was at 12.77 percent of Maharashtra population.

3.3.2 Growth Rate

There was change of 29.53 percent in the population compared to population as per 2001. In the previous census of India 2001, West Khasi Hills District recorded increase of 33.05 percent to its population compared to 1991.

3.3.3 Density

The initial provisional data released by census India 2011, shows that density of West Khasi Hills district for 2011 is 73 people per sq. km. In 2001, West Khasi Hills district density was at 56 people per sq. km. West Khasi Hills district administers 5,247 square kilometers of areas.

3.3.4 Literacy Rate

Average literacy rate of West Khasi Hills in 2011 were 77.87 compared to 65.10 of 2001. If things are looked out at gender wise, male and female literacy were 78.53 and 77.19 respectively. For 2001 census, same figures stood at 66.49 and 63.65 in West Khasi Hills District. Total literate in West Khasi Hills District were 230,678 of which male and female were 117,307 and 113,371 respectively. In 2001, West Khasi Hills District had 147,590 in its district.

3.3.5 Sex Ratio

With regards to Sex Ratio in West Khasi Hills, it stood at 980 per 1000 male compared to 2001 census figure of 968. The average national sex ratio in India is 940 as per latest reports of Census 2011 Directorate. In 2011 census, child sex ratio is 967 girls per 1000 boys compared to figure of 975 girls per 1000 boys of 2001 census data.

3.3.6 Child Population

In census enumeration, data regarding child under 0-6 age were also collected for all districts including West Khasi Hills. There were total 87,214 children under age of 0-6 against 69,333 of 2001 census. Of total 87,214 male and female were 44,342 and 42,872 respectively. Child Sex Ratio as per census 2011 was 967 compared to 975 of census 2001. In 2011, Children under 0-6 formed 22.74 percent of West Khasi Hills District compared to 23.42 percent of 2001. There was net change of -0.68 percent in this compared to previous census of India.

Description	**Rural**	**Urban**
Population (%)	**88.76 %**	**11.24 %**
Total Population	**340,356**	**43,105**
Male Population	172,380	21,335
Female Population	167,976	21,770
Sex Ratio	**974**	**1020**
Child Sex Ratio (0-6)	965	981
Child Population (0-6)	**78,310**	**8,904**
Male Child(0-6)	39,848	4,494
Female Child(0-6)	38,462	4,410

Child Percentage (0-6)	**23.01 %**	**20.66 %**
Male Child Percentage	23.12 %	21.06 %
Female Child Percentage	22.90 %	20.26 %
Literates	**200,573**	**30,105**
Male Literates	102,493	14,814
Female Literates	98,080	15,291
Average Literacy	**76.54 %**	**88.02 %**
Male Literacy	77.33 %	87.96 %
Female Literacy	75.73 %	88.08 %

3.4 Geography

Meghalaya is one of the Seven Sister States of India.

The state of Meghalaya is also known as the "Meghalaya Plateau". It consists mainly of Archean rock formations. These rock formations contain rich deposits of valuable minerals like coal, limestone, uranium and sillimanite.

Meghalaya has many rivers. Most of these are rainfed and seasonal. The important rivers in the Garo Hills region are Daring, Sanda, Bandra, Bhogai, Dareng, Simsang, Nitai and the Bhupai. In the central and eastern sections of the plateau, the important rivers are Umkhri, Digaru, Umiam, Kynchiang (Jadukata), Mawpa, Umiam or Barapani, Myngot and Myntdu. In the southern Khasi Hills region, these rivers have created deep gorges and several beautiful waterfalls.

The elevation of the plateau ranges between 150 m to 1961 m. The central part of the plateau comprising the Khasi Hills has the highest elevations, followed by the eastern section comprising the Jaintia Hills region. The highest point in Meghalaya is Shillong Peak, which is a prominent IAF station in the Khasi Hills overlooking the city of Shillong. It has an altitude of 1961 m.

3.5 Climate

With average annual rainfall as high as 1200 cm in some areas, Meghalaya is the wettest place on earth. The western part of the plateau, comprising the Garo Hills region with lower elevations, experiences high temperatures for most of the year. The Shillong area, with the highest elevations, experiences generally low temperatures. The maximum temperature in this region rarely goes beyond 28 °C (82 °F),[17] whereas sub-zero winter temperatures are common.

The town of Cherrapunji in the Khasi Hills south of capital Shillong holds the world record for most rain in a calendar month, while the village of Mawsynram, near the town of Cherrapunji, holds the record for the most rain in a year.[18] The best time to visit Meghalaya is during the months of March to July

3.6 Economy of Meghalaya State

Meghalaya is predominantly an agrarian economy. Agriculture and allied activities engage nearly two-thirds of the total work force in Meghalaya. However, the contribution of this sector to the State's NSDP is only about one-third. Agriculture in the state is characterised by low productivity and unsustainable farm practices. Despite the large percentage of population engaged in agriculture, the state is still dependent upon imports from other states. Infrastructural constraints have also prevented the economy of the state from creating high income jobs at a pace commensurate with that of the rest of India.

Meghalaya's gross state domestic product for 2012 was estimated at ₹16173 crore (US$2.7 billion) in current prices. As of 2012, according to the Reserve Bank of India, about 12% of total state population is below poverty line, with 12.5% of the rural Meghalaya population is below the poverty line; while in urban areas, 9.3% are below the poverty line.

3.6.1 Agriculture

Meghalaya is basically an agricultural state with about 80% of its population depending entirely on agriculture for their livelihood. Nearly 10% of the geographical area of Meghalaya is under cultivation. Agriculture in the state is characterized by limited use of modern techniques, low yields and low productivity. As a result, despite the vast majority of the population being engaged in agriculture, the contribution of agricultural production to the state's GDP is low, and most of the population engaged in agriculture remain poor. A portion of the cultivated area is under the traditional shifting agriculture known locally as Jhum cultivation.

Meghalaya produced 230,000 tonnes of food grains in 2001. Rice is the dominant food grain crop accounting for over 80% of the food grain production in the state. Other important food grain crops are maize, wheat and a few other cereals and pulses. Besides these, potato, ginger, turmeric, black pepper, areca nut, tezpatta, betelvine, short-staple cotton, jute, mesta, mustard and rapeseed etc. are some of the important cash crops.

Besides the major food crops of rice and maize, the state is renowned for its horticultural crops like orange, lemon, pineapple, guava, litchi, banana, jack fruits and fruits such as plum, pear and peach.

3.6.2 Industry

Meghalaya has a rich base of natural resources. These include minerals such as coal, limestone, sillimanite, Kaolin and granite among others. Meghalaya has a large forest cover, rich biodiversity and numerous water bodies. The low level of industrialisation and the relatively poor infrastructure base acts as an impediment to the exploitation of these natural resources in the interest of the state's economy. In recent years two large cement manufacturing plants with production capacity more than 900 MTD have come up in Jaintia Hills district and several more are in pipeline to use the rich deposit of very high quality limestone available in this district.

CHAPTER: 4

ENGINEERING SURVEY & INVESTIGATIONS

4.1 Reconnaissance

Consultant has made an in-depth study of the available land width (ROW) topographic maps, satellite imageries and air photographs of the project area and other available relevant information collected by them concerning the existing alignment. Consultant will make efforts for minimizing land acquisition.

The detailed ground reconnaissance was taken up immediately after the study of maps and other data. The primary tasks to be accomplished during the reconnaissance surveys include;

i) topographical features of the area;

ii) typical physical features along the existing alignment within and outside ROW i.e. land use pattern

iii) realignment requirements including the provision of bypasses, ROBs / Flyovers/via-duct for pedestrian crossings with possible alignment alternatives;

iv) possible alignment alternatives, vis-a-vis, scheme for the construction of additional lanes parallel to the existing road;

v) preliminary identification of improvement requirements including treatments and measures needed for the cross-roads;

vi) traffic pattern and preliminary identification of traffic homogenous links;

vii) sections through congested areas;

viii) inventory of major aspects including land width, terrain, pavement type, carriageway type, bridges and structures (type, size and location), intersections (type, cross-road category, location) urban areas (location, extent), geologically sensitive areas, environmental features:

ix) critical areas requiring detailed investigations; and,

x) Requirements for carrying out supplementary investigations.

xi) soil (textural classifications) and drainage conditions

xii) type and extent of existing utility services along the alignment (within ROW).

The data derived from the reconnaissance surveys are normally utilised for planning and programming the detailed surveys and investigations. All field studies including the traffic surveys should be taken up on the basis of information derived from the reconnaissance surveys.

4.2 Topographic Surveys

The basic objective of the topographic survey is to capture the essential ground features along the alignment in order to consider improvements and for working out improvements, rehabilitation and upgrading costs. The detailed topographic survey was started after the completion of reconnaissance surveys. The detailed field surveys were carried out using high precision instruments i.e. Total stations. The data from the topographic surveys shall be available in (x, y, z) format for use in a sophisticated digital terrain model (DTM).

The detailed field surveys have essentially included the following activities:

i) Topographic Surveys along the Existing Right of Way (ROW): Running a continuous open Traverse along the existing road and realignments, wherever required, and fixation of all cardinal points such as horizontal intersection points (HIP's), centre points and transit points etc. and properly referencing the same with a pair of reference pillars fixed on either side of the centre-line at safe places within the ROW.

ii) Collection of details for all features such as structures (bridges, culverts etc.) utilities, existing roads, electric and telephone installations (both O/H as well as underground), huts, buildings, fencing and trees (with girth greater than 0.3 meter) oil and gas lines etc. falling within the extent of survey.

The width of the survey corridor had taken into account the layout of the existing alignment including the extent of embankment and cut slopes and the general ground profile. While carrying out the field surveys, the widening scheme of Highway or Bridges (i.e. right, left or symmetrical to the centre line of the existing carriageway) has been taken into consideration so that the topographic surveys

cover sufficient width beyond the centre line of the proposed divided carriageway. Normally the surveys should extend a minimum of 30 m beyond either side of the centre line of the proposed divided carriageway or land boundary whichever is more. At locations where grade separated intersections could be the obvious choice, the survey area has been suitably increased. Field notes of the survey has been maintained which would also provide information about traffic, soil and drainage etc. The width of the surveyed corridor is widened appropriately where developments and / or encroachments have resulted in a requirement for adjustment in the alignment, or where it is felt that the existing alignment can be improved upon through minor adjustments.

Where existing roads cross the alignments, the survey has been extend to a minimum of 100 m either side of the road centre line and of sufficient width to allow improvements, including at grade intersection to be designed.

The surveyed alignment has been transferred on to the ground as under:

i) Reference Pillar and Bench Mark / Reference pillar of size 15 cm X 15 cm X 45 cm cast in RCC of grade M 15 with a nail fixed in the centre of the top surface. The reference pillar has been embedded in concrete up to a depth of 30 cm with CC M10 (5 cm wide all around). The balance 15 cm above ground painted yellow. The spacing has been 250m apart, in case Bench Mark Pillar coincides with Reference Pillar, only one of the two has been provided.

ii) Establishing Bench marks at site connected to GTS Bench marks at an interval of 250 metres on Bench mark pillar made of RCC as mentioned above with RL and BM No. marked on it with red paint.

iii) TBM co-ordinates for the project stretch is shown in table below.

Nongstoin-Rambrai-Kyrshai Road TBM List					
Sr. No.	***Ext. Chainage***	***Easting***	***Northing***	***Elevation***	***Remarks***
1	**0**	**29826.3940**	**40085.2640**	**1449.2640**	**RHS On Bridge**
2	**0**	**29834.0410**	**40083.6340**	**1449.2800**	**RHS On Bridge**
3	**185**	**29996.9920**	**40011.5190**	**1449.0500**	**RHS On Road**
4	**200**	**30000.0000**	**40000.0000**	**1450.0000**	**RHS On Road**
5	**400**	**30146.5770**	**39866.1040**	**1450.7810**	**LHS On Tree**
6	**430**	**30168.2140**	**39846.7980**	**1447.7790**	**RHS On Road**

Nongstoin-Rambrai-Kyrshai Road TBM List					
Sr. No.	*Ext. Chainage*	*Easting*	*Northing*	*Elevation*	*Remarks*
7	960	30506.8380	39736.0570	1456.7460	RHS On KM Stone
8	1000	30542.1350	39718.9260	1458.2020	RHS On Road
9	1040	30581.6210	39704.9540	1459.0380	RHS On Road
10	1800	31209.5210	39873.5790	1481.1750	LHS On KM Stone
11	2030	31377.4150	39980.5500	1486.7680	LHS On Road
12	2050	31392.6840	39988.1170	1486.6270	LHS On Road
13	2585	31446.9860	39631.1090	1505.9180	LHS On Road
14	2600	31459.8340	39623.6100	1506.8450	RHS On Road
15	2790	31567.5240	39501.3810	1515.5340	RHS On KM Stone
16	2930	31664.7410	39406.2430	1522.4400	RHS On Tree
17	2950	31682.8900	39400.8350	1524.4300	RHS On Tree
18	3770	32259.9230	38963.1610	1567.4430	RHS On KM Stone
19	4550	32654.3230	38482.5020	1599.4780	RHS On Road
20	4560	32663.5590	38476.8910	1600.5360	RHS On Road
21	4760	32775.3000	38319.5530	1608.1180	RHS On KM Stone
22	5020	32953.2940	38144.1800	1610.9150	RHS On Road
23	5490	33246.7560	37798.3250	1606.4070	RHS On Road
24	5760	33385.1810	37878.4150	1585.5760	LHS On KM Stone
25	5980	33595.0230	37856.6840	1565.4290	LHS On Road
26	5985	33597.7040	37854.8550	1565.7600	LHS On Road
27	6555	34101.3080	37953.8490	1547.5090	LHS On OFC
28	6570	34117.7680	37951.3360	1547.2340	LHS On Road
29	6750	34289.3540	37933.0570	1549.3080	RHS On KM Stone
30	7230	34731.4000	37833.7870	1554.2610	RHS On Tree
31	7930	35345.7390	37786.4120	1558.5320	RHS On R/Wall
32	8150	35490.4670	37684.1530	1575.2900	RHS On Road
33	8155	35494.9560	37684.0430	1575.4260	RHS On Road
34	8300	35639.8370	37659.4200	1582.7860	RHS On R/Wall
35	8310	35654.8320	37665.2030	1584.2490	RHS On Road
36	8540	35876.2210	37702.2660	1596.6340	LHS On KM Stone
37	8760	36095.2980	37729.2570	1611.5220	RHS On Culvert
38	8790	36122.2280	37731.5160	1614.1980	RHS On Road
39	9440	36646.5550	37596.5180	1607.5320	RHS On KM Stone
40	9810	36973.3230	37512.1660	1587.4220	RHS On Road
41	9840	37001.1950	37518.2270	1585.6820	LHS On Road
42	10085	37226.1870	37507.6940	1574.7830	RHS On Road
43	10115	37244.4450	37487.0950	1571.3370	RHS On Road
44	10510	37575.2700	37379.0820	1562.2360	LHS On KM Stone
45	10840	37890.3520	37431.5480	1567.7630	RHS On Road
46	10910	37955.3810	37429.5200	1564.8550	RHS On Road
47	11500	38422.8860	37333.1740	1559.9890	RHS On KM Stone
48	12300	39156.1270	37359.6770	1539.7010	LHS On Road
49	12340	39186.5110	37355.7680	1539.1600	RHS On Road
50	12500	39300.4780	37380.6680	1529.1720	RHS On KM Stone

