CHAPTER - 1

INTRODUCTION

1.1 INTRODUCTION

Road Sevoke-Gangtok (NH-31A) connects Gangtok, Capital of Sikkim with rest of the Country. The road was declared as National Highway – 31A on 12 February 1963. The road was built for the route to Tibet and then to China for the purpose of trade and movement of armed forces. The road subsequently metamorphosed into the National Highway – 31A, which is strategically the most important road in the country. This highway holds great significance and is of great importance in the defence of India. The National Highway 31-A leads from Gangtok via Cottage Industries and ends at White hall and has been in media for the past several months. The highway also known as 'life line of Sikkim' is the shortest route connecting Sikkim to rest of India and is very important from strategic as well as socio-economic point of view. The road is strategically important to Army being the link to China border in Sikkim and being the vital link to state of Sikkim. The NH-31A is also very important form tourism point of view and as it links important tourist destinations like Gangtok, Changu lake, Nathula Pass, Rumtek monastery etc. The highway is the vital lifeline and constitutes the single most indispensable infrastructure for further continuous growth of Sikkim.

National Highway 31A was taken over by Border Roads Organisation from CPWD during Jan 1969 after extensive damages occurred to the road formation due to floods of 1968. The road was included in BRDB Programme for development and maintenance. The road is being maintained under scale –I maintenance grant.

Initially the road was of NH single lane specification when it was taken over from CPWD. Keeping in view the steady increase in the volume of traffic intensity, requirements of Sikkim Govt. and strategic importance of China Border, it was decided to widen the road in 1991-92 from Km 0.300 to Km 81.00. Accordingly, stretch wise widening to intermediate lane (5.5 m carriage width) specification was carried out along the entire length of 92.600 Kms.

1.2 BACKGROUND

Road Sevoke-Gangtok (NH-10) connects Gangtok, Capital of Sikkim with rest of the Country. .The highway also known as 'life line of Sikkim' is the shortest route connecting Sikkim to rest of India and strategically important to Army being the link to China border in Sikkim. The NH-10 was handed over to BRO with a view to accelerating economic development and strengthening defence preparedness through rapid and co-ordinate expansion and improvement of road network. Fast development of industrial, commercial, Tourism in the state of Sikkim has caused increased the traffic intensity many times in the National Highway. Nathula trade with China has also imparted increase in traffic because of trade and tourism

The traffic has been increased manifold and has been increasing day by day on the National Highway. In order to make National Highway of NHDL specification it is proposed to construct Bridge 48.0 mtr span at Km 75.30.

There is two parallel existing bridges (U/S RCC bridge & D/S steel bridge) having length of about 12m at Km 75.300 of Sevoke Gangtok Section of NH-10 .

U/S RCC Bridge was constructed in 2014 having width single lane and D/S Steel bridge was constructed about 20 years ago.

The existing bridge is 40R loading having width 4.25 m with very sharp curve location resulting frequent traffic jams & vehicle congestion. Therefore it is proposed to construct new bridge with geometric improvement existing road.

1.3 OBJECTIVE OF THE PROJECT

Presently there is two Bridges located at km 75.30 on Chubba Khola (12.0 Mtr span RCC Bridge). The existing width of bridge is 4.25 mtr, which is causing disruption in smooth two-way traffic movement at Chubba Khola Nallah, it is proposed to construct Permanent Minor Bridge at km 75.30 of 48.0 Mtr span with its approach roads at D/S of existing bridge. The Bridge is proposed on open foundation with 10.50 mtr carriage width and total width 13.0m.

1.4 SALIENT FEATURES OF THE PROJECT

Take off point	:	75+300 on NH-10
Length of Existing Bridge	:	12.0 m
Width of the Existing Bridge	:	4.250 m
Loading on existing bridge	:	40 R IRC loading
Existing Bridge	:	Steel Truss (D/S) / RCC Slab (U/S)
Proposed Bridge Length	:	48 m
Width	:	13.00 m
Carriageway	:	10.50 m
Loading	:	70 R IRC loading
HFL	:	673.945 m
Type of Superstructure	:	PSC I-Girder
Footing	:	Open Foundation (A1) Abutment Ht-18.0 m (Counter fort type and (A2) Abutment Ht-10.0m (Cantilever)
Approach road	:	205.00 m (Singtam side)
		235.00 m (Gangtok side

1.5 **Pavement Design**

Construction of approach road on both sides of proposed tunnel .On Singtam side 100 m length of existing single lane formation need to be widen to two lane and in Gangtok side 70m new approach road needs to be constructed. The pavement crust has been designed as per IRC 37:2012 for design life of 15 years & design traffic of 20 MSA, considering soil CBR 9%, the crust composition is as follows:

Crust details		Thickness
GSB Sub base	-	250mm
WMM Base	-	250 mm
DBM	-	60mm
BC	-	40mm
Total Thickness	**-**	**600mm**

1.6 Construction of minor bridges

S. No	Bridge at km	Span Arrangement (m)	Remarks
1	**75+520**	**48m**	**PSC I girder with open foundation**

1.7 Drainage Measures

Following measures shall be adopted: Trapezoidal drains PCC (Lined) of 440 m length.

1.8 Unit Rates

The unit rates for arriving at cost of different components of works are based on Sikkim PWD Schedule of Rates 2012 (for National Highways) with WPI upto july 2018. 12 % GST provision added in civil work cost. For those items of works which are not available in the SOR, separate Analysis of Rates have been carried out and incorporated in this DPR.

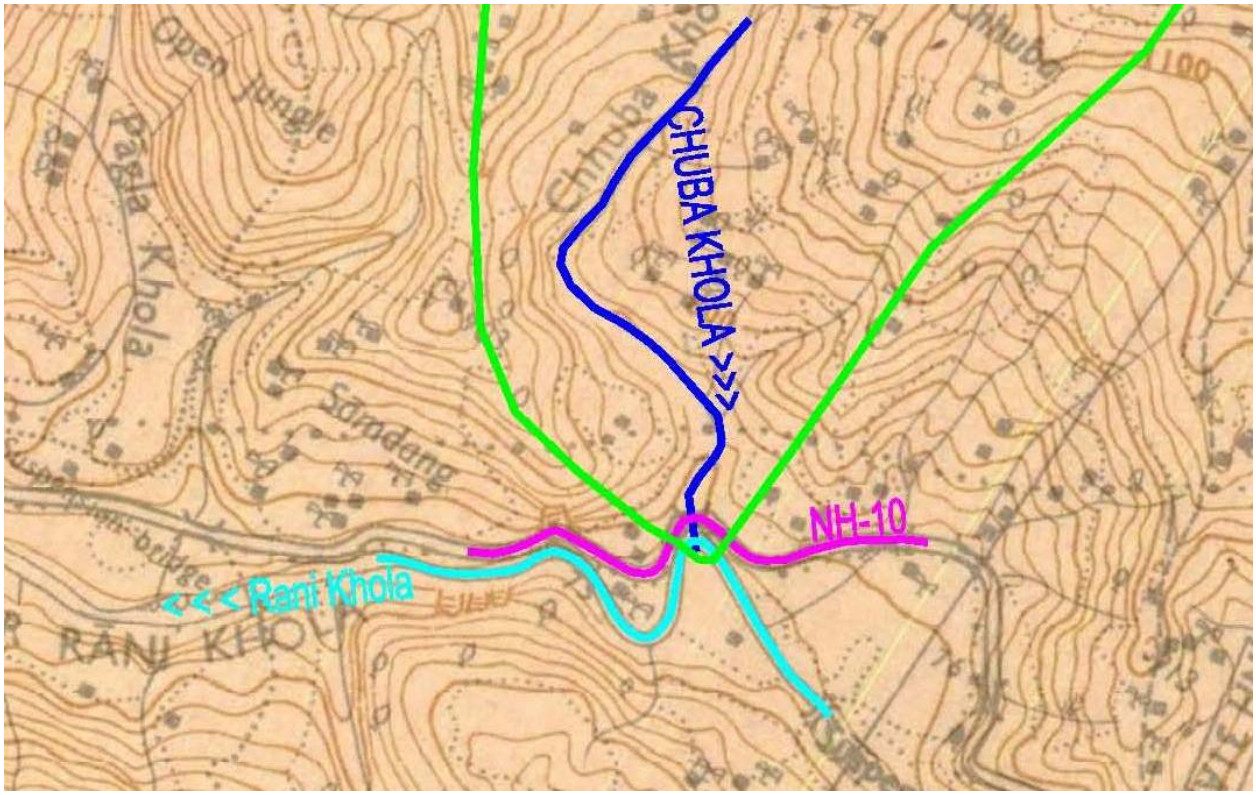
As SOR -2012 is already built-up with 6 % of Taxes like Vat, Excise therefore input item 6.0% of taxes excluded and to bring the input items tax free.

