"WIDENING AND UPGRADATION TO 2 LANE WITH PAVED SHOULDER CONFIGURATION AND GEOMETRIC IMPROVEMENT FROM 0 KM - 16.990 ON CHENANI – SUDHMAHADEV SECTION OF NH-244"

A

PROJECT REPORT

Submitted in fulfilment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

Mr. Ankur Verma

Planning Engineer

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by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN-173234

HIMACHAL PRADESH, INDIA

May-2019

STUDENTS' DECLARATION

We hereby declare that the work presented in the project report entitled **"Widening and Upgradation to 2 lanes with paved shoulder configuration and geometric improvement from km 0.000to km 16.990 on Chenani – Sudhmahadev section of NH-244"** submitted for fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Mr.Ankur Verma (Planning Engineer) SRM Contractors Pvt. Ltd.**. We are fully responsible for the contents of my project report.

Puneet Singh	Shally Singh	Gourav Mahajan
151602	151612	151650
Department of	Department of	Department of
Civil Engineering	Civil Engineering	Civil Engineering
May 24,2019	May 24,2019	May 24,2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Widening and Upgradation to 2 lanes with paved shoulder configuration and geometric improvement from km 0.000to km 16.990 on Chenani – Sudhmahadev section of NH-244"** in the fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering. **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Puneet Singh (151602), Shally Singh (151612), Gourav Mahajan (151650),** during a period from 11th February, 2019 to 20th May,2019 under the supervision of **Mr.Ankur Verma (Planning Engineer) SRM Contractors Pvt. Ltd.**The above statement made is correct to the best of our knowledge.

Date: May 24,2019

Dr. Ashok Kumar Gupta
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Internal Supervisor

External Examiner

ACKNOWLEDGEMENT

This report highlights the progress of our work that we have achieved in "Design Basis Report (DBR) Chenani-Sudhmahadev" till 22th May,19 for the project entitled "Widening and Upgradation to 2 lanes with paved shoulder configuration and geometric improvement from km 0.000 to km 16.990 on Chenani–Sudhmahadev section of NH-244 in the State of Jammu & Kashmir".

We would like to take an opportunity to extend our heartily gratitude to our Training Head **Mr. Ankur Verma (Planning Engineer) SRM Contractors Pvt. Ltd** who has helped us in every situation and has always entertained our doubts no matter how much busy or exhausted he was. We want to thank **Dr. Ashok Kumar Gupta, Professor and H.O.D Civil Engineering** who helped us in achieving the progress we could not have made without his help. We would like to thank all the SRM Team for their constant support and guidance.

Date: May 24,2019

ABSTRACT

The National Highway & Infrastructure Development Corporation Ltd (NHIDCL) has entered into a Contract Agreement on with EPC Contractor / Client for the project entitled “Widening and Upgradation to 2 lanes with paved shoulder configuration and geometric improvement from km 0.000 to km 16.990 on Chenani–Sudh Mahadev section of NH-244 in the State of Jammu & Kashmir”.

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ABBREVATIONS

NHIDCL	National Highway & Infrastructure Development Corporation Limited
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
CBR	California Bearing Ratio
EPC	Engineering, Procurement, Construction
FWD	Falling Weight Deflectometer
GAD	General Arrangement Drawing
GPS	Global Positioning System
HFL	Higher Flood Level
IRC	Indian Road Congress
LVUP	Light Vehicular Underpass
LWL	Lowest Water level
MORT&H	Ministry of Road Transport and Highways
NHDP	National Highways Development Project
PUP	Pedestrian Underpass
RCC	Reinforced Cement Concrete
ROB	Road Over Bridge
RUB	Road Under Bridge
SSD	Safe Stopping Distance
VUP	Vehicular Underpass

CHAPTER 1

INTRODUCTION AND SCOPE OF WORK

1.1 PROJECT BACKGROUND

The National Highway & Infrastructure Development Corporation Ltd (NHIDCL) has entered into a Contract Agreement on with EPC Contractor / Client for the project entitled "Widening and Upgradation to 2 lanes with paved shoulder configuration and geometric improvement from km 0.000 to km 16.990 on Chenani–Sudh Mahadev section of NH-244 in the State of Jammu & Kashmir".

Table 1.1 Key Features of Project

1	Project Length	in Km	22.713	16.990
2	Major Bridges	in No's	-	2
3	Minor Bridges	in No's	3	8
4	Culverts (Slab/Box/HP/Arch)	in No's	104	90
5	ROB/RUB	in No's	-	-
6	Elevated Structure/Flyover	in No's	-	-
7	Vehicle Underpass	in No's	-	-
8	Light Vehicular Underpass	in No's	-	-
9	Pedestrian Underpass	in No's	-	-
10	Cattle Underpass	in No's	-	-
11	Intersections	in No's	5	4
12	Truck Lay by	in No's	-	4
13	Bus bays/Bus Shelter	in No's	-	4
14	Length of Service Roads	M	-	-
15	Tunnel	Number	-	-
16	Toll Plaza	Number	-	-

1.2 LOCATION PLAN

Figure 1.1 Location Plan

Figure 1.2 Location Plan (Satellite Image)

1.3 SCOPE OF DESIGN SERVICES

Scope of Design Services includes:

- Preparation of Design Basis Report
- Pavement and Material Investigations
- Detailed Design of Highways, Pavement and Structures based on the Schedules A & B.
- Detailed designs for the project facilities as per Schedule C.

- Preparation of Detailed Design Report
- Preparation of Detailed Design Drawings
- Preparation of Bill of Quantities
- Addressing comments if any from Client and Authority Engineer
- Preparation of Good for Construction Drawings and
- Preparation of As Built Drawings

1.4 PURPOSE OF THE DESIGN BASIS REPORT

The purpose of this report is to formalize the design standards to be adopted for the project road stretch. This report shall also form basis for any improvement proposals (Value Engineering) associated with the EPC Agreement. The Design Basis Report also adopt design standard specified in Schedule D.

CHAPTER 2

HIGHWAY DESIGN STANDARDS

2.1 GENERAL

The main objective is the improvement of the existing single lane road to two lane with paved shoulder. Also to construct new two - lane in virgin land in accordance with IRC-SP: 73: 2015, IRC / SP: 48: 1998 and other relevant codes including standard good practices of the road construction.

The Highway must follow the existing alignment unless otherwise specified by the Authority and shown in the alignment plans. If any kind of geometric deficiencies, in the existing horizontal and vertical profiles exits shall be corrected as per the prescribed standards for mountainous/hilly terrain to the extent land is available.

As per schedule D of the EPC Agreement, the Project Highway have to conform to the Manual of Specifications and Standards for Two Laning of Highways, issued by Indian Road Congress except the deviations specified in Schedule-D. In the absence of any specifications in the Manual the relevant IRC code has to be followed.

2.2 DESIGN CONTROLS

2.2.1 Classification of Terrain

The project road alignment traverses through the Hilly & Mountainous terrain. Geometric standards relevant to Hilly & mountainous terrain as per IRC: SP: 73-2015 and relevant IRC codes for Hilly terrain IRC: SP: 48-1998 will be applicable. For Built-up areas the width of the carriageway shall be as per Fig. 2.13 of IRC: SP 73-2015

2.2.2 Design Speed

The design speed shall be the minimum design speed of 40 km/hr for mountainous/hilly terrain as per IRC SP 48:1998/ IRC SP 73:2015

Table 2.1 Design Speed.

Nature of Terrain	**Cross Slope**	**Design Speed (km/hr)**	
		Ruling	**Minimum**
Plain and Rolling	<=25%	100	80
Mountainous to Steep	>25%	60	40

2.3 CROSS SECTIONAL ELEMENTS

The standard width of carriageway is as indicated in Table 2.2

Table 2.2 Cross Sectional Elements

Element	**Width to be followed**
Carriageway Width	7.0 M
Median width	Not Applicable ,as per Schedule
Paved shoulder width	Width of Paved Shoulder should be 1.5m as per Schedule
Earthen shoulder width	Earthen shoulder width should be 1m towards valley side as per Schedule
Service Road width	Not applicable, as per Schedule of the EPC Agreement

Table 2.3 Cross Sectional Elements

Sr. No.	**Detail**	**TCS**	**Length Sr. No.**	
			(m)	**(km)**
1	One side Hill & One side valley (Breast Wall on hill side)	1	6902.00	1
2	One side Hill & One side valley (Drain on hill side)	2	451.00	2
3	One side Valley & One side Built up or open area	3	800.00	3
4	Approach to Bridge	4	1000.00	4
5	One side Hill & One side valley (Breast Wall and Gabion Box Protection on hill side)	5	1676.00	5
6	Realignment	6	5734.00	6
7	Bridge		427.00	7
	Total Length		16990.00	

Following typical cross sections shall be provided for the Project Highway However to be designed as per manual.

2.4 HORIZONTAL ALIGNMENT

2.4.1 Radius of Horizontal Curves

For the Project stretch the minimum values for Horizontal Curve Radii should be as per Schedule D of the tender documents. In places where improvement of the existing road geometrics to the prescribed standards is not possible, the existing road geometric shall be improved to the possible extent within the given Right of Way.

2.4.2 Cross-fall

The cross-fall on straight sections, paved shoulders and paved portion of the median shall not be more than 2.5%. The camber on the existing road has to be modified to unidirectional cross-fall. The cross-fall for granular shoulder on the portion which is straight has to be 0.5% steeper than the slope of the pavement. paved shoulder subject to a min. of 3.0%. In Super elevated section, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse camber of 0.5% so that the earth does not drain on the carriageway.

