Government of India
Ministry of Road Transport & Highway

NAME OF THE WORK :-SPECIALISED CONSULTANCY SERVICES FOR 'GOOD FOR TENDER' DESIGN BASED ON DETAILED INVESTIGATIONS, ESTIMATION, SURVEY, COSTING AND PREPARATION OF TECHNICAL SCHEDULES OF EPC DOCUMENTS FOR CONSTRUCTION OF MOREH BYPASS ON NH-39 NEAR INDO-MYANMAR BORDER IN THE STATE OF MANIPUR.

Detailed Project Report

Volume II - Design Report

DECEMBER 2018

Consultants:-

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1.1 INTRODUCTION

"Specialized Consultancy Services for 'Good for Tender' design based on detailed investigations, estimation, survey, costing and preparation of Technical Schedules of EPC documents for construction of Moreh Bypass on NH-39 near Indo-Myanmar Border in the State of Manipur " **(Total Design Length 2.52 km)**

M/s Choice Consultancy Services Pvt. Ltd. has been appointed by the National Highways & Infrastructure Development Corporation Limited for providing Detailed Engineering Design Consultancy Services for the above mentioned Section.

The National Highways & Infrastructure Development Corporation Limited is required to carry out detailed engineering design beside surveys, investigations and preparation of working drawings for all components relevant to the improvement and Up gradation of the Project Highway to fulfill the scope of the Project as envisaged in the TOR.

The scope of the project has been provided in TOR of the Contract Agreement. The design for the various elements of the Project shall conform to the design requirements set out in the Manual of Specifications and Standards for HILL ROAD MANUAL published by Indian Roads Congress – IRC: SP: 48-1998 and IRC: SP: 73-2015 .

This geometric design reports highlights the design of horizontal and vertical geometry of project corridor as per the given scope and specifications of the TOR. It also highlights the improvements suggested in the design without violating the specifications and standards as per IRC: 73-1980 and IRC: SP: 48-1998.

1.2 SCOPE

Scope of the project has been clearly highlighted in TOR. The basic scope of the project includes two lanes with Paved Shoulder.

Table 1.1: Project Summary

Item	Provision
Realignment	1 location (length= 0.30 km)
Major Intersections	2 Nos
Minor Intersections	6 Nos.
Major Bridges	Nil.
Minor Bridges	1 Nos. (1 No. Retain)
Culverts	10 reconstruction + 3 New culverts
Bus Bays/Passenger Shelters	Nil.

Item	Provision
Truck Lay-bye	1 Nos.
Retaining Wall	0.070 km
Breast Wall	1.605 km

1.3 DESIGN STANDARDS

The Project highway shall be designed in accordance with provisions of Two-Lane with paved shoulders of the Project Highway shall conform to the Manual of Specifications and Standards for Hill Road manual published by Indian Roads Congress – IRC: SP: 48-1998.

Table 1.2 Geometric Design Standards for Roadwork's

Sl. No.	Attributes	Geometric Design Standards
1	Design Speed :- Steep Terrain	Ruling: 40kmph Minimum: 30kmph
2	Carriageway Width	7.0m
3	Width of Shoulder	
	a) Paved	2 x 1.5m in Open Country
	b) Earthen	1.0m on Valley Side in stretches without retaining wall
4	Camber	
	a) Carriageway & Paved Shoulder (Flexible pavement)	2.5%
	b) Earthen Shoulder	3.00%
5	Super-elevation	Maximum limited to 10.0%
6	Minimum Radius of Horizontal Curves - Steep Terrain.	Desirable Minimum: 50m Absolute Minimum: 30m
7	Extra Width of Pavement	
	Radius of Curve	Extra Width
	Up to 40m	1.5m
	41-60m	1.2m
	61-100m	0.9m
	101-300m	0.6m

Cross Sectional Parameters

Based on the Manual and standards, the Consultancy has developed design proposal consisting of typical cross sections and widening schemes as mentioned below.

Consultancy has considered Five (4) different types of typical cross sections for Km 0+000 to Km 2+520, as given below:

I. Open country - Mountainous terrain with retaining wall & parapet

a. Carriage Way Width - 7.00m
b. Paved Shoulder Width – 2 x 1.5m
c. Roadway Width - 10.0m

II. Open country - Mountainous terrain without retaining wall & parapet

a. Carriage Way Width - 7.00m
b. Paved Shoulder Width - 2x1.5m
c. Earthen Shoulder Width - 1.0m (valley side)
d. Roadway Width - 11.0m

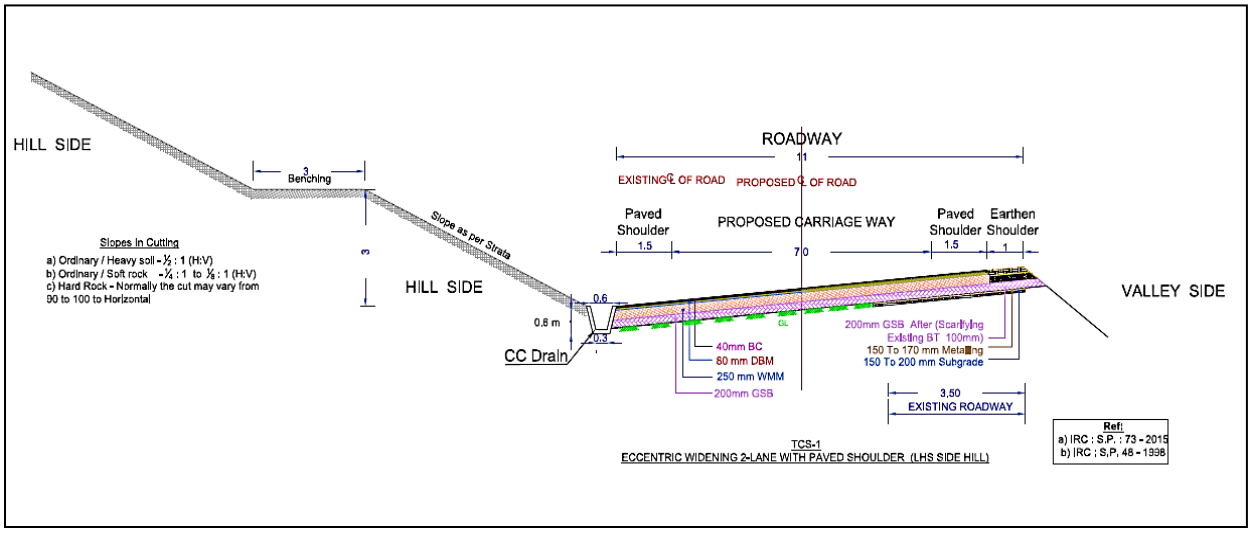

Figure 1.1: TCS-1 Eccentric Widening 2-Lane with Paved Shoulder (LHS Hill)

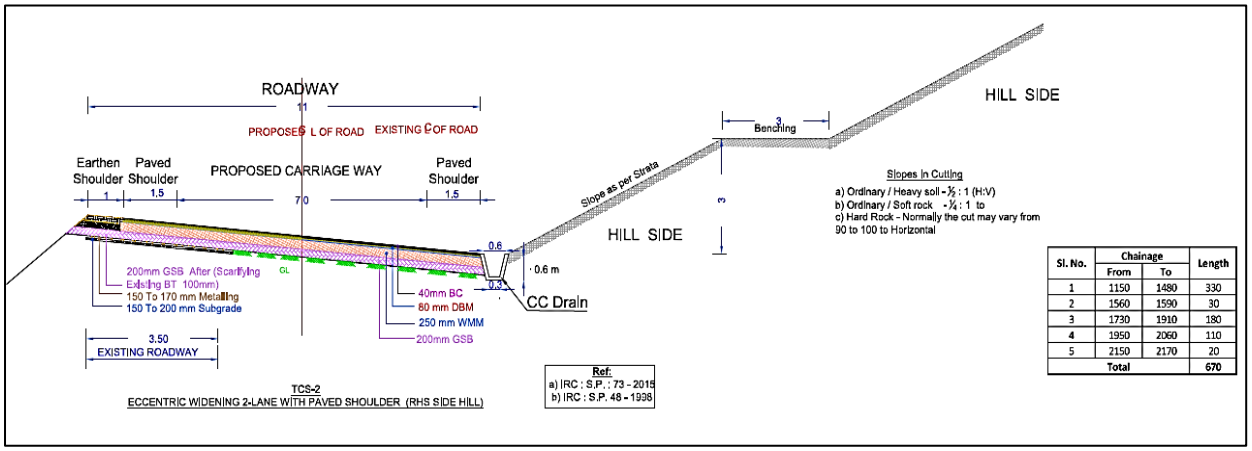

Figure 1.2: TCS-2 Eccentric Widening 2-Lane with Paved Shoulder (RHS Hill)