Nongstoin-Rambrai-Kyrshai Road TBM List					
Sr. No.	*Ext. Chainage*	*Easting*	*Northing*	*Elevation*	*Remarks*
51	12740	39480.6660	37333.2660	1519.9130	RHS On EP
52	13430	40015.8700	37407.6770	1502.6940	LHS On KM Stone
53	13440	40016.1750	37398.6930	1502.0240	LHS On OFC
54	14000	40478.7420	37142.1140	1510.6420	LHS On Road
55	14030	40511.7800	37127.3320	1512.5670	LHS On R/Wall
56	14400	40855.2970	37003.9390	1532.3000	LHS On Tree
57	14480	40924.9510	36971.7440	1534.6180	LHS On KM Stone
58	15425	41703.4830	36517.2060	1554.7390	LHS On KM Stone
59	16300	42219.9290	36057.2970	1537.1460	LHS On Road
60	16310	42231.4620	36051.7070	1536.7770	LHS On Road
61	17420	43142.8710	35567.2090	1521.5170	RHS On Road
62	17425	43147.8230	35565.0460	1522.4270	RHS On KM Stone
63	17430	43155.5810	35567.9610	1522.2210	RHS On Road
64	18030	43599.1030	35456.2380	1541.7120	RHS On Road
65	18035	43605.5570	35452.5880	1542.0350	RHS On Road
66	18310	43808.2410	35414.3070	1545.0510	RHS On Road
67	18320	43814.5860	35420.5230	1544.6830	RHS On KM Stone
68	18350	43837.8520	35437.6660	1544.6820	RHS On Culvert
69	18495	43956.6630	35511.1430	1548.9800	RHS On R/Wall
70	18505	43968.8220	35515.8480	1548.9930	RHS On R/Wall
71	18670	44120.9120	35562.8020	1554.9720	LHS On Shop
72	18680	44126.8390	35548.4520	1555.3440	RHS On Culvert
73	19125	44416.1490	35287.5540	1539.9880	RHS On Culvert
74	19130	44422.1730	35280.8910	1539.8380	RHS On Road
75	19330	44534.7740	35149.6010	1528.5240	LHS On Tree
76	19350	44556.0930	35149.6610	1527.4110	LHS On Tree
77	19580	44748.5150	35242.7950	1516.9590	LHS On Vill. Road
78	19840	44764.1630	34987.0080	1515.2640	RHS On Vill. Road
79	19845	44766.2300	34979.9400	1514.8540	RHS On Vill. Road
80	19885	44784.4200	34945.6350	1515.7010	RHS On R/Wall
81	20455	45099.0370	34772.3160	1522.1210	LHS On Tree
82	20465	45112.5540	34774.1270	1522.9850	LHS On Tree
83	21010	45511.8960	34993.9840	1527.5240	LHS On Tree
84	21020	45522.3100	34994.3570	1528.4020	LHS On Tree
85	22255	46469.4130	35472.0490	1520.9830	LHS On Track
86	22265	46478.8830	35479.2970	1523.0830	LHS On R/Wall
87	22400	46603.5370	35430.5860	1525.4640	RHS On Track
88	24010	46612.5570	35432.2020	1524.9230	RHS On Track
89	22520	46595.7360	35386.3010	1511.5550	LHS On Track
90	22560	46590.6830	35384.4350	1512.7040	LHS On Track
91	22605	46630.4810	35353.8250	1510.0550	On Road Center
92	22610	46633.7020	35352.1240	1510.1230	On Road Center
93	23230	46573.5160	35038.6260	1475.8120	RHS On Track
94	23230	46577.1420	35037.0140	1476.1670	LHS On Track

Nongstoin-Rambrai-Kyrshai Road TBM List					
Sr. No.	*Ext. Chainage*	*Easting*	*Northing*	*Elevation*	*Remarks*
95	23395	46715.2390	35050.5150	1466.0280	LHS On Track
96	23400	46720.1300	35052.2320	1466.2260	LHS On Track
97	23520	46825.6750	35100.1010	1461.9810	LHS On Track
98	23835	47101.7930	35202.8900	1439.9510	LHS On Track
99	23840	47106.5220	35203.1470	1439.9890	LHS On Track
100	24260	47451.5900	35304.8380	1416.9100	LHS On Track
101	24265	47454.7810	35303.5180	1417.4870	RHS On Track
102	24600	47733.9620	35335.0370	1399.2060	LHS On Track
103	26450	48382.4300	35294.4360	1341.9980	RHS On Track
104	26455	48383.7790	35289.8740	1342.5470	RHS On Track
105	26695	48557.6820	35135.1270	1346.9580	LHS On Track
106	26695	48547.7110	35128.9310	1344.0220	RHS On Track
107	27880	49267.0700	34392.0620	1332.9830	RHS On Track
108	27945	49322.8020	34359.4470	1331.0210	On Track Center
109	27980	49328.3330	34326.3540	1329.8950	LHS On Track
110	27985	49330.1600	34323.1280	1330.9280	LHS On Track
111	28410	49549.3930	34037.9450	1311.9010	LHS On Track
112	27440	49569.2570	34024.9270	1309.9570	LHS On Track
113	28680	49735.0140	34115.3200	1297.2480	LHS On Track
114	28680	49742.7020	34115.9020	1294.9730	RHS On Track
115	29030	49952.7110	34135.0060	1267.0920	RHS On Track
116	29035	49960.2170	34136.8590	1268.0600	LHS On Track
117	29210	50017.4290	33970.0740	1256.8620	LHS On Track
118	29235	50008.2910	33947.4930	1256.4780	LHS On Track
119	30580	50750.0060	33708.6520	1199.8710	LHS On Track
120	30585	50754.4590	33711.7400	1199.5370	LHS On Track
121	30910	51067.5910	33656.2600	1180.6950	RHS On Track
122	30915	51069.3920	33653.3100	1182.0990	RHS On Track
123	31375	51295.5380	33321.7040	1145.6430	LHS On Track
124	31390	51308.3980	33309.4670	1143.8140	On Track Center
125	31730	51353.4760	33065.7370	1119.5960	LHS On Tree
126	31735	51353.7350	33060.5900	1120.0500	LHS On Tree
127	31800	51395.2630	33004.8450	1113.8700	LHS On Tree
128	32320	51439.9240	33269.1620	1093.4660	LHS On Tree
129	32320	51429.8320	33271.9630	1097.8590	LHS On Tree
130	33280	51803.1000	33087.1080	1063.7270	RHS On Track
131	33285	51811.1960	33080.9640	1065.3830	LHS On Track
132	34400	52568.1160	32900.1170	1025.2430	LHS On Tree
133	34400	52564.3680	32904.0830	1026.0150	LHS On Tree
134	34530	52572.0970	32992.1180	1012.1540	LHS On Road
135	34535	52578.9930	32997.4760	1009.9170	LHS On Tree
136	35525	53267.2500	32513.4810	970.0080	LHS On Tree
137	35530	53276.8780	32514.3850	968.4960	LHS On Tree

Longitudinal and Cross-Sections

The topographic surveys for longitudinal and cross-sections has covered the following:

i) Longitudinal and cross sections for major and minor streams as per recommendations contained in IRC:5-1998 ("Standard Specifications & Code of Practice for Road Bridges, Section 1 – General Features of Design") and IRC Special Publication No. 13 (Guidelines for the Design of Small Bridges and Culverts).

ii) Longitudinal section levels along final centre line at every 25 m interval, at the locations of curve points, small streams, and intersections and at the locations of change in elevation.

iii) Cross sections at every 50 m interval in full extent of survey covering sufficient number of spot levels on existing carriageway and adjacent ground for profile correction course and earth work calculations. Cross sections shall be taken at closer interval at curves.

iv) Longitudinal section for cross roads for length adequate for design and quantity estimation purposes. At feasibility study stage cross sections at 200m interval may be taken.

Details of utility Services and Other Physical Features

1. Details of all important physical features along the alignment were collected in topographic survey. These features affect the project proposals and should normally include buildings and structures, monuments, burial grounds, cremation grounds, places of worship, railway lines, water mains, sewers, gas/ oil pipes, crossings, trees, plantations, utility services such as electric, and telephone lines (O/H & U/G) and poles, optical fibre cables (OFC) etc. The survey has covered the entire right-of-way of the road on the adequate allowance for possible shifting of the central lines at some of the intersections locations.

2. The information collected during reconnaissance and field survey is shown on a strip plan so that the proposed improvements can be appreciated and the extent of land acquisition with L.A schedule, utility removals of each type etc.

assessed and suitable actions can be initiated. Separate strip plan for each of the services involved has been prepared for submission to the concerned agency.

4.3 Road and Pavement Investigations

The Consultant carried out detailed field studies in respect of road and pavement. The data collected through road inventory and pavement investigations was in such a way so as to meet the input requirements of HDM-IV.

Road Inventory Surveys

1. Detailed road inventory surveys have been carried out to collect details of all existing road and pavement features along the existing road sections. The inventory data include but not limited to the following:

   i) terrain (flat, rolling, mountainous);

   ii) land-use (agricultural, commercial, forest, residential etc) @ every kilometer;

   iii) carriageway width, surfacing type @ every 500m and every change of feature whichever is earlier;

   iv) shoulder surfacing type and width @ every 500m and every change of feature whichever is earlier;

   v) sub-grade / local soil type (textural classification) @ every 500m and every change of feature whichever is earlier;

   vi) horizontal curve; vertical curve

   vii) road intersection type and details, at every occurrence;

   viii) retaining structures and details, at every occurrence;

   ix) location of water bodies (lakes and reservoirs), at every occurrence; and,

   x) height of embankment or depth of cut @ every 200m and every change of feature whichever is earlier.

   xi) land width i.e. ROW

   xii) culverts, bridges and other structures (type , size, span arrangement and

location)

xiii) Roadside arboriculture

xiv) Existing utility services on either side within ROW.

xv) General drainage conditions

xvi) Design speed of existing road

Pavement Investigation

1. Pavement Composition

Consultant has done trial pits to ascertain the pavement composition. Test pits are excavated manually along the existing road at the pavement-shoulder interface extending through the pavement layers down to the subgrade level. The detailed layer composition of the existing pavement was recorded at every pit and the observations have been presented in table below. Generally the existing pavement structure comprises of two layers namely PC (premix carpet) and WBM (water bond macadam).

Table: 4.1 Existing Pavement Composition

Location	PC	WBM
0+000 Km	35	150
5+000 Km	45	150
10+000 Km	40	145
15+000 Km	45	140
20+000 Km	50	145

2. Road and Pavement Condition Surveys

Detailed field studies have been carried out to collect road and pavement surface conditions. The data cover:

i) pavement condition (surface distress type and extent);

ii) shoulder condition;

iii) embankment condition; and

iv) drainage condition

Pavement Condition data was collected on the basis of visual means supplemented by measurements. The data so collected pertains to:

- % area of fine cracks < 3mm
- % area of fine cracks > 3mm
- % area of raveling
- % area of patching
- % area of potholes
- Length of edge failure in meters
- Rut depth
- Shoulder and embankment conditions including distress

The objective of the road and pavement condition surveys is to identify defects and sections with similar characteristics. The pavement condition survey was carried out using visual means. Supplemented by actual measurements and in accordance with the widely accepted methodology (AASHTO, IRC, OECD, TRL and World Bank Publications) adapted to meet the study requirements The shoulder and embankment conditions was evaluated by visual means and the existence of distress modes (cuts, erosion marks, failure, drops) and extent (none, moderate, frequent and very frequent) of such distress manifestations would be recorded.

4.4 Sub-grade Characteristics and Strength

Based on the data derived from condition (surface condition, roughness) and structural strength surveys, the project road section has been divided into segments homogenous with respect to pavement condition and strength. The delineation of segments homogenous with respect to roughness and strength has been done using the cumulative difference approach (AASHTO, 1993).

i) For the widening of existing road within the ROW, at least three sub-grade

soil samples for each homogenous road segment or three samples for each soil type encountered, whichever is more are taken

ii) For the roads along new alignments, the test pits for sub grade soil were done @2 km or for each soil type, whichever is more. A minimum of three samples have been tested corresponding to each homogenous segment.

The testing for sub grade soil includes:

i. in-situ density and moisture content at each test pit

ii. field CBR using DCP at each test pit

iii. characterization (grain size and Atterberg limits) at each test pit and

iv. laboratory moisture-density characteristics (modified AASHTO compaction);

v. laboratory CBR (unsoaked and 4-day soak compacted at three energy levels) and swell.

Following laboratory tests were carried out in respect of sample taken from the test pits.

Grain size analysis	:	IS 2720 (part IV)
Atterberg Limit	:	IS 2720 (part V
Optimum Moisture Content and Dry Density (Heavy compaction)	:	IS 2720 (part VII)
CBR test (Unsoaked and 4 days soaked at Three energy levels	:	IS 2720 (part XVI)

4.4.1 Laboratory Test

The samples collected from Test pits were carefully sealed and labelled for laboratory assessment. The laboratory test comprises of determination of Atterberg's Limit, Modified Proctor test, soaked CBR and Grain Size Analysis

etc. Test results and their analysis obtained from laboratory tests are presented in Annexure and discussed below.

4.4.2 Soil Classification

The soil samples have been primarily classified on the basis of Bureau of Indian Standards (BIS) which is based on the Unified Soil Classification System. This classification system is based on the result of grain size analysis and plasticity index of the soil.

It is observed from the grain size analysis that most of soil samples comprise of Silty clay soil. Majority of Subgrade soil is classified in Soil group of CL (Clay with low plasticity) .The other soil groups are CI.

4.4.3 Atterberg's Limit

The tests have been carried out according to provision given as per IS 2720 Part 5. The liquid limit and plasticity index are varying from 25.5 % to 30.6 % and 9.2% to 11.9 % respectively.

4.4.4 California Bearing Ratio (CBR)

CBR tests in Laboratory had been carried out on samples collected from pit as per IS: 2720 (Part- 16). CBR moulds are prepared by compaction of soil in five layers. Quantity of water taken during remoulding of CBR specimen was equal to optimum moisture content. Soaked CBR values had been worked out for 97% of MDD. The test result indicates variation of CBR value for 2.5mm and 5.0mm dia plunger

Table: 4.2 Summary of Existing Subgrade

Type of Test	Maximum	Minimum	Average
Liquid Limit %	30.6%	25.5%	28.2%
Plastic Limit %	19.0%	16.2%	17.8%
Plasticity Index %	11.9%	9.2%	10.4%
MDD gm /cc	1.82	1.68	1.74
OMC %	12.5	11	11.6
CBR @ 2.5mm	8.9%	6.4%	7.6%
CBR @ 5.0mm	7.8%	5.5%	6.7%

Table: 4.3 Existing Subgrade Details

Location	Gravel Content	Sand Content	Silt & Clay Content	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	OMC (%)	MDD (g/cc)	CBR @ 2.5mm	CBR @ 5.0mm
0+000	3.0%	30.0%	67.0%	27.3%	18.1%	9.2%	11.0	1.75	8.9%	7.8%
10+000	1.4%	27.3%	71.3%	28.1%	16.9%	11.2%	12.0	1.74	7.0%	6.5%
20+000	2.2%	26.6%	71.2%	29.1%	18.9%	10.3%	11.3	1.74	6.9%	6.2%
30+000	0.5%	31.1%	68.4%	27.7%	18.0%	9.7%	11.4	1.72	8.3%	7.0%
40+000	0.7%	26.1%	73.2%	28.1%	18.1%	9.9%	11.9	1.75	6.4%	5.5%
50+000	2.3%	36.9%	60.8%	25.5%	16.2%	9.3%	11.0	1.82	8.9%	7.6%
60+000	1.6%	25.6%	72.7%	29.1%	17.2%	11.9%	11.7	1.71	7.4%	6.8%
70+000	1.2%	23.2%	75.6%	30.6%	19.0%	11.6%	12.5	1.68	7.1%	6.5%

Where ever required, Subgrade material will be used for filling purpose.

4.4.5 Material Investigation

Basic requirement for existing road improvement is road widening, raising of existing road, and provision of realignment. For this purpose various construction materials are required. To identify the availability of suitable materials within reasonable lead along with their suitability, material survey and its investigation is undertaken.

Quarry Materials

The Consultant has identified Quarries for the purpose of course aggregate and fine aggregates on the basis of aggregate suitability and without leading to any adverse environmental impact. Quarry chart has been given at the end of the chapter.

The samples collected from the quarries were tested for:

Course Aggregate

Aggregate Impact value : IS 2386 (Part IV)

Water Absorption : IS 2386 (Part III)

Specific Gravity : IS 2386 (Part II)

Stripping Value : IS 2386 (Part VII)

Soundness : IS 2386 (Part IV)

Description of Test	1	2	3
Flakiness index Value	14.76%	14.66%	29.93%
Impact Value	14.86	16.22	15.68
Water Absorption	0.91%	1.02%	0.83%

4.4.5 Investigations for Bridges and Structures

Inventory of all the structures (bridges, viaducts, ROBs, culverts, etc.) along the road under the project have been carried out. The inventory for the bridges, viaducts and ROBs has been conducted as per the guidelines of IRC-SP: 35-1990.

Hydraulic and Hydrological Investigations

i. The hydrological and hydraulic studies has been carried out in accordance with IRC: 5-1998 ("Standard Specifications & Code of Practice for Road Bridges, Section I General Feature of Design") and IRC Special Publication No. 13 ("Guidelines for the Design of Small Bridges and Culverts") These investigations has been carried out for all existing cross drainage structures along the road sections under the study.

ii. All available data on topography (topographic maps, stereoscopic aerial photography), storm duration, rainfall statistics, top soil characteristics, vegetation cover etc. have been collected so as to assess the catchment areas and hydraulic parameters for all existing and proposed drainage provisions. The findings of the desk study would be further supplemented and augmented by a reconnaissance along the area.

iii. Information on high flood level (HFL), low water levels (LWL), discharge velocity etc. from available past records, local inquiries and visible signs, if any, on the structural components and embankments have also been collected. Local inquiries were made with regard to the road sections getting overtopped during heavy rains.

