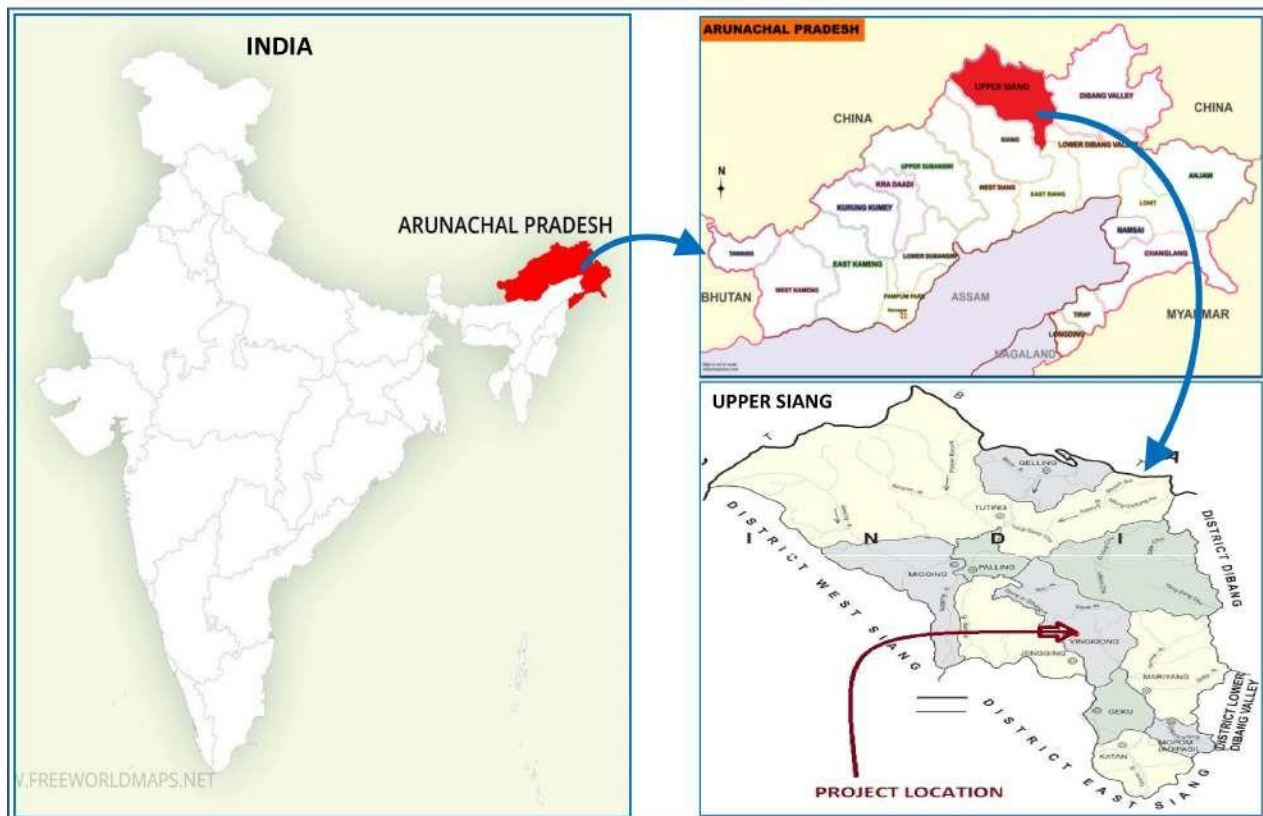




# Border Roads Organisation

Ministry of Defence  
Government of India

**Name Of Project:-** Consultancy Services for Feasibility Study, Preparation of Detailed Project Report (DPR) and Providing Preconstruction Services (including Selection of Site, Type of bridge, Sub Soil Investigation, Estimation, Preparation of Tender documents etc.) (Indicative length of Bridge-300 mtr & Approach Road -4.50 Kms) over Siang River at Km 93.50 on Ditte-Dimme-Migging Road under 761 BRTF of Project Brahmark in Arunachal Pradesh State



## DETAILED PROJECT REPORT (PKG-I:BRIDGES) SEPTEMBER 2022

DOCUMENT NO : VKSIMPL-BRO-P134-AR

TITLE : VOLUME I MAIN REPORT (PKG-I:BRIDGES)