Rates of the following items taken from INAM Pro and OIL site on the month of July-2018

- Bitumen (VG-30) (Ex-Singtam) (Basic rate = Rs 28370/ MT +transportation from Barauni to Singtam (462Km xRs.11) Rs.5082= Rs 33452.0)
- Emulsion (Ex-Singtam) (Basic rate = Rs 23490/ MT +transportation from Haldia to Singtam (740Km xRs.11) Rs.8140= Rs 31630.0)
- Cement (43 grade) (Ex-Singtam) (Basic rate = Rs 6160/ MT +transportation from Guwahati to Singtam (=510Km xRs.5.6) Rs.3264.0= Rs 9424.0)
- Cold twisted bars (HYSD Fe 500 Bars)(Basic rate = Rs 46700.00/ MT +transportation from Siliguri to Singtam (90Km xRs.5.6) Rs.504= Rs 47276.00)
- Sand & Aggregate from Teesta River.

Other Charges: Other charges include Centages for the civil works are taken as follow:

- Contingency = 2.8%
- Construction Supervision Charge = 3.0%
- Maintenance for 10 Years = (5x0.25%+5x0.5%)=3.75%
- Escalation for 2 Years = 2 x 5.0% =10.0%
- Administrative (NHIDCL) Charge = 3.0 %



Topo Map at Bridge Location

Bridge location Google Image

CHAPTER – 2: RECONNAINCE SURVEY

2.1 REVIEW OF DATA & DOCUMENTS

The Team identified the data, documents and information requiring study and review. In addition, the data is procured and collected about likely constraints in execution of the project like existence of structures along the road, which would require interaction with the local authorities for their relocation and removal. The data as collected has been studied and reviewed.

The teams made in depth study of data/information, as available, about the project sites. The inter alias includes:

- Topographical sheets, geological and meteorological maps etc.
- Detailed of on – going works.
- Details of works already proposed on the project road.
- Study reports/ investigation reports of specialized agencies for trouble spots/ other problems on the project site.

2.2 FURTHER STUDIES & INVESTIGATIONS

Based on this study/review, the team has identified the data and investigation gaps, so that, further data collection and investigations, as required, are carried out during the detailed surveys and investigations proposed for the project.

2.3 GROUND RECONNAISSANCE:

In addition to the discussion and study of maps, report and available data, the consultant conducted the ground reconnaissance and general survey of the proposed bridges and tunnel sites. It included:

(a) Data Collection
(b) Compilation of salient feature
(c) Evaluation of bridge and tunnel condition
(d) Major problems on the proposed bridge site & tunnel site / approach, if any

2.4 LOCATION SURVEY

General

Based on the reconnaissance survey of the bridge & tunnel by the consultant staff, the location study is summarized in the matrix as attached.
The data collected helps the consultants to appreciate the requirement of the project, the challenges to be faces on the ground and the thrust area to be covered in the study, engineering and design of the project bridge.
We carried out the following studies as part of the Preliminary Stage (Siting of the proposed bridge and tunnel alignment / orientation)

- Location
- General physical feature
- Geophysical features
- Hydrological features
- Environmental

- Derivation

THE DATA OF LOCATION STUDY ARE AS UNDER:

Location study of Bridge At River Rangpo at 75.399 Km of NH - 10		
Sn	**Study Item**	**Location Study**
1	Proposed Bridge	Permanent Bridge (Double Lane)
2	Location	On River Chuba at Sikkim
3	Topography of the area	Hilly
4	Existing facility	Steel Truss Bridge
5	Bridging requirement	Permanent bridge
6	Geometric approach	Curve at starting & Straight at end
7	Traffic	Very High
8	Terrain and soil condition	Hilly
9	Geology	Rock/ banks with soil mixed with rocks
10	Cliff & Gorges	Deep Gorge
11	Drainage characteristic	Perennial stream
12	Veg. Extent	Low
13	Temperature	30°C Daytime
14	Rainfall	3200 mm per year
15	Snowfall	Nil
16	Wind direction / Velocity	Moderate
17	Visibility	Clear
18	Exposure to sun	Sunny
19	History of Cloud burst	No cloud burst
20	Ecology	Natural and undisturbed
21	Slope stability of approaches	Stable
22	Scour condition of stream	No scour condition
23	Stream Reach (Straight or meandering)	Meandering on downstream site & Straight on upstream site

2.4.1 PROBLEMS AND CHALLENGES AREAS

Based on the ground study, reconnaissance survey and the data collected from PWD Sikkim & BRO, the consultants have gained appreciation of the technical and project management problems and have insight of the challenge areas of the project. In addition, each project road sector has its own local challenges. The general appreciation of the thrust areas is described in the following paragraphs.

Approach to the bridge site: Presently all types of vehicle cross the location of the bridge through an existing Steel Truss Bridge. However, the bridge is weak and for limited traffic.

Plantation: There is little growth of vegetations on both sides of the bridge and very high vegetation growth on both sides of tunnel

Sand and stones for Bridge construction: Good quality sand is available in the Teesta River. Good quality stones have been identified in the vicinity of the proposed bridge site. Alternatively, the good quality stone can be transported from identified quarries. While extracting stones from concrete works, the quality materials should be selectively chosen.

Water: Generally, water available in the area has been found suitable for use in the bridge & tunnel construction work.

Work force: Most of the local people are engaged in agriculture. Bridge construction requires tradesmen of sort, skilled labourers and unskilled labourers. Manpower may need to be brought from other part of the country. It requires planning and organization for recruitment, training, induction and maintenance including provision of campage, food supplies, medical welfare activities, etc. Independent facilities are necessitated to cater for the increased workforce**.**

Contractor: Though small supply of Contractor are available in Sikkim, the bulk of the requirement is initially to be augmented from outside. The stone crushers have to be installed for meeting the project requirement for major bridge.

Approach road for bridge

Based on the reconnaissance survey, review of the available data and the desk study, we have arrived at the conclusion to approach the problem of siting of the bridge by a comprehensive study and the survey of the project influence area and thereafter to decide the siting of the bridge.