Condition Survey for Bridges, Culverts and Structures

Inspection of the existing structures about their condition was done as per Inspection pro-forma of IRC-SP; 35-1990.

Geo-technical Investigation for Bridge and structures

The Consultants will carry out geo-technical investigations and sub-surface explorations for the proposed Bridges / Road over bridges/tunnels/viaducts/ interchanges etc., including high embankments and any other location as necessary for proper design of the works and conduct all relevant laboratory and field tests on soil and rock samples. The minimum scope of geo-technical investigations for bridge and structures shall be as under:

Sn	Description	Location of Boring
1	Over all length = 6 – 30 m	One abutment location
2	Over all length = 30 – 60 m	One abutment location and at least one intermediate location between abutments for structures Having more than one span.
3	Over all length >60 m	Each abutment and each pier locations.

4.5 Environmental impact assessment

First stages of the Environmental Assessment Study, valued environmental components were identified in consultation with local habitants, experts and local official from the states departments of forest & Environment and Pollution Control Board and so on.

Initial environmental survey was carried out and strip map of the entire length of the highway were prepared. The environmental survey concentrated on the primary impact areas of the proposed highway, which was within ROW on either side of the highway. Sources of information were mainly based on secondary level information including topographic sheets of Survey of India, (1:25,000 and 1:2500000 scales). An environmental Screening report was prepared.

At screening report stage the analysis aimed at screening of important and major environmental issues. It also helped to assess the scope of work for further detailed Environmental Assessment. Main output of the report was to identify major areas of environmental concern. Its purpose was also to work out and develop probable alternatives that should be tried at the preliminary design and feasibility assessment stage of the Report.

At Feasibility stage of the Report all the environmental issues that issues that were identified at screening stage was assessed further to look into the feasibility of the proposed project from the environmental point of view. Various alternatives have been analyzed to arrive at the selection of proposed alignment, which would be the most appropriate and environmental feasible proposition. The report should also

refer the "Environmental and Social Screening Report". Detailed methodology has been dealt in the relevant section.

4.6 Social Impact Assessment and Rehabilitation

Social Impact Assessment has been undertaken to determine the significant social issues that would emerge from implementation of the project. The tools used are questionnaire, screening survey, and collections of secondary data, compilation of data and analyses.

The Social analysis study has been be carried out in accordance with the World Bank/ADB guidelines, as the case may be. The social analysis report, among other things, has provided a socio-economic profile of the project area and address in particular, indigenous people, communicable disease particularly HIV/AIDS poverty alleviation, gender, local population, industry, agriculture, employment, health, education, child labour, land acquisition and resettlement.

The consultant has conducted base line socio-economic and census survey to assess the impacts on the people, properties and loss of livelihood. The socioeconomic survey established the benchmark for monitoring of R&R activities. A social assessment is conducted for the entire project to identify mechanisms to improve project designs to meet the needs of different stakeholders. A summary of stakeholders' discussions, issue raised and how the project design was developed to meet stakeholders need would be prepared. The consultant would prepare Resettlement and Rehabilitation Plan-assess feasibility and effectiveness of income restoration strategies and suitability and availability to relocation sites. The resettlement plan which accounts for land acquisition and resettlement impacts has been based on a 25% socio-economic survey and 100 % census survey of project affected people which provide the complete assessment of the number of affected households and persons, including common property resources.

- Assessment on the impact of the project on the poor and vulnerable groups along the project road corridor.

- Based on the identified impacts, developing entitlement matrix for the project affected people.

- Assessment on social issues such as indigenous people, gender, HIV/AIDS, labours including child labour.
- Implementation budgets, sources and timing of funding and schedule of tasks.
- Responsibility of tasks, institutional arrangements and personnel for delivering entitlement and plans to build institutional capacity.
- Internal and external Monitoring plans, key monitoring indicators and grievance redress mechanism.

4.7 Economic & Financial Analysis

The economic evaluation and analysis has been made with "Highway Design and Maintenance Standard Model Version IV (HDM – IV) development by World Bank". The HDM –IV analysis total transport cost of alternative road improvement and maintenance the economic viability of the cycle economic evaluation. The main objective is to be establish the economic viability of the proposed rehabilitation and upgrading of existing single/intermediate-lane to 2-lane carriageway configurations. It has been carried out by making comparative evaluation cost/benefit between the base situation I. e. "Without Project" or "Do Minimum" situation and the improvement options I. e. "With Project" (or 2-laning) situation.

The economic analysis shall cover the following aspects:

i) assess the capacity of existing roads and the effects of capacity constraints on vehicle operating costs (VOC);

ii) calculate VOCs for the existing road situation and those for the project;

iii) quantify all economic benefits, including those from reduced congestion, travel distance, road maintenance cost savings and reduced incidence of road accidents; and,

iv) Estimate the economic internal rate of return (EIRR) for the project over a 30-year period. In calculating the EIRRs, identify the tradable and non-tradable components of projects costs and the border price value of the

tradable components.

v) Saving in time value.

Economic Internal Rate of Return (EIRR) and Net Present Value (NPV), "with" and "without time and accident savings" has been worked out based on these cost-benefit streams. Furthermore, sensitivity of EIRR and NPV worked out for the different scenarios as given under:

- Scenario - I Base Costs and Base Benefits
- Scenario - II Base Costs plus 20% and Base Benefits
- Scenario – III Base Costs and Base Benefits minus 20%
- Scenario - IV Drop in traffic growth rates by 50%
- Scenario - V No generated traffic benefits
- Scenario - VI Two-year project implementation delay
- Scenario - VII Less than optimal road maintenance such as delay or omission of periodic maintenance
- Scenario - VIII Base Costs plus 20% and Base Benefits minus 20%

The sensitivity scenarios given above are only indicative. The Consultants has selected the sensitivity scenarios taking into account possible construction delays, construction costs overrun, traffic volume, revenue shortfalls, operating costs, exchange rate variations, convertibility of foreign exchange, interest rate volatility, non-compliance or default by contractors & political risks.

The Consultant has studied the financial viability of the project under a commercial format and under different user fee scenarios and funding options.

The Financial analysis for the project has covered financial internal rate of return, projected income statements, balance sheets and fund flow statements and should bring out all relevant assumptions. The sensitivity analysis carried out for a number of probabilistic scenarios. The financial analysis has covered identification, assessment, and mitigating measures for all risks associated with

the project. The analysis covers, but be not limited to; risks related to construction delays, construction costs overrun, traffic volume, revenue shortfalls, operating costs, exchange rate variations, and convertibility of foreign exchange, interest rate volatility, non-compliance or default by contractors, political risks. The consultants has suggested positive ways of enhancing the project Viability and furnish different financial models.

CHAPTER - 5

DESIGN STANDARDS & SPECIFICATIONS

5.1 DESIGN PHILOSOPHY

Project road is being improved to 2-lane Standard / Specifications. The Project Road will have two lane carriageway facilities.

Design Standards for the highway requirements have been framed for following items for providing the desirable level of service and safety. For this Project it is proposed to follow Design Standards given in IRC Standards, Codes, Guidelines and Special Publications besides MORTH circulars and specifications as applicable to National Highways and the Concession Agreement stipulations in this respect. In the absence of any definite provisions on any particular issue, the following standards shall be referred to in that order.

- Bureau of Indian Standards
- American Association of State Highway and Transport Officials(AASHTO)
- American Society of Testing Materials(ASTM)
- British Standards
- Any other National or International Standard as considered suitable

In case certain provisions are not available and uncertainties exist, these will be discussed with Meghalaya PWD (NH) / MORTH and consensus reached.

5.2 SPECIFICATIONS

The material to be used in the Project work (including facilities there on) shall conform to MORTH Specifications. Where these specifications are silent in regard to certain specifications for the material in question, in that case, specifications under Bureau of Indian Standard/AASHTO/ASTM/BS shall apply in that order. But where these specifications are silent, the specifications for the material in question shall be got designed from the Consultant.

5.3 GEOMETRIC DESIGN STANDARDS

For this Project Highway, Geometric Design Standards shall be as per IRC:SP:73-2015 Manual of specification & standards for two laning of highways with paved shoulder.

IRC:73-1980 Geometric Design Standards for Rural Highways

IRC:SP:19-2001: Manual for survey, investigations and preparation of road projects.

IRC:52-2001 Recommendations about the Alignment survey and Geometric Design of Hill Roads (Second Revision).

IRC:SP:48-1998: Hill Road Manual

5.4 DESIGN PARAMETERS

Terrain Classification

Terrain as pertinent to the road structure is classified as given in the following table;

Table: 5.1 -Terrain Classification

Terrain	Cross Slope (%)
Plain	**0-10**
Rolling	10-25
Mountainous	25-60
Steep	> 60

This Road Corridor is generally in mountainous terrain with stretches on steep mountainous terrain.

Design Speed:

Design speeds for various categories of hill roads of hill road is given in table below

Table: 5.2 - Design Speed (Km/h)

Road Classification	Mountainous Terrain		Steep Terrain	
	Ruling	Minimum	Ruling	Minimum
National / State Highway	50	40	40	30
Major District Road	40	30	30	20

The ruling design speed should generally be the criterion for correlation of the various design features.

Minimum design speed should be adopted in sections where site conditions or economic do not permit a design based on the ruling design speed. This will be adopted in consultation with the client.

Cross Section Elements:

- **Right of Way (ROW)**

IRC: 73-1980 Table-3 recommends the following land width for National Highway:

ROW Width

Sn.	Road Classification	Mountainous and steep Terrain	
		Open areas	Built-up areas
		Normal	Normal
1	National Highways	30m	16m

The existing ROW along the project road is not uniform. The width of ROW is not defined in the road. ROW of 24/20 will be maintained. However there are stretches where the ROW has been encroached. It would require restoration to 24/20m width.

- **2-Lane Carriageway:**

Total road width	:	12.00 meter
Carriageway	:	7.000 m
Earthen Shoulder Hill side	:	2.50m
Earthen Shoulder Valley side	:	2.50m

- **Cross-slope**

Each carriageway shall have cross slope of 2.50 per cent

The earthen shoulder shall have a slope of 3.0 per cent.

- **Stopping Sight Distance:**

Sufficient stopping distance is made available for drivers to stop their vehicles when faced with an unexpected obstruction in the carriageway. The safe stopping sight distance, overtaking sight distance as recommended in the manual is as below:

Minimum recommended Sight Distances

Speed (Km/h)	Safe Stopping Sight Distance (m)	Intermediate Sight Distance (m)
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120

- **Horizontal Alignment:**

  ❖ **Super elevation**

  No super elevation is proposed when its value obtained is less than the road camber e.g. Radii beyond which super elevation is not proposed are as mentioned below:

Radius beyond which super elevation not required

Design speed (km/hr)	Radius (m)					
	Proposed as per IRC 73	4%	3%	2.5%	2%	1.7
20		50	60	70	90	10
25		70	90	110	140	150
30		100	130	160	200	240
35		140	180	220	270	320
40		180	240	280	350	420
50		280	370	450	550	650

- **Radius**

Radii for horizontal curves corresponding to ruling minimum and absolute minimum design speeds are as given below:

Minimum Radius for National Highways / State Highways

Steep Terrain	
Ruling Min Radius (m)	**Absolute Minimum Radius (m)**
50	30

There will be corresponding speed limit in case the radius is less than the above due to hill physical features and economic consideration.

Hair-Pin Bends

Hair-pin bends where unavoidable, may be designed either as a circular curve with transition at each end, or as a compound circular curve. The following criteria should be followed normally for their design

a) Minimum design speed - 20 km/h
b) Minimum roadway width at apex
   i. National / State Highways 11.5m for double-lane
      9.0m for single-lane
c) Minimum radius for the inner curve - 15.0 m

d) Minimum length of transition curve - 15.0 m

e) Gradient

Maximum - 1 in 40 (2.5%)

Minimum - 1 in 200 (0.5%)

f) Super-elevation - 1 in 10 (10%)

At hair-pin bends, the full roadway with will be surfaced

Widening of Pavement at Curves

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passers of vehicle. Extra width to be provided on horizontal curve is given below (refer clause 6.8.5 of IRC: SP: 48: 1998).

Radius of Curve (m)	Up to 20	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Extra width(m) 2 Lane	1.5	1.5	1.2	0.90	0.60	Nil

Wherever the radius is less than the specified minimum design speed, the transition curve, super elevation and pavement widening will be introduced. This will minimize the intrusion of vehicles on to adjacent lanes, tend to encourage uniformity of speed and increase vehicle speed at the curves.

- **Transition Length**

Transition length is given in Table below:

Transition Length of Curve
As per IRC: SP: 48-1998

Curve Radius (m)	Design Speed Km/h				
	50	40	30	25	20
	Transition length - metres				
15				NA	30
20				35	20
25			NA	25	20
30			30	25	15
40		NA	25	20	15
50		40	20	15	15
55		40	20	15	15
70	NA	30	15	15	15
80	55	25	15	15	NR
90	45	25	15	15	
100	45	20	15	15	
125	35	15	15	NR	

150	30	15	15		
170	25	15	NR		
200	20	15			
250	15	15			
300	15	NR			
400	15				
500	NR				

NA-Not Applicable

NR- Transition not required

- **Vertical Alignment:**

Codal Provisions

The gradients to be maintained in the design are as per following guidelines:

Codal Reference	Clause No.
IRC : SP-48 – 1998, Hill Road Manual	12.2.1
IRC : 52-2001, Recommendations about Alignment Survey and Geometric Design of Hill Roads	6.9.1.3

Gradients for Different Terrain

SL. No	Terrain	Ruling gradient	Limited gradient	Exceptional gradient
1	Steep terrain up to 3,000 m height above mean sea level	6 % (1 in16.7)	7 % (1 in 14.3)	8 % (1 in 12.5)

Gradients upto the ruling gradient may be used as a matter of course in design (Ref. Clause No. 6.9.1.4 of IRC-SP: 48 – 1998).

The limiting gradients may be used where the topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. In such cases, the length of continuous grade steeper than the ruling gradient should be as short as possible. (Ref. Clause No. 6.9.1.5 of IRC-SP: 48 – 1998)

Exceptional gradients are meant to be adopted only in very difficult situations and for short lengths not exceeding 100 m at a stretch. Successive stretches of exceptional gradients must be separated by a minimum length of 100 m having gentler / flatter gradient (Ref. Clause No. 6.9.1.6 of IRC-SP: 48 – 1998).

Vertical Curves

Minimum length of Vertical Curve (As per IRC: SP: 48-1998)

Design speed km/h	Maximum grade change (percent) not requiring a vertical curve	Minimum Length of vertical curve (m)
35	1.5	15
40	1.2	20
50	1.0	30

The actual length for the vertical curve shall however be provided as per IRC: 73–1980

- ***GEOTECHNICAL DESIGN***

Earth Embankment

i) The fill material, compaction and other requirements shall conform to IRC: 36-1970. Where these specifications are in variance with the MORT&H specifications, the later shall govern and accordingly followed.

ii) Side slope of 2:1 is provided

Side Slopes Formation in Cutting

The following values are adopted as per IRC: SP: 48:1948 Clause 7.4.

Side Slope in Cutting

Sn	*Item*	*Slopes of Cutting*
1	Ordinary Soil / Heavy Soils	1 : 1 to ½ : 1
2	Ordinary / Soft Rock	¼ : 1 to 1/8 : 1
3	Hard rock	80^0 to 90^0 to Horizontal

(Explanation: The slope 1: 1 signifies 1 in the horizontal direction and 1 in the vertical)

ROAD FURNITURE

Km Stones

Km Stones, 200m stones and 5^{th} km stones shall be provided as per codal provisions.

Road Signs:

All signs shall be placed on the valley side of the road. Where extra emphasis is warranted, they may be duplicated on the right hand side as well as per IRC: 67-1977.

The extreme edge of the sign shall be not less than 2 m from the edge of the carriageway.

Road Marking:
Provisions shall be made for center line marking with thermo-plastic paint as per IRC: 35-1970.

Safety Barriers:
Guardrail shall be provided on approaches to bridges and high embankments.