2.4.3 Super-elevation

Super elevation shall be limited to 10% if the radius of the curve is less than desirable minimum. If the radius of curve is more than desirable minimum, super-elevation will be limited to 8%. As per IRC-SP:73-2015, for design speed of 100 km/hr, super elevation is not required for radius of curve greater than 1,800 m and a normal camber of 2.5% would be maintained. Design formula and method of attaining super elevation will be as per IRC SP: 73-2015. That is rate of attainment would be 1 in 150 in plain and rolling terrain and 1 in 60 in hilly terrain. The pavement is rotated about inner edge of median.

2.4.4 Transition length at curve locations

IRC Geometric Design Standards for Rural (non-urban) Highways, IRC SP: 73-2015 suggests that the length of the transition curve should be the larger of the two values arrived at on the basis of the following criteria:

i) Rate of change of centrifugal acceleration;

ii) Rate of change of super elevation.

The values given in the IRC Geometric Design Standards for Rural Highways are obtained from the criterion of rate of change of centrifugal acceleration, with pavement width at the particular location.

2.4.5 Sight distance

The Safe SSD and Desirable Minimum Sight Distance for divided carriageway for various design speed are given in Table 2.3. The project is Two laning with paved shoulder configuration of existing single/2Lane corridor, a minimum Safe Stopping Distance (SSD) shall be adopted.

Table 2.4 Safe Sight Distance (as per IRC: SP: 73; 2015)

Design Speed (kmph)	Safe SSD (m)	Desirable Minimum SD (m)
100	**180**	**360**
80	**130**	**260**
60	**90**	**180**
40	**45**	**90**

2.5 VERTICAL ALIGNMENT

Vertical alignment will be designed in such a way that smooth longitudinal profile is maintained throughout the stretch without frequent changes in grade to avoid kinks and visual discontinuities. As per IRC-SP:73-2015 there has to be no change in grade within 150m, so that desired distance between consecutive Vertical Intersection Points shall not be less than 150m. Minimum length of vertical curve for design speed would be maintained as per *Table 20 of IRC-SP: 73-2015.*

2.5.1 Gradient

Limiting gradient shall be adopted in difficult situations and for short length.

Table 2.5 Gradient

Terrain	Ruling Gradient	Limiting Gradient
Plain and Rolling	2.50%	3.30%
Mountainous	5.00%	6.00%
Steep	6.00%	7.00%

As per IRC: SP: 73-2015, gradients has not be steeper than 2.5% in grade separators. But at some locations a deviation with this gradient is mentioned in Schedule-D of the EPC Agreement and this would be followed.

2.6 AT-GRADE INTERSECTIONS

The intersection will be designed as per the guidelines given in MORT&H for intersections on National Highways,1992 and on the basis of IRC:SP:41-1994,'Guidelines for the Design of At Grade Intersections in Rural and Urban areas.

Properly designed intersections must be provided at the locations.

Table 2.6 At Grade Intersections

S.N.	Location of intersection (existing road chainage)	Type of intersection	Other features	Remarks
1	0	Y	Link to Srinagar	-
2	1.46	Y	Y Link to Patnitop	-
3	1.675	Y	Link to Chenani town	Not as per schedule B
4	5.54	Y	Link to Chenani town	Not as per schedule B
5	7.36	Y	Link to Village Road	-
6	12.49	Y	Link to Village Road	-
7	15.883	Y	Link to Village Road	-
8	17.31	Y	Link to Village Road	-
9	21.57	Y	Link to PMGSY Road to Patnitop	-
10	21.69	Y	Link to Sudhmahadev	Not as per schedule B

2.7 GRADE SEPARATED INTERSECTIONS

2.7.1 Pedestrian/Light Vehicular /Vehicular Underpass/Flyover

The lateral and vertical clearances for Vehicular Underpasses will conform to Schedule-B of the EPC Agreement and Manual of Specification & Standards for two Laning of highway with paved shoulder. No VUP/flyover/LVUP/PUP has been proposed as Schedule B in this project stretch.

2.8 SERVICE ROADS

There is no service road proposed as per Schedule

2.9 SPECIAL CONSIDERATIONS IN HILLY SECTIONS

Special considerations in hilly sections include:

- Where any new construction/realignment is involved in hill sections large scale cutting or filling shall be avoided;
- Unstable hill slopes, if any will be adequately addressed with appropriate stabilizing measures as per latest IRC code available and best engineering practices and additional land is to be acquired by client in deep cuts.
- Protection measures in the form of Breast walls, boulder nets and cutting at correct angle and benching towards hill section would be done as per Guidelines given IRC:SP:48; and
- For effective system of drainage to runoff the natural water courses, in particular catch water drains shall be provided above the cut slopes. The outfalls of these drains are given outside any village areas.

2.10 FACILITIES AND FURNITURE

2.10.1 Bus Bays

The minimum length of the bus bay shall be 15m. The location of Bus Bays and Bus Shelters shall be provided as per Schedule. Two types of Bus bays both at hill section and plain section will be proposed based on location.

2.10.2 Truck Lay-Byes

Truck Lay-byes has to be provided by following Schedule-C of the EPC Agreement.

2.10.3 Traffic Control Devices

The road markings and road signs are to be provided as per relevant IRC codes and Manual of Specifications and Standards for two laning of Highways IRC SP 73 2015. The road markings shall be designed in accordance with IRC: 35-2015. The road signs will be designed in accordance with IRC: 67-2012.

2.10.4 Safety barriers, pedestrian guard rails and pedestrian facilities

Safety barriers and pedestrian guard rails will be as per section 9 of Two Laning Manual (IRC: SP: 73 2015).

2.10.4.1 Roadside safety barriers

Roadside safety barriers are provided to shield from high embankments and roadside hazards. Crash barrier of specifications will be provided as per IRC: SP:73 – 2015 for high embankments and at hazard

2.10.4.2 Median safety barriers

The requirement of median safety barrier is based on function of width of the median and traffic volume on the road. The warrants for provision of median barriers in terms of the combination of median width and Average Daily Traffic (ADT) in Passanger Car unit. But in our stretch road no such median is proposed.

2.10.4.3 Pedestrian facilities

As per Clause 2(c) of Technical Schedule, pedestrian facilities shall be provided in urban areas.

2.10.5 Kilometer Stones

The design and placement of Highway kilometer stones, their dimensions, size, color and arrangement of letters shall be as per IRC: 8-1980. For the 200-metre stones, IRC:26-1967 shall be followed. These stones are to be made of pre-cast M-15 grade reinforced cement concrete and lettering /numbering as per the respective IRC code.

2.10.6 Right of Way

Existing ROW

S. No	Chainage (km)	ROW (m)	Remarks
1	0.000 to 22.713	15	

Proposed ROW

ITEM	DESCRIPTION
Proposed Right of Way (PROW)	24.0m (Entire length) (to be provided on appointed date)
Proposed ROW on Realignments	24.0m (Within 150 days after the appointed Date)

CHAPTER-3

PAVEMENT DESIGN STANDARDS AND SPECIFICATIONS

3.1 INTRODUCTION TO PAVEMENT DESIGN:

Pavement structure consists of various layers placed on a sub-grade to support and scatter the traffic load to the sub-grade which acts like a foundation. Pavement design is basically guided by robust mechanistic-empirical principles and there by promising durability. The objective of is to determine total thickness of the pavement structure and thicknesses of individual structural layers. Though design is mainly evolved from structural performance criteria, but end user constraints are functional performance criterion like riding quality, safety and economic design which may decide options in choosing type of pavement and individual pavement layers.

3.2 PAVEMENT DESIGN CONSIDERATIONS

The scope of project is Rehabilitation and up-gradation of existing two/single lane carriageway to two lanes with paved shoulder configuration. Based on primary surveys & investigations and in turn design requirements will decide the future of existing carriageway, either to rehabilitate with bituminous overlay or to reconstruct as a new pavement.

3.2.1 Applicable Design Codes

A feasible design option is flexible pavement. As per the recommendations the pavement shall be designed in accordance to;

- IRC: 37-2012: Guidelines to be followed for design of flexible and composite pavements.
- IRC: 115-2014: Guidelines for structural evaluation and strengthening of flexible road pavements using Falling Weight Deflectometer (FWD) technique.

3.2.2 Design Life

Schedule B Clause 4.9 of the EPC Agreement refers Section 5 of Design Manual and 5.4 of Manual says design life will be as follows:

Flexible Pavement: - for widening and strengthening of existing pavement design period to be 15 years.

3.2.3 Traffic Loading

Design traffic loading shall be expressed as cumulative million standard axles (CMSA) for flexible pavement and in case of rigid pavement it will be cumulative commercial axle repetitions in respective single, tandem and tri-dem axles.

3.2.4 Commercial Vehicles Axle load

In specific, design traffic loading depends up on commercial vehicle loads that are plying on the project road. The loading characteristics are variable and are measured in terms of vehicle damage factor (VDF) for flexible pavement design and unique axle load spectrum as generated from axle load data that obtained by weighing the axles of commercial load trucks.

3.2.5 Design Traffic Volume

Design Traffic Volume shall be assessed based on IRC: 9-1972. The design volume as per traffic census and minimum as stipulated in the EPC Agreement will decide the final input in determining the traffic loading.

3.2.6 Design Subgrade Strength

In general subgrade is made up of in-situ soil, borrow area soil which is a plain granular material or granular material stabilized. For design of flexible pavement, subgrade strength is expressed as effective design California Bearing Ratio (CBR, in %) which is a combination of embankment / natural ground strength and borrow area soil material. In case of rigid pavement design, modulus of subgrade reaction (k, in N/mm3) represents subgrade strength. Borrow area soil for embankment and subgrade construction shall be identified and tested jointly by EPC Contractor and Authority / Independent Engineer. The initial pavement design will be carried out with assumed minimum required design subgrade strength, which can later be iterated accordingly based on laboratory results evolved from joint testing. This is to avoid delay in design submissions.