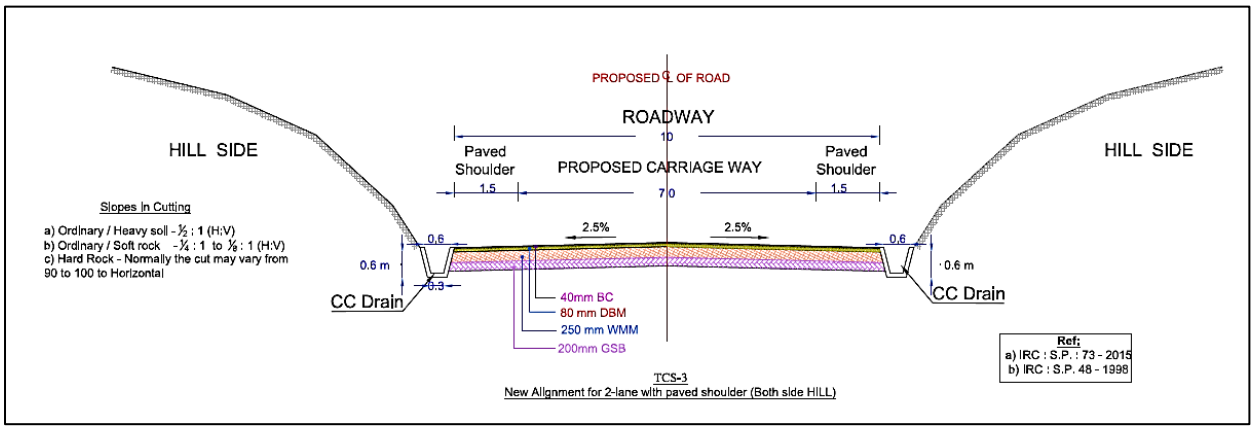

Figure 1.3: TCS-3 New Alignment for 2-lane with paved shoulder (Both side HILL)

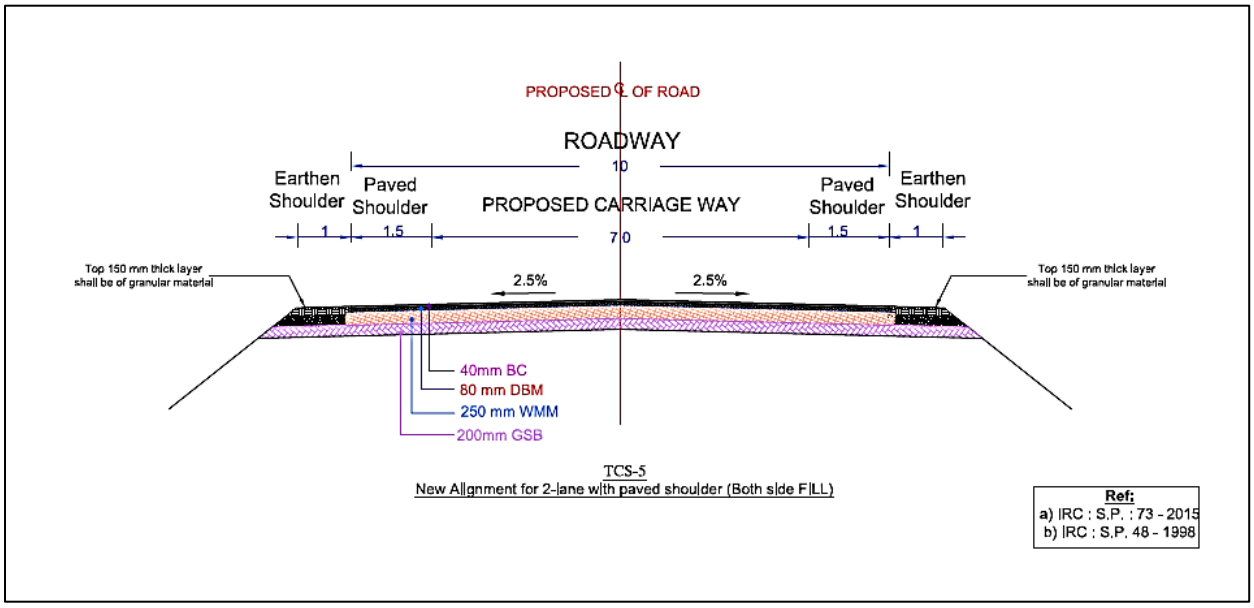

Figure 1.4: TCS-5 New Alignment for 2-lane with paved shoulder (Both side FILL)

The adopted Cross Section type and Widening Scheme is presented in the following table:

Table 1.3 Adopted Cross Section

Sl. No.	Chainage		Length	TSC Type	Description
	From	To			
1	0	200	200	Type-1	Eccentric Widening 2-Lane with Paved Shoulder (LHS Hill)
2	200	250	50	Type-3	New Alignment for 2-Lane with Paved Shoulder (Both Side Hill)
3	250	300	50	Type-1	Eccentric Widening 2-Lane with Paved Shoulder (LHS Hill)
4	300	350	50	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
5	350	380	30	Type-1	Eccentric Widening 2-Lane with Paved Shoulder

Sl. No.	Chainage		Length	TSC Type	Description
	From	To			
					(LHS Hill)
6	380	410	30	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
7	410	490	80	Type-1	Eccentric Widening 2-Lane with Paved Shoulder (LHS Hill)
8	490	520	30	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
9	520	650	130	Type-1	Eccentric Widening 2-Lane with Paved Shoulder (LHS Hill)
10	650	1150	500	Type-3	New Alignment for 2-Lane with Paved Shoulder (Both Side Hill)
11	1150	1480	330	Type-2	Eccentric Widening 2-Lane with Paved Shoulder (RHS Hill)
12	1480	1560	80	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
13	1560	1590	30	Type-2	Eccentric Widening 2-Lane with Paved Shoulder (RHS Hill)
14	1590	1630	40	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
15	1630	1730	100	Type-3	New Alignment for 2-Lane with Paved Shoulder (Both Side Hill)
16	1730	1910	180	Type-2	Eccentric Widening 2-Lane with Paved Shoulder (RHS Hill)
17	1910	1950	40	Type-3	New Alignment for 2-Lane with Paved Shoulder (Both Side Hill)
18	1950	2060	110	Type-2	Eccentric Widening 2-Lane with Paved Shoulder (RHS Hill)
19	2060	2150	90	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
20	2150	2170	20	Type-2	Eccentric Widening 2-Lane with Paved Shoulder (RHS Hill)
21	2170	2390	220	Type-3	New Alignment for 2-Lane with Paved Shoulder (Both Side Hill)
22	2390	2510	120	Type-5	New Alignment for 2-Lane with Paved Shoulder (Both Side Fill)
23	2510	2520	10	Type-1	Eccentric Widening 2-Lane with Paved Shoulder (LHS Hill)

1.4 DESIGN OF HORIZONTAL GEOMETRY

The horizontal geometry design is as follows according to the specifications and standards of IRC: SP-48-1998 & IRC: 73-1980.