BRIDGES & CULVERTS

- All Cross- Drainage structures shall be classified as culverts, minor bridges & major bridges depending on the length of the structure as per IRC standards. Structures up to 6m length fall into the category of culverts, more than 6m but up to 60m in length as minor bridges and beyond 60m length as major bridges.
- For bridge on 2-lane SH the carriageway width shall be 10.90m The deck width including carriageway footpath and crash barrier/railing is required to be kept 12.00m for 2-lanes.
- Project road falls under Zone-V of seismic zone as provided in IRC: 6-2014.
- The list of IRC codes given below but not limiting to shall be referred during formulation of the design and drawings of bridges.

List of IRC Codes

IRC: 5-1998	Standard Specification & Code of practice for Road Bridges. Section – I General Features of Design (Seventh Revision)
IRC: 6-2014	Standard Specification & Code of practice for Road Bridges. Section – II Loads & Stresses (Fourth Revision)
IRC: 18-2000	Design Criteria for Prestressed Concrete Road Bridges (Post- Tensioned Concrete) (Third Revision)
IRC: 21-2000	Standard Specification & Code of practice for Road Bridges. Section – III Cement Concrete Plain & Reinforced (Second Revision)
IRC: 22-2008	Standard Specification & Code of practice for Road Bridges. Section – VI Composite Construction (First Revision)
IRC: 24-2010	Standard Specification & Code of practice for Road Bridges. 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.
IRC: 73-1980	Geometric Design standards for Rural (Non-Urban) Highways.
IRC: 78-2014	Standard Specification & Code of practice for Road Bridges. Section – VII Foundation & Substructure (First Revision)
IRC: 83-1999 Part-I	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-I Metallic Bearings (First Revision)
IRC: 83-1987 Part-II	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-II Elastomeric Bearings
IRC: 89-1997	Guidelines for Design & Construction of River training & control works for

	road bridges.
IRC: 112-2014	Code of practice for Road Bridge.
IRC:SP:33-1989	Guidelines on supplemental Measures for Design, Detailing & Durability of Important Bridge Structures.

Design loads

- **Dead Loads:**

Apart from all the actual dead loads, irrespective of the type of wearing coat and crash barrier proposed, the structure shall be designed to allow for

- Wearing coat load = 2 kN/m^2.
- RCC crash barriers P1 type as per IRC: 6 -2014

- **Live Loads:**

The bridges shall be designed to carry one lane of Class 70R for every two lanes or one lane of Class A for each lane.

- **Seismic Effects:**

(i) Basic horizontal seismic co-efficient - As per zone V
(IRC: 6–2014)

(ii) Importance Factor - as per IRC: 6-2014

Reinforcement detailing of structures shall conform to the provisions of IS 13920

(iii) Soil Foundation factor β = 1.2 for foundations

- **Loading due to Crash barrier:** As per provision of IRC: 6 – 2014
- **Temperature Effect:**

(i) Temperature stresses to be worked out as per Clause 215 of IRC: 6 – 2014.

For design of structure the temperature range to account for temperature effect shall be:

In the present case t = +/- 25^0 C

(ii) The superstructures shall also be designed for effects of distribution of temperature across the deck depth.

- **Differential Settlement:** 6 mm with instantaneous E value of concrete. This will be deemed to cover lifting of superstructure also.

PAVEMENT DESIGN

Design for new pavement has been carried out in accordance with the latest version of IRC: 37-2012.

DRAINAGE

- An effective drainage system for drainage of road shall be designed as per stipulations of IRC SP: 42-1994.
- The road side channel will be rectangular V-shaped of adequate capacity to carry 100% surface runoff of drainage area of highway ROW. It will be drained to the nearest available natural water course. We propose to adopt section R.C.C covered drain in built-up area. This will be lined drain to drain out in the open field or to the defined outfall points. V shaped unlined drain will be adopted in the hard rock hill sections V shaped lined drain will be provided in soil and soft rock sections.
- The superstructure of bridges shall be drained with suitable drainage spouts.

TRAFFIC SAFETY MEASURES

The design layout and materials chosen for the safety barrier shall suitably blend with the surrounding and shall further conform to MOSRT&H circulars and shall be finalized in consultation with and approved by PWD.

TECHNICAL SPECIFICATIONS

- In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the codes, standards and specifications of IRC, MORT&H guide lines and official publications as applicable to National Highways, AASHTO, ASTM, BS or any other international standards in that order. Where even these are silent, the construction and completion of the works shall conform to sound Engineering practice as approved by the Engineer.
- The material to be used in the Project work (including facilities there on) shall conform to MORT&H Specifications for Road & Bridge Works 4th Rev. 2001. Where these specifications are silent in regard to certain specifications for the material in question, in that case, specifications under Bureau of Indian Standard /AASHTO /ASTM/BS shall apply in that order. But where these specifications are silent, the specifications for the material in question shall be got approved from the Independent Consultant.

CHAPTER: 6
TRAFFIC SURVEY & ANALYSIS

6.1 Introduction

Traffic surveys are conducted to understand the traffic behavior pattern of the project road and its surrounding area. The traffic surveys have been carried out along the corridor to establish base year traffic as well as travel characteristics. The baseline traffic characteristics are very important for the assessment of future traffic and travel pattern. The primary objectives of the traffic surveys are to:

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

The project road lies in West Khasi Hills District & starts from Design Chainage 0+335 which is a newly proposed T junction with NH 44E near Nongstoin and after traversing a length of about 73 Km, the project road ends within the Kyrshai town.

6.2 Traffic Survey

Traffic surveys are essential to appreciate the prevailing traffic and travel characteristics of the project influencing area. The traffic surveys were planned and conducted on the, project roads as per the schedule given below. All the traffic surveys were conducted manually by employing sufficient number of enumerators and traffic surveyors. Our traffic experts trained the traffic enumerators prior to commencement of traffic survey.

The surveys carried out are listed in the **Table** below:

Table 6.1 Traffic Surveys Location

S. No.	Type of Survey	Name of Road	Location	Start Date	End Date	No of Days
1	Classified volume count surveys	Between Nongstoin and Rambrai	At km 0+745	6 Feb 2013	12 Feb 2013	7
2	Origin – Destination Survey	On NH-44E near Nongstoin	At km 0+745	6 Feb 2013	7 Feb 2013	1

6.3 Traffic Intensity

In order to establish traffic intensity on project road directional classified traffic volume was conducted for 7 consecutive days.

6.3.1 Classified Traffic Volume Count

Methodology

At the selected traffic volume count locations, the classified directional traffic volume counted over seven consecutive days for 24 hours on each day. The vehicle classification considered was in accordance with IRC-64 and covered cars, jeeps, vans, buses, standard trucks, multi axle vehicles, light goods vehicles, tractors (with and without trolleys), motorised two-wheelers, three wheelers, slow moving vehicles (cycles, cycle rickshaw and carts). Traffic volume data was collected using our standard survey forms, which record the direction-wise traffic for every one Hour on round the clock basis. The road name, the count location, weather, name of the enumerator, time-interval and the traffic direction were recorded.

6.3.2 Analysis

The classified traffic count data collected as above has been analysed for hourly and daily traffic intensity, traffic composition, peak hour factor (PHF), directional distribution, average daily traffic (ADT) and finally annual average daily traffic (AADT) by applying the seasonal correction factors.

Traffic volume analysis has been carried out to assess the volume of traffic, the composition, the hourly variation in traffic over 24 hours, and the daily variation in traffic over 7 days at the project locations. A summary of volume count analysis is detailed in the paragraphs below. The compiled data obtained from field traffic survey have been analysed to work out the average daily traffic in terms of total vehicles and total PCUs. The PCU factors used in the analysis, as referred from IRC: 64 are presented in the Table 6.2.

Table 6.2 PCU Values Used

Vehicle Type	*PCU Factor*
Fast Moving Vehicles	
Car, Jeep and Van	1.0
Three Wheeler (Auto Rickshaw)	1.0
Two Wheeler	0.5
Mini Bus	1.5
Bus	3.0
Light Goods Vehicle (LGV)	1.5
2-Axle Truck	3.0
3-Axle Truck	3.0
Multi-Axle Vehicle (MAV)	4.5
Agricultural Tractor	1.5
Agricultural Tractor with Trailer	4.5
Slow Moving Vehicles	
Cycle	0.5
Cycle Rickshaw	2.0
Animal Drawn Cart	6.0
Hand Drawn Cart	8.0

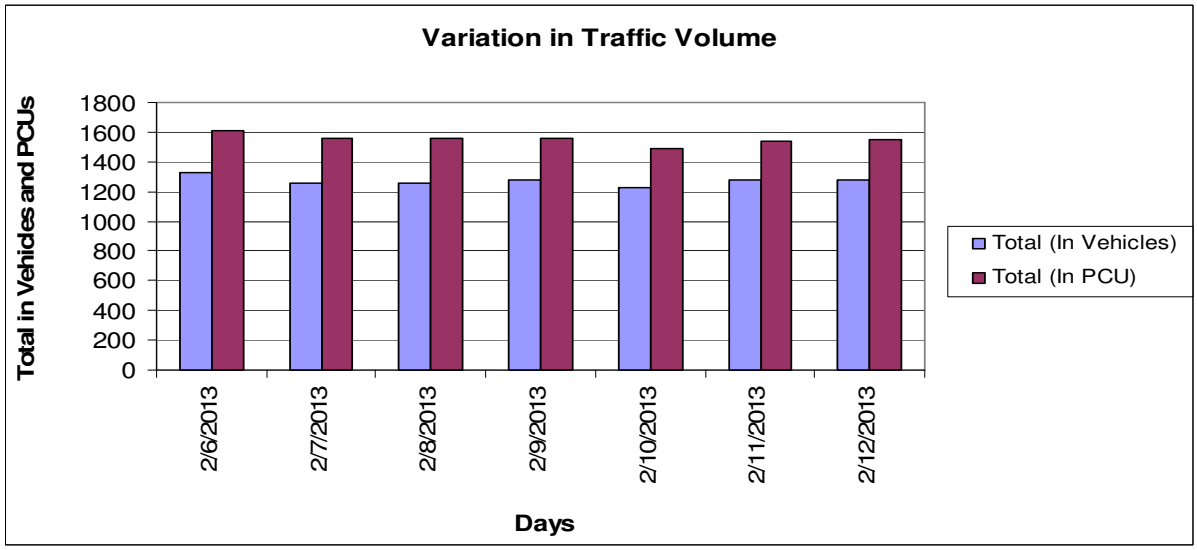
6.4 Traffic Study on Project Roads

The seven day's average classified traffic volume in terms of Number of Vehicles and PCUs direction wise as well a directional split is summarized in the Table and its variation over seven days is shown in Fig 6.1 below.

Table 6.3 Traffic Volumes Summary

Date	Direction: Towards Nongstoin	Direction: Towards Rambarai	Total (In Vehicles)	Total (In PCU)
2/6/2013	704	626	1330	1608
2/7/2013	682	580	1262	1560
2/8/2013	678	579	1257	1560
2/9/2013	678	604	1282	1562
2/10/2013	664	566	1230	1489
2/11/2013	669	608	1277	1538
2/12/2013	682	599	1281	1551
ADT	**680**	**595**	**1274**	**1552**
Directional Split	**53.34%**	**46.66%**		

Figure 6.1 Daily Traffic Volume



6.4.1 Traffic Composition on Nongstoin - Rambrai Road

The traffic composition observed on Nongstion - Rambrai road is analysed and presented in the form of the Pie charts below.

Figure 6.2 Composition of Fast and Slow moving vehicles

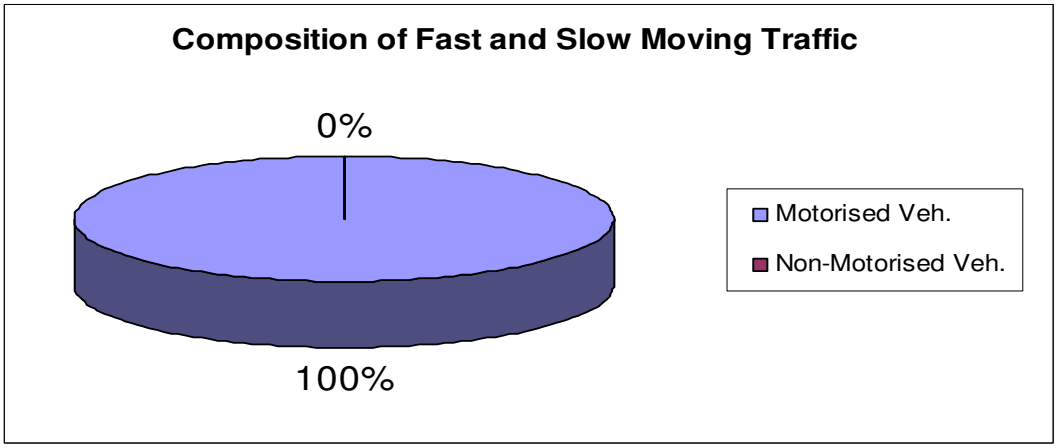
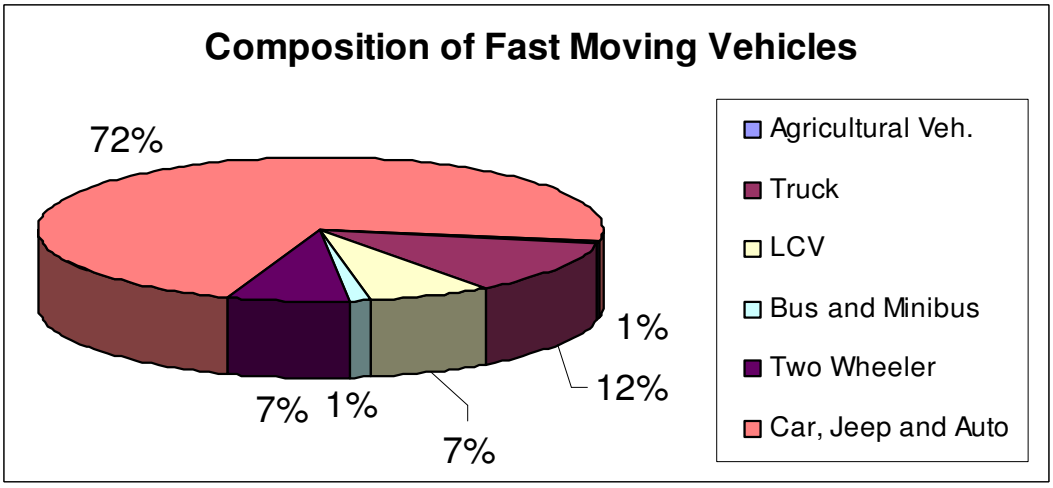


Figure 6.3 Composition of fast moving vehicles



6.4.2 Temporal Variation and Peak Hour Factor

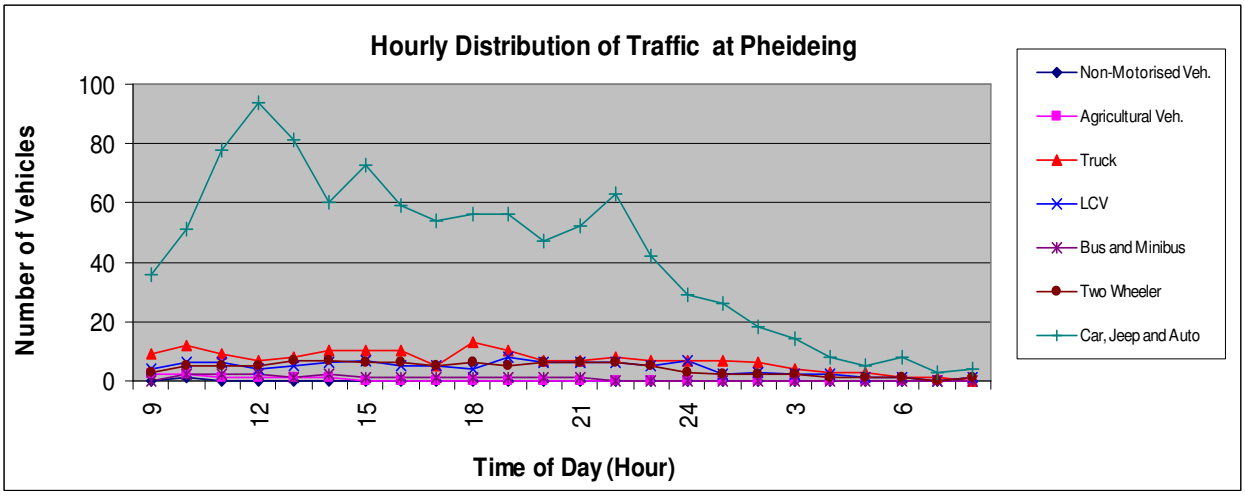
Analysis has been carried out to understand hourly variation and peak hour traffic characteristics on the Project roads. The hourly distribution of traffic at Project location is illustrated in **figure.** The Peak Hour Factor (PHF) (defined as the ratio between the number of vehicles in terms of PCU counted during the peak hour to the total vehicles in

terms of PCU counted in same day) calculated at count locations is presented in the **Table 6.4** below

Table 6.4 Peak Hour Factor

Name of Road	Survey Location	Peak Hour Volume (PCU)	Total Volume (PCU)	PHF (in %)	Peak Hour (Hrs.)
Nongstoin-Rambrai	At km 0+745	131	1771	7.40	9:00-10:00

Figure 6.4 Hourly Distribution of Traffic for Nongstoin-Rambrai Road



6.4.3 Seasonal Correction Factors

The traffic plying on any road generally varies over different periods of year depending on the cycle of different socio-economic activities in the regions through which it passes. Therefore, in order to have more realistic picture of the traffic on the project road, it is required to assess seasonal variation in traffic to estimate Annual Average Daily Traffic (AADT) and Peak Season ADT. Therefore, the ADT observed during the survey is multiplied by a Seasonal Correction Factor (SCF) to derive AADT and Peak season ADT. The seasonal correction factor is generally derived from secondary data sources such as past month-wise traffic data on the project road, monthly toll revenues from existing tolled highways in the immediate influence area, sales of fuel at different filling stations along the project highway etc.

