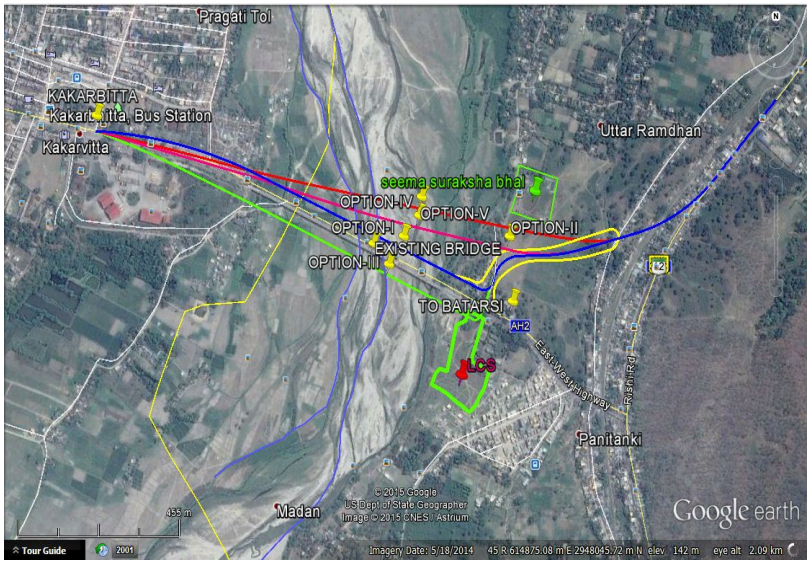
ADB TA No. 8116-IND

TA SUBPROJECT NO. 25
DETAILED DESIGN OF THE SASEC SUBREGIONAL ROAD CONNECTIVITY PROJECT



Funded by:

Asian Development Bank

Implementation Agency:

Ministry of Road Transport and Highways
Government of India

DETAILED PROJECT REPORT FOR MECHI BRIDGE

Volume-I
Main Report

Sheladia Associates Inc (ADB TA Consultant)

August 2016

SHELADIA ASSOCIATES, INC.

ES EXECUTIVE SUMMARY

ES.1 Project Background

The Asian Highway (AH) project, also known as the Great Asian Highway, is a cooperative project among countries in Asia and Europe and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), to improve the highway systems in Asia. It is one of the three pillars of the Asian Land Transport Infrastructure Development (ALTID) project, endorsed by the ESCAP commission at its 48th session in 1992, comprising Asian Highway, Trans-Asian Railway (TAR) and facilitation of land transport projects. Agreements have been signed by 32 countries to allow the highway to cross the continent and also reach to Europe. The project aims to make maximum use of the continent's existing highways to avoid the construction of newer ones, except in cases where missing routes necessitate their construction. The Intergovernmental Agreement on the Asian Highway Network (IGA) was adopted on November 18, 2003, by the Intergovernmental Meeting; which identifies 55 AH routes among 32 member countries total approximately 140,000 km.

There are eight Asian Highway Routes in India including AH 2 and AH 48. The total length of the Asian Highways in India is about 11,458 km, comprising 11,432 km of National Highways and 26 km of State roads. Out of 11,432 km of Indian NH roads on Asian Highways routes, about 5,200 have been developed to 4-lane standard under the National Highways Development Project (NHDP); development of 4-lanes of about 1,400 km is underway and about 2,500 km of National Highways have been earmarked under various phases of NHDP, about 150 km of National Highways have been identified for development to four lane under SARDP-NE. Thus, about 9,250 km of Indian NH roads along Asian Highways are either already developed to 4-lane standards or programmed to be developed. The development of the Asian Highways Network in India, as well as in SAARC and ASEAN countries, will facilitate increased trade, transport, tourism and economic development.

Asian Development Bank is supporting the preparation of the Sub regional Road Connectivity Project in the state of West Bengal, which is programmed for implementation starting in 2014 with funding support from ADB. The Project has been endorsed by the SASEC Trade Facilitation and Transport Working Group Meeting held in Kolkata on 5 March 2012. The SASEC program is helping to transform challenges into opportunities in one of the world's poorest, most densely populated areas. It is an initiative to promote economic cooperation between Bangladesh, Bhutan, India, and Nepal. In 1996 four of the seven member countries of the South Asian Association for Regional Cooperation (SAARC), namely, Bangladesh, Bhutan, India, and Nepal, formed the South Asian Growth Quadrangle (SAGQ), with the primary objective of accelerating sustainable economic development among these countries. This sub regional initiative was endorsed at the SAARC summit in Male, Maldives in 1997. Subsequently, these four countries requested ADB's assistance in facilitating their economic cooperation initiative. This request led to the implementation of the SASEC program. The ADB study on regional connectivity endorsed two major highway connector corridors which forms

part of two Asian Highway corridors AH2 and AH 48 for development as part of SASEC program in India including the border crossing facilities.

In order to facilitate the implementation of the project, the ADB has engaged Sheladia Associates Inc. (SHELADIA) as Technical Assistance Consultant to prepare Detailed Engineering Design, Bid Documents and Safeguard Documents for the AH2 and AH 48 corridor. SHELADIA was subsequently entrusted the project report preparation for upgrading the link of AH 2 from Kakarvitta to Panitanki Bypass including a Major Bridge across river Mechi of about 675m length to improve the connectivity between India and Nepal through the State of West Bengal for possible financing by the ADB. The goal of this improvement is to encourage regional socio economic development, trade and tourism between the countries.

This Project Report presents the design and detailing for the upgrading of Kakarvitta to Panitanki Bypass including the construction of a new Mechi bridge and the implementation of this component was overseen by the National Highways Infrastructure and Development Corporation Limited (NHIDCL) and MORT&H.

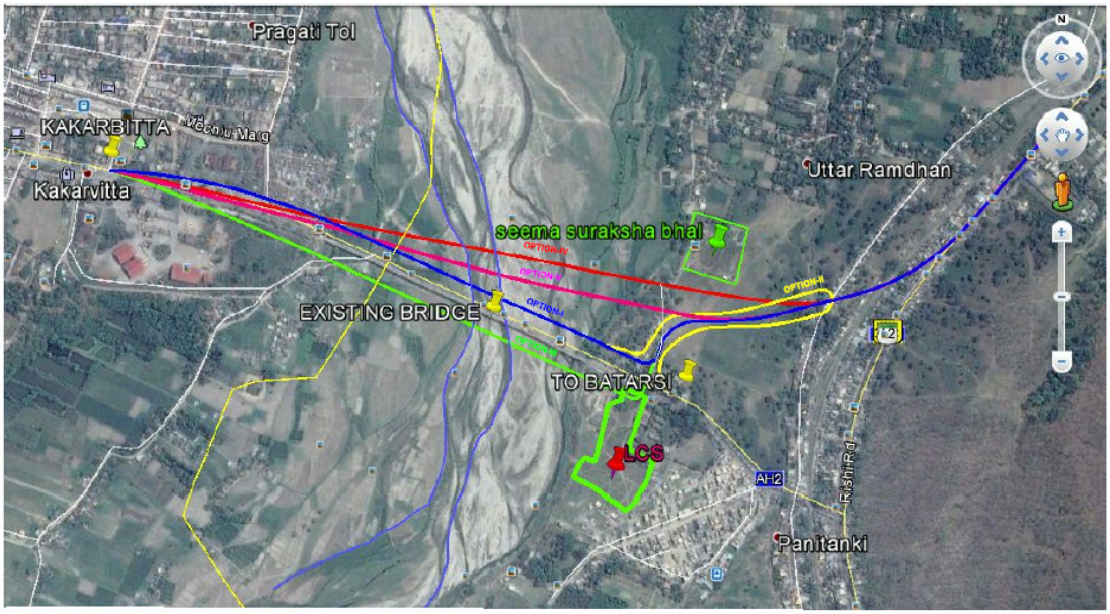
ES.2 Existing Scenario

Mechi Bridge is an important link connecting India and Nepal, serving immensely, both the countries in trans-border trade, Industrial, social and cultural exchange and development in the region. The existing bridge connecting Nepal to India is located at about 400m from Kakarvitta junction in Nepal, towards India side; connecting Panitanki in India.

The topography falls under the plain terrain of IRC classification and traverse generally through rural area. The first 1.2 Km of this road from Kakarvitta in Nepal border is a state highway which has been declared as National Highway 327B.

Existing Mechi Bridge consists of 20 spans of each 29.3m having PSC Superstructure resting on well foundations. The clear deck width of the bridge is 7.0m and overall deck width is about 8.0m. As per the enquiry, the bridge is built in the year 1968 (approx.) and is about 47 years old. The bridge is in fair condition as per condition survey with minor distress at some locations. The carriageway width of bridge is to cater for 2 lane loading only where as at present there are many slow moving vehicles along with pedestrian traffic plying on the bridge in addition to fast moving / commercial traffic and the capacity of the bridge is in sufficient to take care of the present traffic. Also keeping the projected traffic based on the existing, it is proposed for the construction of a new bridge.

The following figure shows the existing scenario and the proposed improvement option in birds view.



ES.3 Scope of Services

The main tasks for the Design Consultant as per the TOR are (i) Detailed Engineering Design and Cost estimation and (iv) prepare Detailed Project Report. As required by the TOR, the Design Consultant will carry out the detailed engineering design of the project, design of service roads, quantities of various items, detailed drawings, detailed cost estimates, environmental and social feasibility, social and environmental action plans as appropriate and documents required for tendering the project on commercial basis for international competitive bidding**.**

ES.4 Improvement Proposal for Road & Bridge

Various alignment options for the bridge alignment has been submitted to NHIDCL and the approval has been given to Option V vide their letter no: NHIDCL/Mechi Bridge/2015 dated 05.08.2015 as shown in the above figure.