3.3 DESIGN METHODOLOGY

The above highlighted design parameters are fixed accordingly to design flexible and rigid pavements which are unique. The detailed methodology is divided in to two parts;

- Design of New Pavement as shown in Figure 3.1
- Strengthening of Existing Bituminous Pavement as shown in Figure 3.2.

Figure 3 1 New Pavement Design Methodologies (Flexible and Rigid)

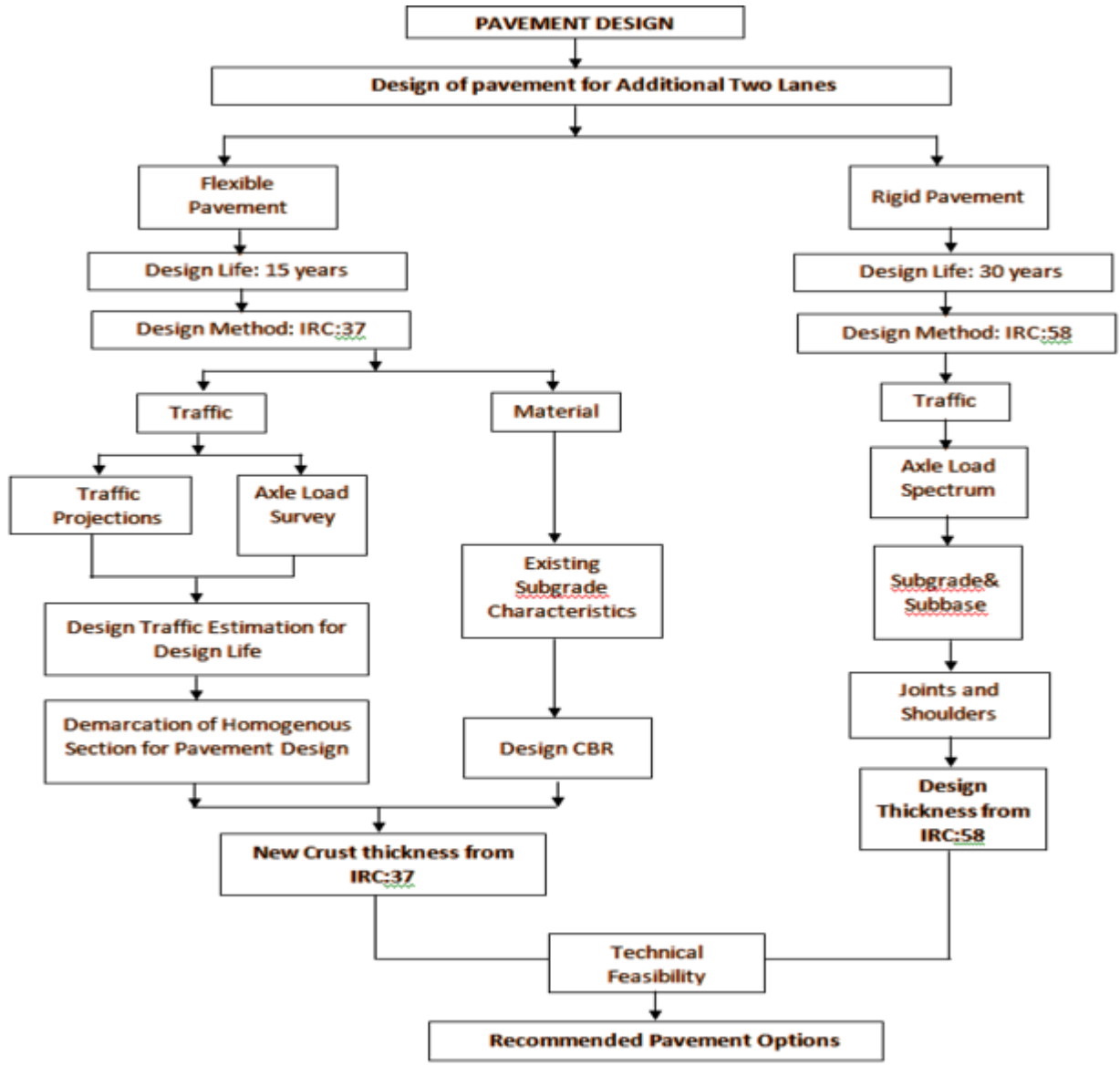
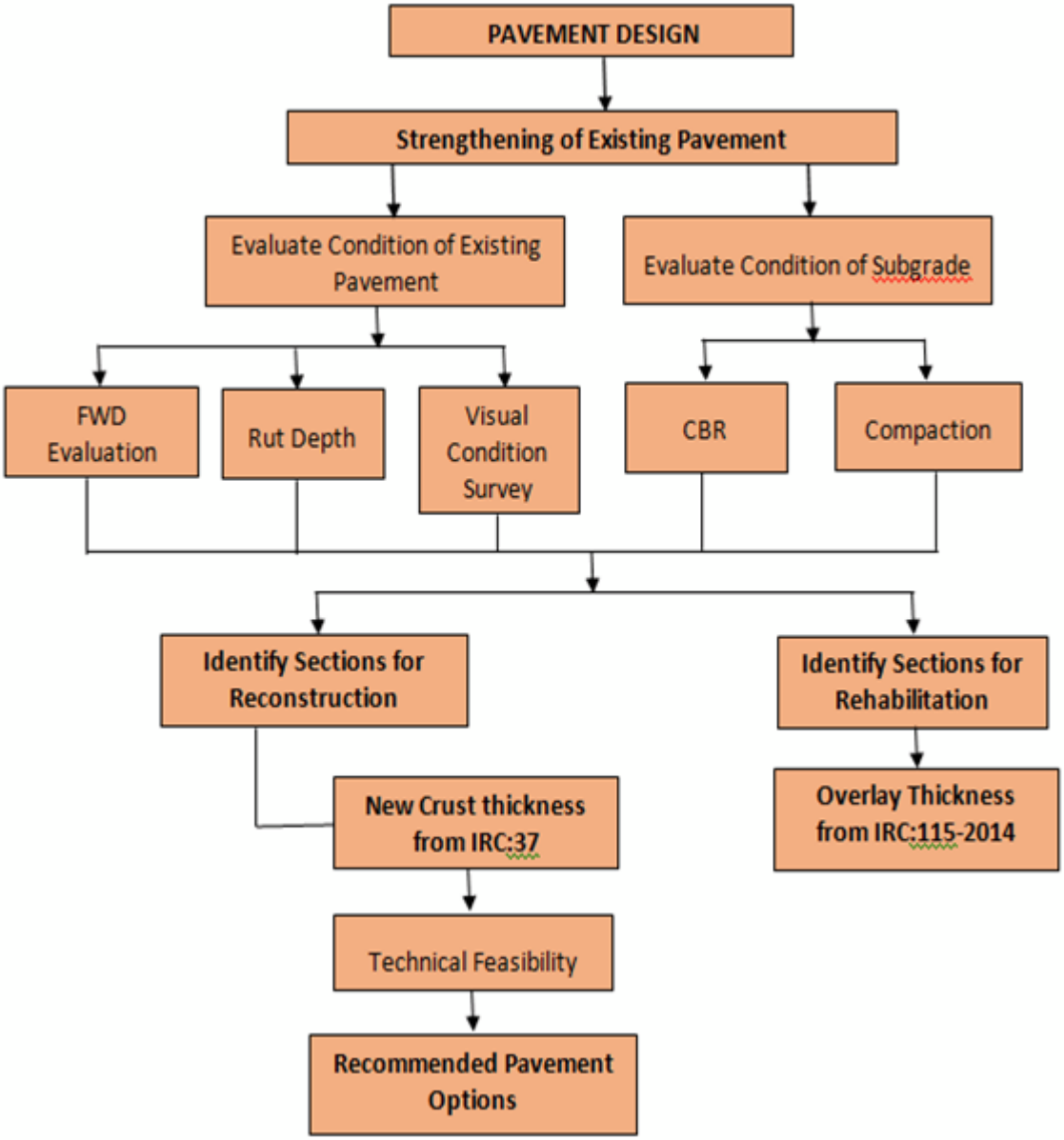


Figure 3.2 Pavement Design Methodologies



3.4 TRAFFIC SURVEYS & PAVEMENT INVESTIGATIONS

Traffic and travel characteristics with respect to existing conditions are identified during reconnaissance survey and are further studied in detail from available primary and secondary data. It is understood about homogeneous sections and accordingly traffic studies were conducted as per design provisions.

3.4.1 Classified Volume Counts

Traffic studies in detail as classified volume counts for consecutive 7days 24 hours, turning movement count at proposed major intersections for 12 hours to 24 hours are conducted. The

base numbers are further analyzed to determine design traffic volume, hourly variation, and average daily traffic. Analysis and design outcome will be provided in traffic & pavement design report.

3.4.2 Axle load Survey

Distribution of commercial loading to which pavement will be subjected during the design life is identified from axle load study. Commercial vehicles are weighed as combination of individual axles and accordingly damaging effects are established. Axle load survey along with origin and destination study has been conducted for 1day 24 hours during the 7 days of classified volume count.

3.4.3 Deflection test by Falling Weight Deflectometer (FWD)

The extent of pavement deflection under a loading confirms its structural strength. It's a study of pavement crust deflection under an impulse loading which simulates the amplitude of the load pulses produced by moving wheel loads.These form the basis for estimation of pavement residual life and design of overlay satisfying structural strength requirements.

3.4.4 Pavement Crust and Test Pits Study

It is a must and should requirement to have a clear idea of existing pavement crust in terms of layer thicknesses and the material composed thereof. The primary reasons for existing pavement distresses can be justifiable in proper along with overloading effects. Test pits will be taken on side of pavement edge to do the in-situ studies as required and further existing pavement material are characterized by detailed laboratory testing.