CHAPTER – 3: SURVEY AND INVESTIGATION FOR BRIDGE

3.1 TOPOGRAPHICAL SURVEY OF BRIDGE SITE

Objective

The Topographical Survey is carried out to map the topographical features of the approach road and bridge location on the abutting land and abutting areas. It is aimed at preparation of the Base map of the area, to facilitate review of alignment layout and preparation of plan for the bridge.

The objectives of the survey are:

- Enable a definitive design to be made for the bridge
- Enable a definitive influence to be made for the profile of the approach road.
- Define clearly and contractually the extent of the bridge work to be done.
- Enable quantity estimate to be prepared.
- Provide record of work that will serve maintenance planning needs.
- Surveyed corridor is suitably extended for overall view of the area.

Resource Input

The detailed survey is carried out using Total Station. Other Survey equipment may also be used. The work of verification is carried out by deploying survey Expert and survey Assistant along with the bridge Engineer.

Control Points

For mapping we have the control points as follows:

P-1 Singtam side on pillar (TBM-1 X=656033.138 Y=3017012.769 Z=689.459)

P-2 Singtam side on pillar (TBM-2 X=656020.805 Y=3017017.057 Z=689.312)

P-3 Gangtok side on pillar (TBM-3 X=656220.660 Y=3017057.953 Z=702.957)

P-4 Gangtok side on pillar (TBM-4 X=656218.108 Y=3017055.012 Z=702.959

Cross Section of the River Regime

Seven number cross sections have been taken to capture complete profile of the river. These are shown in the sketch attached and are as under.

Water level

Base on the local survey, the water level has been established as under:

HFL	673.945 m

Survey data

The approach road to the bridge site has also been surveyed in order to have overall appreciation of the bridge project. The survey data is also attached for reference.

- Chainage
- Approach to Singtam Side
- Approach to Gangtok Side
- Cross sections
- Record of GPS control point
- Record of water level

3.2 HYDROLOGICAL SURVEY AND ASSESSMENT

General

This includes the general enquiry, visual inspection, analysis of available data, and historical background in order to make assessment of hydrological behavior and design parameters. It is to lead to the conclusion with respect to:

- Terrain
- Rainfall and runoff
- Cloud burst or such factor
- Gorge/ Cliff
- Discharge
- Velocity of flow
- Scour condition
- Bed slope
- Stream configuration
- Stability of banks
- Factor with negative impact

The hydrological and hydraulic study has been carried out in accordance with IRC Special Publication No 13 (Guidelines for the design of small bridges and culverts). IRC: 5 – 1998 (Standard Specification & Code of Practice for Road bridges, Section 1: General Feature of design), etc.
We have carried out our visual examination and evaluate the data made available by the client as well as data collected by local enquiry that the design parameter arrived at are appropriate. The investigation is also carried out for other drainage structures(s) along the section under study.

We undertook a desk study of available data on topography, storm duration, rainfall statistics, top soil characteristic, vegetation cover etc., so as to assess the catchments area and hydraulic parameters for all existing and proposed drainage provision. The finding of the desk study is further supplemented and augmented by a reconnaissance along the area. All important features are noted during field reconnaissance.

It is carried out on the basis of the following items:

- Location study
- Stream condition
- Peak flood condition
- Deck level / adequacy
- Adequacy of span
- Road, Geometric of the approaches
- Adequacy of design for smooth and comfort to the traffic
- Bridge / Road width matching to the traffic requirement and futuristic assessment
- Protection work.

Base on the above, the parameters have been identified for carrying out the hydraulic study for aiming at the design parameter of the bridge.

Location of the Bridge:

- The proposed bridge is on the NH -10 at Chuba River
- Take off point on Singtam Side
- Approach road upto bridge point is being upgraded
- The area is in seismic zone of India (Zone – IV)
- Rainy season in mostly May – September
- Flood is normally during July

River Condition

- The bridge is about Km 75.30 on NH-10
- The road alignment is already marked and defined on the ground
- Siting of the bridge is already defined on the ground. We have considered proposals while carrying out the option study
- Presently the river is negotiable by existing steel truss bridge
- Upstream side nallah is steep
- The stream in the peak flood condition more attracted toward Singtam side
- The river in the low water level condition flows more towards Singtam side
- Sikkim side river bank very shallow and a part of the river bed are having vegetation on slope.
- There is an out crop of rock on Singtam side and jetting toward towards low water level. It is indicative of rock formation underneath. Whereas on Gangtok side river rock available at shallow depth.

Peak flood condition

- In the peak flood conditions, the depth of the water is to the tune of 2 to 3m
- We have done the contouring of the entire area up – stream and downstream and also have marked the higher flood level. It indicated a defined flood line of the river during peak flow condition.
- Location enquires indicates that the velocity of the flow in peak flood condition is high. There is no historical data to confirm the exact velocity of the river peak flow condition.

Adequacy of deck level

- The level of the approach on either side decides the deck level of the proposed bridge
- There is no flooding of the approaches by the river
- The river remains at a distance from the toe line of the approaches.
- There is sufficient clearance between the deck level and the high flood level

Adequacy of Span

- The length of the existing bridge is 12meters
- The span of the bridge has been provided for the complete regime width during the peak flood condition.
- There is no provision of contraction in the design of bridge span
- The existing abutments are also placed on the banks, which do not obstruct the regime width of the river.
- The level of the span is calculated base in the regime width and of the deck level.
- It is considered that the bridge of around 48 meters length would be meeting the requirement

Foundation Condition

- Based on the preliminary study and the initial inspection, it is found that the deep gorge at the proposed site may have the rock formation.
- The upper layer of the soil deposit appears to be due to siltation
- The foundation have founding on rock formation.

Road Geometric of the Approaches

- The approaches have been constructed
- There is no indication of any toe scour of the approaches.
- Singtam side approach is curve & Gangtok side approach is straight.
- Our proposal indicates the modification to the existing approaches. However, it being of minimal nature, it is not included in bridge proposal and would be taken care in the up gradation road programme in hand.

Comfort level

- The proposed bridge is expected to meet the design level of comfort to the traffic.
- Since the traffic is in smooth flow situation, there will be no un-comfort in the commuters.

Bridge width

- It is proposed to construct a double lane bridge. The 2 – lane will match with the assessed traffic requirement

3.3 PRELIMINARY GEO – TECH ASSESSMENT SURVEY

General

It include general enquiry, foundation inspection, analysis of available data and historical background in order to make assessment and geo – technical behavior of the design parameters. The activities involved under the task are as under:

- Location study
- Conduct analysis of design operation
- Select Option
- Working out soil investigation requirement
- Define parameter, level of investigation and deliveries
- Assess requirement of bore holes
- Organize drilling of the bore holes
- Prepare characteristic and test on samples

Location Study

- The official inspection indicates that ample possibility of rock formation at this location. There is out crop of rock on Singtam side & rock at shallow depth on Gangtok side
- The out crop of rock shows possibility of good foundation on rock of the bridge
- The situation of the soil on the surface in the river bed appears to be false and consequence of siltation.

Design Foundation

- The design option available would be abutment on rock and to cater for scour depth upto hard rock / strata.
- Alternative is to take foundation deep to cover for its scour in case the subsoil survey indicates soil/ soil mixed with bolder condition

3.4 PRELIMINARY MATERIAL ASSESSMENT SURVEY

General

- Soil and materials survey is carried out for resource input for the construction activity
- Good quality sand is available.
- Approved stone is available.
- Alternatively, good quality stone can be transported from other areas
- Water is available in the area

3.5 INITIAL ENVIRONMENTAL EXAMINATION

General

Initial environment screening has been carried out in accordance with government of India Guidelines, as applicable.