The section from Panitanki Bypass to Bangladesh Border is already under implementaiton. Hence to match with capacity of AH2 section and keeping in view of future requirements, **6 Lane Major Bridge is proposed across river Mechi with 15 spans of 45m having 3 span continuous superstructure with abutment and piers resting on pile foundation on the u/s of the existing bridge** connecting Nepal and India**.**

ES.5 Improvment proposal for pavement

As the most of existing roadd is proposed reconstrction, the following pavement thickness is proposed with a overall MSA of 50 with 7 CBR for a period of 15 years.

Main Carriageway : BC 40mm, DBM 100mm, WMM 250mm, GSB 230mm and Sub-grade 500mm

Service Road : BC 40mm, DBM 50mm, WMM 250mm, GSB, 150mm and Subgrade 500mm.

ES.6 Environmental and Social Impact Assessment (EIA and SIA)

An environmental and social impact assessment was undertaken to identfy the environmental and social impacts of the proposed project and an Environmental Management Plan (EMP) and Resettlement Plan (RP) were prepared. The EIA, EMP, SIA and RP are submitted as a separate report.

As per ADB SPS 2009 project has been categorised as a ' B' category project accordingly an IEE report has been prepared. The Indian Regulatory framework pertaining to environment does not require prior environmental clearance for the Bridge and approaches , but in Nepal, Government Regulatory framework requires preparation of IEE report and its approval from Ministry of Planning and Works.

The proposed improvements will require land for construction of approach road on either side of the bridge and also for connecting the approach road to the proposed Panitanki bypass on the Indian side. Further, the improvements will also impact squatters and encroachers causing physical and economic displacements.

Except two land parcels in the Nepal side, all land being acquired are either Government land or Tea Garden land. The Tea Garden land are also Government land on long lease to private parties. The total land required will be 0.785ha in Nepal side and 5.302ha in Indian side. This project will be categorised as A-Category as per ADB SPS 2009 as it involves physical displacement to 27 DHs, physical and economic displacement to 3 DHs and economic displacement to 52 DHs.

ES.7 Cost Estimate

The construction cost for the above approved proposal for Option V alignment of 6 Lane Major Bridge with its apporach in Nepal and India is **114.74 Crore**.

S. No.	Bill of Items	Amount
1	BILL NO. 1 : SITE CLEARANCE AND DISMANTLING	1,346,304
2	BILL NO. 2 : EARTHWORK	8,965,008
3	BILL NO. 3 : GRANULAR SUB-BASE AND BASE COURSE	21,542,415
4	BILL NO. 4 : BITUMINOUS COURSE	27,170,699
5	BILL NO 5: BRIDGES	1,019,657,949
6	BILL NO 6: DRAINAGE AND PROTECTIVE WORKS	61,128,867
7	BILL NO. 7: TRAFFIC SIGN, MARKING & OTHER APPURENANCES	7,592,220

Total Civil Cost (A) =		**1,147,403,461**
	Total Civil Cost (2016) in Rs. Crore	**114.74**
	Contingency at 2.8% on A	32,127,297
	Sub Total (B) =	**1,179,530,758**
	Supervision at 4% on B	47,181,230
	Agency Charges at 3% on B	35,385,923
	Quality Control at 0.5% on B	5,897,654
	Road Safety at 0.5% on B	5,897,654
	Escalation Charges @ 5% per year for 2 years = 10% on B	117,953,076
	Maintenance charges for 4 years @ 1.75 % on B	20,641,788
	Fund for Greening @ 1% on A	11,474,035
	Utility shifting (Provisional sum)	1,000,000
	EMP and Environmental Monitoring	4,800,000
	Land Acquisition and Resettlement	71,160,000
	Total Project Cost (2016)	**1,500,922,118**
	Total Project Cost (2016) in Rs. Crore	**150.09**
	Length (Km)	**1.40**
	Total Project Cost in USD @ INR 66/USD	**22,741,244**

1.0 PROJECT DESCRIPTION, SURVEY AND INVESTIGATIONS

1.1 General

The surveys and investigations are carried out is presented in this chapter.

1.2 Description of Existing Bridge & Road

The inventory and condition survey of road and structures are carried out and presented below. The present scope of work is detailed design of new Major bridge across river Mechi with minimum length of existing road to be improved on Nepal side.

The existing road on Nepal side consists of wider 2 lane up to 150m from Kakarvitta junction in Nepal and the balanceis is 4 lane with central median of 0.5m with railing having footpaths on both sides for pedestrain movement up to mechi bridge.

Existing Mechi Bridge consists of 20 spans of each 29.3m, with cast-in-place, concrete T-girder and slab superstructure, resting on solid wall type concrete substructures and well foundations. The bridge is built in the year 1968 (approx.) and is about 47 years old. The bridge is in fair condition as per condition survey with minor distress at some locations. The carriageway width of bridge is to cater for 2 lane loading only where as at present there are many slow moving vehicles along with pedestrian traffic plying on the bridge in addition to fast moving / commercial traffic and the capacity of the bridge is in sufficient to take care of the present traffic.

The clear deck width is about 7.0m only to cater for the two lane traffic with concrete kerb and railings. As per visual inventory and condition survey, the bridge is in fair condition. There is no scour or settlement in the well foundation. The superstructure is also in fair condition with minor spalling of concrete observed at some locations at the bottom of deck slab. Outflanking of the embankment / erosion of bund is observed at Abutment A2 / Indian side because of the nature of direction flow which is in bend in plan.

Some of the photographs of the Existing Road and Major Bridge:

	
View towards the Nepal side Approach	**View towards the immdiate Bridge Approach on Nepal side**

	
View of Exit Gate of Existing LCS on Nepal side	**View of Entry Gate of Existing LCS on Nepal side**
	
View towards the starting point of Kakarvitta Junction	**View of the Existing Bridge**
	
Showing u/sside of river bed with braided channels	**Showing d/s side of river bed with braided channels**

	
General Elevation of the bridge from d/s and Combined interlaced channels	**Showing d/s bend and deep erosion (see arrow) on A2 of Indian side**
	
Groins/Spurs constructed to stop erosion of fragile Indian side d/s bank.	**Erosion of Abutment Spill on A2 side. Arrow shows eroded spill.**

1.3 Topographic Survey

Topographic survey using the state of the art technology instruments such as Total stations, digital levels and GPS coordinates for permanent referencing have been used. Topographic survey collected all the permanent features within the corridor width of available ROW. Detailed cross sections have been collected at 20 m interval.

S. No.	Point ID	Easting	Northing	MSL	Remark
1	Old GPS Pillar	616087.21	2947427.191	129.695	L/S 20 m before bridge India side
2	TBM Pillar	616169.73	2947364.062	128.4721	L/S 34 m from road India Side

1.4 Traffic Surveys

The detailed traffic surveys conducted are presented in the Chapter 2.

1.5 Hydrological Surveys and Geotech Investigations

The brief summary of hydrological surveys and the geotechnical investigatiosn carried out are presented in Chapter 4 and 5 respectively.

1.6 Environmental Impact Assessment

The proposed Mechi bridge project is linear in nature. The Executive Agency (EA) in the current project is Ministry of Roads , Transport and Highways (MoRTH) Government of India and Department of Roads, Government of Nepal is the implementing agency for Nepal portion works and for works in India portion, implementation agency is National Highways Infrastucture and Developement Corporation Limited (NHIDCL). The project portion in India is located in Darjeeling district and Nepal portion is located in Jhapa district under the Mechi Nagar Municipality.

The Indian Regulatory framework pertaining to environment does not require prior environmental clearance for the Bridge and approaches , but in Nepal, Government Regulatory framework requires preparation of IEE report and its approval from Ministry of Planning and Works.

As per ADB SPS 2009 project has been categorised as a ' B' category project accordingly an IEE report has been prepared.

The baseline data for the IEE report preparation was generated during the DPR preparation of AH-02 project. In the year 2015 the primary data related to trees to be cut and stakeholder consultations were carried out. The project area has hot tropical climate. The bridge approaches are in undulating terrain. There are no endangered species of flora and fauna in project area and surroundings. The aquatic flora and fauna in Mechi River is not of significance as it is a seasonal River. The ambient air quality and water quality monitoring indicates all parameters of ambient air quality and water quality are well within the stipulated limits of AAQ standards and Drinking Water quality standards (specified in IS:10500). The measured noise levels are also well within the stipulated limits. The soils in the study area are moderately fertile and are not contaminated with pollutants. The dominant tree species in proposed RoW are Bamboo, Mango, Peepal, Jamun, etc. There are no protected or reserved forest within the proposed RoW of the project. Both the locations (Panitanki and Kakarbhitta) on either side of bridge location have basic amenities such as educational schools, health facilities, banks, post offices and transport facilities.

The impacts have been assessed in IEE on different components of environment. The impacts on ambient air quality will be due to dust generations and emissions of construction equipment and machinery. During operation phase impacts on AAQ will be due to increased vehicular traffic. Impacts on water quality will be due to construction material handling and during pier construction in river bed and on ground water due to extraction of ground water for the construction. The impacts on flora will be due to removal of trees and vegetation from the RoW. It is expected that there will be removal of about 116 trees. These trees have been identified and marked. Impacts on soil will be on account of borrow area operations, waste water discharge from construction camp and due to disposal of construction waste on the open ground. The increased noise impacts will be felt during the construction phase on account of construction activity and during operation phase on account of increased vehicular traffic. No significant

impacts on fauna are anticipated as bridge site is located between two major habitations. The project will have a positive impact as it will provide employment opportunities during the construction phase. The adverse impacts identified on socio-economic environment are land acquisition and removal of encroachers and squatters from the RoW. The project affected people have been identified and a separate resettlement action plan has been prepared to address the impacts related to Involuntary Resettlement.