3.4.5 Pavement Condition Survey

Prior recommending the options of rehabilitation and strengthening, a detailed pavement evaluation has been carried with suitable mapping formats to establish:

- The type and extent of distresses through visual assessment.
- Deficiencies effecting pavement functional and structural performance.
- Suitability of repair and rehabilitation techniques, in specific to condition that exists.

CHAPTER-4

STRUCTURES

4.1 INTRODUCTION

The site of the Project Highway (National Highway-244) commencing from Km 0+000 to Km 16+990 i.e. Chenani – Sudhmahadev section in Jammu & Kashmir. The project section is proposed for up-gradation of existing Single Lane section to 2-lane section under NHDP-III on EPC mode. In this section of DBR, existing structures details as per Schedule-A, proposed structures details as per schedule-B, Design consultants' proposal, Design Philosophy for Structures, Bore log plans for Underpasses/Minor bridges and typical drawings for proposed structures along the project road are presented.

4.2 LIST OF EXISTING STRUCTURES ON THE PROJECT ROAD

Table 1 List of Existing structures

S. N.	Type of Structure	Number of structures as per Schedules A
1	Major Bridges	0
2	Minor Bridges	3
3	ROB	Nil
4	Vehicular and Non-vehicular Underpass	Nil
5	Grade Separators	Nil
6	Box culverts	Nil
7	Pipe culverts	74
8	Slab culverts	15
9	Stone Masonry	12
10	Causeways	3
11	RUB	Nil

4.3 DESIGN STANDARDS AND METHODOLOGY FOR STRUCTURES

The design of structural components shall conform to the criteria as per given in the latest edition of the IRC codes of practice, guideline/circular/specification of MORTH, IRC and BIS published up to the date of commencement of EPC contract. Wherever Indian codes are silent, International codes shall be considered. Design Team will collect the available data and information relevant for the Study.

4.4 BRIDGES AND STRUCTURES INVESTIGATIONS

The primary objective of the Inventory would be to assess and list out the existing features of the project corridor pertaining to roads, bridges and structures, and cross-drainage structures.

A format based on the guidelines in the IRC Special Publication IRC:SP-35, shall be adopted for inventory & condition survey and shall be elaborated as per design requirement. Instruments and tools such as GPS, measuring tapes, plumb bob, small hammer, mirror, binoculars and camera shall be used for the inventory. The data collected shall be analyzed and strategy shall be proposed for treatment of each structure in terms of maintenance, rehabilitation or replacement during widening and improvement. The data shall be collected in the following lines:

- Structure Number
- Structure Co-ordinate (Geographical location)
- Location and name of the stream / river
- Year of construction of the major structures
- Structure type and span arrangement
- Structure dimensions such as length, clear width, overall width, clear span, effective span,
- size of the vent, height from road level to existing bed level and height of parapet and railing
- Type of construction materials used
- Alignment of structures viz. straight or skew

- Type and size of the bearing
- Type of expansion joint
- HFL & LWL
- General Conditions

Data Collection

Data collection will be done by total station on site considering the up and down stream of the river. A temporary bench mark will be established at the bank of the river and after that the survey work will be done. During the first reconnaissance survey, tentative location of proposed bridge has been selected. River cross-sections will be taken during the survey on upstream as well as downstream up to approximate distance of 500 m on either side of proposed bridge location at the closed interval of 100 m each as per the guidelines provided in IRC: 13-2004 for working out accurate bed profile of river across the channel as well as along the channel.

4.5 HYDRAULIC AND HYDROLOGICAL INVESTIGATIONS

The hydraulic and hydrological studies shall be carried out in accordance with IRC Special Publication No. 13 ("Guidelines for the Design of Small Bridges and Culverts") and IRC: 5-1998 ("Standard Specifications & Code of Practice for Road Bridges, Section I General Feature of Design"). The study on topography (stereoscopic aerial photography), storm duration, rainfall statistics, top soil characteristics, vegetation cover etc. will be done so as to assess the catchment areas and hydraulic parameters for all existing and proposed drainage provisions.

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

The available Digital elevation model (DEM) of the influence area will be analyzed with the help of suitable GIS software to identify the number of streams crossing the alignment of the road, to demarcate their catchments areas so as to assess the runoff characteristics. These again verified with top sheets and hydrological reconnaissance survey. A Hydrological survey will be carried out to properly identify and match the existing structures with proper valley locations, and locations for culverts and drains, to ascertain the hydraulic condition of the

existing structures and to get an idea of the general drainage pattern of the area. Information on past floods and their effects on existing structures will be collected from site. Estimation of Design discharge and high flood level (HFL) will be established using these data and information collected from field and their detailed interpretation and analysis. Topographic survey will be carried out to get the required number of cross sections and longitudinal sections of the river/streams for those structures, which have sizeable catchments area and defined definite stream keeping in view the guidelines set out in IRC:5 and IRC:SP:13.

Scope of Hydrological Study

The broad scope of work of hydrological study includes:

a) Hydrological survey/ study of all major and minor river crossings enroute;

b) Calculation & finalization of hydraulic design parameters such as Catchment area, des i--gn discharge,
design HFL, LWL on the basis of hydrological survey/ study of all rivers;

c) Finalization of bridge locations, length and span configuration as given in DPR; and

d) To check the location, adequacy ofreconstructed and proposed culverts of the road ali gnment.

4.6 GEO-TECHNICAL INVESTIGATIONS AND SUB-SOIL EXPLORATION

To evaluate the subsoil properties needed for the design of foundations, detailed geo- technical investigations need to be conducted at all bridges, flyovers, underpasses, ROBs, embankment locations along the project road location as necessary for proper design of the works and conduct all relevant laboratory and field tests on soil and rock samples.

Table-2 Bore Location

S. No.	Description	Location of Boring
1	Length = 6 to 30m	Each abutment location
2	Length = 30 to 60 m	Each abutment location & at least one intermediate location between abutments for structures having
3	Length >60 m	Each abutment and each pier locations

The Depth of bore-Logs is based on expected type of foundation. As per the preliminary survey it seems deep foundation shall be suitable. In case of open foundation, the bore hole will be done as per IRC: 78 i.e. 1.5 times the width of the foundation below the proposed foundation level. The depth of drilling/ boring shall be 5.0m in soft rock & 3.0m in hard rock.

4.7 MATERIAL INVESTIGATIONS

Sources of all materials, quarry sites and borrow areas has to be identified. On site and laboratory testing of the materials, quality and quantity of various construction materials shall be undertaken and their use on the basis of techno-economic principles shall be recommended.

- It shall be ensured that no material will be used from the right-of-way except by way of leveling the ground as required from the construction point of view or for landscaping and planting of trees etc. or from the cutting of existing ground for obtaining the required formation levels.
- Environmental restrictions, if any, and feasibility of availability of these sites to prospective civil works contractors, will be duly taken into account while selecting new quarry locations.

4.8 RELEVANT CODES FOR DESIGN OF STRUCTURES

Standards and Codes of Practices

All activities related to field studies, design and documentation will be done as per the latest guidelines/ circulars of MoRT&H and relevant publications of the Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). For aspects not covered by IRC and BIS, international standard practices, such as, British and American Standards may be adopted. DPR Consultants will finalize this in consultation with NH Works.

List of IRC Codes

The list of IRC codes for the design of various types of structures are as follow:

Table 3 List of IRC Codes

Code Number	Description
IRC:5-1998	**General Features of Design**
IRC:6-2017	Loads and Stresses
IRC:112-2011	Code of Practice for Concrete Road Bridge
IRC:22-1986	Composite construction for Road Bridges
IRC:24-1967	Steel Road Bridges
IRC:78-2000	Foundations and Substructure
IRC:83-(Part-IV)-1982	Spherical and Cylindrical bearings
IRC:83-(Part-III)-1982	POT-cum-PTFE, Pin & Metallic Guide Bearings
IRC:87-2011	Guidelines for the Design and Erection of False work for Road Bridges
IRC: SP 48-1998	Hill Road Manual
IRC:SP:64-2005	Guidelines for the Analysis and Design of Cast-in- Place Voided Slab Superstructure
IRC:SP:66-2005	Guidelines for Design of Continuous Bridges
IRC:SP:69-2005	Guidelines & Specifications for Expansion Joints
IS-2911	For Pile foundations
	MORT&H Specifications for Road and Bridges Works,(Fifth Revision)

Structural Detail

- EPC Contractor will prepare General Arrangement Drawing (GAD) and Alignment Plan showing the salient features of the 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.) shall be finalized based upon hydraulic and geo-technical studies, cost effectiveness and ease of construction. guidelines. EPC Contractor will furnish the detailed design and drawings for carrying out the above improvements.

Retention / Replacement of Cross Drainage Structures

The retention/replacement criteria for the structures have been firmed up in line with stipulations of Codes and with due consideration of climate change effect.

Design of New Bridge Structures

As per schedule provided in the contract document, these bridges will be designed, and any improvements required for better utility and value engineering will be done and got it approved by NHAI/AE. These All new Structures are being designed for 50-year Return period Flood as stipulated in four Lane Manual. In case of existing culverts, they are checked for opening sizes (carrying capacities) Vis a Vis estimated design flood. Primarily, such hydrological/hydraulic analyses, in conjunction with the assessed structural condition, will be studied to reach recommended criteria for replacement/retention of the culverts. In addition, the extent of choking of any culvert and the possibility of economic clearance of the same will be duly considered before taking the final decision. Guidelines regarding retention or replacement, as stipulated in the IRC: SP: 73-2007 Manual of Specifications and Standards for two Laning of Highways with Paved Shoulders will be followed to the applicable extent. Other criteria will be considered are as follows:

- Hazards of replacement
- Ease of routine maintenance

General criteria for replacement or retention of culverts, as stipulated in IRC: SP: 73- 2007 and IRC: SP: 84-2014 will be followed in principle. In a nutshell, the general criteria followed are as follows:

a) All pipe / box / slab culverts having size less than 0.9m will be recommended for replacement.

b) All pipe culverts of 0.9m diameter or above having hydraulic and structural adequacy and functioning properly will be recommended for retention / widening.