- The Consultant carried out the preliminary environmental screening to assess the direct and induced impacts due to the project
- The Consultant ensured to document baseline conditions relevant to the project with the objectives to established the benchmarks

- The Consultants assessed the potential significant impacts and identify the mitigate measures to address these impact adequately
- The Consultants carried out the analysis incorporating environmental concerns. This would include with and without scenario and modification incorporated in the proposed project due to environment considerations

Special Features of the Project

- Name of the Project : Construction of Double lane Bridge over Chuba Khola
- Length of the bridge : 48.0 m.
- Location : On NH-10 at Km 75.30
- Nature of terrain : Hilly
- Nature of Soil : Hard rock and on surface soil or soil mix with soil and rock

The Project

The project is for the construction of the bridge. The project is for bridging the gap in the road on the existing route alignment

Present Facility

Presently there is existing steel truss bridge at this location

Environmental grading

Factors affecting environmental resources and values and their IEE grading level is given in the Table given below

Beneficial Impact of the Bridge Project

The project will have several beneficial impacts as given in the table attached

Negative impact

We do not contemplate any negative impact of this project on the environmental aspect

INITIAL ENVIRONMENTAL EXAMINATION (IEE)

Actions affecting environmental resources and values		Recommended feasible mitigate measures	IEE grading (suggestive)
(A)	**Environmental Impacts Due to Project Location**		
(i)	Disruption to Hydrology	There will be no disruption to flow of stream as the bridge is planned for full require width	D1
(ii)	Resettlement	No resettlement involved	-
(iii)	Environmental aesthetics degradation	Care shall be taken to avoid/ minimize effect	D1
(iv)	Inequitable locations for rural roads	Cross roads suitable clubbed for access to the road. For the purpose, suitable connectors are planned and under implementation NHIDCL	D1
(v)	Loss of terrestrial ecology including forest and wildlife	Not involved	-
(vi)	Loss of swamp ecology	Not involved	-
(B)	**Impacts during construction phase**		

Actions affecting environmental resources and values		Recommended feasible mitigate measures	IEE grading (suggestive)
(i)	Site runoff from cut and fill area	Suitable measures to be adopted during construction	D1
(ii)	Safety of works from accidents	All safety measures to be incorporated in tender document	D1
(iii)	Slum creation hazards	Appropriate planning for housing of construction workers to be made	D1
(iv)	Cultural difference hazards	It is to be avoided and public learning be made and considered	-
(v)	Escape of hazardous materials	Strict monitoring the movement of hazardous materials	D1
(vi)	Escape of air pollution (including dusts)	Suitable measures to be adopted to prevent/ minimize	D1
(vii)	Noise and vibrations	Effects shall be assessed and measures taken based on significance	D1
(viii)	Quarrying hazards(including use of explosives)	Appropriate planning operation of blasting and use of operating quarries	D1
(ix)	Disruption of utilities along route	Not involved	
(x)	Disruption of traffic along route	Alternative	
(C)	**Impacts from Project Operations**		
(i)	Noise disturbance	Not involved	D1
(ii)	Vibration disturbance	Appropriate planning and post construction monitoring may be made	D1
(iii)	Air Pollution	Appropriate planning and post construction monitoring will be made	D1
(iv)	Continuing erosion	Protective vegetation and other methods shall be adopted	D1
(v)	Highway runoff contamination	Appropriate planning and post construction monitoring to take care	D1
(vi)	Highway spills of hazardous materials	Appropriate spills control program and post construction monitoring to take care	D1
(vii)	Escape of sanitary wastes	Appropriate planning/ post construction monitoring to be considered	D1
(viii)	Congestion at access/ exit points	Not involved	-
(ix)	Inadequate highway maintenance	Not involved	-

Note IEE grading Scale:
D1 - Not significant
D2 - Small significant effects
D3 - Moderate significant effect
D4 - Major significant effect

Beneficial Impacts of Bridge Project

- Employment opportunity to people
- Enhancement of local industry, agriculture and handicrafts
- Income from visitors and taxes
- Enhancement of rural development through quick and easy transportation of building materials
- Transporting, processing and marketing of agricultural products
- Opening up of opportunities for new occupations
- Approach to quick services and safety

- Improved quality of life for people and so on

CHAPTER – 4: OPTION STUDY

4.1 FOR SELECTION OF LOCATION OF THE BRIDGE

General

In order to carry out the option study for the siting of the bridge, we have carried out survey of the possible locations and the influence area.

All the surveys and investigations have already been described in Chapter-2 and 3.

The route alignment of NH-10 is already fixed and is in place. The road is being upgraded and it is in the final stages of development. Apart from this, the route forms approach from either side of the proposed bridge. The siting of the bridge is more or less fixed and decided. However, revalidation of the sitting has been conducted with an understanding to find alternative site which may be more economical, stable, comfortable and cost effective.

Options

Seven number cross sections have been taken to capture the profile of the river at various locations. There are two possible locations for sitting the bridge within the constraints of the road alignment. The brief analyses of these options are given as under:

Option No.	Location (U/S OR D/S)	Remark
1.	Downstream side	This option is most feasible (a) the river is wide, (b) the river banks are built up , (c) river reach is straight (d) rock formation on banks offers good foundation conditions (e) geometry of road improved.
2.	Near existing Bridge site	This option is the not feasible (a) it may affect running traffic (b) geometry of road is not going to improve (c) bridge required to construct in curve .
3.	Upstream side	This option is the not feasible (a) new approach road is required, (b) is at the curvature of the stream, (c) geometry of road is not going to improve (d) bridge required to construct in curve . (e) Hill side is steep & huge cutting required , which may create slide zone later on or rock fall zone.

In view of the above, the siting of the bridge at a location at Downstream has been considered as the select option. Details are:

- The bridge is proposed to be kept at 20.80 m center to center of the existing bridge.
- Singtam side abutment is kept backward 16.20 m to have good foundation condition on rock
- Gangtok side abutment is kept 19.5 forward to existing abutment

The option recommended by the Consultant based on the technical, economic, ease in construction, suitability and constructability.

4.2 OPTION STUDY OF SPAN ARRANGEMENT

Based on the site conditions of the bridge site, various span arrangement options have been proposed and are summarized as under:

S/N	Item	Option-1	Option-2	Option-3
1	Span Arrangement	1x48	1x48	1x48
2	Structural System	PSC I girder	PSC Single cell box girder	Steel Truss
3	Depth of Structure	3.431m	3.0 m	Height of truss 6.5 m
4	Material	PSC	PSC	Steel Truss & RCC Deck slab
5	Width of bridge	13.0m	13.0m	13.0m
6	Carriage width	10.5 m	10.5 m	10.5 m
7	Substructure	Abutment at both ends	Abutment at both ends	Abutment at both ends
8	Foundation	Open	Open	Open
9	Waterway	Not affecting	Not affecting	Not affecting
10	Formwork	Simple	Comparatively difficulty & costly from option-1	Very simple
11	Span launching	Simple and easier	Comparatively difficulty from option-1	Comparatively simple from option-1 &2
12	Constructability	Simple and conventional	Comparatively more skilled from option-1	Needs very high technical skilled required.
13	Construction period	Less	More compare to option-1	Less compare to Option -1 & 2
14	Aesthetic	Simple	Good	Simple
15	Durability & Maintenance	Very High & Less	Very High & Less	High & More
16	Civil Work Cost as per 2012 SOR only bridge Part work	4.84 Cr.	5.10 Cr.	6.80 Cr.

Select option:

Option no: 1 – PSC –I Girder (1x48) is recommended select option.