To avoid adverse environmental impacts mitigation measures have been formulated for the pre construction, construction and operational phases. An Environmental Management Plan has been prepared. This EMP provides mitigation measures for each identified adverse impact, responsible agency for implementation and supervision, monitoring requirements and reporting system. The budget for implementation of mitigation measures has also been estimated in the EMP. Total EMP budget has been estimated as INR 4.8 millions (approx US $ 74,000). This budget has been added in overall project cost. The EIA and EMP are submitted as a separate report along with social impact assessment.

1.7 Socail Impact Assessment

The proposed improvements will require land for construction of approach road on either side of the bridge and also for connecting the approach road to the proposed Panitanki bypass on the Indian side. Further, the improvements will also impact squatters and encroachers causing physical and economic displacements.

Except two land parcels in the Nepal side, all land being acquired are either Government land or Tea Garden land. The Tea Garden land are also Government land on long lease to private parties. The total land required will be 0.785ha in Nepal side and 5.302ha in Indian side. In all a total of 6.087ha will be required for this project.

The 5.302ha of land in the Indian side comprises of 2.148ha of Government land classified as River and 3.154ha of Tea garden land. The project does not involve acquisition of any private land in the Indian side. Alienation of tea garden land is governed by the provisions of the of the West Bengal Estates Acquisition (WBEA) Act, 1953. Further, the tea garden owner is compensated for the tea bush in the garden.

In the Nepal side the 0.785ha of land comprises of 0.025ha of private land and 0.760ha of Government land. The private land will be acquired in accordance with the provisions of the Land Acquisition Act, 2034 of 1977 of Nepal.

The project will cause impact to 28 residential structures, 3 residence cum commercial structures and 51 kiosk/street vendors. Amongst the affected structures 15 structures were semi-permanent in nature and 67 were kiosks/street vendors. Further, the project will impact 1 place of worship and 8 government buildings.

Consultations were held at 2-palces, one at Mechi nagar in the Nepal side and the second one at Korsing Jote at the Indian side. Both meetings were attended by PAPs and other stakeholders and comprised many women.

	
Consultation at Mechi Nagar, Nepal	**Consultations at Korsing Jote, India**

This project will be categorised as A-Category as per ADB SPS 2009 as it involves physical displacement to 28 DHs, physical and economic displacement to 3 DHs and economic displacement to 51 DHs. The total resettlement cost for the subproject is INR 71.16 million

2.0 TRAFFIC ASSESSMENT REPORT

2.1 Introduction

Traffic surveys are an essential task to assess the likely quantum and composition of traffic over the design period on the project road. The details of various traffic surveys conducted, methodologies adopted collection of data in understandable formats and analysis, including traffic forecast has been discussed in detail in subsequent paragraphs. The proposed technical assistance project involves detailed engineering study of Mechi Bridge;

The Nepal Border to Bangladesh border corridor comprising of the Kakarvitta – Panitanki and the Panitanki land customs station (LCS); in the sub-regional context, this is part of AH-02.

2.1.1 Project Road Section

Project road start from India Nepal Border and passes through the Panitanki market area for a length of 1.3 kilometers and merges with NH 31 C at Km 15+500 of NH 31C.

2.2 Objectives of the Traffic Surveys

The main objectives of the traffic surveys are:

- To assess the volumes of traffic flows along the project road and their characteristics.
- To assess the future traffic
- To assess the international bound traffic for Nepal, Bhutan and Bangladesh.

2.3 Homogeneous Section:

Project road section from India/Nepal Border to Panitanki to Junction is considered as single homogenous sections for better understanding of traffic characteristics. The detail of project road homogenous section is given in **Table 2.1**.

Table 2.1: Homogenous Section

S. No	Homogenous Section Details	Description of Homogenous Section
1	HS 1: India/Nepal Border to Panitanki to Junction.	Start from zero chainage of India/Nepal border to Panitanki Junction at Km 1+600 on NH 31 C at Km 15+500. The total length of HS 1 is 1+300 kilometers.

Figure 1.1: Project Route Map for AH 2

2.4 TRAFFIC SURVEY LOCATIONS AND PERIOD

In order to understand the traffic characteristics and the volume of traffic using the project road, primary surveys are carried out to know the existing travel pattern. A detailed reconnaissance survey was carried out to identify the appropriate location for the mid-block traffic volume count survey. A reconnaissance of the project road indicates that majority of project road is a rural area with a mix of through and local traffic due to mixed land use (residential and commercial) along some areas of the project road. To achieve the stated objectives, the traffic surveys have been conducted at the following location mentioned in **Table 2.2**.

Three days classified traffic volume counts have been carried out on project road section. The details of each traffic survey location are given below:

Table 2.2: Classified Traffic Volume Count Survey

S. No	Description of Location	Duration	Dates of Survey
1	TVC 1 at Km 0+750 (Near Panitanki Road) (HS 1)	3 days	7th to 9th March 2013

2.5 SURVEY METHODOLOGY

Trained enumerators were used for counting traffic under the supervision of qualified and experienced traffic engineer. The vehicle classification system is prepared to capture all type of vehicles using project road. For the purpose of analysis of the data IRC 64 – 1990 was used to convert the classified traffic volume in to equivalent passenger car units (PCU). **Table 2.3 and 2.4** shows the vehicle classification and the PCU values respectively.

Table 2.3: Vehicle Classification System Adopted

S. No	Vehicle Type	S. No	Vehicle Type
Passenger Traffic Motorized		Commercial Vehicles	
1	Car/Jeep/Van	12	3 Tyre LCV
2	Taxi	13	4 Tyre LCV
3	Two Wheeler	14	6 Tyre LCV
4	Three Wheeler	15	2 Axle Truck
5	Mini Bus	16	3 Axle Truck
6	Standard Bus	17	4 Axle Truck
Passenger Non Motorized		18	5 Axle truck
7	Bicycle	19	6 Axle Truck
8	Cycle Rickshaw	20	7 or more Axle Trucks
9	Animal Drawn Carts	Agriculture Vehicles	
10	Hand Carts	21	Tractor with Trailer
11	Other Slow Moving If any	22	Tractor without Trailer

Table 2.4: Recommended PCU as per IRC: 64-1990

S. No	Type of Vehicle	PCU
	Fast Moving Vehicles	
1	Motor Cycle or Scooter	0.5
2	Passenger Car, Pick-up Van or Auto Rickshaw	1.0
3	Agriculture Tractor, Light Commercial Vehicle	1.5
4	Truck or Bus	3.0
5	Truck Trailer, Agriculture Tractor-Trailer	4.5
	Slow Moving Vehicles	
6	Cycle	0.5
7	Cycle-Rickshaw	2.0
8	Hand Cart	3.0
9	Horse Drawn Vehicle	4.0
10	Bullock Cart*	8.0

2.5.1 Traffic Characteristics

The data collected from the traffic volume count survey was coded and processed in order to analyze the results with respect to existing traffic intensity, flow pattern, hourly variation and composition of traffic on the road network under study. The various traffic characteristics have been presented in the following:

- Average Daily Traffic (ADT)
- Hourly variation and Peak Hour Percentage
- Directional distribution
- Traffic composition

- Annual Average Daily Traffic (AADT).

Each of the above is discussed in detail in the following subsections.

2.5.2 Average Daily Traffic (ADT)

The traffic volume data collected (for three days) at the survey locations were averaged out to arrive at the average daily traffic (ADT) on the project road sections. The summary of ADT in terms of vehicles and PCU is given in Table 2**.5**.

Table 2.5: Average Daily Traffic Volume (ADT) on AH 2 & AH 48

S. No	Vehicle Type	TVC 1 at Km 0+750 (Near Panitanki Road)
1	Car/Jeep/Van	1317
2	Taxi	1258
3	2- Wheeler	4547
4	3- Wheeler	325
5	Mini Bus	13
6	Std Bus	3
7	Cycle	5228
8	CRK	5375
9	AC	0
10	HC	0
11	Others	0
12	3- Tyre	176
13	4-Tyre	173
14	6-Tyre	182
15	2-Axle	104
16	3-Axle	232
17	4-Axle	177
18	5-Axle	51
19	6-Axle	2
20	7 Axle	0
21	Tractor Trailers	0
22	Tractor	2
Total Fast Vehicles		8562
Total Fast PCU		7957
Total Slow vehicles		10603
Total Slow PCU		13364
Grand Total Vehicles		19165
Grand Total PCU		21321

2.5.3 Hourly Variation and Peak Hour Percentage

The hourly variation of traffic illustrates the distribution of traffic over the day with respect to time and the peak hour percentage is the maximum percentage of the total traffic that uses the project highway in one single hour of the day. It is of significance as

highway capacities and design calculations are based on peak hour percentage. The peak hour percentages observed at all the locations are set out in **Table 2.6.**

Table 2.6: Peak Hour Percentage

Survey Location	Peak Hour (Vehicle)	Peak Hour Percentage	Observed Peak Hour
TVC 1 (HS1)	1484	7.74%	5:00-6:00 PM

2.5.4 Directional Distribution

It is an important parameter to study the traffic pattern existing on the corridor. It has been observed for the project section that the traffic is almost equal in both directions. The directional distribution ratios in terms of percentage are given in **Table 2.7.**

Table 2.7: Directional Distribution (ADT)

Count Station	Directional Distribution
TVC 1 (HS 1)	49.76% : 50.24%

2.5.5 Traffic Composition

Traffic composition has been established from the ADT for the homogeneous section for of India/Nepal border to Panitanki Junction i.e, Mechi river bridge section , it is observed more than 50% slow moving (non motorized) vehicular volume comprises of the total vehicular volume.

The vehicle composition for all vehicles is given along with the summary for passenger traffic, slow moving traffic and commercial traffic is set out in **Table 2.8**.