- Desirable Minimum Speed as 30 Kmph

- Minimum radius for desirable minimum speed is 30m (30kmph)
- Maximum Super Elevation is 10% (In hilly areas not bound by snow)
- Road Camber 2.5% (Flexible Pavement)
- Maximum value of the transition curve length is calculated from the considerations of *rate of change of centrifugal acceleration* & rate of change of super-elevation;
- The rate of change in super-elevation is restricted to 1 in 60 (that corresponds to roads in Hilly/Mountain terrain).
- Method of attaining super-elevation adopted is "revolving pavement about the centre".
- The pertinent details of the horizontal geometry designed for the project corridor are highlighted in table below.

Table 1.4: Horizontal Alignment Curve details

S. No	Chainage	Radius	Direction	Curve Length	L_S Start	Super Elevation	Speed
1	80.81	30	Left	38.067	30	-10.00%	30
2	144.379	50	Right	41.504	0	8.00%	30
3	233.171	50	Left	51.92	0	-8.00%	30
4	328.396	50	Right	45.939	40	8.00%	30
5	510.754	50	Right	3.129	40	8.00%	30
6	754.032	70	Left	146.883	30	-10.00%	40
7	838.34	80	Right	6.41	25	10.00%	50
8	1060.104	210	Right	32.266	0	5.29%	50
9	1154.539	30	Right	39.415	0	10.00%	30
10	1204.635	30	Left	25.03	0	-10.00%	30
11	1250.294	100	Right	13.235	20	10.00%	50
12	1347.245	210	Left	25.163	0	-5.29%	50
13	1423.798	150	Right	67.539	15	7.41%	50
14	1790.756	125	Left	47.963	15	-8.89%	50
15	1893.761	125	Right	86.226	15	8.89%	50
16	2072.576	250	Left	137.576	0	-4.44%	50
17	2199.257	125	Right	42.111	15	8.89%	50
18	2314.648	70	Left	41.864	30	-10.00%	40
19	2357.342	125	Right	36.543	15	8.89%	50
20	2507.115	70	Left	62.202	30	-10.00%	40

1.5 DESIGN OF VERTICAL GEOMETRY

The vertical geometry design is as follows according to the specifications and standards of IRC: SP-73-2015, IRC: 48-1998, IRC: 73-1980 & IRC: SP-23

- Min Design Speed of 30 km/h;
- Minimum K – value for summit curve is 2.045 (SSD) & 3.750 (ISD)
- Minimum K – value for sag curve is 3.529.

Gradient:-

The vertical alignment is provided with a smooth longitudinal profile consistent with the terrain through which the road passes. Gradients up to the "ruling gradient" are used as far as possible in the design.

Table 1.5: Gradients to be adopted for Roads in Different Terrains (IRC: SP: 48-1998)

Sl. No.	Terrain	Ruling Gradient	Limiting Gradient	Exceptional Gradient
1	Mountainous terrain & steep terrain more than 3000 m height above MSL	5.0% (1 in 20)	6.0% (1 in 16.7)	7.0% (1 in 14.3)
2	Steep terrain up to 3000 m height above MSL	6.0% (1 in 16.7)	7.0% (1 in 14.3)	8.0% (1 in 12.5)

Sight Distance:-

On consideration of driver's perception time & braking time required to control their vehicles to avoid unwarranted accidents before meeting a stationary object in his path, proper sight distance will be required.

Table 1.6: Criteria for measuring sight distance

Sl. No.	Sight Distance	Driver's eye sight	Height of object
1.	Safe stopping distance	1.2 m	0.15 m
2.	Intermediate sight distance	1.2 m	1.20 m

Table 1.7: Stopping Sight Distance (IRC: SP: 48-1998)

Sr. No.	Design Values (metres)		
	Speed (km/h)	Stopping sight Distance	Intermediate sight distance
1	20	20	40
2	25	25	50
3	30	30	80
4	35	40	80
5	40	45	90
6	50	60	120

The pertinent details of the vertical geometry designed for the project corridor are highlighted in table below and also elaborated table.

Table 1.8: Vertical Alignment Curve details

Sr. No	IP Chainage (km)	Curve Start Gradient (%)	Curve End Gradient (%)	Curve Length (m)	" K " Value	Curve Type	Design Speed (Km/h)
1	32.338	-2.00	-6.30	40	9.302	Hog	50
2	549.708	-6.30	-6.00	60	200.000	Sag	50
3	1155.439	-6.00	0.00	30	5.000	Sag	30
4	1200.798	0.00	6.00	30	5.000	Sag	30
5	1450.918	6.00	0.50	200	36.364	Hog	50
6	1788.759	0.50	-5.00	200	36.365	Hog	50
7	2052.736	-5.00	-6.00	150	149.967	Hog	50

2. PAVEMENT DESIGN REPORT

2.1 INTRODUCTION

The report presents the pavement design for Moreh Bypass from NH-39 near Indo-Myanmar border to land custom port of India to bypass the Moreh town in the state of Manipur. The Project Road link passes through urban area of Moreh city passing through the habited areas of Vamnom, Moulmom and Tl.e.l.Saijang etc. The existing BT carriageway is having single without paved shoulders in urban stretches and earthen road for remaining stretch. The total length of Project Road is 2.520 km and One Minor Bridge is to be retained in the stretch.

For pavement design the life of the Project Road is considered as 15 years. The granular layer is designed for entire life of 15 years. It is proposed to provide strengthening layer of Flexible Pavement for the main carriageway carrying heavy and fast moving vehicles on the bypass road. The main carriageway will be carrying fast moving traffic of Cars, LCUs, and Motorcycles etc. For carriageway carrying Bus, Truck and Multi axle vehicle traffic, Flexible Pavement is proposed. For parking of the trucks, truck lay byes are proposed.

2.2 DESIGN OF FLEXIBLE PAVEMENT

Flexible pavements respond to a wheel load as a very flexible material (Bitumen) over softer materials (Sub Base and Sub Grade). A flexible pavement is modelled as an elastic multilayer structure. Stresses and strains at critical locations are computed using a linear layered elastic model. Tensile strain, Ct, at the bottom of the bituminous layer and the vertical subgrade strain, 6V, on the top of the subgrade are conventionally considered as critical parameters for pavement design to limit cracking and rutting in the bituminous layers and non-bituminous layers respectively. The computation also indicates that tensile strain near the surface close to the edge of a wheel can be sufficiently large to initiate longitudinal surface cracking followed by transverse cracking much before the flexural cracking of the bottom layer if the mix tensile strength is not adequate at higher temperatures.

2.3 DESIGN STANDARDS

Pavement design basically aims at determining the total thickness of the pavement structure as well as the thickness of the individual structural components. Different International accepted methods for design of flexible pavement such as IRC, AASHTO, AUSTROADS etc. are available. However it is recommended to carry out the design using IRC standards. Designs of Flexible pavement for the project have been carried out in Compliance with IRC: 37-2012 "Tentative Guidelines for the Design of Flexible Pavements".

2.4 DESIGN METHODOLOGY

Flexible pavement is designed based on the method given in IRC: 37-2012. This method is stated to have been developed based on performance of existing designs and using analytical approach (to limit the vertical compressive strain at the top of subgrade and horizontal tensile strain at bottom of bituminous layer adopting linear elastic model), and this is being currently used on most of the major highway projects in this country.

2.5 METHOD OF DESIGN OF FLEXIBLE PAVEMENT

The design of flexible pavement is covered in two parts viz, i) reconstruction pavement and ii) widening and strengthening of existing pavements. Reconstruction pavement are designed in accordance with the method prescribed in IRC:37 for pavement design, subject to the condition that the overall pavement composition shall not be less than the minimum requirement as specified in IRC:37. Strengthening of existing pavement is designed on the basis of the procedure outlined in IRC: 81. As the entire road is proposed for reconstruction / new construction only reconstruction Pavement is designed for project road.