4.9 HYDROLOGY AND HYDROLOGICAL STUDY

General

Main objective of hydrology is to determine anticipated flood and other parameters such as Design Discharge, Flow Velocity, HFL, and Scour Depth. Bridge structure shall be designed so as to cater for the anticipated floods without endangering the structure. The hydrological and hydraulic studies shall be carried out in accordance with IRC SP. 13-2004 ("Guidelines for the Design of Small Bridges and Culverts") and IRC: 5-1998 ("Standard Specifications & Code of Practice for Road Bridges, Section- I General Feature of Design.Detailed Hydrological Investigations for all Structures shall be done in Hydrology report.

Data Collection

The various essential data shall be collected for hydrological investigation. Catchment area will be calculated from the Topo sheets available on a scale of 1:50000 for small catchments and 1:250000 for large catchments. Highest flood level will be observed and measured during site visit supplemented by local enquiry. Attempts shall be made to collect the data of existing bridge and their performance during past floods from the Governing Departments.

Estimation of Flood Discharge

The most common methods to estimate the flood discharge are as under:

a) Empirical Method
b) Rational Method
c) Unit Hydrograph
d) Area Velocity Method

a) Empirical Method:

Dickens's Formula can be used for the project area.

$Q = C M^{3/4}$

Where, Q = Peak run-off in m^3/sec

M = Catchment area in Sq. Km.

C = Coefficient of run-off, depends upon annual rainfall

The catchment area M is determined from the Topo sheet, Coefficient of run-off 'C' is determined from IRC SP: 13-2004 depending upon the intensity of rainfall. This formula gives a simplified approach and results are approximate. Comparisons are made with alternative methods for important structures.

b) Flood Assessment Based on Rational Approach:

The rational formula for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances, and time of concentration and critical intensity of rainfall. Basic formulae are as under:

One-hour rainfall (Io), Io = (F/T)*{(T+1) /(1+1)} Critical rainfall intensity,

Ic = Io* (2 /(1+tc)) Discharge,

Q = 0.028* P*f* A*Ic

Time of concentration, $tc = (0.87*L3 / H)^{0.385}$

Where,

tc = Time of concentration i.e. time taken by runoff from farthest point on the periphery of Catchment (hrs)

Io = One-hour rainfall in cm

Ic = Critical intensity of rainfall in cm per hour

P = Coefficient of runoff for the catchment characteristics (Ref: Table - 4.1, P-13 and IRC SP: 13-2004)

A = Catchment area in hectare

Q = Maximum discharge in cumec

L = Distance from the critical point to the structure (Length of path in Km)

H = The difference in level from the critical point to the structure in meter F= Maximum rain fall in mm

T = Duration of storm in hours

f = A fraction of maximum point intensity at the center of the storm and related with the catchment area (IRC: SP: 13-2004.)

In the present study, storm rainfall and storm duration data of 50 Years return period shall be utilized from design flood hydrograph of nearby project sites, developed on the basis of Hydro-meteorological studies as per relevant Flood estimation reports of the particular regional area.

c) Unit Hydrograph approach for assessment of design flood discharge:

The unit hydrograph (UG) of a drainage basin is defined as the direct runoff (outflow) hydrograph resulting from one unit of effective rainfall which is uniformly distributed over the basin at a uniform rate during the specified period of time known as unit time or unit duration.

This method is applicable for Catchment area varying between 20-25 Sq. Km to 2500- 5000 Sq. Km. In present study, the design discharge calculations shall be done for 100 Years return period.

d) Area Velocity Method

The area velocity method uses Manning's formula (as per IRC SP: 13-2004 manually or using HEC-RAS Software) for calculating flow velocity as under:

$Q = A*V;$ $V = (1/n)\, R^{2/3}\, S^{1/2}$

Where,

Q = Peak run-off in m3/sec

A = Cross sectional area of flow

V = Velocity of flow

n = Rigidity coefficient

R = Hydraulic mean radius = A / P; P= Wetted perimeter

S = Energy slope which may be taken equal to bed slope

Cross sections of the streams are taken both upstream and downstream at a distance as specified in IRC SP: 13-2004 by Topo survey in the field. Longitudinal slope of the bed is also calculated by taking long section over a reasonably long reach of the stream. HFL can be observed in the field by flood marks and local enquiry. This formula gives fairy reasonable estimation of flood discharge.

i) Design Discharge

Design discharge is fixed as per provisions of Clause 6.2 of IRC SP: 13-2004. The values of peak discharge calculated by above methods are compared. The highest of these values is adopted as design discharge, provided it does not exceed the next highest discharge by more than 50 percent. If it does, restrict it to that limit.

ii) **Scour Depth**

Determination of scour depth is important factor for deciding depth of foundation and shall be derived as per Cl. 703.2 of IRC: 78 - 2000 according to which:

$dsm = 1.34 * (D_o \; I \; Ksf)^{1I3}$

Where, dsm = Mean depth of scour

D_o = Design discharge per meter width of effective waterway

Ksf = Silt factor of bed material,

The maximum depth of scour below the highest flood Level (HFL) for the design of piers and abutments located in a straight reach and having individual foundations without any floor protection works is taken as under.

In the vicinity of piers = 2.0 dsm;

Near abutments = 1.27 dsm

iii) Vertical Clearance

Provision of Vertical clearance in bridge above HFL shall be kept as per IRC SP: 13-2004, Clause 12.3 as under

Table 4 Vertical clearances for different discharge values

S. N.	Discharge in m^3/s	Minimum Vertical Clearance (m)
1	Up to 0.30	0.15
2	Above 0.3 and up to 3.0	0.45
3	Above 3 and above 30	0.6
4	Above 30 and up to 300	0.9
5	Above 300 and up to 3000	1.2
6	Above 3000	1.5

4.10 CULVERTS

Design criteria/assumption for pipes /Boxes:

1. Hydraulic of pipes are considered flowing full for 50 years of return period;

    a) Permissible heading up at inlet:
    When natural velocity of flow is not very high over the terrain restriction in waterway by providing by pipe structures will head up the flow. This will continue till the disch arge passing through the boxes equals the discharge coming towards the pipes;

    b) For a specific design discharge the extent of upstream heading up depends on the vent way / opening area (A). The vent way has to be so chosen that the upstream head should not go higher than a predetermined safe level. Safe level should take care of no overtopping and no property damage at upstream. In the present criteria in design upstream safe level has been kept up to top of upstream slab level of the Boxes and 0.6 m above pipes;

    c) Tail water level: tail water is kept as natural HFL or water level that exists without co nstruction of culvert;

Operating head of boxes/pies flowing full:

a) When the tailrace water level is below the crown of exit of box Operating head H= i nlet water surface level -crown level of box

b) When tail water is above the crown of Box /pipes Operating head H =inlet level of w ater surface –tail water level

The operating head H supply energy to generate

a) Velocity of flow through box;

b) Forcing water through inlet to enter the box; and

c) Overcoming the friction generated inside the wetted surface of boxes.

d) Design discharge through boxes with vent way /area (A)

$Q= \lambda\sqrt{2gh}$

Where

$\lambda = A/(1+Ke+Kf)^{1/2}$

A= area of wetted area of Box

H = operating Head

Coefficients Ke and Kf are entry and friction loss coefficients.

Value of Ke and kf for Boxes are given below:

Sl. No.	Entry and friction loss	Square entry	Bevelled entry
1	Ke	0.572R^ 0.3	0.05
2	Kf	0.0035L/R ^1.25	0.0035L/R^1.25

Minimum size is recommended as 1.2 m dia

Adequacy of the slab culverts will be checked by Area Velocity methods

Q = A *V

V will be found out from manning's formula.

Area will be considered as opening area of the proposed size and height will be from ground l evel to bottom of slab

Summary of Culverts Proposal

Table5 Summary Culvert Proposal

Sl. No.	Culvert	Nos	Size (LxB)	Proposal
1	Box	30	2X2	Additional new
2	Box	60	2X2	Reconstruction
3	HPC/Box	0	-	Widening

4.11 SELECTION OF TYPE OF SUPERSTRUCTURE

Considering small spans ranging from 9.0m to 25 .0m (centre to centre of expansion gap) RCC beam and Slab type superstructure has been adopted here for overall economy, and easy and rapid construction. The following types of superstructures have been considered though in

some cases RC Solid Slab type superstructure has been considered at end span to adjust total bridge length and linear waterway.

4.12 GRADE OF MATERIALS

The Grade of Concrete used shall be as per design requirement & mentioned in execution drawings of the structure. Cement & Water Content shall be as per mix design requirement; Modulus of elasticity of concrete is to be considered as per the Table 6.5 of IRC: 112-2011

Table 6 Grades of construction material used

Foundation		
	Concrete Grade	Initially M35 will be adopted but may be modified depending upon the proposed type of foundation.
	Reinforcement	HYSD of Grade Fe 500 D
Abutment / Abutment Cap and Pier/Pier Cap		
	Concrete Grade	M35 (min)
	Reinforcement	HYSD Steel of grade Fe 500 D
Super-Structure		
	Concrete Grade	M35 for RCC T beam & Slab (min.)
		M40 for PSC/Precast & CIP Box Girder(min.)
	Reinforcement	HYSD of grade Fe 500D
	Structural Steel	Grade E250/Fe410 W B grade/HTS
	Joint Connections	HSFG Bolts
Pre-stressing Strands :		HTS 12T15, 19T13, 19T15 etc.
	Crash Barrier	
	Concrete Grade	M40
	Reinforcement	HYSD steel of grade Fe 500D
Clear Cover to any Reinforcement is followed as below		
	Foundation	75 mm
	Sub-Structure	50 mm
	Super-Structure	40 mm

Bearings

Bearings for Structures shall be designed to transmit all the loads and appropriate horizontal forces. Pot fixed/Pot PTFE sliding bearings shall be proposed for superstructures (RCC or PSC Pre-cast/ cast-in-situ Girders/ Box Girders/ RCC Voided slab/ Composite). Wherever Large are proposed, spherical bearings shall be adopted for catering large movement and rotation as per IRC: 83 (part-IV).