Table 2.8: Traffic Composition

S. No	Vehicle Type	Traffic Composition (%)
1	Car/Jeep/Van	6.82
2	Taxi	6.51
3	2- Wheeler	23.55
4	3- Wheeler	1.68
5	Mini Bus	0.07
6	Std Bus	0.02
7	Cycle	27.07
8	CRK	27.83
9	AC	0.00
10	HC	0.00
11	Others	0.00
12	3- Tyre	0.91
13	4-Tyre	0.90
14	6-Tyre	0.94
15	2-Axle	0.48
16	3-Axle	1.20
17	4-Axle	0.92

18	5-Axle	0.26
19	6-Axle	0.01
20	7 Axle	0.00
21	Tractor Trailers	0.00
22	Tractor	0.01
Total Percentage		100.00
% of Passenger Vehicles		38.97
% of Slow Moving Vehicles		55.36
% of Commercial Vehicles		5.66
% of Agriculture Vehicles		0.00

2.5.6 Annual Average Daily Traffic (AADT)

The traffic plying on any road generally varies over the different periods of the year depending on the cycle of different socio-economic activities in the regions through which it passes. Therefore, in order to have more realistic picture of the traffic on the project road, it is required to assess seasonal variation in traffic to estimate Annual Average Daily Traffic (AADT). Therefore, the ADT observed during the survey duration is multiplied by a Seasonal Correction Factor (SCF) to derive AADT. The seasonal correction factor is generally derived from secondary data.

In the present study SCF is estimated based on the fuel sales data which was collected from Indian Oil Company (IOL) for last three years for three districts namely Darjiling, Jaloaiguri and Coochbehar. From the collected fuel sales data SCF is computed for each month of the year for Motor Spirit (MS) and High Speed Diesel (HSD) separately.

As the traffic surveys were carried out during the month of March, the SCF for the same month is considered for further computations of AADT and it is in the order of 1.09 and 1.00 for MS and HSD. The SCF computations are set out in Table 2.9(a). The computed AADT is set out in Table 1.9(b).

Table-2.9(a): Fuel sales data at Indian Oil Company and SCF

Petrol and Diesel Sales in KL										
Month	**2010-11**		**2011-12**		**2012-13**		**Total Fuel Sales**		**SCF**	
	MS	**HSD**	**MS**	**HSD**	**MS**	**HSD**	**MS**	**HSD**	**MS**	**HSD**
Apr	89	535	87	513	84	372	260	1420	1.12	1.00
May	114	510	103	521	139	509	356	1540	0.82	0.92
June	97	503	92	460	111	525	300	1488	0.97	0.95
July	90	438	93	387	104	460	287	1285	1.01	1.10
Aug	88	440	51	561	108	446	247	1447	1.18	0.98
Sep	97	383	90	342	91	489	278	1214	1.05	1.17
Oct	93	411	89	343	132	488	314	1242	0.93	1.14
Nov	105	483	87	381	116	590	308	1454	0.94	0.98
Dec	104	568	93	423	102	630	299	1621	0.97	0.87
Jan	89	451	79	389	107	598	275	1438	1.06	0.99
Feb	90	462	84	420	127	570	301	1452	0.97	0.98

Petrol and Diesel Sales in KL										
Month	2010-11		2011-12		2012-13		Total Fuel Sales		SCF	
	MS	HSD	MS	HSD	MS	HSD	MS	HSD	MS	HSD
Mar	99	513	90	462	77	442	266	1417	**1.09**	**1.00**

Table 2.9(b): Average Daily Traffic Volume (AADT

S. No	Vehicle Type	TVC 1 at Km 0+750 (Near Panitanki Road)
1	Car/Jeep/Van	1436
2	Taxi	1258
3	2- Wheeler	4956
4	3- Wheeler	354
5	Mini Bus	13
6	Std Bus	3
7	Cycle	5228
8	CRK	5375
9	AC	0
10	HC	0
11	Others	0
12	3-Tyre	176
13	4-Tyre	173
14	6-Tyre	182
15	2-Axle	104
16	3-Axle	232
17	4-Axle	177
18	5-Axle	51
19	6-Axle	2
20	7 Axle	0
21	Tractor Trailers	0
22	Tractor	2
Total Fast Vehicles		9119
Total Fast PCU's		8309
Total Slow vehicles		10603
Total Slow PCU's		13364
Grand Total Vehicles		19722
Grand Total PCU's		21673

2.6 TRAFFIC GROWTH RATE ESTIMATON

Traffic growth on a road facility is generally estimated on the basis of historical trends. Demand changes are usually because of shifts in the pattern of economic activities in the surrounding regions. Hence, future traffic estimation necessitates a preview, however imprecise, of the probable pattern of future growth of the economy.

The exercise of normal traffic growth rate estimation has been carried out by the consultants using the Vehicle registration method and elasticity approach.

The total traffic that is likely to patronize to improves road facility will comprise three distinct streams via) normal traffic, ii) generated (or induced) traffic and iii) diverted traffic.

Normal Traffic: refers that stream of traffic which is currently using the project road and will continue to grow even without the proposed improvement.

Generated/Induced Traffic: connotes that stream of traffic which will get generated on account of the improved service (e.g. reduction in transport cost, reduced transit time, safe and comfortable travel, etc.,) attributes to the proposed improvements on the project road. The induced traffic is considered negligible.

Diverted Traffic: denotes that stream of traffic which will get diverted from other routes / modes of transport to the project road because of the improved transport services traceable to the proposed improvements and possible diversions from project road sections to other road network. The scope for divertible traffic has been studied and described in the diversion Analysis compartment.

Growth rates have been computed by the following three methods:

1. State Vehicle Registration Data;
2. Elasticity Method from IRC:108-1996;
3. From historical trends in Export and Import Data for last 5 years for Nepal, Bhutan and Bangladesh Countries;

2.6.1 State Vehicle Registration Data

Vehicle registration data for West Bengal State, Chhattisgarh State, Jharkhand State, Orissa State, Assam State, Arunachal Pradesh State, Manipur State, Nagaland State, Sikkim State, Bihar State and All India vehicle registration data has been collected from the "Road Transport Year Book, Govt. of India" for the years from 2004-05 to 2010-11 because the influence from these states are observed on AH 2.

2.6.2 Recommended Growth Rates

The vehicle registration data available from "Road Transport Year Book, Govt. of India" shows the negative growth from year 2004-05 to year 2010-11 in case of West Bengal. As explained earlier, the all India vehicle growth rates adjusted proportionally to the NSDP growth rates of West Bengal and all India has been used to estimate the indicative vehicle growth rates. For the traffic projection, a 5% growth rate is adopted for all motorized vehicles.

Secondly the share of slow moving vehicles (Non Motorized) for Homogenous Section 1 of project road section is 55.36%. Due to border taxes, slow moving vehicles component is more for transporting people and goods from India to Nepal and vice versa. For analysis, a minimum growth of 2% considered for slow moving vehicles till year 2020. The summary of recommended growth rates from 2013 to 2045 is given below:

Table 2.10: Summary of Recommended Growth Rates

Vehicle Type	2012-15	2016-20	2021-25	2026-30	2031-35	Beyond 2036
Car/Van/Jeep	5.00	5.00	5.00	5.00	5.00	5.00
2 Wheeler	5.00	5.00	5.00	5.00	5.00	5.00
3 Wheeler	5.00	5.00	5.00	5.00	5.00	5.00
Bus	5.00	5.00	5.00	5.00	5.00	5.00
LMV/LCV	5.00	5.00	5.00	5.00	5.00	5.00
All Trucks	5.00	5.00	5.00	5.00	5.00	5.00
Tractor Trailer	5.00	5.00	5.00	5.00	5.00	5.00

2.6.3 Traffic Projections

Traffic projections for all the homogenous sections were computed with the growth rates given in **Table 2.10**. The yearly projections summary for Vehicles and PCU for the homogenous section of project road is given in **Table 2.11.**

Table 2.11: Year wise AADT Projections (Vehicles and PCUs)

Year	Car/ Jeep /Van	Taxi	2- W	3- W	Mini Bus	Std Bus	Cycle	CRK	AC	HC	OSM	3-Tyre	4-Tyre	6-Tyre	2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	7 or more Axle	Tractor with trailers	Tractor with out trailers	Vehicles	PCU
2014	1317	1258	4547	325	13	3	5228	5375	0	0	0	176	173	182	104	232	177	51	2	0	0	2	19165	21321
2015	1383	1321	4774	341	14	3	5333	5483	0	0	0	185	182	191	109	244	186	54	2	0	0	2	19807	21990
2016	1452	1387	5013	358	15	3	5442	5593	0	0	0	194	191	201	114	256	195	57	2	0	0	2	20475	22680
2017	1525	1456	5264	376	16	3	5553	5705	0	0	0	204	201	211	120	269	205	60	2	0	0	2	21172	23402
2018	1601	1529	5527	395	17	3	5666	5819	0	0	0	214	211	222	126	282	215	63	2	0	0	2	21894	24145
2019	1681	1605	5803	415	18	3	5782	5935	0	0	0	225	222	233	132	296	226	66	2	0	0	2	22646	24917
2020	1765	1685	6093	436	19	3	5900	6054	0	0	0	236	233	245	139	311	237	69	2	0	0	2	23429	25720
2021	1853	1769	6398	458	20	3	6023	6175	0	0	0	248	245	257	146	327	249	72	2	0	0	2	24247	26556
2022	1946	1857	6718	481	21	3	6023	6175	0	0	0	260	257	270	153	343	261	76	2	0	0	2	25097	27423
2023	2043	1950	7054	505	22	3	6023	6175	0	0	0	273	270	284	161	360	274	80	2	0	0	2	25984	28327
2024	2145	2048	7407	530	23	3	6023	6175	0	0	0	287	284	298	169	378	288	84	2	0	0	2	26909	29269
2025	2252	2150	7777	557	24	3	6023	6175	0	0	0	301	298	313	177	397	302	88	2	0	0	2	27868	30239
2026	2365	2258	8166	585	25	3	6023	6175	0	0	0	316	313	329	186	417	317	92	2	0	0	2	28874	31256
2027	2483	2371	8574	614	26	3	6023	6175	0	0	0	332	329	345	195	438	333	97	2	0	0	2	29920	32313
2028	2607	2490	9003	645	27	3	6023	6175	0	0	0	349	345	362	205	460	350	102	2	0	0	2	31012	33415
2029	2737	2615	9453	677	28	3	6023	6175	0	0	0	366	362	380	215	483	368	107	2	0	0	2	32148	34558
2030	2874	2746	9926	711	29	3	6023	6175	0	0	0	384	380	399	226	507	386	112	2	0	0	2	33333	35746
2031	3018	2883	10422	747	30	3	6023	6175	0	0	0	403	399	419	237	532	405	118	2	0	0	2	34571	36985
2032	3169	3027	10943	784	32	3	6023	6175	0	0	0	423	419	440	249	559	425	124	2	0	0	2	35864	38278
2033	3327	3178	11490	823	34	3	6023	6175	0	0	0	444	440	462	261	587	446	130	2	0	0	2	37210	39620
2034	3493	3337	12065	864	36	3	6023	6175	0	0	0	466	462	485	274	616	468	137	2	0	0	2	38616	41020