CHAPTER – 5: DESIGN STANDARD

5.1. INTRODUCTION

Design standards form the basis of the design for various elements of a particular project. Formulation of design standards is required in order to avoid any inconsistency in design from one section to the other and provide a desirable level of service and safety.

The standards for the project presented in the sections that follow has been formulated primarily based on IRC publications, MORT&H Circulars and guidelines, Manual of Standards and Specifications for Two Laning of State Highways on B.O.T. basis, as well as current international best practices such as AASHTO and TRL standards and procedures.

5.2. HIGHWAY ROAD APPURTENANCES

5.2.1 Geometric Design Standards

Geometric Design Standards has been largely extracted from IRC: 73 – 1980 and The Hill Road Manual (IRC: SP: 48 – 1998). Since IRC standards do not specify standards for median widths, raised or sunk median, shyness strips etc., these will be recommended as per MOST circulars.

For this Highway Project, Geometric Design Standards shall be as per the following:

- IRC: 73-1980 shall be generally followed.
- 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

Terrain Classification:

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

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

This Road Corridor is generally in mountainous to steep terrain.

Design Speed:

Sr/No	**Mountainous Terrain**		**Steep Terrain**	
	Ruling	**Minimum**	**Ruling**	**Minimum**
1.	50	40	40	30

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

Minimum design speed may be adopted in sections where site conditions or economic do not permit a design based on the ruling design speed. The adopted design speed is 30 Km/hr.

Cross Section Elements:

- ***Right of Way (ROW)***

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

ROW Width

Sl. No.	Road Classification	Mountainous and Steep Terrain	
		Open areas	Built-up areas
		Normal	Normal
1	National & State Highways	24	20

The existing ROW along the project road is not uniform. . The width of ROW 24 m and 20 m have been adjusted to accommodated the public concern provided. However there are stretches where the ROW has been temporarily encroached. However, for improvement of junctions, relocation, etc, design will be as per functional requirement. Additional land acquisition shall be kept to the minimum for these areas

- ***Roadway Details***

- Total Road Width : Total roadway width shall be 12.00 m.
- Carriageway Width : The National Highway shall be designed as a 2- lane carriageway. The width of two lane shall be 7.0 m.
- Shoulder : The carriageway width of 7.0m and paved shoulder width of 1.5 m on each side shall have the same pavement as the carriageway. The remaining 1.0m on each side shall be used to accommodate side drain on hill side or parapet/soft shoulder on valley side. In the hill side, depending on the total width of side drain, there is a small width remaining between the wall of side drain and paved shoulder, therefore it is also paved to avoid erosion by surface water
- Cross-Slope : Each carriageway shall have cross slope of 2.50 percent. The shoulder shall have a slope of 3.5 percent.
- ***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

Speed (Km/h)	Safe Stopping Sight Distance (m)	Intermediate Sight Distance (m)
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)	Radii (Meters) For Camber of					
	Proposed as per IRC: SP: 48-1998	4%	3%	2.50%	2%	1.70%
20		50	60	70	90	100
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

As per IRC guidelines the value of super elevation provided in horizontal curves to counter the effect of centrifugal force will be calculated using the following formula:

$$e = \frac{V^2}{225R}$$

e = Super elevation;

v = Design Speed in kmph; and

R = Radius of Curve in m.

The value of super elevation thus obtained will be limited to the following values:

- In plain and rolling terrain: 7 percent; and
- In hilly terrain: 10 percent.

The length of transition curve is larger of the two values arrived at on the basis of the following criteria:

- Rate of change of centrifugal acceleration; and
- Rate of change of super elevation (not steeper than 1 in 150 for plain/rolling &not steeper than 1 in 60 for Mountainous/Steep terrain).

- ***Radius***

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

Minimum Radius for National Highways

(As per IRC: SP: 48-1998)

Mountainous Terrain		Steep Terrain	
Ruling Min Radius (m)	Absolute Minimum Radius (m)	Ruling Min Radius (m)	Absolute Minimum Radius (m)
80	50	50	30

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

- ***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)	**Upto 20°**	**20° to 40°**	**41° to 60°**	**61° to 100°**
Extra width (m) 2 Lane	1.5	1.5	1.2	0.90

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***

The transition length, in meters, thus obtained is given in Table 5-1 below.

Table 5-1: Length of Transition Curves (M)

Plain and Rolling Terrain				
Curve Radius (m)	**Design Speed in Kmph**			
	100	**80**	**65**	**50**
45				
60				NA
90				75
100			NA	70
150			80	45
170			70	40

Mountainous and Steep Terrain					
Curve Radius (m)	**Design Speed in Kmph**				
	50	**40**	**30**	**25**	**20**
14				NA	30
20				35	20
25			NA	25	20
30			30	25	15
40		NA	25	20	15
50		40	20	15	15

Plain and Rolling Terrain				
Curve Radius (m)	Design Speed in Kmph			
	100	80	65	50
200		NA	60	35
240		90	50	30
300	NA	75	40	25
360	130	60	35	20
400	115	55	30	20
500	95	45	25	NR
600	80	35	20	
700	70	35	20	
800	60	30	NR	
900	55	30		
1000	50	30		
1200	40	NR		
1500	35			
1800	30			
2000	NR			

Mountainous and Steep Terrain					
Curve Radius (m)	Design Speed in Kmph				
	50	40	30	25	20
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				

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 : SP-52-2001, Recommendations about Alignment Survey and Geometric Design of Hill Roads	6.9.1.3

- ***Gradients for Different Terrain***

The gradients to be adopted for different terrains are given in Table 5-2.

Table 5-2: Gradients for Roads

Terrain	Gradient in percentage		
	Ruling	Limiting	Exceptional
Plain or Rolling Terrain	3.3	5	6.7
Hilly Terrain upto 3000m above MSL	6	7	8

- 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).

The available standards for vertical profile do not specify the minimum distance between two Points of Vertical Intersection (PVIs). However, a minimum distance of 150m will be followed. This distance may be reduced to 80m for the existing widened carriageway in case the profile correction becomes excessive.

The minimum length of vertical curve along with the maximum grade change not requiring vertical curve is given in Table 5-3.

Table 5-3: Minimum Length of Vertical Curve

Design Speed in Kmph	Max. grade change not requiring vertical curve in percent	Minimum length of vertical curve in meters
upto 35	1.5	15
40	1.2	20
50	1	30
65	0.8	40
80	0.6	50
100	0.5	60

5.2.2 Grade Compensation at curves

At horizontal curves .the gradients should be eased by an amount known as grade compensation which is intended to offset the extra tractive effort involved at curves. This is calculated by following formula Hill Road Manual (IRC: SP: 48 – 1998). Clause 6.9.2

Grade compensation (per cent) = (30+R/R) subject to maximum of 75/R

where R is radius of the curve in meters. Since grade compensation correction, the gradients need not be eased beyond 4 per cent.

5.2.3 Design Criteria for Hair Pin Bends

The design standards to be adopted for hair-pin bends are given in Table 5-4. This will be extracted from the Hill Road Manual (IRC: SP: 48 – 1998).