Expansion Joints

Expansion joint shall be provided as per IRC: SP: 69-2005 depending upon the anticipated expansion/ contraction. These shall conform to Section 2600 Technical Specification of MORTH. Types of expansion joint based upon the length of span and movements are as given below:

Table7-Type of Expansion Joints

Sl. No.	Span	Expansion Joints
1	For RCC Box/ Slab type structures up to 12 m span only	Filler type expansion joints
2	For all other bridges having span longer than 12 m and where movements are up to ± 70mm	Elastomeric Single Strip Seal type expansion joints
3	where movements are above ± 70mm	Double strip Seal/Modular type expansion joints

Wearing Coat

Wearing coat shall be 40mm thick Bituminous Concrete as per MoRTH guidelines.

Approaches

RCC Return or Retaining wall for approaches up to certain length shall be adopted and approaches shall be well protected with stone pitching/ wired nets as required.

4.13 DRAINAGE PROVISIONS

Drainage Spouts:

Drainage spouts will be provided in accordance with MoRTH standard plans. The minimum spacing shall be kept preferably as 5.5 c/c which may be adjusted to suit span length .Spacing shall not exceed 10m c/c as stated in guidelines issued by MORTH 5th revision. The drainage spouts at Bridge are proposed with free down fall.

Weep Holes

Weep holes shall be provided with 100 mm dia AC/PVC pipe for plain/reinforced concrete abutment, wing wall and return walls etc. Weep holes shall extend through the full width of concrete with slope of about 1 vertical: 20 horizontal towards the draining face. The spacing of weep holes shall generally be 1.0m in a staggered manner or as shown in the drawing with the lowest weep hole at about 150 mm above the low water level or ground level, whichever is higher.

4.14 LOADS AND FORCES TO BE CONSIDERED IN DESIGN

Vertical Loads

a) Dead Loads

Following unit weights shall be assumed in the design as per IRC-6:2017 Codes:

Reinforced Concrete	-	2.5	t/cu.m
Plain Cement Concrete	-	2.5	t/cu.m
Structural steel	-	7.8	t/cu.m
Dry Density of Backfill Soil	-	2.0	t/cu.m

b) Superimposed Dead Loads

Superimposed Dead load consists of load due to Wearing coat (surfacing coat), crash barrier and foot path with hand rails. Unit weight for superimposed dead load shall be in conformity with IRC: 6-2017 and as indicated in Design Assumptions mentioned earlier. Loads

corresponding to the dimensions given for bridge furniture details in IRC: 5-1998 shall also be considered as SIDL for design of structure.

c) Live Loads

i) Carriageway Live Loads: The following load combinations will be considered in the analysis and whichever produces the worst effect will be considered:

- One/Two/Three lanes of IRC Class A.
- One lane of IRC Class 70R (wheeled/ tracked)
- One lane of IRC Class 70R (wheeled) with one lane of IRC Class A

ii) Minimum clear distance between 70R vehicle and Class A vehicle, when placed side by side in combination, shall be 1.2m for design.

iii) Resultant live load stresses shall be reduced by 10% in case all the three lanes are loaded i.e. in case of three lanes of IRC Class 'A' or one lane of IRC Class 70R with one lane of IRC Class A.

iv) Impact factor shall be as per Cl. 211 of IRC: 6 for the relevant load combination

(a) Centrifugal Forces

If bridge is situated on curvature, effect of centrifugal forces shall be considered as per the provisions of Cl.212 of IRC: 6 for design speed.

(b) Wind Effect

Wind Forces shall be considered in accordance with the provisions mentioned in clause 209 of IRC: 6-2017, acting perpendicularly to the structure. Drag Coefficient, Gust Factor and Lift coefficient shall be calculated accordingly.

(c) Seismic Effect

The road stretch is located in Seismic Zone-IV The seismic forces will be calculated as suggested.The modified clause for the interim measures for seismic provisions.

(d) Water current forces

Water Current Forces shall be considered as per clause 210 of IRC: 6-2017. The structures shall be designed for a variation of 20 degrees with respect to orientation of pier. HFL, velocity

of flow, scour depth has been taken as per past data received and hydraulic calculations. On piers parallel to the direction of water current, the intensity of pressure is given by following equation.

$p = 52 K V2$

Where,

p = intensity of pressure in kg/m2

K = a constant, value depends on shape of pier

V = velocity of current at point where pressure intensity is to be determined in m/s. (which is zero at the point of deepest scour and √2 times maximum mean velocity at the free surface).

Serviceability Limit State

Loads are required to be combined to satisfy the serviceability requirements. The serviceability limit state check shall be carried out in order to have control on stress, deflection, and crack width. The Rare combination of loads shall be used for checking the stress limit. The Frequent combination of loads shall be used for checking deflection. For crack width calculation quasi permanent load combination shall be considered for pre-stressed with unbounded tendons & RCC member, and frequent combination will be used for pre-stressed members with bonded tendons. The permissible stresses for pre-stressing and reinforcement shall be considered as per chapter 12 of IRC: 112-2011.

- Allowable compressive stresses in concrete under rare combination of loads shall be limited to 0.48fck.
- Allowable compressive stresses in concrete under quasi permanent combination of loads shall be limited to 0.36fck.
- Allowable stresses in reinforcement for reinforced concrete structures under rare and quasi permanent combination of loads shall be limited to 300MPa.
- Crack width calculations shall be done as per Cl. 12.3.4 of IRC: 112. The crack width shall be limited to 0.3 mm for RC members & pre-stressed with unbounded tendons under quasi-permanent load combination and 0.2 mm for pre-stressed members with bonded tendons under frequent load combination as per Table 12.1 of IRC: 112.

Ultimate Limit State

Loads are required to be combined to check the equilibrium and the structural strength under ultimate limit state. The equilibrium of the structure shall be checked against overturning, sliding and uplift. It shall be ensured that the disturbing loads (overturning, sliding and uplifting) shall always be less than the stabilizing or restoring actions. The structural strength under ultimate limit state shall be estimated in order to avoid internal failure or excessive deformation. The equilibrium and structural strength shall be checked under basic, accidental and seismic combination of load.

4.15 REINFORCEMENT DETAILING

- The bar sizes and distance between bars shall be in accordance with section 15 of IRC: 112-2011.
- Curtailment of bars shall be as per clause 16.5.1.3 of IRC: 112-2011,
- Minimum Reinforcement and Distribution reinforcement in pre-stress shall be as per IRC: 112-2011
- Minimum shear reinforcement shall be as per IRC: 112-2011.
- Minimum diameter of any reinforcement shall not be less 10mm for open foundation, transverse ties, stirrups and all secondary reinforcement for slab.
- Minimum diameter of any reinforcement shall not be less than 12 mm for pier vertical bar, pier cap main bar.
- Ductile detailing shall be done as per chapter 17 of IRC: 112-2011.

4.16 PERMISSIBLE STRESSES

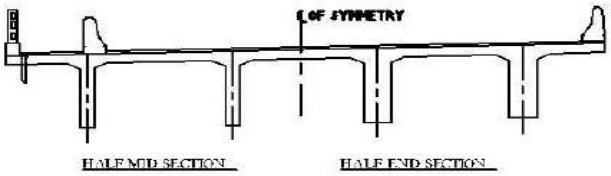
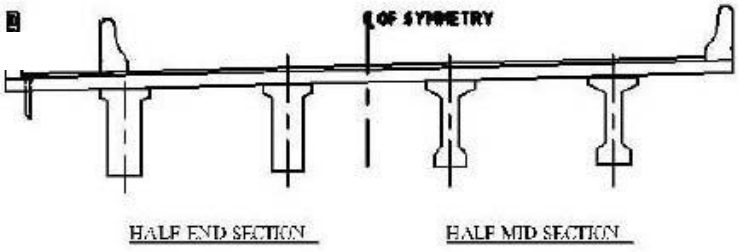
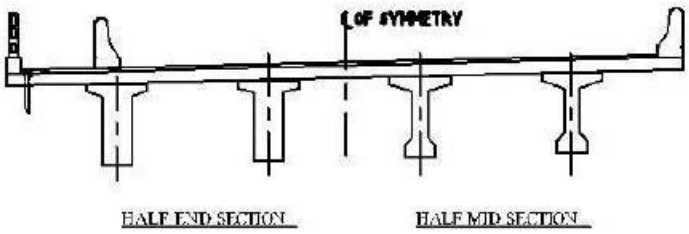
The Permissible Stresses in the RCC members shall be as per IRC: 112. The Permissible Stresses in the composite members & steel pre-stress structures considered in design shall be as per IRC: 112-2011 respectively. Increase in Permissible Stress in steel and concrete due to various load combinations shall be as per IRC: 6-2017.

4.17 SOFTWARE FOR ANALYSIS AND DESIGN

In house developed programs and spread sheets for checking stresses and capacity of structural element. Structural Analysis: STAAD., Midas, Adapt.