2035	3668	3504	12668	907	38	3	6023	6175	0	0	0	489	485	509	288	647	491	144	2	0	0	2	40082	42479
2036	3851	3679	13301	952	40	3	6023	6175	0	0	0	513	509	534	302	679	516	151	2	0	0	2	41613	43996
2037	4044	3863	13966	1000	42	3	6023	6175	0	0	0	539	534	561	317	713	542	159	2	0	0	2	43215	45584
2038	4246	4056	14664	1050	44	3	6023	6175	0	0	0	566	561	589	333	749	569	167	2	0	0	2	44886	47238
2039	4458	4259	15397	1103	46	3	6023	6175	0	0	0	594	589	618	350	786	597	175	2	0	0	2	46628	48954
2040	4681	4472	16167	1158	48	3	6023	6175	0	0	0	624	618	649	368	825	627	184	2	0	0	2	48448	50749
2041	4915	4696	16975	1216	50	3	6023	6175	0	0	0	655	649	681	386	866	658	193	2	0	0	2	50346	52614
2042	5161	4931	17824	1277	53	3	6023	6175	0	0	0	688	681	715	405	909	691	203	2	0	0	2	52332	54567
2043	5419	5178	18715	1341	56	3	6023	6175	0	0	0	722	715	751	425	954	726	213	2	0	0	2	54404	56600
2044	5690	5437	19651	1408	59	3	6023	6175	0	0	0	758	751	789	446	1002	762	224	2	0	0	2	56570	58724
2045	5975	5709	20634	1478	62	3	6023	6175	0	0	0	796	789	828	468	1052	800	235	2	0	0	2	58831	60935

2.7 CAPACITY AUGMENTATION

2.7.1

The projected traffic is compared with the Design Service Volume (DSV) at Level of Service (LOS) -B and C (for rural roads, IRC: 64- 1990) to examine whether the facility would be able to carry the anticipated traffic or capacity augmentation would be needed. The design service volumes and capacities based on IRC 64-1990 are shown in **Table 2.12**.

Table 2.12 Design Service Volume (PCU/day)

As per IRC: 64 –1990 (based on 8-10 % PHF)			
Terrain	**Lane Configuration**	**Design Service Volume (LOS B)**	**Design Service Volume (LOS C)**
Plain Terrain with Low Curvature.	2 Lane with earthen shoulder	15,000	22,500
	2 Lane with 1.5m paved shoulder	17,250	25,875
	4 Lane with 1.5m paved shoulder.	40,000	60,000

Based on the above design service volume for LOS B and LOS C the capacity augmentation till 2045 is established and is given in **Table 2.13**.

Table 2.13 Design Service Volume (PCU/day)

Homogenous Section	Two lane with Earthen shoulder		Two Lane with Paved Shoulder		Four Lane with Paved Shoulder	
	LOS B	LOS C	LOS B	LOS C	LOS B	LOS C
Project Road Section on AH 2						
HS 1	AA	2015	AA	2020	2033	2044

AA: Already Achieved & NA: Not Achieving

At present project road section i.e., India/Nepal Border to Panitanki to Junction has two lane carriageway configuration, further four lane facility has been recommended if the design service volume of LOS "C" for two lane paved shoulder achieved with in 15 years period from year 2015.

From the above warrants, the project road section under study for warrants four lane carriageway in the year 2020 and six lane carriageway between 2033 and 2044. Hence it is recommended for upgradation of existing bridge to 6-Lane configuration on Mechi River.

3.0 DESIGN OF STRUCTURES

3.1 General:

As mentioned in the Chapter 1, the proposals are carried out by the Consultants for the approved Alignment Option V by NHIDCL.

Features of the Option V:

A six lane major bridge is proposed connecting Nepal side border to Indian side border and further to Kakarvitta on Nepal side and Panitanki bypass of Asian Highway AH 02 on Indian side.

Bridge Deck Configuration:

The 6 lane Major Bridge having a total length of 675m consists of 3 Span Continuous Precast PSC Segmental Box Superstructure having a deck width of 24.2m.Fishbelley type superstructure is proposed keeping in view of importance & aesthetics of the structure..

The span arrangements for the 3 Span Continuous modules are 5 units of 3 x 45m.

One Light Vehicular Underpass (1x12.0x3.5) having Box Type structure has been proposed near the abutment A1 in the approach on Nepal for the free movement of slow moving vehicles.

Substructure and Foundation:

Circular piers are proposed considering the possible direction of flow of water and from aesthetics point of view resting on pile foundation.

3.2 Design Basis and Standards for Roads

General

Establishment of uniform design standards is essential to avoid any inconsistency in design from one section to the other and to provide the desired level of service and safety. For this project it is proposed to follow the latest Design Standards specified by the Indian Road Congress, and the Technical Circulars issued by the Ministry of Road Transport and Highways from time to time.

Horizontal Geometry:

The geometry of the Project Highway is designed for the approved alignment option V which is connecting proposed ROB and Proposed Bridge over Mechi river.

Ruling Design Speed: 80Kmph

Sight Distance: 90m

Stopping sight distance has been adopted for the design of Geometry.

Vertical Profile:

Gradients: A minimum gradient of 0.3% and maximum vertical gradient of 3.0% has been adopted

Vertical Curves: For Summit curves a K – Value1 8.4, and sag curves K – value 17.4, minimum length of vertical curve shall be 40.0m.

Cross camber: 2.5%

Super elevation is limited to 5.0%

Width of the Carriageway Elements:

Main Carriageway: 3.5m each lane with a kerb shyness of 0.25m

Four Lane road: 7.0m

Paved Shoulder: 2.0m

Service Road: 5.5m

Footpath: 2.0m

Traffic Safety Features, Road Furniture, Road Markings and Other Facilities

For safety and operational reasons it will be necessary to provide suitable safety features, road furniture and other facilities along the project road. These features will include safety barriers, road signs, road markings, road lighting, road delineators, and landscaping. Where possible these features will be provided in accordance with relevant IRC or other standards, as detailed below. If no IRC Codes or the MORTH Specifications are available, international standards such as BIS /AASHTO/ ASTM /British Standards will be used in detail design.

Road Signs - The colour, configuration, size and location of road signs shall be in accordance with IRC: 67-2001.

Road Markings - Road markings shall be as per IRC: 35-1997. These markings shall be applied to road centre lines, edge line, continuity line, stop lines, give-way lines, diagonal/chevron markings, and zebra crossing areas by means of an approved self-propelled machine which has a satisfactory cut-off value capable of applying broken

lines automatically. The approach noses of the traffic islands will be marked for additional guidance of traffic by means of diagonal markings and chevrons.

Overhead Signs - Standards prescribed by MOSRTH and IRC: SP-35 shall be followed for overhead signs.

Road Delineators – The design and location for road delineators shall be as per IRC: 79-1981.

Strengthening of existing pavement:

Strengthening of existing pavement shall be done in accordance with IRC: 81-1997. Before laying the overlays, profile corrective course shall be carried out with DBM/BM/WMM as the case may be based on detailed vertical design.

Roadside Drainage:

An effective drainage system shall be planned for the drainage of roadway as per stipulations or IRC SP: 42-1994 and IRC SP: 50-1999 for maintaining structural soundness and functionality of the project road. The following types of drains shall be provided for surface drainage of roadway:

Covered RCC drains are proposed at the outer edge road in urban area.

Specifications:

The General Technical Specifications shall be as per MORTH Specifications for Road and Bridge works (Fifth Revision) issued by the Ministry of Road Transport and Highways, Govt. of India and published by the Indian Roads Congress along with its updating/amendments/ addendum issued from time to time

3.3 Design Basis for Structures

Codes and References:

The design of various components of the structure, in general are based on provisions of IRC/IS Codes. The list of IRC Codes (latest revisions) given below will serve as a guide for the design of structures.