Table 2.1: lists the definitions for each pavement structure design category.

Category	Definition
New Pavement Structure:	A combination of sub base and surface course place on a sub grade to support the traffic load and distribute it to the road bed.
Pavement Reconstruction:	Construction of the equivalent of new pavement structure, which usually involves complete removal and replacement of the existing pavement structure including new and / or recycle materials
Pavement Rehabilitation:	Resurfacing, restoration, and rehabilitation (3R) work undertaken to restore serviceability and to extend the service life of an existing facility. This may include partial recycling of the existing pavement, placement of additional surface materials, or other work necessary to return an existing pavement, including shoulders, to a condition of structural or functional adequacy. This activity is done by carrying out Conventional Flexible Pavement.

2.6 DATA REQUIRED FOR FLEXIBLE PAVEMENT DESIGN

Data required for the design of flexible pavement has been identified as follows:

- Traffic
- Sub grade Soil strength
- Base Sub-Base

2.6.1 TRAFFIC

Commercial vehicles with laden weight exceeding 3 T and its axle load spectrum have been considered for the design of flexible pavement.

2.6.1.1 Axle Load

The unique condition of overloading on Indian road has been considered for a flexible pavement design. The design wheel load is depend on the extent of overloading on the project road and has been determined from an axle load spectrum survey conducted for a day covering a minimum sample size of 20% commercial vehicles.

Vehicle Damage Factors

Project specific comprehensive axle load surveys were conducted at one location along the project stretch to estimate the loading behavior of commercial vehicles plying on the project road. The VDF are adopted is given at Table 4.2 of IRC 37 2012 for Rolling/Plain Terrain and shown in Table below.

Table 2.2: Summary of VDF Computation

V.D.F	
Vehicles	**VDF adopted**
LCV	1.5
Bus	1.5
2 Axle	1.5
3 Axle	1.5
MAV 4-6 Axle	1.5

2.6.1.2 Design Traffic

The design traffic is the cumulative number of commercial vehicles that will be plying on the project road during the complete design life of the project. Its computation involves estimation of the initial volumes of commercial vehicles per day, lateral distribution of traffic, growth rate and design life in years.

- Initial Traffic Volume

Since it is a new construction, the Estimation of the initial daily average traffic flow for Road section is based on 7 days 24 hour classified traffic counts conducted on the adjacent road i.e. on Imphal-Moreh road

- Growth Rate

The traffic growth rate is normally established by studying the past trends in traffic growth. However the other factors also to be considered to get appropriate prediction of traffic growth which is described under. In absence of adequate data, the growth rate can be obtained 5% as per Para 4.2.2, IRC 37 - 2012. It is also recommended in Para 5.5.4, MANUAL OF SPECIFICATIONS & STANDARDS, Planning Commission, Government of India New Delhi state that the Concessionaire shall adopt a realistic value of e rate of traffic growth, provided that annual rate of growth of commercial vehicles shall not be adopted less than 5 per cent.

The growth rate of commercial vehicle is considered to be directly proportional to the growth rates estimated for different sectors such as agriculture, industry, trade and mining etc. of the influence regions. The specific NSDP factors for the various sectors are considered for Manipur state. In order to arrive at the growth rate of commercial vehicles, the influence of each zone in terms of commercial traffic has been considered. The relative impact of each sector was considered by calculating the commodities being carried by goods vehicles.

As the new road bypasses the Moreh city, it is expected that most of the traffic will be using this bypass in future and traffic is expected to grow rapidly than earlier, so the growth rate is higher than the project area. However IRC-37-2012 suggests that in absence of data 5% should be considered, the growth rate of 5% has been considered for the design life for flexible pavement due to the road improvement and due to bypass to NH-39 which may have more traffic in future.

- ✓ Design Period

As per Para. 4.3.2, page no. 6, IRC: 37-2012, the flexible pavements have a life span of 15 years and should be designed for this period.

2.7 DESIGN TRAFFIC

The design traffic is calculated in terms of the cumulative number of repetition of standard axles to be carried during the design life of the proposed road. It requires the estimation of initial number of commercial vehicles per day when road is operational.

The following equation has been used to calculate the design traffic:

$$N = \frac{365x[(1+r)^n - 1]}{r} xAxDxF$$ ... (Ref. IRC: 37-2012, para. 4.6.1, page-9)

Where,

N = Cumulative number of axles during the design period.

A = Initial number of axles per day in the year when the road is operational.

r = Annual rate of growth of commercial traffic (expressed in decimals).

n = Design period in years.

AADT on the project road for year 2016 is as shown in table;

Table 2.3: AADT of project road for base year 2016

Vehicle category	Moreh Bypass
Two Wheeler	1333
Car / Jeep / Van / Taxi	1116
Three Wheeler	1670
LCV	114
Govt. Bus	4
Pvt. Bus	4
Mini Bus	3
Tractor	0
Tractor With Trolly	0
2 - Axle	27
3 - Axle	11
Multi-Axle Truck	0
Total Fast Moving	**4282**

2.8 EXISTING SOIL AND SUB-GRADE CONDITIONS

Nature of soil present at existing condition where proposed road is to be constructed also has a significant consideration in the pavement design. The trial pits (1.5m x 1.5m xl.5m) has been taken on existing shoulder and widening side to determine the suitability of data for sub-grade material. The details of trial pits results are enclosed in separate Geotechnical Report. The summary of trial pits results are given below.

Table 2.4: CBR of subgrade

Chainage	CBR %	MDD g/cc	OMC%
0+450	7.34	1.921	16.17
1+550	8.12	1.780	17.05
2+000	7.68	1.907	16.25

The details of soil characteristics and test results are as follows.