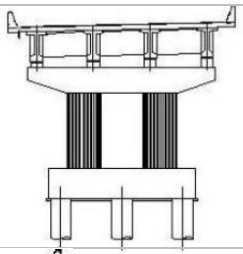
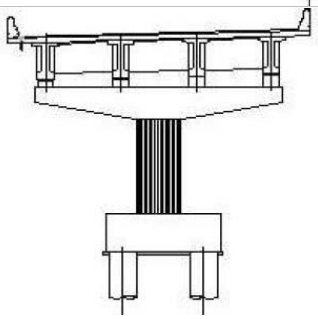
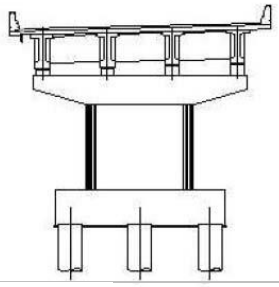
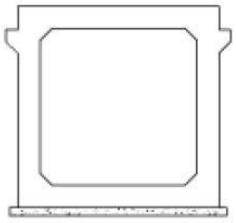
4.18 DESIGN METHODOLOGY FOR SUBSTRUCTURE AND FOUNDATION

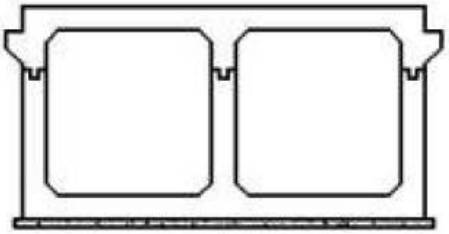
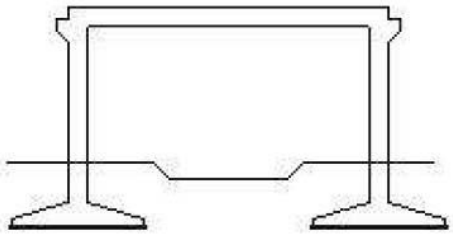
Table 7: Appropriate Shape and Type of Superstructure

Reinforced Concrete T- Beam(CIP) (a) Spans 10 to 14m (b) Span/depth ratio (1) Simply Supported: 12 (2) Continuous : 16	
Reinforced Concrete T-beam (precast girder with cast in situ deck) (a) Spans 15 to 25m. (b) Span/depth ratio (1) Simply Supported: 12 (2) Continuous : 16	
PSC (Precast-girder) (a) Spans 30 to 40m. (b) Span/depth ratio (1) Simply Supported : 16 (2) Continuous : 18 (c) Max. depth = as per design	

Steel Girder (a) Spans 30 to 76m. (b) Span/depth ratio (1) Simply Supported: 18 (2) Continuous : 20	

Table 8 Appropriate type of substructure

S.NO.	DESCRIPTION	SKETCH
1.	MULTI COLUMNS PIER	
2.	SINGLE PIER CANTILEVER TYPE	
3.	PLATE TYPE PIER	
4.	SINGLE CELL RCC BOX OFTEN USED FOR CULVERT/MINOR BRIDGE/ VUP/PUP IN SHORT SPAN RANGE	

5.	MULTICELL RCC BOX OFTEN USED FOR BRIDGES IN SHORT TO MEDIUM SPAN RANGE	
6.	INTEGRAL BRIDGE SUITABLE FOR SPANS LESS THAN 40m AND SKEW ANGLES LESS THAN 20 DEGREE	

4.19 PROPOSAL FOR STRUCTURES

Proposal for Structures (Minor Bridges (07 MNB) & Major Bridges (03 MJB)

Table -9 Proposal for Bridges

Sl. No.	Structure	Bridge Type	Length (m)	No	Span (m)	Type
1	0.928	MJB	75	3	22.5+30.0+22.5	RCC T/ PSC I beam & Slab
2	2.575	MJB	250	3	83.35	Steel Truss
3	4.220	MNB	6	1	6.0	RCC Box
4	7.500	MNB	6	1	6.0	RCC Box
5	8.730	MNB	6	1	6.0	RCC Box
6	8.950	MNB	6	1	6.0	RCC Box
7	9.334	MJB	60	1	60.00	Steel Truss
8	13.270	MNB	6	1	6.0	RCC Box
9	14.500	MNB	6	1	6.0	RCC Box
10	14.840	MNB	6	1	6.0	RCC Box

4.20 ROADSIDE DRAINAGE

Drainage system including surface and subsurface drain for the Project

Table 10 Proposal for Drains

SL no.	**DESIGN CHAINAGE (Km)**	**Length (m)**	**TCS TYPE**	Drain
1	From 0.000 to 0.800	0.800	TCS 3	Lined covered drain
2	From 1.015 to1.466	0.451	TCS 2	RRM Drain on Hill

4.21 PROTECTION WORK

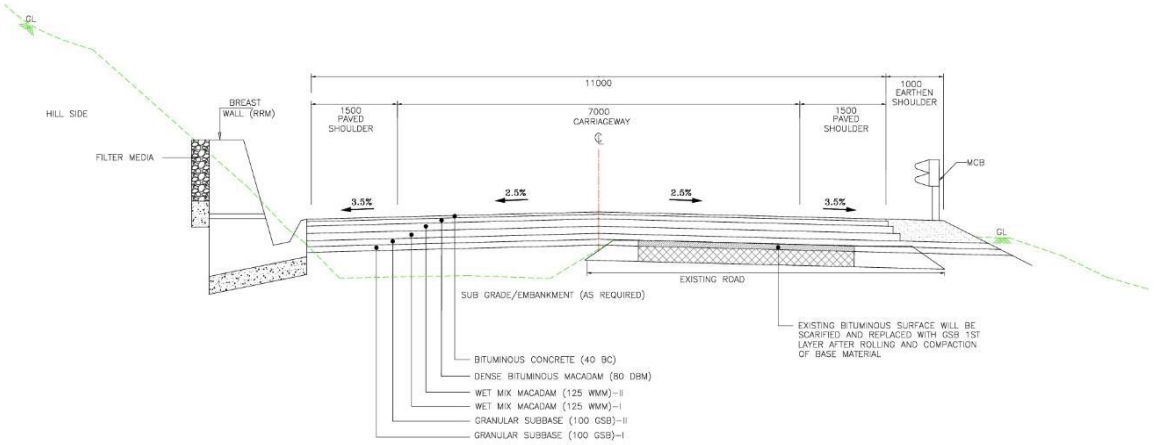
Table -11 Proposal for Protection Works

SL no.	Type of Protection	Length
1	Retaining wall	4.0km
2	Breast wall	14.312km
3	Boulder Pitching for high Embankment	1.676 km
4	Gabion Walls	1.0 km
5	Energy Dissipation basins	1.0 km

- Cutting of existing hill slopes, it is imperative that slopes are stabilized for ensuring longevity of the slope and the road.
- Slope stability, erosion control and landslide correction in accordance with IRC: SP: 48-1998.
- Reference may be drawn from IRC: 56-201

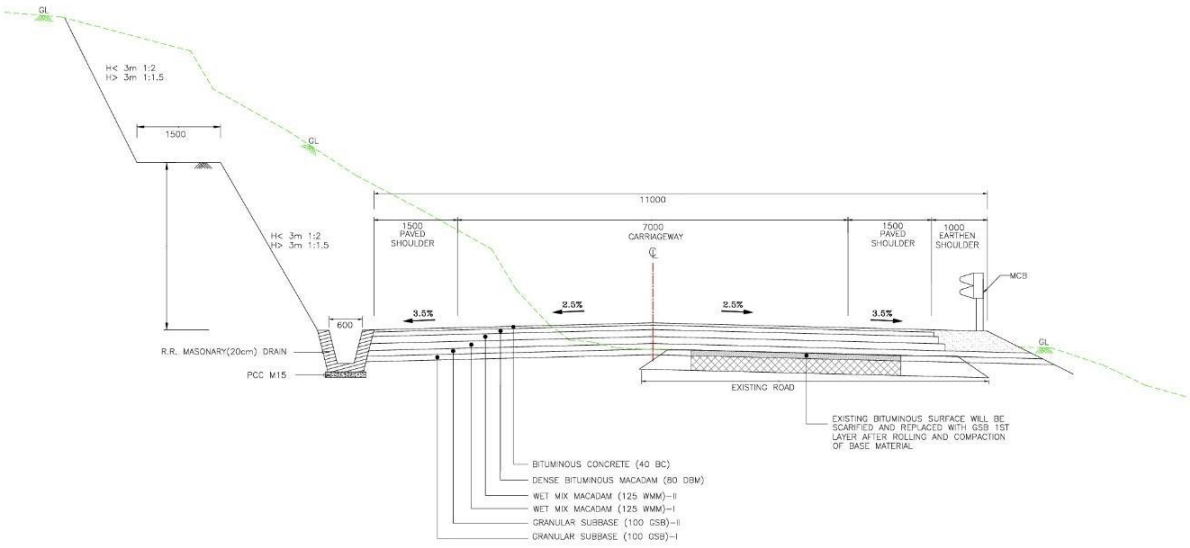
4.22. APPENDIX-2

TCS – I - One side Hill & One side Valley (Breast Wall on hill side)



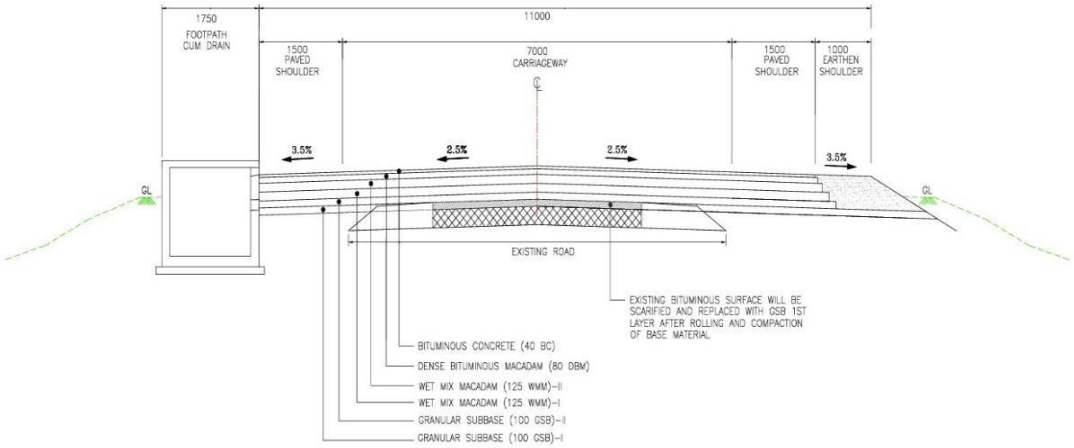
TYPICAL CROSS-SECTION TYPE-1 FOR MOUNTAINOUS TERRAIN ONE SIDE HILL (WITH BREAST WALL) & ONE SIDE VALLEY