IRC: 5-1998	Standard Specifications and Code of Practice for Road Bridges Section-I – General features of Design
IRC: 6-2014	Standard Specifications and Code of Practice for Road Bridges Section-II – Loads and Stresses

IRC: 22-2008	Standard Specifications and Code of Practice for Road Bridges, Section-VI – Composite Construction
IRC: 78-2014	Standard Specifications and Code of Practice for Road Bridges, Section-VII – Foundation & Substructure.
IRC: 83-1987 (PII)	Standard Specifications and Code of Practice for Road Bridges, Section-IX – Bearings- Part II: Elastomeric Bearings.
IRC: 83-2002 (PIII)	Standard Specifications and Code of Practice for Road Bridges, Section-IX –Bearings-Part III: POT, POT-cum-PTPE and Metallic guide Bearings.
IRC: 112-2011	Code of Practice for Concrete Road Bridges.
IRC: SP: 13-2004	Guidelines for Design of Minor Bridges & Culverts.
IRC: SP: 80-2008	Guidelines for Corrosion Prevention, Monitoring and Remedial Measures for Concrete Bridge Structures.
IRC: SP: 84-2014	Manual of Specifications and Standards for Four Laning of Highways through Public Private Partnership
IS: 2911:2010 (Part I Sec-2)	Code of Practice for Design and Construction of Pile Foundations: Concrete Pile - Bored Cast-in-Situ
IS: 2911 PIV	Code of Practice for Design and Construction of Pile Foundations: Load test on Piles.

Wherever IRC code is silent, following standards will be followed.

(i) American Association of State Highway and Transport Officials (AAHSTO) Standards

(ii) British Standards

(iii) Any other National or International Standard as considered suitable.

3.3.1 Loadings

3.3.1.1Dead Load (DL):

Unit weight of dead loads calculation shall be considered as per IRC: 6 as below.

Materials	:	Unit weight
Plain Concrete	:	25 KN/m3

Reinforced Concrete &

Pre-stressed Concrete: 25 KN/m3

Wearing Coat : 22 KN/m3

Structural Steel : 78.5 KN/m3

3.3.1.2Super Imposed Dead Load (SIDL):

Unit weight of superimposed dead load shall be in conformity with IRC: 6.

The crash Barrier will be designed as per table 3 of IRC: 6 under P-1 "Normal Containment" category. The crash barrier shall be provided as per IRC: 5.

3.3.1.3Live Load (Carriageway (CWLL) + Footpath (FPLL)):

The CWLL load combination shall be for 6 lane loading as per Table 2 of IRC: whichever is producing critical effects shall be considered in design. Reduction in Longitudinal effect for three lane loading shall be considered as per clause 211 of IRC: 6

3.3.2 Braking and Centrifugal Force:

Breaking and centrifugal forces are to be considered as per codal provisions mentioned in Cl. 211 & 212 of IRC: 6.

3.3.3 Temperature Forces (Temperature Gradient):

Temperature forces considered for calculation of bearing movement and for the design of expansion joint shall be as per clause 215 of IRC: 6.The design is based on the range of effective bridge temperature at the site location of the structure. The temperature gradient considered for stress calculations of all structure members are as per the clause 215.3 of IRC: 6.

Minimum temperature = 0° C

Maximum temperature = 40° C

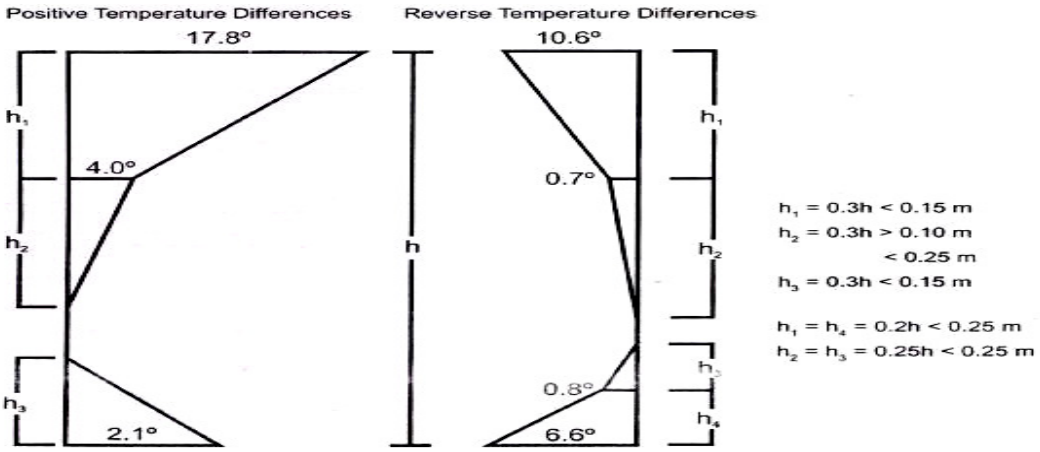
Mean temperature = (0 + 40) / 2

= 20°

Mean temperature $+10^0$C or -10^0C shall be considered as the Bridge temperature when the structure is effectively restrained.

Temperature increase/ Decrease = 40- (20 - 10) = 30° C

Coefficient of Thermal expansion = 12 x 10-6 /° C (Cl. 215.4 IRC 6)



For the calculation of shrinkage effect, the shrinkage strain of 2 x 10-4 has been converted into equivalent temperature fall as shown below:

Total temperature fall due to shrinkage = 2 x 10-4 / 117 x 10-7 = 17/° C

While considering the forces due to these strains, young's modulus of elasticity of concrete can be reduced to 50% of the original value to consider the long term effect.

3.3.4 Wind Forces:

Wind Forces shall be considered as per clause 209 of IRC: 6. Drag Coefficient, Gust factor and Lift Coefficient shall be calculated as per the above clauses.

3.3.5 Water Current Forces:

Water Current Forces shall be considered as per Clause 210 of IRC: 6.Thepier and abutment of the structures shall be designed for a variation of 20 deg with respect to orientation of pier depending upon the location of abutment / pier.

3.3.6 Buoyancy:

Buoyancy shall be considered as per Clause 213 of IRC: 6 in the design of submerged components of structures, the buoyancy effect through pore pressure shall be limited to 15% of full buoyancy.

3.3.7 Earth Pressure:

Active pressure due to filling behind the retaining / abutment shall be evaluated by Coulomb's formula.

The Coefficient of active pressure (horizontal):

$$Ka = \frac{\sin^2(\alpha+\phi)\cos\delta}{\sin^2\alpha \sin(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi+\beta)}{\sin(\alpha-\delta)\sin(\alpha+\beta)}}\right]^2}$$

Following soil properties for filling behind abutment and between return walls shall be considered in the design.

i) Angle of Internal friction (□) : 30°

ii) Angle of Wall friction (□) : 20°

iii) Angle of cohesion, c : 0

iv) Dry density of backfill material : 2.0 T/m^3

The value for coefficient of active earth pressure, Kais calculated using the above formula and design parameters, case by case..

Surcharge live load, equivalent to 1.2m of earth fill shall be considered in the design.

3.3.8 Seismic Forces:

The project stretch falls under Seismic Zone IV as per clause 219 of IRC: 6. The seismic coefficient is calculated considering the Importance factor (I) of 1.5 as there is no alternative alignment is available except the existing bridge. Seismic reduction factor (R) is considered as 3 for Piers / Columns with POT bearings / STU for the design of substructure & foundation. Seismic reduction factor shall be 1.0 for bearings.

3.3.9 Partial Safety Factors for various limit state:

Partial safety factor of 1.5 has been adopted for Concrete and 1.15 has been adopted for steel as per clauses 6.4.2.8 & 6.3.5 of IRC: 112 respectively.

Rectangular stress distribution has been considered for concrete as per Annexure A-2 of IRC: 112.

The partial safety factor for loads for different limit states has been adopted, as given in IRC:6, shall be as per

Table 3.1 for the verification of equilibrium

Table 3.2 for checking the structural strength

Table 3.3 for verification of serviceability

Table 3.4 for base pressure & design of foundation

3.3.10 Ultimate Limit State of Shear, Punching Shear and Torsion:

Ultimate Limit State of Shear, Punching Shear and Torsion shall be checked as per section of 10 of IRC: 112.

3.3.11 Serviceability of Limit State

Serviceability of Limit states of Stress levels, Crack width and deflection shall be carried out as per section of 12 of IRC: 112.

3.3.12 Features of Proposed Superstructure Type

Type of Superstructure:

Precast PSC Segmental Box Continuous Superstructure with spans of 3x45mis proposed for the 6 lane bridge.

Type of Substructure:

The substructure is proposed with RCC circular having cantilever cap for pier and cap with dirt wall for full abutment.

Type of Foundation:

Considering the site condition and the type of soil, pile foundations are proposed.

3.3.13 Bridge Deck Width

The cross section of 6-lane bridge is 24.2 having 11.0m for each carriageway with 0.5m crash barrier at outer ends and 1.2m central median.

3.3.14 Drainage Requirements

Suitably designed drainage arrangement shall be provided for Flyover consists of rigid PVC pipes connecting down spouts below the deck with funnels and along the pier up to ground level and eventually joined to the road drainage system.

All carriageways and footpath surfaces shall have anti-skid characteristics.

3.4 Design of Bridge

3.4.1 Analysis for Superstructure with 3 Span Continuous Precast PSC Box Girder for Bridge

Grillage Analysis: The 3 span continuous PSC segmental Box Superstructure is analyzed as a two dimensional grillage for the geometry by applying calculated grillage properties. Analysis is carried out for static as well as moving loads.

The analysis is carried out using Grillage model on MIDAS software.

3.4.2 Pre-stressing details for Precast PSC Box Superstructure

Maximum pre-stressing force, the losses in pre-stressing force and Partial factors for pre-stressing shall be as per Clause7.9 of IRC: 112.

Design parameters

- It is proposed to use 19K13 cables conforming to Class2 of IS: 14268 (Low relaxation strands) with Steel duct sheathing for pre-stressing (VSL Pre-stressing systems).
- Values of friction and wobble coefficient (μ and k) for pre-stressing strands shall be considered asμ=0.18 and k=0.006. (Ref Table 7.1 of IRC: 112).
- Relaxation losses shall be computed as per Clause 6.3.6 of IRC: 112.
- Ultimate resistance of the Girder in flexure shall be checked against yielding of steel and against crushing of concrete.
- Duct diameter shall be 97mm as per the number of strands in cable. Clear cover protecting cable from the nearest concrete surface is kept as 75mm as per Clause 14.3.2 of IRC: 112.