In the absence of any other data, either of the project road or in the vicinity, only the monthly figures of fuel sales collected from one petrol pump on the project road is considered in the estimation of seasonal variation and seasonal correction factors.

Traffic surveys were carried out in the month of Feb.'13. To account for seasonal variation and to estimate average annual daily traffic (AADT), seasonality factors have been estimated on the basis of sale of motor spirit and high-speed diesel. Seasonal factors have been estimated for private passenger vehicle modes and commercial vehicle modes. Table 6.5 presents conversion factors:

Table 6.5 Seasonal Factor

Seasonal Correction Factor		
Name of Road	**Petrol Vehicles**	**Diesel Vehicles**
Nongstoin-Rambrai Road	1.11	1.09

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

6.4.4 Annual Average Daily Traffic (AADT)

The AADT on Project Roads as been arrived by multiplying the seasonal factor with Average daily traffic (ADT).The AADT is given below in the Tables.

Table 6.6 Annual Average Daily Traffic (AADT)

Type of Vehicles	AADT
Car	1008
Jeep, Van (New Tech)	0
3-Wheeler including Auto Rickshaw	79
Two Wheeler	81
Mini bus	11
Standard Bus	0
Private Bus	0
Light Goods Vehicle (Passenger)	92
Light Goods Vehicle (Goods)	0

Type of Vehicles	AADT
2-axle Truck	122
3-axle Truck	18
Multi-axle Truck Semi Articulated	0
Multi-axle Truck Articulated	0
Agri. Tractor	0
Agri. Tractor with Trailer	6
Pedal Cycle	1
Cycle Rickshaw	0
Hand Cart	0
Animal Cart	0
Total Vehicle	**1418**
Total PCU	**1730**

Axle load Survey

Axle load survey for the project road is not required as the volume of traffic is low. Hence a VDF of 1.5 has been assumed as per IRC 37-2012 clause No 4.4.6.

6.5 Travel Pattern

6.5.1 Origin & Destination Survey

Methodology

The OD survey was conducted continuously for 24hrs on working day. These surveys were conducted for both passenger and goods vehicles. Roadside interview method was adopted for conducting OD survey. Vehicles for OD survey were selected on a random sampling basis in both directions. The successful completion of these surveys with a large sample has been achieved through adequate assistance from the local police to stop the vehicles for interviewing the road users.

Analysis

The OD survey data was analyzed to study the traffic movement on road links in project influence area to assess the potential divertible traffic under various development scenarios. Towards this, a comprehensive traffic zone system was designed to understand the influence area of the project road. During the analysis, vehicle type wise OD matrices were developed so as to assess the influence area for

each vehicle type. The O-D matrix & desire line diagrams have been presented in Annexure.

Information from Passenger vehicles included origin, destination, travel time, purpose, frequency of travel, while from the goods traffic, information of the type and payload of commodity carried along with the information as stated for passenger vehicles was collected.

A reasonable sample size for different types of vehicles was considered depending on the magnitude of traffic flows. Output derived from this survey in terms of O-D trip length, purpose of travel for different modes was obtained to assess the magnitude of local and through traffic, trip length distribution, frequency of trips, purpose of trips etc.

The locations of O-D survey are same as classified volume count as given in the Table 6.1. Travel patterns for passenger and goods traffic were established on the basis of these surveys.

6.5.2 Zoning for Project Roads

For delineating the zoning system, the entire country was broadly divided into two regions. These are, Immediate Influence Area (IIA) and Broad Influence Area (BIA) of the project. The area adjacent to the project road, which contributes most of the trips, observed on the project road, namely, Nongstoin, Rambrai and rest of West Khasi Hill constitute Immediate Influence Area (IIA), where as, other districts of Meghalaya, and other states in the country constitute Broad Influence Area (BIA). In all 12 zones were defined for the project, while defining zone boundaries the following were considered:

- Important towns and industrial areas along or near the Project Road
- Administrative boundaries, e.g. district and state boundaries.
- Important roads in the region, like, SH, other link roads, etc.

The OD matrices for individual vehicle types (Cars & Jeeps, Buses, Trucks) at project location were derived from coded OD data. The OD matrices produced from the analysis at project locations were then assigned to project Road and their network to assess number of vehicles category wise passing through the project road. OD matrix & desire line diagram have been shown in appendix.

Table 6.7 Zoning system adopted for OD analysis

Zone No.	Zone Name/ Description
1	Nongstoin
2	Rambari
3	Rest of West Khasi Hills
4	East Khasi Hills
5	RI-Bhoi
6	Jaintia Hills
7	East Garo Hills
8	South Garo Hills
9	West Garo Hills
10	Guahati Side (Assam)
11	Goaparan Side (Assam)
12	Arunachal Pradesh

6.5.3 Trip Distribution

The O-D matrix estimates describing the travel pattern of both goods and passenger vehicles observed at both the O-D survey locations are analysed. Internal zones may be defined as immediate influence area and external as rest zones defined in the zoning system.

Of the total goods traffic observed at the O-D survey location, about 39.18% generates (including both originating and terminating traffic) internally, 2.06 % traffic generates externally.

Table 6.8 O-D Matrix for Goods Vehicles for Project Road

	Internal	External
Internal	**39.18%**	**11.34%**
External	**47.42%**	**2.06%**
Total	**100.00%**	

Of the total passengers traffic observed at the O-D survey location, about 46.64% generates internally, 2.37% traffic generates externally.

Table 6.9 O-D Matrix for Passenger Vehicles

	Internal	External
Internal	**46.64%**	**12.25%**
External	**38.74%**	**2.37%**
Total	**100.00%**	

6.6 Axle load Survey

In case of Nongstoin – Rambrai – Kyrshai road, sufficient information on axle load is not available due to less traffic, VDF has been assumed as given in IRC: 37-2012.

As sufficient information on axle load is not available due to less traffic in case of Nongstoin – Rambrai – Kyrshai road, VDF has been assumed as given in IRC: 37-2012. IRC recommended value of VDF for the traffic range of 150-1500 is 1.5 for trucks, is adopted in the Design .The detailed analysis of axle load survey has been presented in Annexure.

6.7 TRAFFIC DEMAND FORECASTING

Traffic growth rate have been estimated by adopting "Elasticity of Transport Demand Method". As it is coming 5%, hence realistic growth rate for traffic projection has been adopted for project road. as per IRC 37-2012 clause 4.2.2.

Nongstoin – Rambrai - Kyrshai Road: After analyzing the project influence area, it was found that traffic volume is low on existing road at present due to poor geometrics, poor condition of road & improper connectivity from Rambrai to Kyrshai, once the road is developed, significant amount of diverted & generated traffic would add to current traffic on the road., traffic that flows from external zone (zone 4 to zone 12) to internal zone (zone 1 to zone 3) mostly moves via shillong. There are significant numbers of vehicles moving from Guhati, dispur (zone 10) to Nongstoin (zone 1). Once the project road is developed, this traffic will be diverted on the project road. Traffic originating from zone 10, 5, 11 and moving towards zone 1, 3, 4, 8 have to move via Shillong, as there is no other good road available. Development of project road will attract this traffic.

Traffic projection (based on diverted, generated & develoment traffic) is shown in table 6.10.

Table No 6.10 Traffic Projections

Year	Car	3-Wheeler including Auto Rickshaw	Two Wheeler	Mini bus	Standard Bus	Light GoodsVehicle (Passenger)	2-axle Truck	3-axle Truck	Multi-axle Truck Articulated	Agri. Tractor with Trailer	Pedal Cycle	Total Fast Moving Vehicles	Total Slow Moving Vehicles	Total Vehicles	PCU(Fast Moving)	PCU(Slow Moving)	Total PCU
2013	1008	79	81	11	0	92	122	18	0	6	1	1417	1	1418	1729	1	1730
2014	1058	83	85	12	0	97	128	19	0	6	1	1488	1	1489	1815	1	1816
2015	1111	87	89	12	0	101	135	20	0	7	1	1562	1	1563	1906	1	1907
2016	1167	91	94	13	0	107	141	21	0	7	1	1640	1	1642	2002	1	2002
2017	1225	96	98	13	0	112	148	22	0	7	1	1722	1	1724	2102	1	2102
2018	1286	101	103	14	0	117	156	23	0	8	1	1808	1	1810	2207	1	2207
2019	1351	106	109	15	0	123	163	24	0	8	1	1899	1	1900	2317	1	2318
Construction Period of 2.5 Years																	
2020	1418	111	114	15	0	129	172	25	0	8	1	1994	1	1995	2433	1	2434
2021	1489	117	120	16	0	136	180	27	0	9	1	2094	1	2095	2555	1	2555
2022	1564	123	126	17	0	143	189	28	0	9	2	2198	2	2200	2682	1	2683
Diverted traffic after construction of road																	
Diverted traffic	782	61	63	9	0	71	95	14	0	5	1	1099	1	1100	1341	0	1342
Total Traffic	**2346**	**184**	**188**	**26**	**0**	**214**	**284**	**42**	**0**	**14**	**2**	**3297**	**2**	**3300**	**4023**	**1**	**4025**

6.8 CAPACITY ANALYSIS

Capacity analysis for project road has been carried out in order to define the level of service offered by road section under the prevailing roadway and traffic conditions.

6.8.1 Capacity and Level of Service Guidelines

Capacity and design service volumes for various lane configurations specified by IRC-64-1990 "Capacity of Roads in Rural areas " has been adopted for determining the Level of Service offered by the road sections during design period. As per IRC-64-1990 under normal circumstances, use of LOS B is considered adequate for the design of rural highways. At this level, volume of traffic will be around 0.5 times the maximum capacity and this can be taken as design service volume. These capacity and design service volumes are presented in Table 6.11 below.

Table 6.11 Recommended design service for intermediate lane road

S.No	Terrain	Curvature (Degrees per Kilometer)	Design Service Volume in PCU/day
1	Plain	Low (0 - 50)	6000
		High (above 51)	5800
2	Rolling	Low (0 -100)	5700
		High (above 101)	5600
3	Hilly	Low (0 -200)	5200
		High (above 201)	4500

6.8.2 Capacity Augmentation

Projected Annual average Daily Traffic is compared with Design Service Volume as Recommended in IRC 64-1990. The design LOS for project road is considered as LOS B and capacity augmentation is suggested when traffic volume on the project road exceeds the design service volume.

The analysis shows that projected traffic on Nongstoin – Rambrai - Kyrshai road demands 2 lane road by 2024.

CHAPTER – 7

ENGINEERING DESIGN & IMPROVEMENT PROPOSALS

7.1 Identification of Improvement

The project corridor does not conform even to single-lane standard of IRC at some locations. Therefore while deciding the improvements, the need of highway users, environmental/ social integrity, existing right of way, constraints along the existing road like congestion etc. have been fully considered. Project road has been planned for 2 lanes with earthen shoulder up-gradation. The following improvements are required to upgrade it to 2 lane with earthen shoulders as per IRC standards.

1 Widening of the existing road to 2-lane with earthen shoulders.

2 Widening of existing cross drainage works including construction of new CD works to 2 lane standard.

3 Adequate shoulder paved/ unpaved.

4 Adequate cross-fall.

5 Easing of sharp horizontal curves.

6 Co-ordination of horizontal and vertical alignments.

7 Adequate roadside drainage.

8 Strengthening of existing pavement.

9 Improvement of Road junctions.

10 Proper safety features, road furniture and road markings.

11 Arboriculture and Landscaping.

12 Road appurtent works like rest areas; bus stop, parking areas etc.

7.2 Widening Option

Normally in a widening project, new carriageway is located on the side of the existing one so that the latter is fully utilised and work on the former can proceed without undue hindrance to public traffic. However, this aspect becomes critical when the existing road is

concentric with the ROW and the road land is limited in width. The project road falls under this category, and for such cases fixing the location of the widening carriageway becomes a crucial issue to be decided upon at the initial stage itself so that the improvement measures could be appropriately tailored, the land acquisition needs are identified and the social impacts are ascertained to develop rehabilitation and resettlement of project affected persons. This issue has accordingly been addressed, and the manner of developing recommendations in this regard through matrix analysis is described hereunder:

a) For the 2-laning project, the following three possibilities are available:

i) Locating new portion of the carriageway on the left of the existing one. This will call for work operations and more land on the left of the existing road.

ii) Similar to (i) above but the new portion of the carriageway located on the right of the existing road.

iii) Widening symmetrical about the centre of the existing road.

b) The objectives of the widening scheme have been taken to be as follows:

i) It should be conducive for use of the existing carriageway to the maximum extent possible. But the present road does not qualify to be used; only the existing roadway width can be used.

ii) It should cause least disturbance to the environment, i.e. to avoid heavy cut/fill, obstruction to watercourses, acquisition of built-up area, spilling on to protected forestland etc.

iii) It should be compatible with the operational requirements (speed, safety, comfort)

iv) It should be accommodated within the existing ROW to the maximum extent feasible.

c) For fulfilling the objectives at b) above, the following physical considerations in descending order of precedence were taken into account:

i) Wherever possible the existing roadway width will be used.

ii) Alignment shall be decided to avoid acquisition of structures

iii) It should suit location of major bridges and their approaches

iv) For better safety and convenience in operation, widening will not generally be changed from one type to other in less than 5 km unless otherwise warranted by site conditions.

v) In the overall, the project should be economical to construct and operate.

For improvement of existing road with earthen shoulders is proposed including the improvement of substandard curves, construction of bypass and realignments in the built up areas. Symmetrical widening is proposed in the existing road reaches which shall from part of the improved facility.

Symmetrical widening is considered to be more suitable in built-up reaches. It will facilitate construction in stages and make best use of the land available. Whereas unsymmetrical or eccentric widening on left or right side of existing road mostly in rural stretches shall involve acquisition of minimum of additional land strip through out the corridor for the road formation, embankment construction and drainage system.

Therefore in view of the present scenario and the TOR requirement proposals for locating the widening of carriageway have been worked out mostly concentric and eccentric widening will be followed only at those location where geometric improvement is required or depending upon the existing topographic features and available ROW.

7.3 Alignment Proposals

As alignment passes through hilly terrain, there are sharp curves and steep gradient on existing alignment. Curve improvements have been proposed between Nongstoin and Rambrai. After Rambrai, there is existing Katcha & jungle track having very sharp curves and steep gradients. Gradients go up to 10-12% at some locations. It is not possible to follow the existing jungle track after Rambrai. New alignment has been proposed after km 21 to provide good geometrics. New alignment is more or less near to existing alignment.

As per the directions of NHIDCL the consultant has divided the project into three Packages

as per the table below

Table 1: Package Detail

Package No.	From(Km)	To (Km)	Length(Km)
1	0+335	34+039	33.704
2	35+155	53+500	18.345
3	53+500	72+863	19.363
Total	**0+335**	**72+863**	**71.412**

In general, Project road has been designed for a speed more than 40kmph but at few locations, 30kmph speed has been provided in unavoidable circumstances due to steep terrain. Proposed Vertical gradient is not exceeding 6% along the project road.

7.3.1 Cross section schedule

Description of Typical cross section used in project roads, are given below:

TCS - 1: 2 Lane Carriageway for New Construction (One side hill)

TCS - 2: 2 Lane Carriageway for New Construction (Box Cut section)

TCS - 3: 2 Lane Carriageway for widening (one side Hill)

TCS - 4: 2 Lane Carriageway for widening (Box Cut section)

TCS - 5: 2 Lane Carriageway for Built-up section

Typical cross sections have been shown in drawing volume.