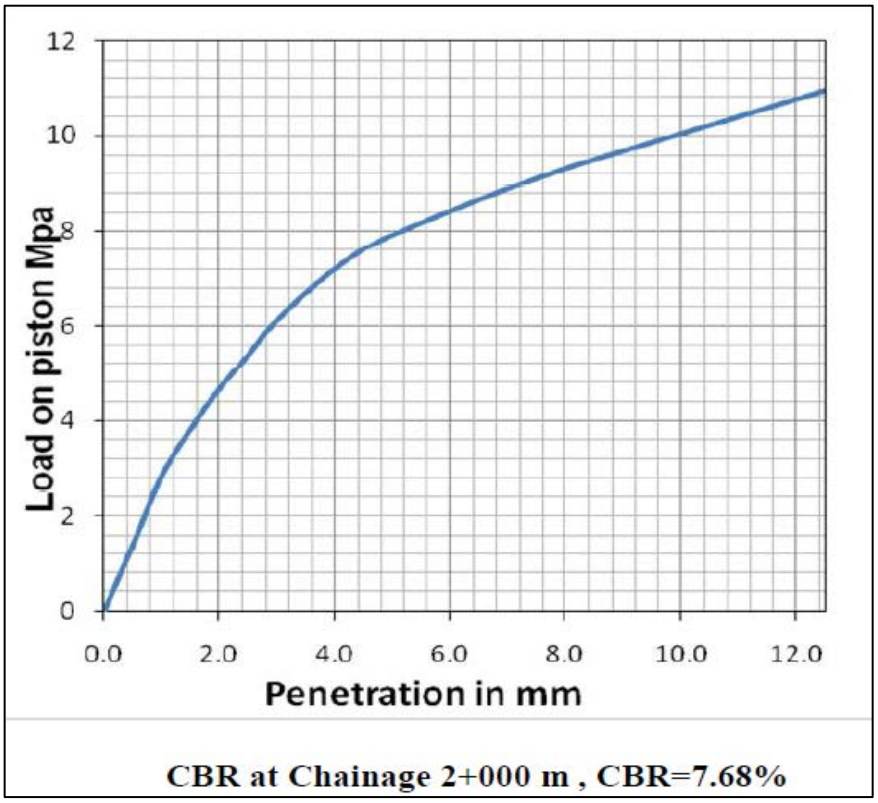

Figure 2.1: CBR at CH 2+000

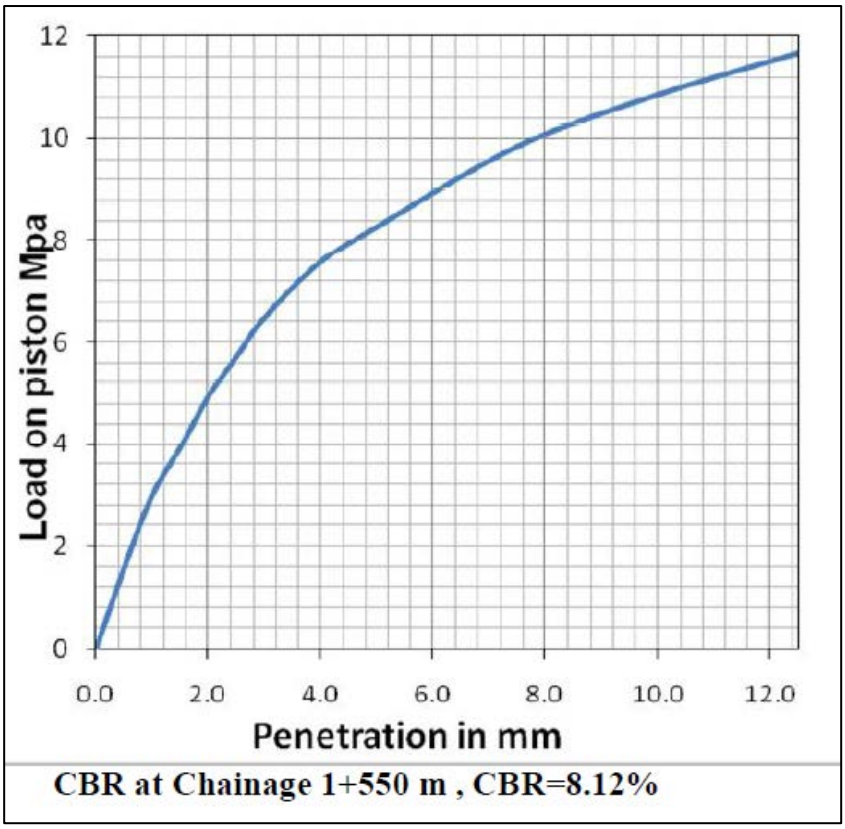

Figure 2.2: CBR at Chainage 1+500

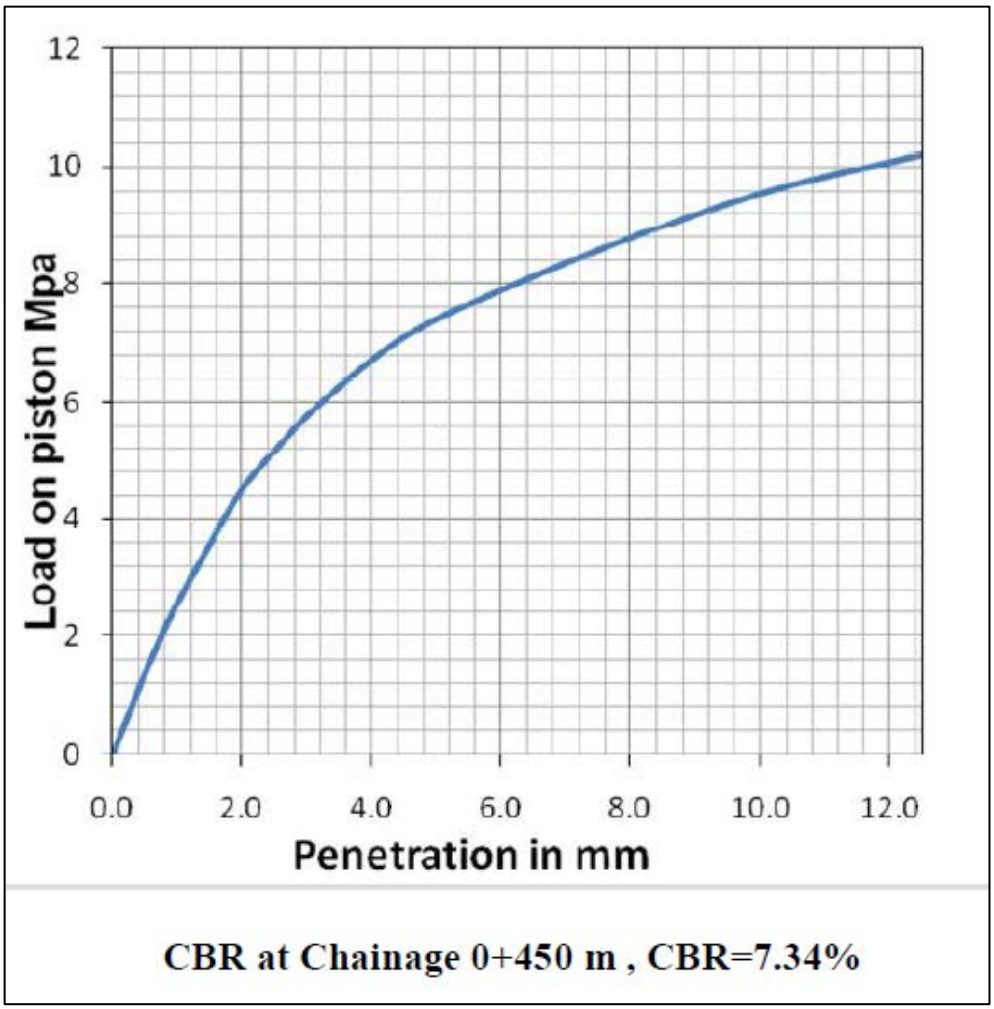

Figure 2.3: CBR at 0+450

2.8.1 SUB-GRADE AND SUB-BASE

2.8.1.1 Sub-grade

The strength of sub-grade is expressed in terms of modulus of sub-grade reaction, k. The modulus of sub grade reaction is determined by CBR tests.

The sub-grade soil strength is dependent on moisture condition. As the minimum subgrade strength is obtained at the worst moisture condition, CBR test is conducted for 4 days soaked CBR for the assessment of design strength. An approximate idea of k-value of a homogeneous soil sub-grade may be obtained from its soaked CBR value as per the following correlation.

Table 2.5: CBR test result

Chainage (Km)	Soaked C.B.R. of soil at Existing	Recommendation
0+450	7.34	

1+500	8.12	
2+000	7.68	

Note - Excavated sub-grade material CBR less than *6%* but having MDD >15.2 can be used as embankment layer at BC soil location.

2.8.2 SUBGRADE ON WIDENING SIDE

It is also noted from the laboratory results that the CBR value of soil at widening side is not suitable for sub-grade however it can be used as embankment foundation. The foundation has to be compacted as per MORT&H specification Table 300-2 which the compaction should be 95% of lab density. The required density for the embankment material is also should satisfy the density requirement of embankment material as per MORT&H, Table 300-1.

The trial pits results at widening side can be found in separate Geotechnical report. However the summary of results and recommendations are given below.