Table 5-4: Design Criteria for Hair-Pin Bends

Design Speed	20 Kmph
Minimum Carriageway Width	11.5 m for two lanes
Minimum Radius of Inner Curve	14.0 m

Design Speed	20 Kmph
Minimum Length of Transition Curve	15.0 m
Maximum Gradient	2.50%
Minimum Gradient	0.50%
Super elevation	10%
Roadway Flaring	Concentric w.r.t. Center Line
Distance between two Hair Pin Bends	60m
Type of Full Roadway Width	Surfaced

5.2.4 At – Grade Intersections

Design standards for at-grade intersections will be in accordance with IRC: SP: 41 – 1994, 'Guidelines for the Design of At-grade Intersections in Rural and Urban Areas' and the MOST Type Designs for Intersections on National Highways. The minimum and maximum radii for left turning lane, rate of taper and other details to be provided are given in Major Bridge.

5.2.5 Surface Drainage

For surface drainage the following points will be collected

- General condition
- Connectivity of drainage turnouts into the natural topography
- Condition in cut sections
- Condition at high embankments

Based on reconnaissance and detailed field survey of the existing drainage system, new system or modification to existing drainage system will be recommended. Some basic principles, which will be taken into consideration in order to meet IRC standards, are described below:

- The surface water from the carriageway, paved shoulders, embankment slopes and the adjoining land must be effectively drained off without allowing it to percolate into the sub-grade.
- The drains must have sufficient capacity and adequate longitudinal slope to drain away the entire collected surface water to the nearest natural surface stream, river or nallah.
- No longitudinal side drains are proposed where the road runs over the canal bank. The rainwater will directly go to the canal.
- No roadside drains are proposed where the longitudinal water bodies are present parallel to the road.

The roadside drainage system will be designed as per IRC SP: 42 and IRC SP: 50. In the project alignment, the following types of drains will generally be proposed:

i) Side ditches of required cross Section for area Drainage on hill Sides of carriageway in rural section.

The hydraulic adequacy of the drains will be checked as per IRC SP-42 "Guidelines on Road Drainage".

The provision of Rainwater Harvesting will be provided as per IRC at every interval @500m c/c.

5.2.6 Safety Barriers, pedestrian Guard Rails and Pedestrian Facilities

The safety barriers will be provided at outer edges of roadways wherever the embankment height is more than 3m in plain terrain, at valley sides in hilly terrain and at major bridge approaches. Pedestrian facilities will be adequately provided in urban sections and at major intersections.

5.2.7 Slope Protection

Embankments less than 3m in height will be turfed, sections where embankment height is greater than 3m will be protected with stone pitching. Slope protection in cut sections of hilly terrain will be provided as per standards given in the Hill Road Manual (IRC: SP: 48 – 1998).

5.2.8 Traffic Control Devices

Road markings and road signs are provided as per relevant IRC codes and MORT&H specifications. Lane markings and object markings will be in accordance with Clause – 803 of MORT&H specifications 2013 (fifth revision). Road markings will be in accordance with IRC: 35 – 2015 and the median kerb and kerb separator painting will be in accordance with Clause 803.3 of MORT&H specifications. The road signs will be in accordance with IRC: 67 – 2012, Code 600 of Addendum to Ministry's technical circular, directives on NH and centrally-sponsored bridge projects, 1996 and IRC: SP: 31. Traffic signboards are to be painted as per IRC: 67 – 2012 and the text in sign boards are to be as per IRC: 30 – 1968.

While the preceding sections discuss details of proposed standards for different constituents, these along with additional pertinent standards for carriageway configuration four-lane divided carriageway are précised in Table 5-5.

Table 5-5: Design Standards for Highway and Road Appurtenances

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
1	**Design Speed, kmph** **i) in plains/rolling terrain** **ii) in mountainous terrain/ steep terrain**	100 -80 60-40	30
2	**RoW, m (desirable)**	30-60 m	24-30 m
3	**Carriageway**		
i)	Width per lane for widening	3.5 m	-same-
ii)	Cross-slope/ Camber		
	a) Flexible pavement having bituminous concrete surfacing	2.5%	-same-

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
	b) Cement Concrete pavement	2.0%	-same-
4	**Paved Shoulder (on Outer Side)**		
i)	Width (rural sections)	1.5 m	-same-
ii)	Width (urban sections)	2.5 m	
iii)	Cross-slope/ Camber	2.5%	-same-
5	**Earthen Shoulder (on Outer Side)**		
i)	Width(rural sections)	1.0 m	-same-
ii)	Cross-slope/ Camber	3.0%	-same-
	Earthen Shoulder (Mountainous & Steep)		
i)	Width (Hill Side) exclusive of parapets &drain	1.0 m	-same-
ii)	Width (Valley Side) exclusive of parapets &drain	2.0 m	-same-
iii)	Cross-slope/ Camber	3.0%	-same-
6	**Edge Strip**		
i)	Rural section - on median side	….	0.250m
ii)	Urban section - on median side	….	0.250m
7	**Stopping Sight Distance**		
i)	Desirable	360m	-same-
ii)	Minimum	180m	-same-
8	**Horizontal Curvature**		
i)	Minimum Radii, m (desirable)	60 to 360 depends on terrain conditions	-same-
ii)	Minimum Radii, m (Absolute)	30 to 230 depends on terrain conditions	-same-
iii)	Desirable requiring no super elevation	depends on terrain conditions	-same-
iv)	Minimum requiring 7% super elevation	….	400
v)	Absolute minimum requiring 7% super	….	360

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
	elevation		
9	**Vertical Alignment**		
i)	Minimum distance between PVI	…..	For Existing Carriageway, a minimum distance of 80m and for new carriageway a minimum distance of 150m
ii)	Minimum length of vertical curve	IRC: 73	-same-
iii)	Maximum grade change not requiring vertical curve	IRC: 73	-same-(0.5%)
10	**Gradient, %**		
i)	Maximum	3.3%	7.30%
ii)	Minimum		
	a) In cut and kerbed sections	0.5-1.0%	-same-
	b) On unkerbed sections on embankment	Near level grades	0.05%
11	**Super elevation,%**		
i)	Minimum	2.5% (Camber)	-same-
ii)	Maximum	10%	-same-
12	**Traffic Control and Road Safety Devices**	IRC: 35, IRC: 67 and MOSRTH guidelines.	-same-
13	**Roadside Furniture**	IRC: 25, IRC: 8, IRC: 103, IRC: 35, MOSRTH guidelines	-same-

5.3. FORMATION WORK

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: 48:1998 Clause 7.4.

Side Slope in Cutting

Sl.No.	Item	Slopes of Cutting

Sl.No.	Item	Slopes of Cutting
1	Ordinary Soil / Heavy Soils	1:1 to 1 : 2
2	Ordinary / Soft Rock	1 : 4 to 1:8
3	Hard rock	80^0 to 90^0

(Explanation: The slope 1: 2 signifies 1 in the horizontal direction and 2 in the vertical)

5.4. PAVEMENT DESIGN

The detailed design of pavement will involve:

- Pavement design for new pavement for main carriageway (flexible)
- Pavement design for paved shoulder

The design of pavement will primarily be based on IRC publications. The design alternatives will include both rigid and flexible design options.

5.4.1. Pavement design for new flexible pavement of main carriageway

The design of flexible pavement for main carriageway will be in accordance with the method prescribed in IRC: 37 – 2012(Guidelines for the Design of Flexible Pavements). Flexible pavement will be designed for a design period of 15 years.

5.4.2. Pavement design for paved shoulder

The paved shoulders were designed as integral part of the pavement for the main carriageway. Paved shoulders have same composition and thickness as that of main carriageway pavement.

5.5. DESIGN STANDARDS FOR STRUCTURES

This section gives the detailed design standards considered for new construction as well as repair and rehabilitation work of structures.