The Widening schedule proposed for 2 lanes is given in table 7.1

Table 7.1: Widening Schedule

Sl No	From	To	TCS Type	Length
Package-1				
1	0+335	2+300	5	1965
2	2+300	2+370	2	70
3	2+370	2+430	3	60
4	2+430	2+510	3	80
5	2+510	2+900	2	390
6	2+900	3+550	3	650
7	3+550	3+640	2	90
8	3+640	4+800	3	1160
9	4+800	4+900	4	100
10	4+900	5+100	2	200
11	5+100	5+400	4	300
12	5+400	6+310	3	910
13	6+310	6+580	2	270

Sl No	From	To	TCS Type	Length
14	6+580	6+880	3	300
15	6+880	6+930	2	50
16	6+930	7+420	3	490
17	7+420	7+680	2	260
18	7+680	7+700	3	20
19	7+700	8+300	2	600
20	8+300	8+537	3	237
21	8+537	8+927	2	390
22	8+927	9+700	3	773
23	9+700	9+750	2	50
24	9+750	10+500	3	750
25	10+500	10+650	2	150
26	10+650	10+790	3	140
27	10+790	10+830	2	40
28	10+830	11+750	3	920
29	11+750	12+100	2	350
30	12+100	12+350	3	250
31	12+350	12+450	2	100
32	12+450	12+680	3	230
33	12+680	12+790	2	110
34	12+790	14+950	3	2160
35	14+950	15+200	2	250
36	15+200	16+790	3	1590
37	16+790	16+950	2	160
38	16+950	17+010	3	60
39	17+010	18+020	5	1010
40	18+020	18+120	2	100
41	18+120	18+410	3	290
42	18+410	18+690	2	280
43	18+690	19+630	3	940
44	19+630	19+700	2	70
45	19+700	20+700	3	1000
46	20+700	22+780	1	2080
47	22+780	22+820	2	40
48	22+820	23+050	1	230
49	23+050	23+450	2	400
50	23+450	23+880	1	430
51	23+880	24+110	2	230
52	24+110	27+100	1	2990
53	27+100	27+250	2	150
54	27+250	28+200	1	950
55	28+200	28+350	2	150
56	28+350	30+250	1	1900
57	30+250	30+350	2	100
58	30+350	34+039	1	3689

Sl No	From	To	TCS Type	Length
Package-2				
59	35+155	39+780	1	4625
60	39+780	40+200	2	420
61	40+200	41+340	1	1140
62	41+340	41+590	2	250
63	41+590	44+420	1	2830
64	44+420	44+530	2	110
65	44+530	53+500	1	8970
Package-3				
66	53+500	58+020	1	4520
67	58+020	58+380	2	360
68	58+380	64+750	1	6370
69	64+750	64+960	2	210
70	64+960	72+863	1	7903

7.3.2 Realignment / Curve Improvement proposed along the project road

The improvement of horizontal alignment was done due to sub-standard geometrics and sharp curves in the project road. As discussed in para 7.3**,** from Rambrai (km 20+700) to Kryshai (km 72+863) realignment/new alignment has been proposed.

Following table shows realignment proposed along the project road.

Table 7.2: Realignment / Curve Improvement for along the Project Road

S.No.	From	To	Length	Remarks
1	6+310	6+580	270	Curve Improvement
2	6+880	6+930	50	Curve Improvement
3	7+420	7+680	260	Curve Improvement
4	7+700	8+300	600	Curve Improvement
5	8+537	8+927	390	Curve Improvement
6	9+700	9+750	50	Curve Improvement
7	10+500	10+650	150	Curve Improvement
8	10+790	10+830	40	Curve Improvement
9	11+750	12+100	350	Curve Improvement
10	12+350	12+450	100	Curve Improvement
11	12+680	12+790	110	Curve Improvement
12	14+950	15+200	250	Curve Improvement
13	16+790	16+950	160	Curve Improvement
14	18+020	18+120	100	Curve Improvement
15	18+410	18+690	280	Curve Improvement
16	19+630	19+700	70	Curve Improvement
17	20+700	72+863	52163	New Alignment

7.4 INTERSECTION DESIGN

7.4.1 General

The basic requirement for the design of intersections is not only to cater safe movements for the driver but also to provide them full traffic information by way of signs, pavement markings and traffic signals. At-grade intersections adversely affect the quality of highway in terms of speed, capacity and safety because of interruptions to traffic flow. 4 legged intersections are more hazardous than 3 legged intersections.

Further, simplicity and uniformity is the guiding principles for intersections design and to ensure the safe passage of maneuvers and reduce conflict points either by elimination of certain maneuvers or separated in space, horizontally or vertically. Based upon these principles the At-grade intersections have been designed as minor / channelised without acceleration and deceleration lanes/ staggered / rotaries/ intersections deepening upon the following parameters.

- Traffic volume and number of lanes on the project road;
- Traffic volume and number of lanes on the cross road;
- Turning traffic volumes;
- Type and category of cross road;
- Maneuvers like diverging, merging, weaving, crossing and reduced conflicts;
- Site conditions / constrains; and
- Any local importance

Standard drawings of the Junctions are given in the drawing volume of the report.

7.4.2 Warrants

IRC: SP-:41 give the monogram for warrants for the different types of at grade or grade separated intersections. These warrants are based upon the traffic volumes on each of the two intersecting road. The type of intersection proposed are based on these IRC guidelines.

Keeping in view the guidelines given in IRC: SP-41 and MORTH Type Designs for Intersections. **Table 7.4** gives the locations of priority intersections with important roads and the recommended configuration for improvement.

Table 7.4: Details of Major/Minor intersections

S. No.	Location of intersection (km)	Type of intersection	Other features
1	0+335	T	Intersection with NH-44E(Starting point of alignment
2	0+450	Y	Cross road leading to Nongstoin town
3	0+800	T	Village Road
4	4+100	T	Village Road
5	5+400	+	Intersection with NH-44E bypass
6	8+610	T	Village Road
7	8+800	T	Village Road
8	10+330	T	Village Road
9	15+950	T	Village Road
10	17+250	T	Village Road
11	17+740	T	Village Road
12	18+650	T	Village Road
13	72+525	T	Connect to Kyrshai Village via Bridge

7.5 Pavement Design

7.5.1 General

For the present project, pavement design exercise has been carried out to determine the total thickness of the pavement structure for good performance against traffic loading.

7.5.2 Design Methodology

The Consultants adopted the following methodologies for designing the pavement under different situations:

i) Overlay for strengthening existing pavement

Strengthening existing pavement has not been proposed due to poor condition of

pavement.

ii) New Pavement Design

Initial design by IRC: 37-2012 using soaked CBR data for borrow material expected to be used in Subgrade.

7.5.3 Parameters for Design

Design Life

The design life adopted in the analysis is 20 years.

Design Traffic

a) Traffic Distribution Factors

Lane distribution factor of 0.5 have been adopted.

b) Vehicle Damage Factor

The vehicle damage factor (VDF) for different types of commercial vehicles as derived from the axle load study shall be for MSA calculations. As the traffic volume on project road is low, there is no requirement for axle load survey. VDF value has been adopted as per IRC 37-2012 clause 4.4.6. The details are presented in Traffic Chapter 6.

c) Equivalent Standard Axle (ESA) Applications

Based on the traffic forecast prepared in Chapter 6, and the VDF values and traffic distribution factors brought out earlier, the traffic loading in the design life in terms of cumulative number of ESA has been computed for design periods.

7.5.4 Design of Flexible Pavement

General

Design of flexible pavement applies to the new carriageway and widening of existing carriageway. The methodologies recommended in IRC: 37-2012 has been adopted and the final designs recommended are based on best engineering judgment.

i) Proposal for existing road

Due to poor condition of existing road, scarification of existing road will be done and scarified surface will be treated as Subgrade top and reconstruction will be done with GSB, WMM, DBM and BC.

ii) Proposal for new road

Flexible pavement shall be adopted for Project Highway. Pavement has been designed for 20 years for 10 MSA and 8% CBR. The crust details are as under

Type	Pavement Thickness
BC	40
WMM	150
CTSB	200

7.6 Extra widening at Curves

Extra widening to be provided on horizontal curves is shown in table below:

Radius of Curve (m)	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Two Lane	1.5	1.2	0.9	0.6	Nil

7.7 GUARD RAILS/ METAL BEAM CRASH BARRIER

Pedestrian guardrail has been designed to control and guard pedestrian and road crossing movements' safety.

W-Beam Metal Crash Barrier have been designed for the major hazard locations e.g. on road sections where embankments height is more than 3m or in bridge approaches.

7.8 TRAFFIC CONTROL DEVICES

Some of the sharp curves are improved and at some of the locations precautionary boards are recommended.

MARKING & SIGNAGES

Traffic sings and markings are important features of traffic control designs as they transmit visually vital information to drivers and ensure increased safety and efficiency in free flow of traffic. IRC standards IRC: 67-2012 for road signs and IRC: 35-1997 for road markings shall be followed. The road markings shall be applied to lane lines, road centerline, edge lines, continuity line, zebra crossing etc. The proposed road signs are:

Mandatory/ Regulatory Signs

- Stop
- Give way
- Overtaking prohibited
- Compulsory Keep Left
- Speed limit
- Restriction ends
- Buses only
- No parking
- Restriction ends
- U-tern prohibited
- No stopping/parking

Cautionary/ Warning Signs

- Right/ Left Hand Curves
- Narrow Bridge
- Gap in Median
- Pedestrian crossing
- School
- Cattle
- Cross Road
- T/Y intersections

Informatory Signs

- Advance Direction
- Destination
- Direction
- Reassurance
- Place identification
- Toll Booth Ahead
- Public Telephone
- Filling Stations
- Hospital
- First Aid post
- Eating place
- Resting place
- Repair facilities
- Police Station
- Railway station
- Bus Stop
- Route maker

The Traffic signs shall be displayed at suitable locations.

7.9 FACILITIES FOR PEDESTRIANS

Facilities for safe and unhindered movement of pedestrians and cyclists are proposed on the project highway wherever it passes through urban/built up area in accordance with the provisions contained in IRC: 103

7.10 USER FACILITIES

For safe and comfortable journey of road users, following facilities shall be provided.

- Bus Stops
- Truck Lay Bye
- Toll Plaza

7.10.1 PICKUP BUS - STOP

The governing consideration for locating bus stops is the overall safety and minimum interference to the through traffic. Normally, the bus stops are sited away from bridges and other important structures, from embankment section, which are more than four meters high as from horizontal curves and from top of vertical curve summit. The need for good visibility all around corresponding to safe stopping right distance is also kept in view. Bus stops are not located too close to the road intersection. A gap of 300 meters from the tangent point of intersection to start/ end of the lay bye is desirable particularly at the junction with the main roads.

The bus stop shall normally be at an interval of 3 Kms. These shall be provided in both directions. Each bus stop shall also have a passenger shelter. There are 26 nos. of Bus stop proposed along the project road at following locations.

Sl No	Chainage	Side	Sl No	Chainage	Side
1	0+550	RHS	14	0+650	LHS
2	1+180	RHS	15	1+220	LHS
3	4+660	RHS	16	4+600	LHS
4	9+000	RHS	17	8+750	LHS
5	11+450	RHS	18	11+500	LHS
6	15+550	RHS	19	15+575	LHS
7	17+300	RHS	20	17+350	LHS
8	17+750	RHS	21	17+725	LHS
9	29+250	RHS	22	29+200	LHS
10	37+850	RHS	23	37+800	LHS
11	42+050	RHS	24	42+000	LHS
12	63+250	RHS	25	63+200	LHS
13	69+550	RHS	26	69+500	LHS

7.10.2 Truck Lay bye

No truck lay bye has been proposed.

7.10.3 Toll Plaza

No Toll Plaza has been proposed on the Project Road.

7.11 Development of Bridges /Structures

There are 5 existing bridges on the project road. All the bridges are wooden/timber

constructed, hence are to be reconstructed. 7 additional new bridges has been proposed.

A summary of the existing bridges/New proposed bridges and respective improvement proposed as given in table no 7.5

Table: 7.5 Structure Details

Sl No	Existing Chainage (km)	Design Chainage (km)	Span Arrangement	Proposal	Type
1		0+410	1x24	New Construction	RCC Girder
2	6+755	6+500	1x 14	Reconstruction	RCC Girder
3	7+925	7+600	1x 8	Reconstruction	RCC Slab
4	13+122	12+340	1x 14	Reconstruction	RCC Girder
5	16+420	15+495	1 x 10	Reconstruction	RCC Slab
6	19+910	18+890	3x14	New Construction	PSC Girder
7	-	41+100	2x14	New construction	RCC Girder
8	-	60+600	1X8	New construction	RCC Slab
9	-	64+540	1X8	New construction	RCC Slab
10	-	67+770	1X14	New construction	RCC Girder
11	-	69+460	1X10	New construction	RCC Slab
12	-	72+664	4X32	New construction	PSC Girder

7.12 Culverts

Based on culverts inventory and structural condition, broadly following treatments are recommended:

a) Minor Repairs: Culverts in good condition, widening not required, cleaning of vegetation is required, and clearing blockage is required.

b) Major Repair: Culverts in good condition, widening not required, parapet to be repaired and constructed, plastering and pointing required.

c) Repair and Widening: a) + b) and Widening required

d) Reconstruction: Reconstruction due to bad condition, insufficient capacity, change in vertical profile.

7.12.1 Culvert

There are 133 culverts existing along, out of which 111 are stone slabs, 6 are slab culverts, 3 wooden culverts and 13 pipe culverts. The structural conditions of culverts are generally poor to very poor. Most of the culverts are fully or partially choked. Consultant has proposed 349 culverts for new/reconstruction on the project road and all of them are box culverts.