(Ref. MORT&H, Table 300-1, Page-64)

Table 2.6: Embankment Details

S. No	Type of Work	Max. Lab Dry Density
1	Embankment up to 3m	Not Less Than 15.2 KN/Cu.m
2	Embankment > 3m	Not Less Than 16.0 KN/Cu.m
3	Subgrade and earthen shoulders/verges/backfill	Not Less Than 17.5 KN/Cu.m

Table 2.7: Subgrade (Ref. MORT&H, Table 300-2, Page-66)

S. No	Type of Work/Material	% Compaction of Max. Lab Dry Density
1	Sub-grade and earthen shoulder	Not Less Than 97%
2	Embankment	Not Less Than 95%
3	Expansive Clays a) Sub-grade and 500 mm portion just below the sub-grade b) Remaining portion of embankment	Not Allowed Not Less than 90-95%

2.9 DESIGN CALCULATION

Table 2.8: Design Calculation of Flexible Pavement

Project Name :-	NH or SH :-	For Year's :-	CBR
Moreh Bypass	NH	15	10%

Traffic Growth Considered is	
5%	0.05

Construction Time	
1	In Year

Traffic Count					V.D.F	
Vehicals	Traffic Count (ADT) Both Side	Variation Factor	Traffic Count (AADT) Both Side	Traffic Count (AADT) Both Side	Vehicals	Count
LCV	110	1.04	114	57	LCV	1.5
Bus	11	1.04	11	6	Bus	1.5
2 Axle	26	1.04	27	14	2 Axle	1.5
3 Axle	11	1.04	11	6	3 Axle	1.5
MAV 4-6 Axle	0	1.04	0	0	MAV 4-6 Axle	1.5
Multi Axle 7++ Axle	0	1.04	0	0	Multi Axle 7++ Axle	1.5
Total	**1py**		**1cn**	**82**		

Table 2.9: Design Calculations

Moreh Bypass (2LPS)

CUMULATIVE MSA CALCULATION FOR for 15 yr for MOREH BYPASS

i) 2 Lane

ii) Initial Traffic in Each Directions

LCV	Bus	2 Axle	3 Axle	MAV 4-6 Axle	Total
114	11	27	11	0	164

Base Year 2016

Traffic Growth Considered is 5.00%

$A = P * (1+r)^x$

Initial Traffic in Each Directions in the Year of Completion of Construction

LCV	Bus	2 Axle	3 Axle	MAV 4-6 Axle	Total
120	12	28	12	0	172

The design should be based on 50% of the total number of commercial vehicles in both directions.

as per clause 3.3.5.1 (ii) page no. 13 IRC:37-2012.

Therefore, Initial Traffic in Each Directions in the Year of Completion of Construction.

LCV	Bus	2 Axle	3 Axle	MAV 4-6 Axle	Total		
120	12	28	12	0	172	CV/Day	Completion Year 2019

iii) Design Life for Grannular Subbase — 15 Years

iv) Design CBR of Subgrade Soil — 10%

v) Traffic Growth Rate — 5.0%

vi) Vehicle Damage Factor (Found out from Axle Load Survey on Existing Road)

LCV	Bus	2 Axle	3 Axle	MAV 4-6 Axle	Multi Axle 7++ Axle
1.5	1.5	1.5	1.5	1.5	1.5

vii) Distribution Factor Cumulative Number of Standard Axles to be carried During Design life of 15 Years — 50.0%

viii) $$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$$

$$LCV = \frac{365 \times [((1+0.1)^{15})-1]}{0.1} \times 120 \times 1.5 \times 0.5 = 0.709 \text{ msa}$$

$$BUS = \frac{365 \times [((1+0.1)^{15})-1]}{0.1} \times 12 \times 1.5 \times 0.5 = 0.071 \text{ msa}$$

$$2\ Axle = \frac{365 \times [((1+0.1)^{15})-1]}{0.1} \times 28 \times 1.50 \times 0.5 = 0.165 \text{ msa}$$

$$3\ Axle = \frac{365 \times [((1+0.1)^{15})-1]}{0.1} \times 12 \times 1.5 \times 0.5 = 0.071 \text{ msa}$$

$$MAV\ 4\text{-}6\ Axle = \frac{365 \times [((1+0.1)^{15})-1]}{0.1} \times 0 \times 1.5 \times 0.5 = 0.000 \text{ msa}$$

Total 1.02 msa

Minimum MSA that should be considered for a National highway as per IRC: Sp 73 2015 Clause 5.4.1 **20.00**

Crust Composition As per IRC 37:2012 Plate 7 P.No. 28

The average CBR of subgrade **10%**

GSB	200	mm
WMM	250	mm
DBM	80	mm

BC	40	mm
Total	**570**	**mm**

3. Structure Design Report

3.1 INTRODUCTION

"Specialized Consultancy Services for 'Good for Tender' design based on detailed investigations, estimation, survey, costing and preparation of Technical Schedules of EPC documents for construction of Moreh Bypass on NH-39 near Indo-Myanmar Border in the State of Manipur " (Total Design Length 2.52 km)

M/s Choice Consultancy Services Pvt. Ltd. has been appointed by the National Highways & Infrastructure Development Corporation Limited for providing Detailed Engineering Design Consultancy Services for the above mentioned Section.

The National Highways & Infrastructure Development Corporation Limited is required to carry out detailed engineering design beside surveys, investigations and preparation of working drawings for all components relevant to the improvement and Upgradation of the Project Highway to fulfill the scope of the Project as envisaged in the TOR.

The Design Report prepared in three parts Part I & II deal with the design of road features & pavement composition while Part III deals with the design of bridges & cross drainage structures. The "Design Report Part III CD works" gives the Methodology, Indicative Design Standards, Engineering Surveys & Investigations, rehabilitation / widening of existing structures; new bridges, reconstruction of existing structures, development proposals, for the project road.

3.2 DETAILED METHODOLOGY

The consultant's approach to the project is in accordance with the "SCOPE OF SERVICES" given in the contract document, understanding of the project objectives and further discussions with client; during progress of project study. Cognizance will also be given to the special directives issued by the client from time to time

3.2.1 Detailed Methodology

The detailed methodology of each task is given in subsequent articles.

3.2.2 Investigation for Bridges, Culverts and Structure

3.2.2.1 Review of Data / Reports

The Consultants had made an inventory of all the structures (bridges & culverts, etc.) along the road under the project. The inventory for the bridges & culverts includes the parameters required as per the guidelines of IRC-SP: 35-1990. The inventory of culverts is presented in a tabular form covering relevant physical and hydraulic parameters & presented at Appendices to Design Report.

3.2.2.2 Hydraulic and Hydrological Investigations

a) The information is collected for high flood level (HFL), low water levels (LWL), discharge velocity etc. from available past records, local inquiries and visible signs on the structural components and embankments. Local inquiries was also be made with regard to the road sections getting overtopped during heavy rains.

b) The Consultants had made a desk study of available data on topography (topographic maps), storm duration, rainfall statistics, top soil characteristics, vegetation cover etc. so as to assess the catchment areas and hydraulic parameters for all existing and proposed drainage provisions. The findings of the study is supplemented and augmented by a reconnaissance along the area. All important hydrological features are noted during this field reconnaissance.

c) For bridges and cross drainage structures having inadequate waterway, history of overtopping and are proposed for reconstruction, the detailed hydrological and hydraulic studies are carried out in accordance with IRC Special Publication No. 13 ("Guidelines for Design of small bridges and culverts") and IRC 5 -1998 ("Standard Specification and code of Practice for Road Bridges, Section I General Feature of Design").

3.2.2.3 Condition Surveys for Bridges, Culverts and Structures

a) The Consultant had thoroughly inspect the existing structures and prepared report about their condition including all the parameters given in the Inspection pro-forma of IRC-SP; 35-1990. The condition and structural assessment survey of the bridges / culverts / structures was carried out by senior experts of the Consultants.

b) The bridges identified in a distressed condition based upon the visual condition survey.