5.5.1. Codes of Practices

Design standards and the loading to be considered are generally based on the requirements laid down in the latest versions of IRC/ IS codes of practices and standard specifications, and guidelines issued by MoRT&H. Additional technical references will be made wherever the provisions of IRC/IS codes are found inadequate. The following IRC/ IS codes are proposed to be used in the design of structures:

- **IRC: 5 - 2015:** Standard Specifications & Code of Practice for Road Bridges, Section I - General Features of Design (Seventh Revision)
- **IRC: 6 - 2014:** Standard Specifications & Code of Practice for Road Bridges, Section II - Loads and Stresses (Third Revision)
- **IRC: 112 - 2011:** Standard Specifications & Code of Practice for Concrete Road Bridges
- **IRC: 78 - 2014:** Standard Specifications & code of Practice for Road Bridges, Section VII- Foundations & Substructure (First Revision)
- **IRC: 83 (Part I) – 2015:** Standard Specifications & Code of Practice for Road Bridges, Section IX - Bearings, Part I: Roller and Rocker Bearings.

- **IRC: 83 (Part II) - 2015:** Standard Specifications & Code of Practice for Road Bridges, Section IX - Bearings, Part II: Elastomeric Bearings.
- **IRC: 89 - 1997:** Guidelines for Design & Construction of River Training and Control Works for Road Bridges (First Revision)
- **IRC: SP 13 - 2004**: Guidelines for Design of Small Bridges & Culverts.
- **IRC: SP 40 - 1993**: Guidelines on Techniques for Strengthening and Rehabilitation of Bridges

For items not covered in the above specifications, provisions of the following standards will be followed in the given order of priority:

- Provisions of IS codes of practices; followed by
- Relevant provisions of BS codes of practices; followed by
- Sound engineering practice, international best practices, technical literatures/ papers and provisions of relevant codes of other nations.

5.5.2. Design Standards

The general standards for design of structures will be as presented in

Table **5-6** below:

Table 5-6: General Design Standards for Structures

S. No.	Item	Standard
1	**Geometry**	Highway alignment and cross-section is followed. Crash Barrier is kept outside the roadway width.
2	**New Construction: Minor Bridges**	Bridge 48m span PSC I-girder and RCC deck slab on RCC abutments.
3	**Cross-Slope**	For new structure deck slab will follow a minimum cross-slope of 2.5 %
4	**Wearing Course**	Bituminous Wearing Course of 56 mm thickness as per MoRT&H Specifications.
5	**Bearing**	POT/PTFE bearing shall be used for girder bridges.
6	**Reinforcement**	FE500D shall be used in correlation to MORT&H specifications.
7	**Expansion Joint**	Strip seal and filler type expansion joint to be used as per MORT&H standard drawings.
8	**Approach Slab**	RCC approach slab as per MoRT&H will be provided in Minor Bridges.
9	**Retaining Walls**	a. Embankment toe wall will be of Plum concrete M-15.
		b. Other cases- RCC/Plum Concrete retaining wall.
10	**Crash Barrier**	RCC M-40 around 0.9 m ht for all structures. (as per IRC: 5 – 2015)
11	**Return wall**	Return wall are proposed with length satisfying criteria of gradient 1: 1.50 with ground level.

S. No.	Item	Standard
12	**Drainage Spout**	G.I. drainage spouts with Cl MS grating.

5.5.3. Material Properties

a) Concrete

Following material properties are proposed to be used for various RCC components of bridge structures:

- Coefficient of Thermal expansion : 11.7 x 10^{-6}/^{o}C as per IRC: 6 - 2014
- Poisson's Ratio : 0.2
- Modulus of Elasticity : As per Table 6.5 of IRC: 112 - 2011
- PSC members : IRC 112:- 2011
- Creep & Shrinkage : As per IRC112:-2011 codes
- Concrete Grade : Refer: Durability Consideration in Design

b) Reinforcement

(i) The reinforcement to be used shall confirm to HYSD Fe 500 D.

(ii) Pre-Stressing Steel System

All ducts and anchorages will be suitable for 19T13 stress relieved low relaxation strands conforming to IS: 14268 – 95. The properties of the strands will be as follows:

- Nominal Diameter : 12.7mm
- Nominal Steel area : 98.7mm^2 per strand
- Ultimate Load : 183.71 KN per strands
- Modulus of Elasticity : 1.95 x 10^5Mpa
- Friction Coefficient : 0.25/radian
- Wobble Coefficient : 0.002/m
- Anchorage Slip : 6mm average
- Loss of force due to relaxation : 2.5% at 0.7 UTS after 1000 hrs.

(iii) Structural Steel

Structural steel will conform to IS: 226 with yield stress of 23.6 Kg/cm^2.

c) Bearings

Depending upon the type of structure, span length of each superstructure, skew angle either Pot fixed/ Pot-cum-PTFE sliding bearings or elastomeric bearing will be suggested.

d) Expansion Joints

Strip seal/ Tar paper expansion joint shall be used depending upon the length and type of structure.

e) Wearing Coat

A 56 mm thick wearing

a. A coat of mastic asphalt 6mm thick with a prime coat over top of the deck before the wearing coat laid.
b. 50 mm thick asphaltic concrete wearing coat in two layers of 25 mm each as per clause 512 of MORT&H's specification for road and bridge work

5.5.4. Load and Load Combinations

a) Dead Loads

Following unit weights will be considered for dead load computations in the design:

- Reinforced Concrete : 2.5 t/m^3
- Pre-stressed Concrete : 2.6 t/m3
- Plain Cement Concrete : 2.2 t/m^3
- Structural Steel : 7.85 t/m^3
- Dry Density of soil : 2.07 t/m^3
- Saturated Density of Soil : 2.2 t/m^3
- Wearing Coat : 2.2 t/m^3
- Crash Barrier : From Design (i.e., 40 kg/m per side)

b) Live Loads

- Pedestrian Live Loads : Minimum 400 kg/m^2 on entire clear footpath width & appropriately considered depending upon the span length as per IRC:6 (Cl.209).
- **Vehicular Live Loads**
  - One lane of Class 70R Wheeled vehicle for every two lanes with one lane of Class A for the remaining lanes
  - One lane of Class 70R Tracked vehicle for every two lanes with one lane of Class A for the remaining lanes
  - Three lane of Class A Vehicle
- Impact factor shall be taken as per IRC: 6 2017 for the relevant load combinations.

c) Longitudinal forces due to Bearing Friction

The coefficient of friction for the sliding bearings will be taken to be 5%. When considering the effects of differential friction on bearings on either side of the fixed piers, the friction on one side of the bearing will be taken as 5% while on the other side it is taken as 2.5%.

d) Horizontal Forces due to Water Currents

The water current forces will be taken as per IRC: 6 – 2017.