Table: 7.6 Proposed Culvert Details

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
Package 1				
1	0+445	1	1.5	RCC Box
2	0+563	1	2	RCC Box
3	0+810	2	3	RCC Box
4	1+100	1	2	RCC Box
5	1+338	1	2	RCC Box
6	1+535	1	2	RCC Box
7	1+590	1	2	RCC Box
8	1+745	1	2	RCC Box
9	1+800	1	1.5	RCC Box
10	1+867	1	1.5	RCC Box
11	1+905	1	2	RCC Box
12	2+200	1	2	RCC Box
13	2+270	1	1.5	RCC Box
14	2+335	1	1.5	RCC Box
15	2+485	1	1.5	RCC Box
16	2+600	1	1.5	RCC Box
17	2+650	1	2	RCC Box
18	2+710	1	1.5	RCC Box
19	2+775	1	2	RCC Box
20	2+966	1	1.5	RCC Box
21	3+390	1	1.5	RCC Box
22	3+480	1	1.5	RCC Box
23	3+610	1	2	RCC Box
24	3+740	1	2	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
25	3+880	1	2	RCC Box
26	3+965	1	1.5	RCC Box
27	4+035	1	1.5	RCC Box
28	4+095	1	2	RCC Box
29	4+145	1	2	RCC Box
30	4+285	1	1.5	RCC Box
31	4+380	1	1.5	RCC Box
32	5+080	1	1.5	RCC Box
33	5+445	1	1.5	RCC Box
34	5+570	1	2	RCC Box
35	5+660	1	2	RCC Box
36	5+765	1	2	RCC Box
37	5+840	1	2	RCC Box
38	5+900	1	1.5	RCC Box
39	6+000	1	1.5	RCC Box
40	6+020	1	1.5	RCC Box
41	6+060	1	1.5	RCC Box
42	6+130	1	2	RCC Box
43	6+210	1	2	RCC Box
44	6+260	1	1.5	RCC Box
45	6+390	1	2	RCC Box
46	6+440	1	2	RCC Box
47	6+640	1	2	RCC Box
48	6+680	1	2	RCC Box
49	6+810	1	2	RCC Box
50	6+875	1	2	RCC Box
51	6+960	1	1.5	RCC Box
52	7+000	1	1.5	RCC Box
53	7+055	1	1.5	RCC Box
54	7+155	1	2	RCC Box
55	7+200	1	1.5	RCC Box
56	7+310	1	1.5	RCC Box
57	7+685	1	1.5	RCC Box
58	8+055	1	1.5	RCC Box
59	8+390	1	2	RCC Box
60	8+635	1	2	RCC Box
61	8+925	1	1.5	RCC Box
62	9+100	1	1.5	RCC Box
63	9+240	1	1.5	RCC Box
64	9+305	1	1.5	RCC Box
65	9+380	1	2	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
66	9+450	1	2	RCC Box
67	9+570	1	1.5	RCC Box
68	9+735	1	2	RCC Box
69	9+770	1	1.5	RCC Box
70	9+800	1	2	RCC Box
71	10+000	1	1.5	RCC Box
72	10+025	1	1.5	RCC Box
73	10+050	1	1.5	RCC Box
74	10+360	1	1.5	RCC Box
75	10+655	1	2	RCC Box
76	10+700	1	1.5	RCC Box
77	10+750	1	1.5	RCC Box
78	11+030	1	1.5	RCC Box
79	11+140	1	1.5	RCC Box
80	11+245	1	2	RCC Box
81	11+490	1	1.5	RCC Box
82	11+630	1	1.5	RCC Box
83	11+735	1	2	RCC Box
84	11+845	1	2	RCC Box
85	12+065	1	2	RCC Box
86	12+165	1	1.5	RCC Box
87	12+495	1	2	RCC Box
88	12+525	1	1.5	RCC Box
89	12+620	2	3	RCC Box
90	12+870	1	1.5	RCC Box
91	12+930	1	1.5	RCC Box
92	13+030	1	2	RCC Box
93	13+195	1	1.5	RCC Box
94	13+290	1	1.5	RCC Box
95	13+385	1	2	RCC Box
96	13+525	1	1.5	RCC Box
97	14+010	1	1.5	RCC Box
98	14+590	1	1.5	RCC Box
99	14+690	1	1.5	RCC Box
100	14+860	1	1.5	RCC Box
101	15+090	1	1.5	RCC Box
102	15+240	1	2	RCC Box
103	15+390	1	1.5	RCC Box
104	15+605	1	2	RCC Box
105	15+975	1	2	RCC Box
106	16+340	1	2	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
107	16+605	1	2	RCC Box
108	16+720	1	2	RCC Box
109	16+845	1	1.5	RCC Box
110	16+900	1	2	RCC Box
111	16+980	1	1.5	RCC Box
112	17+030	1	1.5	RCC Box
113	17+105	1	1.5	RCC Box
114	17+350	1	2	RCC Box
115	17+500	1	2	RCC Box
116	17+680	1	1.5	RCC Box
117	17+760	1	1.5	RCC Box
118	17+885	2	2	RCC Box
119	18+105	1	1.5	RCC Box
120	18+540	1	1.5	RCC Box
121	18+640	1	2	RCC Box
122	18+685	1	2	RCC Box
123	18+995	1	1.5	RCC Box
124	19+040	1	1.5	RCC Box
125	19+195	1	2	RCC Box
126	19+280	1	3	RCC Box
127	19+390	1	2	RCC Box
128	19+555	1	2	RCC Box
129	19+670	1	1.5	RCC Box
130	19+765	1	2	RCC Box
131	19+835	1	1.5	RCC Box
132	19+915	1	2	RCC Box
133	20+035	1	2	RCC Box
134	20+125	1	2	RCC Box
135	20+310	1	2	RCC Box
136	20+410	1	2	RCC Box
137	20+670	1	2	RCC Box
138	20+960	1	2	RCC Box
139	21+300	1	1.5	RCC Box
140	21+485	1	2	RCC Box
141	21+685	1	2	RCC Box
142	21+960	1	2	RCC Box
143	22+195	1	3	RCC Box
144	22+475	1	2	RCC Box
145	22+715	1	2	RCC Box
146	22+885	1	3	RCC Box
147	23+070	2	3	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
148	23+530	2	3	RCC Box
149	23+655	1	2	RCC Box
150	23+830	1	2	RCC Box
151	24+225	1	2	RCC Box
152	24+365	1	2	RCC Box
153	24+640	1	2	RCC Box
154	25+050	1	2	RCC Box
155	25+345	1	2	RCC Box
156	25+565	1	2	RCC Box
157	25+745	1	2	RCC Box
158	26+105	1	2	RCC Box
159	26+350	1	2	RCC Box
160	26+530	1	2	RCC Box
161	26+830	1	2	RCC Box
162	26+970	1	2	RCC Box
163	27+400	1	2	RCC Box
164	27+790	1	2	RCC Box
165	27+900	1	3	RCC Box
166	28+130	1	2	RCC Box
167	28+450	1	2	RCC Box
168	28+685	1	2	RCC Box
169	28+920	1	2	RCC Box
170	28+955	1	2	RCC Box
171	29+215	1	2	RCC Box
172	29+510	1	2	RCC Box
173	29+755	1	2	RCC Box
174	29+965	1	2	RCC Box
175	30+235	1	3	RCC Box
176	30+975	2	2	RCC Box
177	31+300	1	2	RCC Box
178	31+460	1	2	RCC Box
179	31+660	1	1.5	RCC Box
180	31+925	1	2	RCC Box
181	32+070	1	2	RCC Box
182	32+385	1	1.5	RCC Box
183	32+655	1	2	RCC Box
184	32+915	1	1.5	RCC Box
185	33+225	1	3	RCC Box
186	33+425	1	2	RCC Box
187	33+655	1	3	RCC Box
188	33+785	1	2	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
Package 2				
189	35+190	1	2	RCC Box
190	35+260	1	2	RCC Box
191	35+470	1	1.5	RCC Box
192	35+730	1	2	RCC Box
193	35+950	1	2	RCC Box
194	36+180	1	2	RCC Box
195	36+530	1	2	RCC Box
196	36+940	1	2	RCC Box
197	37+080	1	2	RCC Box
198	37+580	1	3	RCC Box
199	37+680	1	2	RCC Box
200	37+750	1	2	RCC Box
201	37+920	1	1.5	RCC Box
202	38+040	1	3	RCC Box
203	38+260	1	2	RCC Box
204	38+500	1	2	RCC Box
205	38+670	1	2	RCC Box
206	38+770	1	2	RCC Box
207	38+920	1	2	RCC Box
208	39+070	1	2	RCC Box
209	39+170	1	2	RCC Box
210	39+320	1	1.5	RCC Box
211	39+520	1	2	RCC Box
212	39+680	1	2	RCC Box
213	40+050	1	3	RCC Box
214	40+320	1	3	RCC Box
215	40+570	1	2	RCC Box
216	40+850	1	3	RCC Box
217	40+980	1	1.5	RCC Box
218	41+180	1	1.5	RCC Box
219	41+700	1	1.5	RCC Box
220	41+900	1	1.5	RCC Box
221	42+080	1	2	RCC Box
222	42+330	1	3	RCC Box
223	43+020	2	3	RCC Box
224	43+330	1	2	RCC Box
225	43+840	2	3	RCC Box
226	44+180	1	2	RCC Box
227	44+630	1	2	RCC Box
228	44+720	1	1.5	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
229	44+820	1	2	RCC Box
230	45+040	1	2	RCC Box
231	45+300	1	2	RCC Box
232	45+700	1	3	RCC Box
233	46+080	1	1.5	RCC Box
234	46+120	1	2	RCC Box
235	46+270	1	2	RCC Box
236	46+410	1	1.5	RCC Box
237	46+720	1	3	RCC Box
238	46+880	1	2	RCC Box
239	47+130	1	2	RCC Box
240	47+240	1	2	RCC Box
241	47+320	1	3	RCC Box
242	47+540	1	2	RCC Box
243	47+710	2	3	RCC Box
244	47+820	1	1.5	RCC Box
245	48+050	1	1.5	RCC Box
246	48+220	1	1.5	RCC Box
247	48+330	1	1.5	RCC Box
248	48+540	1	2	RCC Box
249	48+870	1	1.5	RCC Box
250	49+250	1	1.5	RCC Box
251	49+520	1	1.5	RCC Box
252	49+740	1	1.5	RCC Box
253	50+020	1	1.5	RCC Box
254	50+150	1	1.5	RCC Box
255	50+740	1	3	RCC Box
256	51+030	1	2	RCC Box
257	51+320	1	2	RCC Box
258	51+570	1	2	RCC Box
259	51+700	2	2	RCC Box
260	52+030	1	2	RCC Box
261	52+220	1	2	RCC Box
262	52+340	1	2	RCC Box
263	52+500	1	3	RCC Box
264	52+780	1	2	RCC Box
265	53+030	1	1.5	RCC Box
266	53+210	1	1.5	RCC Box
Package-3				
267	53+630	1	3	RCC Box
268	53+700	1	1.5	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
269	53+930	1	1.5	RCC Box
270	54+180	1	2	RCC Box
271	54+290	1	1.5	RCC Box
272	54+380	1	1.5	RCC Box
273	54+520	1	2	RCC Box
274	54+720	1	2	RCC Box
275	54+940	1	1.5	RCC Box
276	55+270	1	1.5	RCC Box
277	55+300	1	1.5	RCC Box
278	55+480	1	2	RCC Box
279	55+770	1	2	RCC Box
280	56+170	1	2	RCC Box
281	56+570	1	1.5	RCC Box
282	56+730	1	3	RCC Box
283	57+080	1	2	RCC Box
284	57+370	1	1.5	RCC Box
285	57+570	1	1.5	RCC Box
286	57+950	2	3	RCC Box
287	58+370	1	1.5	RCC Box
288	58+490	2	3	RCC Box
289	58+770	1	1.5	RCC Box
290	59+250	1	2	RCC Box
291	59+570	1	2	RCC Box
292	59+730	1	3	RCC Box
293	59+900	1	1.5	RCC Box
294	59+930	1	1.5	RCC Box
295	60+040	1	2	RCC Box
296	60+120	1	3	RCC Box
297	60+260	1	2	RCC Box
298	60+440	1	2	RCC Box
299	60+670	1	2	RCC Box
300	60+970	1	1.5	RCC Box
301	61+270	1	3	RCC Box
302	61+590	1	2	RCC Box
303	61+700	1	2	RCC Box
304	61+920	1	2	RCC Box
305	62+050	1	1.5	RCC Box
306	62+670	1	2	RCC Box
307	62+780	1	1.5	RCC Box
308	63+060	1	1.5	RCC Box
309	63+240	1	1.5	RCC Box

Sl. No	Culvert Location(Design Chainage)	Proposed Span Arrangement	Proposed Span Width (m)	*Remarks
310	63+930	1	1.5	RCC Box
311	64+230	1	1.5	RCC Box
312	64+270	1	1.5	RCC Box
313	64+400	1	2	RCC Box
314	64+630	1	1.5	RCC Box
315	65+140	1	1.5	RCC Box
316	65+420	1	2	RCC Box
317	65+550	1	2	RCC Box
318	65+800	1	2	RCC Box
319	65+870	1	2	RCC Box
320	66+180	1	1.5	RCC Box
321	66+960	1	1.5	RCC Box
322	67+030	1	1.5	RCC Box
323	67+260	1	2	RCC Box
324	67+370	1	1.5	RCC Box
325	67+530	1	1.5	RCC Box
326	67+600	1	2	RCC Box
327	67+880	1	2	RCC Box
328	67+950	1	1.5	RCC Box
329	68+270	1	1.5	RCC Box
330	68+500	1	1.5	RCC Box
331	68+580	1	1.5	RCC Box
332	68+690	1	2	RCC Box
333	68+820	1	1.5	RCC Box
334	69+160	1	2	RCC Box
335	69+340	1	1.5	RCC Box
336	69+740	1	1.5	RCC Box
337	69+820	1	1.5	RCC Box
338	70+020	1	1.5	RCC Box
339	70+270	1	1.5	RCC Box
340	70+380	1	1.5	RCC Box
341	70+460	1	1.5	RCC Box
342	70+570	1	1.5	RCC Box
343	70+750	1	3	RCC Box
344	70+950	2	2	RCC Box
345	71+200	1	2	RCC Box
346	71+330	1	2	RCC Box
347	71+600	2	2	RCC Box
348	71+900	1	2	RCC Box
349	72+420	2	2	RCC Box

7.12.2 Repair/Rehabilitation Proposals

Suitable repair/ rehabilitation plans for the existing structures shall be formulated keeping in view provisions of IRC: SP: 40-1993.

The following common defects will be repaired / rehabilitee of bridges on the Project Road:

1) Wearing coat

Existing damage wearing coat shall be remove and lying of new wearing coat.

2) Expansion Joint

Solid slab decks have buried seal joints. It is not possible to check the condition of expansion joints because of bituminous/pcc overlays, which completely cover the joints. The expansion joints, wearing coat has been proposed to be redone and a footpath on both sides of the bridges has also been recommended.

3) Bearings

Some of the minor bridges are of solid slab type superstructure and Tar paper bearings has been provided in all whereas other are of RCC I-Girder and neoprene bearing has been provided.

4) Vent way blockage by vegetation deposit / growth in vent way

Vent way blockage by vegetation deposit / growth in vent way was noticed in some bridge locations.

5) Revetment/Pitching

Heavy vegetation growth was observed on the revetment in most of the existing bridges. It will be removed and damage pitching has been construction/repaired

6) Hydraulics

At most of the sites, growth of vegetation was observed in the river bed under and around the bridges. However, no serious problem of inadequacy of waterway, degradation of the bed or excessive scour around abutments and piers was observed.

7) Painting

All the existing retained bridge has been painted a new coat.

7.13 TOE WALL/ RETAINING WALL

Toe wall / Retaining Wall are proposed on the outer edges of the roadway where the valley/river/nala/ edge exist.

1. Breast Wall

Breast is proposed at following location to provide stability in rock.

Chainage	Side	Length	Total length	Height
Package-1				
2680	2	20	40	3
2900	2	20	40	3
3060	1	20	20	3
3180	1	20	20	3
3320	1	60	60	3
6080	1	20	20	5
6600	1	20	20	3
7500	2	20	40	3
7540	2	20	40	3
7780	2	20	40	3
7800	2	20	40	3
8460	1	20	20	3
8480	1	20	20	3
8500	1	20	20	3
8520	1	20	20	3
9300	1	20	20	5
9320	1	20	20	5
9540	1	20	20	4
9600	1	20	20	5
9620	1	20	20	5
10520	2	20	40	5
10540	2	20	40	5
10560	2	20	40	5
10580	2	20	40	5
11520	1	20	20	3
11540	1	20	20	3
11560	1	20	20	3
11660	1	20	20	6
11680	1	20	20	6
11700	1	20	20	6
12200	1	20	20	4
12220	1	20	20	4

Chainage	Side	Length	Total length	Height
12520	1	20	20	5
12540	1	20	20	5
12560	1	20	20	5
12960	1	20	20	3
13080	1	20	20	6
13100	1	20	20	6
14140	1	20	20	3
14160	1	20	20	3
14180	1	20	20	3
14780	1	20	20	6
14800	1	20	20	6
14820	1	20	20	6
16580	1	20	20	4
16600	1	20	20	4
16620	1	20	20	4
19580	1	20	20	3
22500	1	20	20	5
22520	1	20	20	5
22540	1	20	20	5
24560	1	20	20	4
24580	1	20	20	4
24600	1	20	20	4
26800	1	20	20	6
26820	1	20	20	6
26840	1	20	20	6
26860	1	20	20	6
26880	1	20	20	6
26900	1	20	20	6
26920	1	20	20	6
26940	1	20	20	6
26960	1	20	20	6
27260	1	20	20	3
27280	1	20	20	3
27920	1	20	20	6
27940	1	20	20	6
27960	1	20	20	6
27980	1	20	20	6
28000	1	20	20	6
28020	1	20	20	6
28040	1	20	20	6
28060	1	20	20	6
Package-2				
39760	1	20	20	2
41320	1	20	20	3.5
41340	2	20	40	4.5
41360	2	20	40	4.5

Chainage	Side	Length	Total length	Height
41380	2	20	40	4.5
41400	2	20	40	4.5
41420	2	20	40	4.5
41440	2	20	40	4.5
41460	2	20	40	4.5
41480	2	20	40	4.5
41500	2	20	40	4.5
41520	2	20	40	4.5
41540	2	20	40	4.5
41560	2	20	40	4.5
41580	2	20	40	4.5
42620	1	20	20	3.5
42640	1	20	20	3.5
42660	1	20	20	3.5
42680	1	20	20	3.5
42700	1	20	20	3.5
42720	1	20	20	3.5
42740	1	20	20	3.5
42760	1	20	20	3.5
42780	1	20	20	3.5
42800	1	20	20	3.5
42820	1	20	20	3.5
42840	1	20	20	3.5
42860	1	20	20	3.5
42880	1	20	20	3.5
42900	1	20	20	3.5
42920	1	20	20	3.5
43420	1	20	20	2
43440	1	20	20	2
43460	1	20	20	2
43480	1	20	20	2
43500	1	20	20	2
44240	1	20	20	2
44260	1	20	20	2
44280	1	20	20	2
44300	1	20	20	2
44320	1	20	20	2
44340	1	20	20	2
44360	1	20	20	2
44380	1	20	20	2
44400	1	20	20	2
50460	1	20	20	4

Chainage	Side	Length	Total length	Height
50480	1	20	20	4
50500	1	20	20	4
50520	1	20	20	4
50540	1	20	20	4
50560	1	20	20	4
50580	1	20	20	4
50600	1	20	20	4
53280	1	20	20	2
53300	1	20	20	2
53320	1	20	20	2
53340	1	20	20	2
53360	1	20	20	2
53380	1	20	20	2
Package-3				
59740	1	20	20	3.5
64740	1	20	20	4
68860	1	20	20	5
68880	1	20	20	5
68900	1	20	20	5
68920	1	20	20	5
68940	1	20	20	5
68960	1	20	20	5

2. Retaining Wall

Retaining walls are proposed at following locations:

Location(Km)	Length (m)	Average Height (m)
5+660	20	2
5+740	20	2
5+760	20	2
5+840	20	4
18+880	20	2
18+900	20	2
44+720	20	5
52+220	20	3

Location(Km)	Length (m)	Average Height (m)
64500	60	2
72600	100	3
Approaches of culverts (appx.)*	2000	4
Total length (m)	2320	

CHAPTER – 8

PRELIMINARY COST ESTIMATE

GENERAL

.Nongstoin – Rambrai – Kyrshai Road is an important link of Meghalaya with neighbouring Assam and rest of the country. The road from Nongstoin to Rambrai(20 Km approx) is a single lane surfaced road and the condition of road is fair to poor. The curves are sharp and the average road width is 5.5 m and carriageway width is 3.75m. After Rambrai, there is a katcha road upto Mawthir (14 Km approx) and thereafter no road exists except for a jungle track. Geometrics of existing katcha road and jungle track are very poor having sharp curves and steep gradients

Cost estimation is an important component of the feasibility study as it provides vital input to economic evaluation. The cost estimates have been prepared for widening or reconstruction of existing Nongstoin – Rambrai road and new construction of Rambrai – Kyrshai road to 2 lane with earthen shoulder. Over and above construction costs, provision has been made for social and environmental mitigation measures. Cost estimates are based on typical cross sections that have been finalized for improvement of project corridor and preliminary designs as elaborated in previous chapters.