**VKS Infratech Management Pvt. Ltd.**

**Consulting Engineers Planners & Managers**

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## ANNEXURES:

1. Hydraulic Calculation
2. Inventory & condition survey of Bridges

**Rev:** R4 (BRO Letter no. 24087/DGBR/BMK/DDM Rd/28/EPC Cell dated 26.08.2022)

**Date:** 09.09.2022



# 1 EXECUTIVE SUMMARY

## 1.1 GENERAL

Border Roads Organisation has assigned the work “*Consultancy Services for Feasibility Study, Preparation of Detailed Project Report (DPR) and Providing Preconstruction Services (including Selection of Site, Type of bridge, Sub Soil Investigation, Estimation, Preparation of Tender documents etc.) (Indicative length of Bridge-300 metres & Approach Road -4.50 Kms) over Siang River at Km 93.50 on Ditte-Dimme-Migging Road under 761 BRTF of Project Brahmark in Arunachal Pradesh State*” to VKS Infratech Management Pvt. Ltd.

The Project corridor is a 300m long road bridge with approach road length of approximately 4.5 km.

The Project has been divided in two packages as directed by BRO vide letter no. 8140/BMK/EPC/02/2021-22//102/E8 dt. 12<sup>th</sup> May 2022, as under;

- a) Package-I: Extradosed Bridge at Km 2.908 over river Siang and Major Bridge at km 2.590 in place of existing Bailey Bridge (Bridges proper only excluding approaches) under EPC Mode.
- b) Package-II: All approach road works including culverts, Breast wall/Retaining wall, LA utility shifting etc. but excluding above two bridges.

This report only applies to package-I.

The report includes a review of previous studies, primary Surveys and Investigations completed and historic planning background information relevant to the provision of a new Bridges. The key findings of these studies are summarised in the report.

## 1.2 BACKGROUND

The existing Gandhi Bridge across Siang River at Yingkiong imposes height and width restrictions for freight and transport due to an existing width and loading restricted bridge spanning across Siang River used for communications. The load and width restrictions are considered a major limitation on this stretch of the road network for the passage of oversize freight and Defence force equipment.

Realizing this need, Border Roads Organization have commissioned this Project and assigned the work “Consultancy Services for Feasibility Study, Preparation of Detailed Project Report (DPR) and Providing Preconstruction Services (including Selection of Site, Type of bridge, Sub Soil Investigation, Estimation, Preparation of Tender documents etc.) (Indicative length of Bridge-300 metres & Approach Road -4.50 Kms) over Siang River at Km 93.50 on



Ditte-Dimme-Migging Road under 761 BRTF of Project Brahmark in Arunachal Pradesh State”.

### 1.3 NEED OF THE PROJECT

- The Project Road Bridge will be life line for local inhabitants of Yingkiong, Tuting, including several other villages of the Yingkiong, Gette, Gobuk, Halleng, Pugging, Simong Janbo Tahsils.
- This road bridge is proposed in order to provide better connectivity to heavy vehicles commuting through Yingkiong-Tuting route and to provide easy and quick access to army and paramilitary forces on the Indo-China border in Upper Siang district of Arunachal Pradesh.
- The proposed bridge connecting Yingkiong to Tuting will shorten the distance from 330km to 150 km for heavy vehicles.
- The proposed Road Bridge will connect the western region of Siang River to NH-513 which will be an alternative route to access the town.
- The project bridge link will enhance the socio- economic profile of the project influence area.

### 1.4 PROJECT LOCATION

The project is located in the Yingkiong town of Upper Siang District of Arunachal Pradesh state. The Proposed Bridge located at Latitude: 28°39'42.60" N & Longitude: 95°00'42.38 E. Yingkiong and Moying village are connected through existing Suspension Bridge (Gandhi Bridge) over Siang River. The project lies in steep terrain. The existing suspension Bridge Latitude is **28°39'45.28"N** & Longitude is **95° 0'42.90"E**. The Fig. 1-1 is showing the location of project.