3.4.3 Proposed Sequence of Construction of PSC Segmental Box Superstructure for Bridge:

Stage I: Substructure and Foundation Construction

- The pile foundations including piles and pile cap are to be cast for the abutment and piers.
- Cast the abutment and pier up to top bearing shelf
- Cast the bearing plinth at top of piers/abutments

Stage II: Assemble Gantry at Abutment

- Erect Gantry props and install tie-downs.
- Assemble Gantry in position for erection of first span
- Install bearings on first span

Stage III: Segment delivery and installation

- Segments for first span are delivered having reached 28 days age

- Starting at abutment, segments are successively lifted and placed on gantry

Stage IV: Segment alignment and Gluing

- Install hand rails
- Field segments are successively aligned and levelled.
- Epoxy glue is successively applied at joint and temporary PT bars are stressed
- Once all filed segments are aligned Pier / EJ segments are aligned and levelled

Stage V: Cast stitches

- Temporary fixity is installed to maintain alignment segments
- Stitch formwork is installed at each end of the span
- Stitches are cast in-situ
- After concrete has reached 15 MPa cube strength, form work is stripped

Stage VI: Install tendons and load transfer

- Temporary fixity is installed to maintain alignment segments
- Stitch formwork is installed at each end of the span

Stage VII: Launch gantry to next span

- Gantry props have been erected at next pier
- Gantry is launched forward into position for erecting next span

Stage VIII: Launch gantry to next span

- Segment for next span are delivered having reached 28-day age
- Starting to the end. segment are successively lifted and placed on gantry

Stage IX: Segment alignment and gluing

- Install handrails
- Field segments are successively aligned and levelled
- Epoxy glue is successively applied at joint and temporary PT bars are stressed
- Once all field segments are aligned Pier/EJ segments are aligned and

levelled

Stage X: Cast stitches

- Temporary fixity is installed to maintain alignment of segments each of stitches
- Stitch formwork is installed at each end of the span
- Stitches are cast-in-situ
- After concrete has reached specific strength. Formwork is stripped

Stage XI: Install tendons and load transfer

- Next stage of tendons is installed and stressed in accordance with PT schedule
- Segment support jacks on gantry are linked such that, as the tendons are stressed, the jack loads are kept constant
- Gantry is lowered in order to load transfer deck onto permanent bearings

Stage XII: Stages 8 to 12 are repeated for successive internal spans

- Tendon duct grouting and anchorage protection measures may proceed
- Parapet erection can commence after each module is completed

Stage XIII: Launch gantry to final span

- Gantry props have been erected at common pier / abutment pier
- Gantry is launched forward into position for erecting final span

Stage XIV: Segment delivered and installation

- Segments for end span are delivered. Having reached 28-day age
- Starting at one end. Segments are successively lifted and placed on gantry

Stage XV: Segment alignment and gluing

- Install handrails
- Field segments are successively aligned and levelled
- Epoxy glue is successively applied at joint and temporary pt bars are stressed
- Once all field segments are aligned pier/EJ segments are aligned and levelled

Stage XVI: Cast stitches

- Temporary fixity is installed to maintain alignment of segments each of stitches
- Stitch formwork is installed at each end of the span
- Stitches are cast in-situ
- After concrete has reached specific strength. Formwork is stripped

Stage XVII: Install tendons and load transfer

- Next stage of tendons is installed and stressed in accordance with PT schedule
- Segment support jacks on gantry are linked such that, as the tendons are stressed, the jack loads are kept constant
- Gantry is lowered in order to load transfer deck onto permanent bearings

Stage XVIII: Completion of pt works

- All remaining internal tendons are installed and stressed
- All tendons ducts are grouted
- All exposed anchorages are protected with specific systems

Stage XIX: Final works

- Parapet is constructed up to abutment (handrails are progressively removed to allow parapet construction)
- Abutment walls are cast
- Expansion joint installed
- Approach embankment and approach slabs completed
- Road surfacing laid

3.4.4 Substructure and Retaining Walls

The pier has been designed for the vertical forces transferring from superstructure and for the biaxial moments developed in both longitudinal and transverse directions due to braking, LL eccentricity, seismic and other horizontal forces.

The abutment and pier is checked for both cracked and un-cracked condition and designed as per section 8 of IRC: 112.

Pedestals are provided under each of the girder. The pier cap is checked for bending and shears arising from vertical forces acting on bearings and torsion due to unbalanced vertical loads on bearings.

The RE retaining walls are proposed wherever required in between service road and adjacent property..

3.4.5 Foundation

Pile foundation is proposed considering the scour and type of strata encountered. Bored cast-in-situ piles are adopted.

Design of pile foundation shall be as per IRC: 112 &IS: 2911 (Part 1). Pile cap is designed as per bending theory. Unsupported length of pile and Length of fixity is calculated as per soil properties. Temporary liner is proposed up to the required depth as per the site conditions.

3.5 Bridge Appurtenances

3.5.1 Drainage Spouts

Drainage Spouts shall be placed not greater than 5m centre to centre. Down-take pipes will be provided up to ground level to dispose the water below soffit of the superstructure.

3.5.2 Seismic Transmission Units, Bearings & Seismic Stoppers:

The design loads for POT/PTFE bearings are calculated as per the guidelines of IRC: 83 (Part III). Seismic Transmission Units are proposed to share the total horizontal force developed during seismic to take equally by the 3 piers because of 3 span continuous superstructure module.

Seismic stoppers are provided in both longitudinal and transverse direction to prevent the dislodgement of superstructure as per the codal provisions for Zone IV.

The horizontal forces due to bearings shall be calculated as per Clause 211 of IRC: 6.

3.5.3 Expansion Joints

Strip seal type of expansion joint is proposed for Major Bridge and Modular type Strip seal expansion joint is proposed for Flyover.

3.5.4 Wearing Course

65mm thick wearing course is proposed consisting of 40mm thick bituminous concrete laid over 25mm thick mastic asphalt.

3.5.5 Durability

Durability of structure depends on the materials used, mix proportions, workmanship achieved, design and detailing including minimum cover to steel. From durability consideration for 100 years of service life, the water cement ratio and maximum cement content shall be as per Table 14.2 of IRC: 112.The grade of concrete, steel and cover to reinforcement to be adopted are given below:

3.5.6 Materials Used:

Concrete:

(a)	PCC Levelling course	:	M15
(b)	PCC members	:	M15
(c)	RCC Pile	:	M40
(d)	RCC Pile Cap	:	M40
(e)	RCC Pier & Abutment	:	M40
(f)	RCC Pedestal	:	M40
(g)	PSC Superstructure (Segmental)	:	M55
(h)	RCC Retaining wall	:	M30
(i)	RCC Approach Slab	:	M30
(j)	RCC Crash Barrier	:	M40

Reinforcement (un-tensioned Steel as per Code IS: 1786):

Grade of HYSD bars shall be Fe 500D & Modulus of elasticity 2.0 X 105Mpa.

3.5.7 Cover

The minimum cover to reinforcement shall be determined from the recommendations of IRC: 112 table 14.2 taking into account the moderate / severe environmental conditions depending upon the location of roads.

3.6 Designs& Drawings

The Following Designs and Drawings are submitting as a separate volume:

1. PSC Segmental Box Superstructure of Major Bridge
2. Fixed/Free/Common Piers & Abutments
3. POT / PTFE Bearings

The detailed designs and drawings of Abutment, Pier and Superstructure for Major Bridge across river Mechi and Box Type Vehicular Underpass are submitting in Volume II.

4.0 HYDROLOGY AND HYDROLOGICAL INVESTIGATION

4.1 General:

Mechi Bridge is an important link connecting India and Nepal, serving immensely, both the countries in trans-border trade, Industrial, social and cultural exchange and development in the region. The existing bridge connecting Nepal to India is located at about 400m from Kakarvitta junction in Nepal, towards India side; connecting Panitanki in India.

Existing Mechi Bridge consists of 20 spans of each 29.3m, with cast-in-place, concrete T-girder and slab superstructure, resting on solid wall type concrete substructures and well foundations. The bridge is built in the early1970 s and is about 45 years old now.

4.2 General Hydrology and Physiography

Mechi is a typical Himalayan river. The project road, AH-2, crosses the river in its sub-mountainous reach. This reach is known as the Duars and the Terai region which is relatively flat with respect to the immediate upper reach of Mechi and the river is characterized by its braided and interlaced system of independent channels/ branches. These braided channels are meandering between relatively large khadir of the Mechi River. The courses of the braided channels are unstable, i.e., during one season some of the channels remain almost dead but in the next season can get active and vice versa. The channels are separated by the shallow sandy beach which is in fact bed of the Mechi itself. At the end of the Khadir, there are banks which on the upstream side of the existing bridge are stabilized by the high bund roads, both on India and Nepal side. The downstream Indian side has natural high bank with a significant deep gorge, hugging on the India side with a large bend. But on the Nepal side, it is quite undefined on the downstream. The braided channels generally carry perennial flow. Three distinct such braided channels are found in active stage on the upstream side, during investigation, with mean width of flow of 10 to 15 m concentrated drainage path meandering between the khadir. As these channels meander, unpredictably. Each of these channels has the potential of getting ferocious and can also combine with the other few, during peak flow. Each of these has high velocity. So, it is best to avoid obstructing these or blocking partially, which may result in many consequences, like deep scouring and even outflanking. The existing is also bank to bank. So, the waterway has to be liberal and recommended to bridge the entire khadir, i.e. high bank to high bank. These streams join together at little downstream of the existing bridge and the combined flow found to

be quite mighty with high current, not less than 2.0 to 2.5m/sec even during ordinary flow situation.