3.2.2.4 Geo-technical Investigations and Sub-Soil Exploration

Description :	Location of Boring
Overall length = 6 - 30 m :	One abutment location
Overall length = 30 - 60 m	One abutment location and at least one intermediate location between abutments for structures having more than one span.
Overall length > 60 m	Each abutment and each pier locations.

i. The Consultants had carried out geo-technical investigations and sub-surface explorations for the proposed new bridges / bridges proposed for reconstruction etc., along 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 as under.

ii. However, where a study of geo-technical reports and information available from adjacent crossings over the same waterway (existing highway and railway bridges) indicates that subsurface variability is such that boring at the suggested spacing will be insufficient to adequately define the conditions for design purposes, the Consultants had review the same and finalise the bore hole locations in consultation with the NHAI.

iii. Sub-soil investigations were done as per IRC 78-2000.

iv. The scheme for the borings locations and the depth of boring was prepared by the Consultants and submitted & got approved from NHAI

v. The sub-soil exploration and testing carried out through the Geo-technical Consultants empanelled by the MORT&H. The soil testing reports are in the format prescribed in relevant IRC Codes.

3.3 Detailed Design of Bridges, and Structures

3.3.1 General

(i) Bridges

(ii) Rehabilitation and repair plan with for bridges and structures design and drawings;

3.3.2 Design Standards

i. The Consultants evolved Design Standards and material specifications for the Study primarily based on IRC publications, MORTH Circulars and relevant recommendations of the international standards.

ii. The Design Standards evolved for the project covering all aspects of detailed design bridges and structures, traffic safety and materials.

3.4 Design of Bridges and Structures

The Consultant had prepared General Arrangement Drawing (GAD) and Alignment Plan showing the salient features of the new bridges and structures proposed to be constructed / reconstructed along the road sections covered under the Study. These salient features such as alignment, overall length, span arrangement, cross section, deck level, founding level, type of bridge components (superstructure, substructure, foundations, bearings, expansion joint, return walls etc.) are finalized based upon hydraulic and geotechnical studies, cost effectiveness and ease of construction. There are no at-grade level crossings along the project. Hence there is no requirement to prepare ROB GAD's.

The existing structures having inadequate carriageway width was proposed for widening/ reconstruction in pat or fully as per the latest MORT&H guidelines. The detailed design and working drawings for carrying out the above improvements are attached with separate volume of CD Structure Drawings.

Suitable repair / rehabilitation measures are suggested in respect of the existing structures as per IRC-SP: 40 along with their specifications, drawings and cost estimate in the form of a report. The rehabilitation or reconstruction of the structures suggested is based on broad guidelines for rehabilitation and strengthening of existing bridges contained in IRC-SP:35 and IRC-SP:40.

The recommendations for protection works for bridges and drainage structures, wherever required are proposed & given in the report.

The land available is not adequate for embankment slope at places along the project road. PCC retaining wall is proposed to restrict the embankment.

3.5 Indicative Design Standards:

3.5.1 Approach:

The aim is to provide maximum safety to the road users viz., service roads and cross traffic, in defining the highway geometry, carriageway and shoulder widths, embankments and other pertinent components for an uninterrupted and smooth flow of traffic:

a) Segregate local traffic from through traffic by providing service roads.
b) Provide appropriate cross traffic facilities without impeding traffic flow.
c) Use ROW only and recommend land acquisition for where absolutely essential.
d) Minimize impact on roadside settlements and environment.
e) Avoid adverse impacts of crowded areas along the stretch of Project Road.
f) Provide cost-efficient, but readily constructible facility with least hindrances, namely, land acquisition, resettlement and rehabilitation.

The Consultants have referred to the latest IRC publications and MORT&H circulars regarding design standards & design guidelines for State Highways in India. The relevant Indian standards consulted include:

Main IRC Publications

IRC: 64-1990	:	Guidelines for Capacity of Roads in Rural Areas (First Edition);
IRC: 65-1976	:	Recommended Practice for Traffic Rotaries;
IRC: 66-1976	:	Recommended Practice for Sight Distance on Rural Highways;
IRC: 73-1980	:	Geometric Design Standards for Rural (Non-Urban) Highways; and
IRC: 86-1983	:	Geometric Design Standards for Urban Roads in Plains

Design Standards for Bridges / Structures

The cross drainage structures are classified as culverts, minor bridges and major bridges depending up on the length of structure as per IRC standards. Structures up to 6m length fall into the category of culverts, more than 6m and up to 60m in length as minor bridges and beyond this as major bridges. Widening of existing culverts and bridges for four lanes and all new structures are constructed for four lane carriageway with an over-all width of roadway.

The design standards and loading considered for culverts & bridges are as per latest IRC codes and/or IS codes.

(i) The Indian Road Congress (IRC) codes are the basis of bridge designs,. For items not covered by latter, provisions of Special Publications and Specification for Roads and Bridges published by IRC are followed.

(ii) Grades of Concrete for superstructures are as per MOST Specifications and IRC Standards. The Minimum grade is M40 for PSC and M25 for RCC respectively.

(iii) For substructures M45, pile foundations M40, Box Bridge & Box Culvert M30, Approach Slab M30 & for Crash Barrier M40 concrete are proposed for use. For PCC substructures minimum grade of M20 is adopted.

(iv) For all new 2-lane structures, 3-lane live load is considered as per IRC-6.

(v) Locations of new Minor Bridges are guided by the alignment of the highway.

(vi) On economic considerations and for ensuring good riding quality, wherever possible, for the new bridges the layout of the existing bridges having a number of small spans was modified by decreasing the number of spans, maintaining the piers parallel and in line with those of the existing structure.

(vii) The deck haves 2.5% unidirectional camber/cross fall and the wearing course will be of uniform thickness of 25mm Mastic and 40mm BC.

(viii) In general pile foundations are proposed for Flyovers Raft foundation for box bridges & for other box culverts/HPC are proposed.

3.6 Design of Bridges and Culverts

(i) All the structures up to 60 m length are constructed with all overall width between outermost faces of the railings / parapets / crash barriers equal to the roadway width of the approaches.

(ii) New structures are constructed with an overall width between the outermost faces of the crash barriers or railings.

(iii) All bridges are high level bridges.

(iv) All structures are designed in accordance with the relevant IRC Codes, Standards and Specifications.

3.7 Widening / reconstruction of existing structures

3.7.1 Existing Culverts

(i) All culverts which are structurally distress are proposed for reconstruction.

(ii) All existing culverts which are not to be reconstructed are proposed for widening.

3.7.2 Existing Bridges

(i) All bridges which are structurally distress are proposed for reconstruction.

(ii) The bridges which are sound but narrower then 7.5 m width (carriageway) are proposed for widening. *(There is no such type of bridge.)*

(iii) All existing bridges in sound condition shall be retained.

3.8 Reference Standards:

"Manual of Standards and Specifications" published by MORT&H and IRC Standards used in general.

3.9 Reference Manual

Design standard is proposed to be adopted as per manual of specifications and standard for two laning of highway through public private partnership IRC SP 73-2007.

3.10 Reference to Codes & Guidelines

Various IRC Codes guides / special publications need to be referred while preparing the improvement / widening proposals. An exhaustive list of such codes / special publications and other recommendation are appended. Besides these, certain guidelines issued by way of circulars from MORT&H & NHAI will be kept in mind. These circulars are –

Following guidelines and standards will be used

IRC: 71-1977	Recommended Practice for Preparation of Notations
MORT&H 2001 Edition	Specifications for Road & Bridge works
IRC : SP-19-2001	Manual for Survey, Investigation and Preparation of Road Projects (Second Revision)
IRC : SP 13-1973	Guidelines for Design & Small Bridges & Culvert.
IRC : 5 – 1998	Standard Specifications & Code of Practice for Road Bridges, Section I General feature of Design.