As per the directions of NHIDCL the consultant has divided the project into three Packages as per the table below

Package No.	From(Km)	To (Km)	Length(Km)
1	0+335	34+039	33.704
2	35+155	53+500	18.345
3	53+500	72+863	19.363
Total	**0+335**	**72+863**	**71.412**

8.1 CONSTRUCTION PROGRAMME

Construction period of the project is 36 Months.

8.2 TYPICAL CROSS SECTION

Typical cross sections of the project road are enclosed in drawing volume.

8.3 ESTIMATION OF QUANTITIES

The quantities of major items of work for the Project road have been estimated on the basis of Improvement proposals suggested for the Project Highway. Salient feature of project Road are as under:

S. No	Description	Proposed
1	Project Length (Design)	71.412 Km
2	New Construction Length	55.027 km (77.06%)
3	Widening/Reconstruction	16.385 Km (22.94%)
4	New/Reconstruction Pipe Culverts	0
5	New/Reconstruction Box Culverts	349
6	New/Reconstruction Minor/Major Bridge	12
7	Bus Stops	26 location both side

8.4 UNIT RATE

Unit rates are applied to the quantities to get the direct cost of construction inclusive of all Taxes, haulage, loading-unloading, Labor cess. Unit rates are based on Schedule of Rates for Road & bridge work under PWD (Roads) National Highway Circle Meghalaya, Shillong (7th Edition) with effect from 01.06.2013. The rates for the items of work not included in Schedule of Rates have been assessed from MoRT&H Standard data book / from current market rates. Loading unloading and lead from source to site is added on the SOR and final rate used for generating the project cost.

8.5 PROJECT COST

8.5.1 Package1 (Km 0+335 to Km 34+039)

As per preliminary cost estimate, construction cost of Package-1 is 218.54 cr (6.48cr. Per Km). The Abstract of project cost is presented in table below

Table : Cost Estimates (Package-1)

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	SITE CLEARANCE	3,510,426	
2	EARTHWORKS	876,195,481	
3	SUB-BASE AND BASE COURSES	526,515,485	
4	BITUMINOUS COURSES	141,027,089	
5	CROSS DRAINAGE WORKS	337,563,189	
6	NEW BRIDGES, ROBS AND UNDERPASSES	112,998,562	
7	DRAINAGE AND PROTECTIVE WORKS	314,744,514	
8	TRAFFIC SIGNS, MARKINGS AND ROAD APPURTENANCES	134,200,047	
9	MISCELLANEOUS	854,460	
A	**Construction Cost (Rates adopted from current October'2019 SOR for National Highway Circle, Meghalaya are inclusive of GST @12% (1 to 9)**	**2,447,609,253**	7.262 cr. Per km
	Cost of GST @ 12%	**262,243,849**	
B	**Construction Cost (Excluding GST)**	**2,185,365,404**	6.484 cr. Per km
	Cost Inflation for the year 2020-21 @ 4.3% based on WPI on B	**93,970,712**	
C	**Estimated Civil Cost/ Cost Put upto Tender**	**2,279,336,117**	6.763 cr. Per km
	Addition of GST @12% of C	273,520,334	
	Contingencies at 2.8% of C	63,821,411	
	Agency charges @ 3% on C	68,380,084	
	O&M cost for Ist five years after construction @ 2.5% of C	56,983,403	
	Supervision @ 3% on C	68,380,084	
	Price Escalation @ 5% per year for 1.5 year on C	170,950,209	
D	**TOTAL PROJECT COST**	**2,981,371,641**	8.846 cr. Per km
1	UTILITY SHIFTING COST	33,206,472	
2	LAND ACQUISITION	712,770,117	
E	**TOTAL NONCIVIL COST (1+2)**	**745,976,589**	2.213 cr. Per km

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
F	**TOTAL PROJECT COST (D+E)**	**3,727,348,230**	11.059 cr. Per km

8.5.2 Package - 2 (Km 35+155 to Km 53+500)

As per preliminary cost estimate, construction cost of Package-2 is 120.29 cr (6.56cr. Per Km). The Abstract of project cost is presented in table below

Table 10: Cost Estimates (Package-2)

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	SITE CLEARANCE	1,947,902	
2	EARTHWORKS	580,056,904	
3	SUB-BASE AND BASE COURSES	291,437,796	
4	BITUMINOUS COURSES	76,163,502	
5	CROSS DRAINAGE WORKS	146,554,030	
6	NEW BRIDGES, ROBS AND UNDERPASSES	27,925,338	
7	DRAINAGE AND PROTECTIVE WORKS	146,562,731	
8	TRAFFIC SIGNS, MARKINGS AND ROAD APPURTENANCES	58,385,421	
9	MISCELLANEOUS	18,189,880	
A	**Construction Cost (Rates adopted from current October'2019 SOR for National Highway Circle, Meghalaya are inclusive of GST @12% (1 to 9)**	**1,347,223,504**	7.344 cr. Per km
	Cost of GST @ 12%	**144,345,375**	
B	**Construction Cost (Excluding GST)**	**1,202,878,129**	6.557 cr. Per km
	Cost Inflation for the year 2020-21 @ 4.3% based on WPI on B	**51,723,760**	
C	**Estimated Civil Cost/ Cost Put upto Tender**	**1,254,601,888**	6.839 cr. Per km
	Addition of GST @12% of C	150,552,227	
	Contingencies at 2.8% of C	35,128,853	
	Agency charges @ 3% on C	37,638,057	

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
	O&M cost for Ist five years after construction @ 2.5% of C	31,365,047	
	Supervision @ 3% on C	37,638,057	
	Price Escalation @ 5% per year for 1.5 year on C	94,095,142	
D	**TOTAL PROJECT COST**	**1,641,019,270**	8.945 cr. Per km
1	UTILITY SHIFTING COST	623,711	
2	LAND ACQUISITION	202,896,149	
E	**TOTAL NONCIVIL COST (1+2)**	**203,519,860**	1.109 cr. Per km
F	**TOTAL PROJECT COST (D+E)**	**1,844,539,129**	10.055 cr. Per km

8.5.3 Package - 3 (Km 53+500 to Km 72+863)

As per preliminary cost estimate, construction cost of Package-3 is 137.76 cr (7.115cr. Per Km). The Abstract of project cost is presented in table below

Table 11: Cost Estimates (Package-3)

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
1	SITE CLEARANCE	2,053,194	
2	EARTHWORKS	700,739,856	
3	SUB-BASE AND BASE COURSES	306,739,754	
4	BITUMINOUS COURSES	80,692,271	
5	CROSS DRAINAGE WORKS	147,645,794	
6	NEW BRIDGES, ROBS AND UNDERPASSES	183,650,504	
7	DRAINAGE AND PROTECTIVE WORKS	58,878,819	
8	TRAFFIC SIGNS, MARKINGS AND ROAD APPURTENANCES	62,307,174	
9	MISCELLANEOUS	189,880	
A	**Construction Cost (Rates adopted from current October'2019 SOR for National Highway Circle, Meghalaya are inclusive of GST @12% (1 to 9)**	**1,542,897,246**	7.968 cr. Per km
	Cost of GST @ 12%	**165,310,419**	

Bill No.	ITEM OF WORK	AMOUNT (INR)	Cost (Crores)/Km
B	**Construction Cost (Excluding GST)**	**1,377,586,827**	7.115 cr. Per km
	Cost Inflation for the year 2020-21 @ 4.3% based on WPI on B	**59,236,234**	
C	**Estimated Civil Cost/ Cost Put upto Tender**	**1,436,823,060**	7.42 cr. Per km
	Addition of GST @12% of C	172,418,767	
	Contingencies at 2.8% of C	40,231,046	
	Agency charges @ 3% on C	43,104,692	
	O&M cost for Ist five years after construction @ 2.5% of C	35,920,577	
	Supervision @ 3% on C	43,104,692	
	Price Escalation @ 5% per year for 1.5 year on C	107,761,730	
D	**TOTAL PROJECT COST**	**1,879,364,563**	9.706 cr. Per km
1	UTILITY SHIFTING COST	658,322	
2	LAND ACQUISITION	214,155,253	
E	**TOTAL NONCIVIL COST (1+2)**	**214,813,575**	1.109 cr. Per km
F	**TOTAL PROJECT COST (D+E)**	**2,094,178,138**	10.815 cr. Per km

8.6 Conclusion and Recommendation

1. As per traffic projection, 2 Lane with earthen shoulders has been proposed for the project road
2. From Nongstoin to Rambrai, existing alignment has been followed except for small realignments/ curve improvement.
3. After Rambrai, new alignment has been proposed.
4. Total Construction cost for the project road is Rs.476.59 crores for the year 2019-20.

CHAPTER: 9

ECONOMIC ANALYSIS

9.1 Introduction

Cost-benefit analysis attempts to assess the benefits of implementing a project to the society as a whole. The measurement of costs and benefits is intended to reflect the value of resources consumed by, or made available to the society as a whole and therefore excludes all transfer payments, such as import duties excise and sales tax, etc.

Costs and benefits are assessed by comparing a project case(s) with a base case (or without project) over the economic lifetime of the project, conventionally taken as 30 years. The costs and benefits are calculated for each year and then discounted at an appropriate rate of interest to obtain the standard measures of project benefit, such as net present value (NPV) and internal rate of return (IRR).

9.2 Economic Benefits

The principal economic benefits to road users arise from the reduction in vehicle operating costs (VOC), including the value of passenger and commodity time savings.

The reduction in vehicle operating costs and time values has been calculated using HDM4 (Highway development and management) model.

9.3 Construction & Analysis period

The analysis period is considered as 20 years including two year of construction cost period. It has been proposed that over this period of time, the existing single, Intermediate and partly two lane facilities would be upgraded to 2-lane carriageway. Construction cost phasing has been distribution as 30%, 40% & 30% over salted 3 year.

9.4 Project Cost

The project cost has to take account of all expenditure over the life of the project and therefore includes:

- Initial construction cost
- Annual routine maintenance cost
- Periodic maintenance cost

Estimated project cost has been detailed below:

Section / Description	Total Length	Construction Cost (Rs. in Cr.)	Per Km Cost (Rs in Cr.)	Economic Cost (Rs. In Cr./Km)
Nongatoin – Rambrai – Kyrshai	71.412 Km	476.59	6.67	6.01

- Routine maintenance cost 0.12 million
- Periodic maintenance cost 4.0 million

The Capital costs, in financial terms, at the prevailing market prices have been computed as at the end of current financial year. The foreign exchange component in the total capital cost is insignificant and is considered almost zero, as all material, machinery and labour are available in India. Standard Conversion factor of 0.90 is used for converting market prices of road construction and maintenance inputs into economic costs.

9.5 HDM 4 Model Input Data

9.5.1 General

The following values have been considered for the HDM4 Model input data:

Analysis Period : 20 years

Construction Period : 3 years (36 months)

Design Life : 15 years

Salvage Value : 15%

Discount Rate : 12%

Investment Schedule : 1st Year - 30%

2nd Year - 40%

3rd Year – 30%

9.5.2 Characteristics of Existing Project Road

The road and pavement characteristics obtained from different field surveys have been used as input to the Model are given in table

Table: Existing Project Road Characteristics

Road Characteristics	***Units***	***Value***
Road Width	m.	3.5
One shoulder width	m.	0.5 – 1.0
Rise & Fall	m/Km	50 m
Super-elevation	%	7
Effective Number of Lanes	No.	Single
Curvature (Existing)	Degree/Km	200
Sub-grade CBR (Existing)	%	6
Roughness (IRI)	m/km	9.8
Percentage of all Cracks	%	22
Percentage of Pot Holes	%	11
Percentage of Ravelling	%	18
Rut Depth	mm	50

9.5.3 Traffic Volume and Composition

Base year annual average daily traffic used for running HDM4 model is given table below.

Section / Description	**AADT**
Car	71.1%
Jeep, Van (New Tech)	0.0%
3-Wheeler including Auto Rickshaw	5.6%
Two Wheeler	5.7%
Mini bus	0.8%
Standard Bus	0.0%
Private Bus	0.0%
Light Goods Vehicle (Passenger)	6.5%
Light Goods Vehicle (Goods)	0.0%
2-axle Truck	8.6%
3-axle Truck	1.3%

Section / Description	AADT
Multi-axle Truck Semi Articulated	0.0%
Multi-axle Truck Articulated	0.0%
Agri. Tractor	0.0%
Agri. Tractor with Trailer	0.4%
Pedal Cycle	0.1%
Cycle Rickshaw	0.0%
Hand Cart	0.0%
Animal Cart	0.0%
Total Vehicle	**1418**

9.5.4 Traffic Growth Rate

Traffic growth rate for the project road is taken as 5 %.

9.6 Economic Analysis

The economic analysis for the project road has been carried out with flexible pavement design with traffic diverted on improved road taken into consideration in the evaluation of EIRR and NPV. The annual stream of cost savings (VOC and value of time savings) "without" project and with project, have been developed through HDM4 model. The results of the economic analysis "with time savings" are summarised in table.

Table: Economic Analysis Results

Project Road	EIRR (%)
Nongstoin – Rambrai - Kyrshai	20.3

Economic analysis results shows that both project roads are economically viable.

9.7 Sensitivity Analysis

Sensitivity Analysis has been carried out to examine the effect on economic viability of the project due to the changes in the levels of the key input factors. The sensitivity has been studied under the following change in conditions.

Condition I: 15% increase in project costs, while traffic volume remains unaffected as per demand estimates.

Condition II: 15% decrease in traffic volume, project costs remaining unchanged

Condition III: 15 % increase in the project costs and 15 % decrease in traffic – worst case scenario.

Sensitivity Analysis results are given below in table

Sensitivity Analysis

Project Road	Condition	EIRR (%)
Nongstoin – Rambrai - Kyrshai	I	19.1
	II	18.6
	III	17.4

The result of sensitivity analysis indicates that the project has got an EIRR value more than the cut of level of 12% EVEN IN THE WORST SITUATION of cost increment by 15% and traffic reduction by 15%.

Hence the project is found to be **economic viable**.

CHAPTER: 10

CONCLUSION & RECOMMENDATION

Broad conclusion & recommendations are as follows:

1. As per traffic projection, 2 Lane with earthen shoulders has been proposed for the project road
2. From Nongstoin to Rambrai, existing alignment has been followed except for small realignments/ curve improvement.
3. After Rambrai, new alignment has been proposed.
4. Total Construction cost for the project road is Rs.476.59 crores.