The river has a sharp bend at existing bridge location and further downstream. As it hugs India side bank, deep erosion and high natural bank is found all along the sharp bend downstream. The bank is protected by series of spurs which are in fair to good condition and found to be serving well and can be retained with minor repair.

During high flood which is never more than 2.0m from the low bed, as per the local information collected from the senior and informed citizen. During high flood the river flow widens to almost bank to bank. The rest of the year the flow of Mechi remains divided and restricted within the shallow braided channels. The flash floods are characterized by high velocity and contribute to deep erosion on the concave side of the bank and silting on Nepal side.

Each of these channels is potential of getting ferocious and can also combine with the other few, during peak flow. So, it is best to avoid tampering with these or blocking partially, which may result in many consequences, like deep scouring and even outflanking.

4.3 Design Discharge

Mechi is extremely important trans international border 4-lane bridge on AH-2. Therefore, flood frequency of 100 years minimum is adopted for design. Comparing discharges obtained from various methods the maximum discharge is obtained by SUH method. The value of this discharge is 1835 cumec. Since no topo-sheet is available, may be due to Survey of India's restrictive policy in and around international boundary. Also, no data of the catchment from the utility Department or CWC could be made available, even after best efforts of the Consultants. Therefore, extra 33.33% discharge is further considered necessary, looking at into the importance of the crossing. Therefore the Design Discharge = 1835*1.33 = 2440 cumec, **say 2500 cumec**.

The detailed hydraulics and hydrological report is given in Volume III.

5.0 GEOTECH INVESTIGATIONS AND DESIGN

5.1 General:

The knowledge of subsoil conditions at a site is prerequisite for a safe and economical design of substructure elements. The field and laboratory studies are carried out for obtaining the necessary information about the subsoil characteristics including the position of ground water table.

A comprehensive geotechnical investigation was planned and executed in the form of deep boreholes for the proposed major bridge in order to obtain information on stratigraphy and physical properties of the soils at site including ground water table at the proposed structure locations.

Rotary boring was adopted as this method is suitable to drill through both cohesive (Clayey) and cohesion-less strata. In this method the drilling is effected by the cutting action of a rotating bit which is kept in firm contact with the bottom of the hole. The bit is attached to the lower end of a hollow drill rod which is rotated by a suitable chuck. Drilling mud which is Bentonite solution, occasionally with some admixtures, is continuously forced down the hollow drill rods. The mud returning upwards through the annular space between the drill rod and the side of the borehole brings the cuttings to the surface. During the process of drilling, field tests (Standard Penetration Test, SPT) were carried out and disturbed and undisturbed samples are collected for conducting laboratory tests and records of field tests were maintained. A detailed methodology of geotechnical investigations undertaken for the proposed major bridge is included in Volume IV: Geotechnical Report.

For most of the structures it is the earth that provides the ultimate support. The behavior of the supporting ground must therefore affect stability of the structures and approach embankment / retaining structures. Structural foundations should transmit the structural loads to the earth in such a manner that the supporting soil is not overstressed and does not undergo deformations that would cause unacceptable settlement of the structure. Hence the engineering characteristics of the supporting soil must be evaluated which affects vitally the choice of the type of structural foundations suitable for a structure.

Detailed methodology adopted for conducting the Geotechnical and Subsoil Investigations are presented Volume IV. Detailed Geotechnical Investigations for the proposed structures is completed through deep boreholes of 150/100mm diameter at planned locations according to the TOR.

Based on the results of geotechnical investigation (both field and laboratory test data), a comprehensive assessment of the shear strength parameters and compressibility characteristics of the founding strata have been carried out to recommend for suitable and economical type of foundation and its load carrying capacity in accordance with the proposed structures. While recommending the foundation level for pile foundation due consideration of the local hydraulic condition has been be taken and accordingly the recommendations are made

Geotechnical investigations were carried out as per the guidelines of IRC: 78-2014 "Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure". The bore holes are conducted at each of the support for the major bridge as per the codal provisions.

The detailed geotechnical investigations are presented in Volume IV.

6.0 RATE ANALYSIS & COST ESTIMATES

6.1 Rate Analysis

6.1.1 General

The cost estimates for the project are extremely important as its entire viability and implementation depends on the project cost. Therefore, cost estimates and rate analysis of the items have been carried out with due care. The project cost estimates have been prepared considering the various items of works and based on the rates calculated as per Standard Data Book for analysis of rates (MoRTH), Schedule of Rates (SOR), Government of West Bengal, PWD Department, 2015-2016 and PWD Schedule of Rates (SOR), 2015-2016.

6.1.2 Material Rates, Lead Charges, Machinery and Hire Charges

The material rates adopted were based on the rates given in Schedule of rates for PWD, Department West Bengal, 2015-2016. Where rates are not available in the SOR, market rates have been incorporated.

The average lead for different construction materials is worked out based on the sources of materials. The lead rates (transportation) are based on the schedule of rates of PWD, Department year 2015-2016 are adopted.

The machinery rates are adopted based on the rates given in Standard Data book of MoRTH 2003 (Base year 2001-2002) and are updated to current year 2015-16 by increasing 5% escalation every year.

6.1.3 Cintinegencies and Price Escalation Charges

The project cost estimate is based on 2015-2016 rates. To the base project cost thus estimated, physical contingencies at 2.8%, Agency and Supervision charges at 3%, Quality & Road Safety Charges at 0.25%, Maintenance Charges during construction 3.5% and price contingency at 5% per annum assuming 2years construction period is added.

6.1.4 Labour and Welfare Cess

Labour Welfare Cess @ 1% is considered to the estimated Project Cost.

6.2 Cost Estimates

The cost estimates for the project are extremely important as its entire viability and implementation depends on the project cost. Therefore, cost estimates and rate analysis of the items have been carried out with due care. The project cost estimates

have been prepared considering the various items of works and based on the rates calculated as per Standard Data Book for analysis of rates (MoRTH), Schedule of Rates (SOR), Government of West Bengal, PWD Department, 2015-2016 and PWD Schedule of Rates (SOR), 2015-2016.

6.3 Computation of Quantities

The quantities of major items of work for the Project road have been estimated on the basis of geometric design, pavement designs and structural designs presented in the drawings volume of the Project Report.

The quantities of the following major items of works are included in the estimate separately.

- General Items
- Site Clearance
- Earth Works
- Granular Sub-base and Base Courses
- Bituminous Courses
- Major Bridge, Underpasses, RE Wall and Retaining Walls etc.
- Drainage and Protective Works
- Traffic Signs, Marking & Appurtenances
- Land Acquisition
- Relocation of Utilities
- Resettlement and Rehabilitation and Social Costs
- Environmental Impact Mitigation and Monitoring on the project cost. Therefore, cost estimates and rate

6.2.2 Computation of Quantities

The quantities of major items of work for the Project road have been estimated on the basis of geometric design, pavement designs and structural designs presented in the drawings volume of the Project Report.

6.3.1 Site Clearance

Site clearance quantity is estimated, as overall area required for construction of road. It includes the dismantling of existing pavement courses, drains if any required, kilometer and hectometer stones, road signs, crash barriers, necessary excavation, back filling, grubbing and disposal of cleared material etc., and reuse/re-fixing of usable material.

6.3.2 Earth Works

Earthwork quantities are calculated using the "MX Roads" software package. As the cross sections are uniform throughout the project road, common strings have been developed for the entire stretch. The positions of service/Slip roads are also taken into account. The earthwork is calculated based on the amount of cut or fill with respect to the datum line defined in the template and the existing ground profile, which in turn is obtained from the DTM surface developed by the software. Care has been taken for estimating additional earthwork quantities required at the approaches of bridges and for back filling around abutments and the same has been incorporated in roadwork items.

6.3.3 Pavement Material (Flexible)

The pavement work includes construction of proposed carriageway. The flexible pavement includes Bituminous Concrete (BC), Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM), Granular Sub-base (GSB), and other related items like prime coat and tack coat etc. over road formation. The quantities of bituminous course are calculated for full width of carriage way.

6.3.4 Major Bridge and Underpass

The construction of bridge and underpass are assessed and the earthwork, pavement and shoulders for bridge approaches have been included as appropriate roadwork items. The other items like RCC and PCC work of Underpass and bridges are calculated as per design and drawings.

6.3.5 Drainage and Protective Works

Drainage and protective works include roadside drains and the protection works for the bridge foundation. RE walls are proposed on either side of main carriageway and outer edge of service road to retain the soil / embankment.

6.3.6 Truck Lay Byes

The quantities for Track lay-byes have been calculated based on the Design drawings provided in the Drawing Volume. No building construction work has been taken in the report.

6.3.7 Traffic Signs, Marking & Appurtenances

Provisions for road safety measures i.e., road signs, markings, street lighting, road appurtenance have been made. Turfing on embankment, earthen shoulder and hedges in median and roadside plantation and landscaping have been considered on the basis of traffic and other requirements.

6.3.8 Land Acquisition, Resettlement and Rehabilitation and Social Costs

Based on alignment design, land and structure acquisition cost including rehabilitation and resettlement costs are being assessed by the social team and will be presented in the separate volume on Social Impact Assessment Report.

6.3.9 Relocation of Utilities

Relocation of Utilities like Electric lines, Telephone lines, OFC etc within the proposed ROW have been estimated for costing purpose. The concerned Administrative Departments have been requested to give the detailed cost estimates dully approved / sanctioned by the competent authority. This will be included in the final submission.

6.3.10 Environmental Improvement Works

The cost of environmental improvements works including the cost of tree cutting is included in the civil works and tree planting and monitoring cost is given separately under EMP cost in the project cost estimate.

The detailed Rate Analysis, BOQ and Cost Estimates are presented in Volume VI.