TCS – II -One side Hill & One side Valley (Drain on Hill Side)



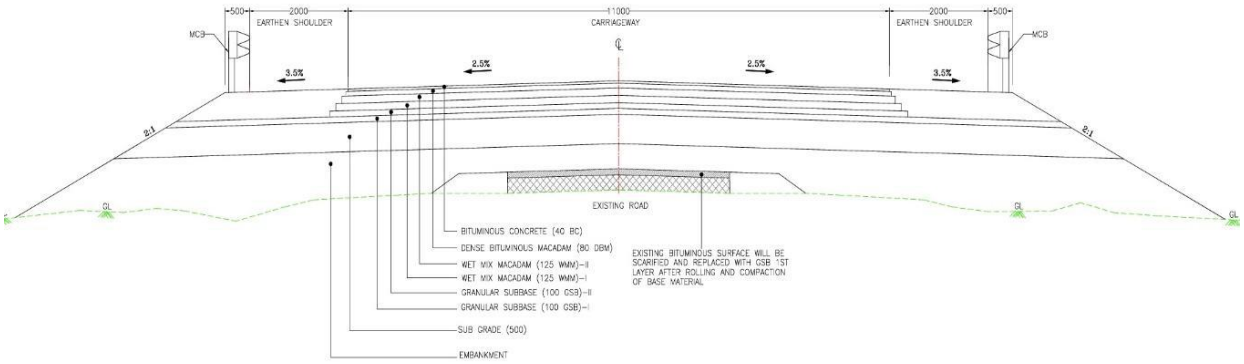
TYPICAL CROSS-SECTION TYPE-2 FOR MOUNTAINOUS TERRAIN ONE SIDE HILL (WITH DRAIN) & ONE SIDE VALLEY

TCS – III - One side Valley & One side Built up or open area



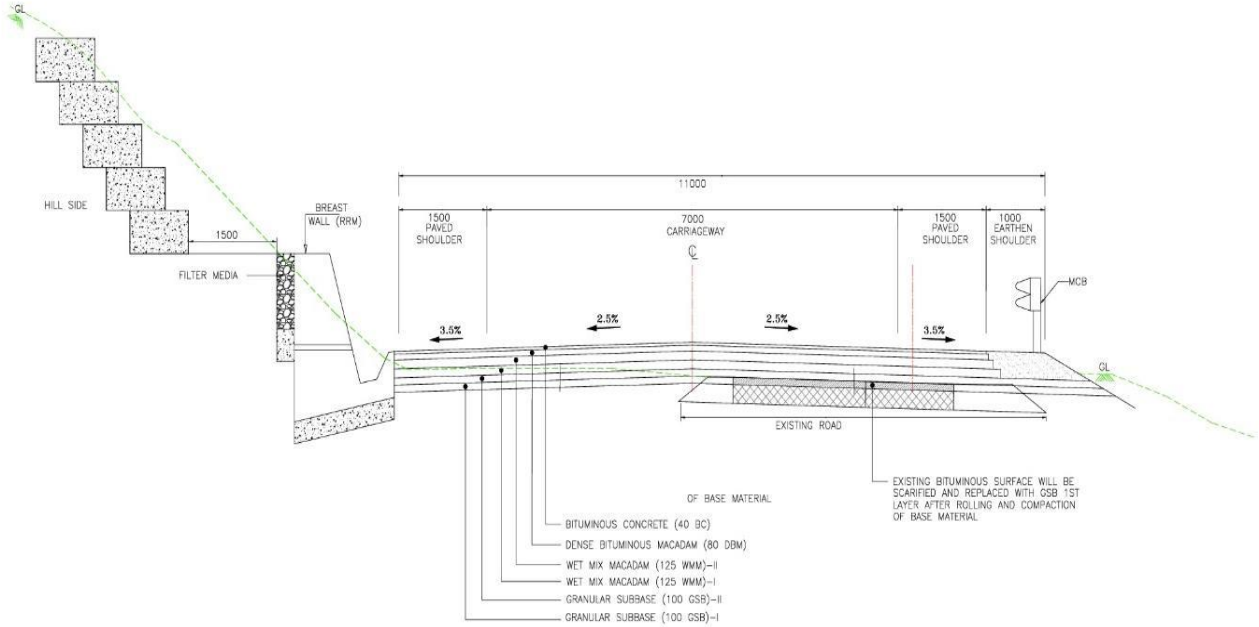
TYPICAL CROSS-SECTION TYPE-3 FOR MOUNTAINOUS TERRAIN ONE SIDE VALLEY & ONE SIDE BUILT UP AREA (COVER DRAIN)

TCS – IV - Approach to Bridge



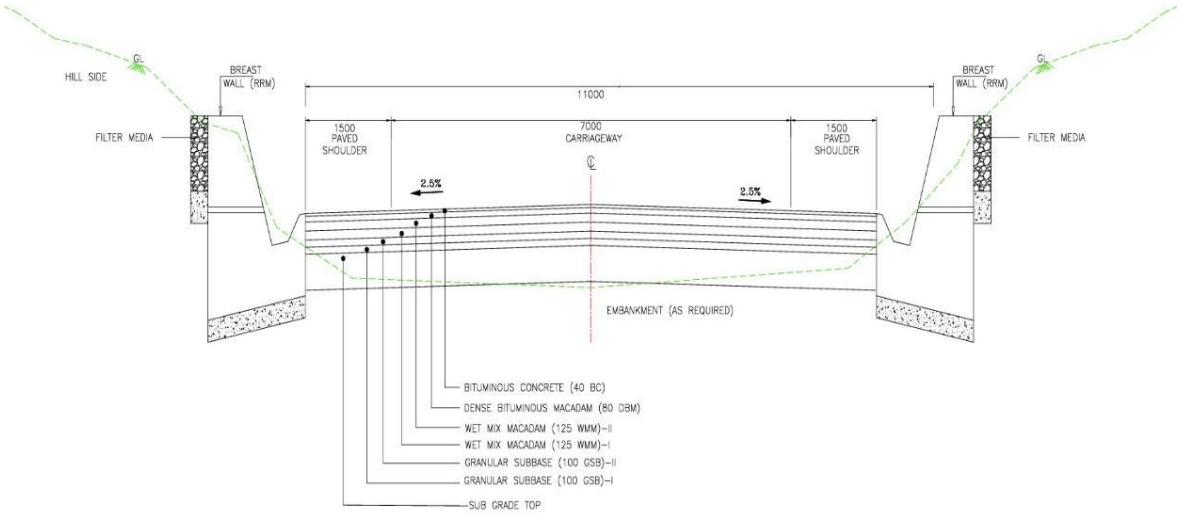
TYPICAL CROSS-SECTION TYPE-4 FOR NEW BRIDGE APPROACHES

TCS – V - One side Hill & One side Valley (Breast Wall and Gabion Box Protection on hill side)

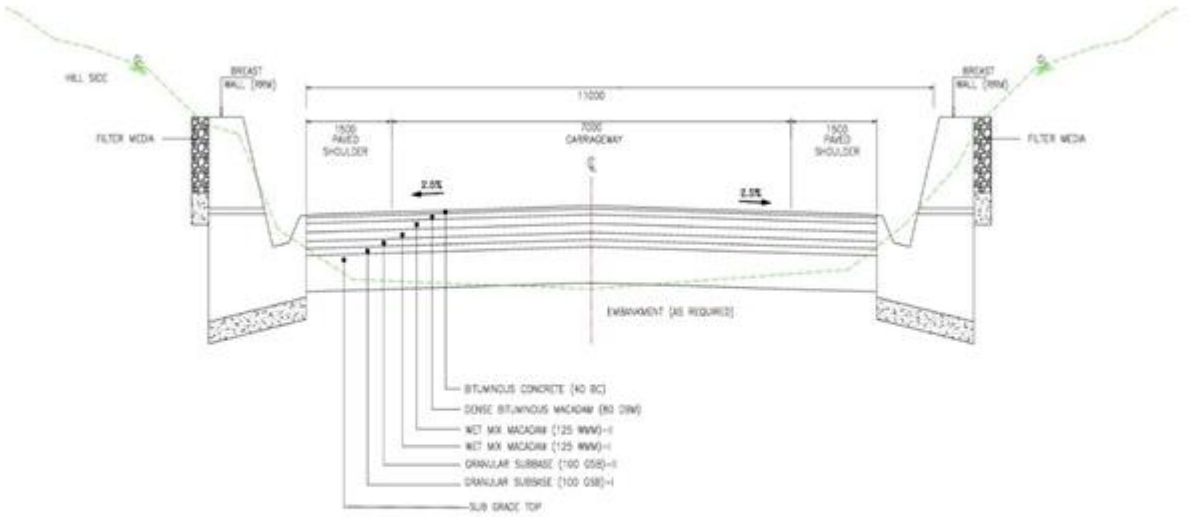


TYPICAL CROSS-SECTION TYPE-5 FOR MOUNTAINOUS TERRAIN ONE SIDE HILL (WITH BREAST WALL) & ONE SIDE VALLEY

TCS – VI – Realignment



TYPICAL CROSS-SECTION TYPE-6 FOR REALIGNMENT SECTION



TYPICAL CROSS-SECTION TYPE-6 FOR REALIGNMENT SECTION