e) Seismic Loading

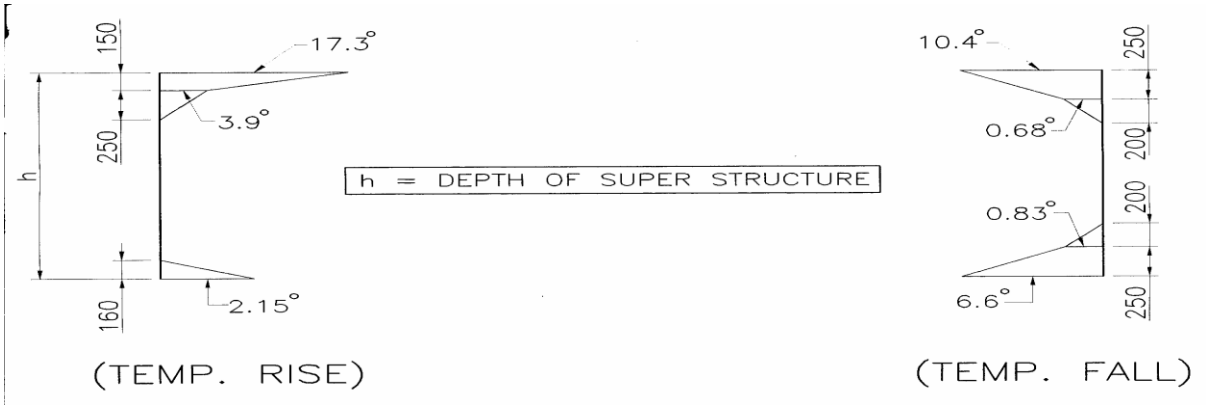
The bridges are located in Seismic Zone - IV as per the relevant IRC code. Hence, seismic forces will be considered only for those bridges having span greater than 15m or overall length of the bridge is more than 60m.

f) Wind Loading

As per IRC: 6 – 2017, the project corridor falls under "single intensity" zone based on which the wind intensity to be taken as per the values given in IRC: 6 – 2017. A wind velocity of 47 Km/hr will be considered for the design of structures.

g) Temperature Loading

- The bridge superstructure/ components i.e. bearings and expansion joints will be designed for a temperature variation of +/- 17oC, considering the severe climatic conditions;
- The superstructure has also been designed for effect of distribution of temperature across the deck depth as given in Sketch - A enclosed. These are based on the stipulations of BD 37/ 88.



- Temperature effect will be considered as follows :
- Effects of non-linear profile of temperature are combined with 50% live load. The value of modulus of elasticity for concrete, "Ec" is taken as "Ei/2"; and
- Effects of global rise and fall of temperature is combined with 100% live load and value of modulus of elasticity for concrete, "Ec" is taken as equal to "Ei".

h) Load Combination

All members are designed to sustain safely the most critical combination of various loads and forces that can co-exist. Various load combinations as relevant with increase in permissible stresses considered in the design are as per of IRC: 6 – 2014and of IRC: 78 – 2014.

5.5.5. Exposure Condition

The project corridor is located in interior part of Sikkim and the condition of exposure is considered as "Normal" for the purpose of structural design.

5.5.6. Cover to Reinforcement

Following concrete covers are proposed to be used for various structural components:

- Fondation : 75mm
- Substructure : 75mm
- Superstructure : 50 mm

5.5.7. Durability Considerations in Design

In view of the severity of the environment, which subjects the bridge to additional loads, considerations will be given for reducing the need for general and long term maintenance and to achieve a durable structure.

The following items will be identified as requiring special attention in this regard:

Concrete Grade to be used is as follows:

Minor Bridges

- RCC Structure M40
- PCC Structure M15

- The design and detailing of various components are such that ease of access for inspection and maintenance operation is addressed for all aspects; and
- Easy access to bearings at Abutment locations will be provided from cap level.

5.6. CONSTRUCTION SEQUENCE

Following construction sequence has been assumed in design of superstructure:

- Cast Main Girder on staging.
- First stage prestressing after 14 days or when concrete attaining 85% strength, whichever is later.
- After 21 days casting cross girder and deck slab.
- After 56 days Stressing of 2nd stage cables.
- After 2nd stage pre-stressing installation joint & casting/laying of footpath, kerb, wearing coat & railing.

5.7. DRAINAGE

The road drainage system is planned as per IRC SP: 42 and IRC SP: 50. A camber of 2.5% / as per superelevation is provided in main carriageway. Longitudinal trapezoidal lined drains are provided on hill sides.

6.0 Detailed Cost Estimate

General

The cost estimate presented in this Section is based on the detailed proposals. It is envisaged that the project would involve site clearance, construction of formation in cutting, slope protection works, pavement work, bridge work and road furniture etc. The detailed cost estimate presented in this report has been worked out using quantities of different items of works derived from the detailed design, drawing and unit rates.

Estimation of Quantities

In arriving at the quantities, the following items of civil works have been computed for the total length of the road:

* Earthwork
* Slope Protection Works
* Bridge Work
* Pavement Work
* Road appurtenances

Detailed estimate of quantities and costs are presented in "Cost Estimate" of the report. Methodology followed for various items are based on Technical Specifications of Ministry of Road Transport and Highways (MoRTH) for material laying, its quality, measurements, etc. and it has been illustrated in brief in the subsequent paragraphs.

a) Earthwork :

Earthwork qualities in cutting and small quantities of filling are calculated by highway design software Mx-Road for the entire length of the project road. The formation cutting consists of earth cutting to get a formation width of double lane standard. Through cutting has also been proposed in some locations especially in curves where the existing alignment has been followed to ease the curves while going round spurs. Embankment s has also been proposed at some stretches.

The classification of soil in cutting has been made in three categories :

Soil : includes ordinary soil, hard, soil mixed with boulder
Ordinary Rock not requiring blasting
Hard Rock requiring blasting.

Locations along the road alignment passing along the above given three were noted down during field surveys and total quantities of earthwork in cutting has been worked out accordingly.

b) Slope Protection Works :

Quantities for retaining walls, breast walls, parapet walls, toe walls, etc. have been worked out based on the design proposals. Gabion walls have also been proposed at specified locations and quantities have been worked out.

c) Bridge :

Quantities of bridges have been worked out for all the stretches of the road based on the structure proposed at each location of cross-stream or river.

d) Pavement :

The provision for pavement includes different layers of sub-base, base, and surfacing course as appropriate throughout the whole stretch of the road.

Granular Sub-base (GSB): 250mm thick sub-base layer of crushed stone aggregate has been proposed. The sub-base course has been extended up to full width of the formation.

Extra quantities for widening at curves, major and minor junction locations are calculated separately and final quantities are worked out.

#Wet Mix Macadam Base (WMM): 250mm thick base layer of Wet Mix Macadam is proposed for 10.0m width.

#Dense Bituminous Macadam of 60 mm thick and 40mm thick of Bituminous Concrete as surfacing course has been proposed.

e) **Road Appurtenances**

Road appurtenances include provision for road signs and markings, etc.

Unit Rates

The unit rates for arriving at cost of different components of works are based on Sikkim PWD Schedule of Rates 2012 (for National Highways) with WPI upto july 2018. 12 % GST provision added in civil work cost. For those items of works which are not available in the SOR, separate Analysis of Rates have been carried out and incorporated in this DPR.

As SOR -2012 is already built-up with 6 % of Taxes like Vat, Excise therefore input item 6.0% of taxes excluded and to bring the input items tax free.

Rates of the following items taken from INAM Pro and OIL site on the month of July-2018

- Bitumen (VG-30) (Ex-Singtam) (Basic rate = Rs 28370/ MT +transportation from Barauni to Singtam (462Km xRs.11) Rs.5082= Rs 33452.0)
- Emulsion (Ex-Singtam) (Basic rate = Rs 23490/ MT +transportation from Haldia to Singtam (740Km xRs.11) Rs.8140= Rs 31630.0)
- Cement (43 grade) (Ex-Singtam) (Basic rate = Rs 6160/ MT +transportation from Guwahati to Singtam (=510Km xRs.5.6) Rs.3264.0= Rs 9424.0)
- Cold twisted bars (HYSD Fe 500 Bars)(Basic rate = Rs 46700.00/ MT +transportation from Siliguri to Singtam (90Km xRs.5.6) Rs.504= Rs 47276.00)
- Sand & Aggregate from Teesta River.