IRC : 6-2000	Standard Specifications & Code of Practices for Road Bridges, Section II -Loads and Stresses (Fourth Revision)
IRC : 21-2000	Standard specifications and Code of Practice for Road Bridges, Section-III -Cement Concrete (Plain and Reinforced)
IRC : 78-2000	Standard Specifications and code Practices for Road Bridges, Section-VIII –Foundation &Substructure (Second Revision)
IRC : SP-33-1989	Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structure
IRC : 45-1972	Recommendations for Estimating the Resistance of Soil Below the maxi-mum scour Level in the Design of well Foundations of Bridges
IRC : 18-2000	Design Criteria for Prestressed Concrete Road Bridges (post-Tensioned Concrete) (Third Revision)
IRC : 22-1986	Standard Specifications and code of Practice for Road Bridges, section - VI - Composite Construction (First Revision)
IRC : 83-1999 Part I	Standard Specifications and code of practice for Road Bridges, Section IX-Bearings, Part I : Metallic Bearings (First Revision)
IRC : 83-1987 Part II	Standard Specifications and code of practice for Road Bridges, Section IX - Bearings, Part II: Elastomeric Bearings
IRC : 89 – 1997	Protection works for bridges
IRC : SP- 35 –1990	Inventory for bridges
IRC : SP - 40 – 2002	Guidelines on Techniques for strengthening Rehabilitation of Bridges.
IRC : SP : 37	Guidelines for evaluation of Load carrying capacity of Bridges
IS : 1892	

IS : 5313	Sub soil exploration for Bridges
IS : 4464	

4. Existing Details of cross drainage structure

4.1 Existing Details of cross drainage structure

The report presents the existing structure for Moreh Bypass from NH-39 near Indo-Myanmar border to land custom port of India to bypass the Moreh town in the state of Manipur. The Project Road link passes through urban area of Moreh city passing through the habited areas of Vamnom, Moulmom and Tl.e.l.Saijang etc. The existing BT carriageway is having single without paved shoulders in urban stretches and earthen road for remaining stretch. The total length of Project Road is 2.940 km and there is 1 minor bridge across the Project Corridor. The minor bridge is new, safe which will be proposed to retain with minor repairs. It is observed that reinforcement is good; expansion joints are safe and no leaching and honey combing in substructure masonry. There are total 15 cross drainage works present across the total stretch.

Table 4.1: Summary of Existing Cross Drainage Structure

Type	Major Bridges	Minor Bridges	Slab / Box Culvert	HP Culvert	RUB
Existing Structure	0	1	10	05	0

4.2 Minor Bridges

Details of existing minor bridges are listed in Table 4.2 as under

Table 4.2: Existing Slab/Box culverts

Sr. No.	Chainage (Km)	No. of Span/span in m	Width of Bridge(inside parapet) (m)	Remarks
1	1/176	2 spans/12 m c/c	9.60	PCC pier and abutment with RCC slab & CC solid returns.

4.3 Slab/Box Culverts

Details of existing Slab/Box culverts are listed in Table 4.3 as under

Table 4.3: Existing Slab/Box culverts

Sr. No.	Existing Chainage	Type of Culvert	No. of Exi. Opening	Span Length (m)	Clear Width of Structure (m)	Remark

Sr. No.	Existing Chainage	Type of Culvert	No. of Exi. Opening	Span Length (m)	Clear Width of Structure (m)	Remark
1	0/130	Slab Culvert	1	1.9	11.15	
2	0/330	Slab Culvert	1	2.75	19.3	
3	O/390	Slab Culvert	1	2.75	18.7	
4	1/553	Slab Culvert	1	3	12.6	
5	1/780	Slab Culvert	1	2.75	20	
6	2/013	Slab Culvert	1	2.75	12.3	
7	2/317	Slab Culvert	1	2.75	12.3	
8	2/581	Slab Culvert	1	3	13.4	
9	2/651	Slab Culvert	2	1.5	13	
10	2/910	Slab Culvert	1	3	12.3	

4.4 H.P. Culverts

Details of existing HP culverts are listed in Table 2.4 as under;

Table 4.4: Existing HP Culvert

Sr. No.	Existing Chainage	Type of Culvert	No. of Exi. Row	Dia. of Exi. Pipe (mm)	Width of Structure (m)	Remark
1	0/645	HPC	1	1000	9.6	
2	0/838	HPC	1	1000	15.5	
3	1/030	HPC	1	1000	10	
4	1/248	HPC	1	500	15	
5	1/720	HPC	1	900	10	

5. IMPROVEMENT PROPOSALS

5.1 General

As per TOR the concept of development & construction of the project highway is for reduction in transport cost, enhanced safety level of service for road users, superior operation & maintenance enabling enhanced operation efficiency, minimal adverse impact on the local population, minimal adverse impact on environment, minimal land acquisition by appropriate engineering solutions. For the purpose of feasibility study, preliminary design of the major components is carried out for the alternative improvement proposals.

5.2 Improvement Scheme

The improvement proposal consist of improvement to existing carriageway by reconstruction and widening to Two lane with paved shoulder standard. The improvement proposal includes to improvement to geometrically deficient curves and grades to meet the geometrical standards. All submersible slab culverts shall reconstruct / widened / newly constructed as per standards of MoRTH. It is also proposed for reconstruction / widened / new construction of the Hume Pipe Culverts / Slab drains to meet the national highway standards.

The improvement proposal includes constructions of project facilities, bus bays and shelters, Land scaping, Arboriculture, Built up drains with raised footpaths, signage system, road markings and painting and Junctions improvements etc.

Table 5.1: Abstract for Cross Drainage Structures

Existing Structure	Proposal				Total
	New Construction	Reconstruction	Widening	Retained with Repairs & Strengthening	
Major Bridge	-	-	-	-	-
Minor Bridge	-	-	-	1	1
Slab Culvert & Box Culvert	3	10	-	-	13

A. Minor Bridge:-

Table 5.2: Retained, Repair, Maintenance of Minor Bridges

Sr. No.	Existing Chainage (Km)	Design Chainage (Km)	Details of Existing Structure			Remark
			Type of Structure	Span Arrang-Ement	Width of Structure (m)	
1	1/176	1/160	Minor	2 x 12.0	11.0	For Existing br. Proposed retain with

Sr. No.	Existing Chainage (Km)	Design Chainage (Km)	Details of Existing Structure			Remark
			Type of Structure	Span Arrang-Ement	Width of Structure (m)	
			Bridge			minor repairs.

B. Slab / Box Culvert:-

Widening, Repair, Maintenance and Strengthening of Existing Slab / Box Culvert: Nil

Sr. No.	Existing Chainage (Km)	Project Chainage (Km)	Design Chainage (Km)	Details of Existing structure			Details of Proposed structure		Remark
				Type of Structure	No. x Span	Existing Width (m)	No. x Span	Proposed Width (m)	
----------Nil----------									

Table 5.3: New construction of box culverts

Sr. No.	Design Chainage (Km)	Details of Proposed structure			Remark
		Type of Structure	No. x Span	Proposed Width (m)	
1	1+470	Box culvert	1X2X2	12	
2	2+030	Box culvert	1X3X3	12	
3	2+520	Box culvert	1X3X3	12	

Table 5.4: Reconstruction Slab / Box Culvert

Sr. No.	Existing Chainage (Km)	Design Chainage (Km)	Details of Proposed structure			
			Type of Structure	Span Arrang-ement	Proposed Width (m)	Remark
1	0+130	0+130	Box Culvert	1x3x3	12	

Sr. No.	Existing Chainage (Km)	Design Chainage (Km)	Details of Proposed structure			
			Type of Structure	Span Arrang-ement	Proposed Width (m)	Remark
2	0+330, 0+390	0+355	Box Culvert	1x3x3	12	
3	0+517	0+503	Box Culvert	1x3x3	12	
4	0+645	0+648	Box Culvert	1x2x2	12	
5	0+838	0+830	Box Culvert	1x2x2	12	
6	1+030	1+028	Box Culvert	1x2x2	12	
7	1+248	1+252	Box Culvert	1x2x2	12	
8	2+013	1+796	Box Culvert	1x3X3	12	
9	2+317	2+140	Box Culvert	1x3X3	12	
10	2+581, 2+651	2+450	Box Culvert	1x3X3	12	

The GAD of cross drainage structures are submitted in a separate drawing volume with this report.