**District:** Upper Siang, **Nearest Town:** Yingkiong, **River:** Siang

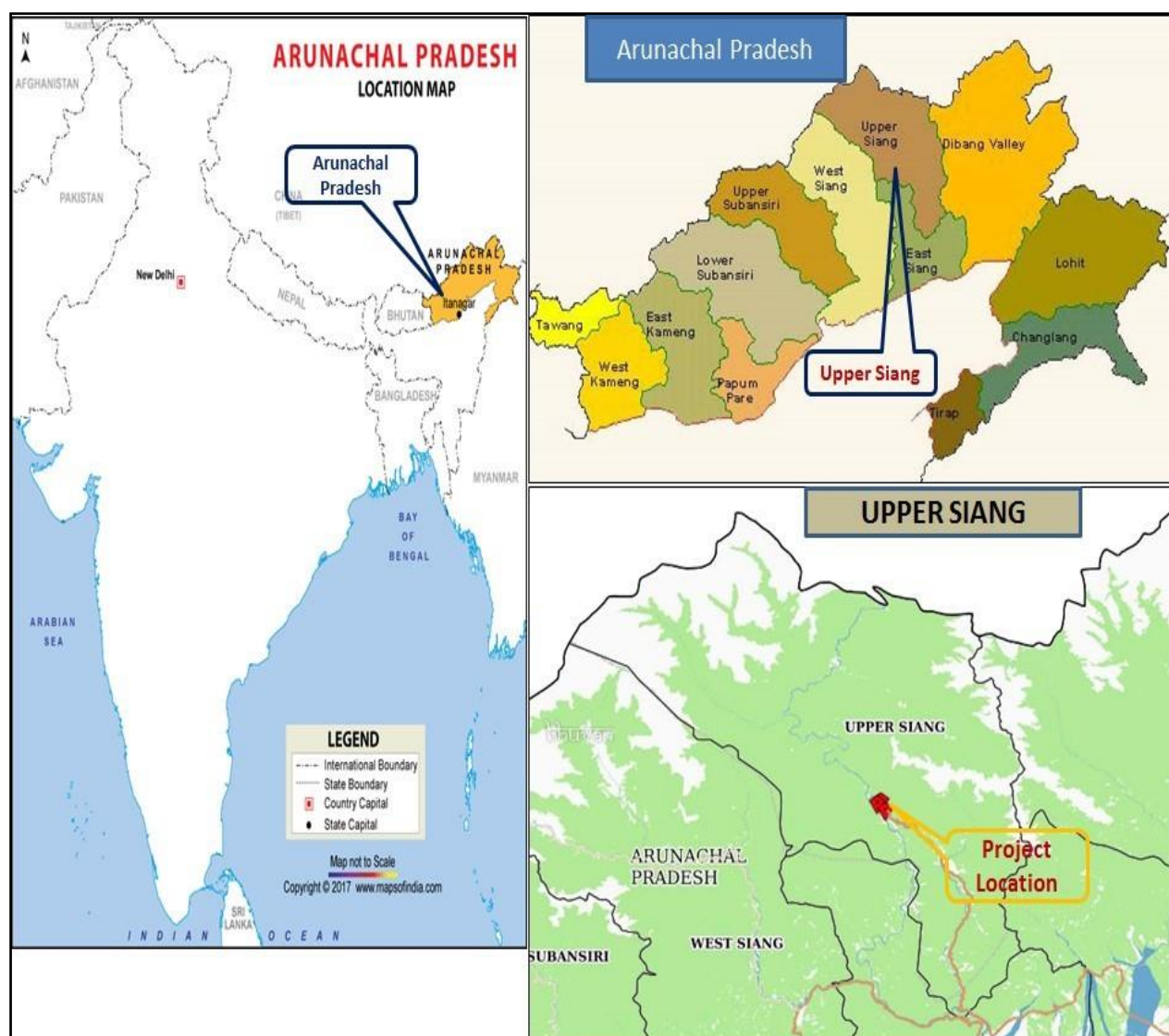


Fig 1-1: Location Map of Project

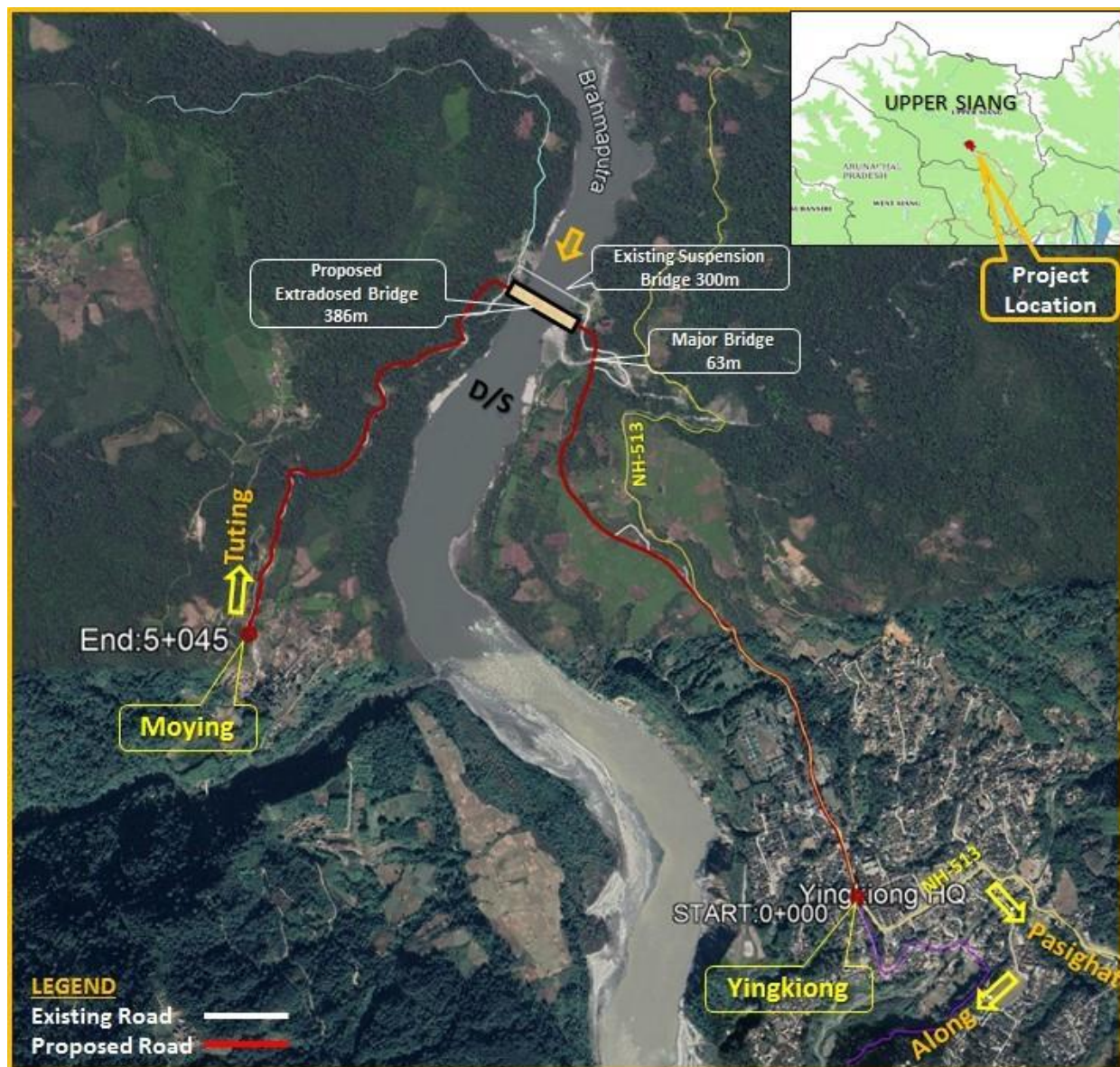


Fig 1-2: Project Location

## 1.5 GENERAL DESCRIPTION OF STUDY AREA

The study area is located in the Upper Siang district of Arunachal Pradesh, between Latitude 94°–95° North and Longitude 28°–29° East with adjoining border with China on northern region. This delineated study Area has been reviewed comprehensively by consultant team to propose possible alignment corridor. The project is located in the Yingkiong town of Upper Siang District of Arunachal Pradesh state. The Proposed Bridge located at Latitude: 28°39'42.60" N & Longitude: 95°00'42.38 E.

The Total Area of this district is 6188 Sq km. It has 3 sub-divisions namely Yingkiong sub-division, Tuting Sub-Division, Mariyang Sub-Division. The district has 11 Administrative Circles



namely Geku, Gelling, Jengging, Katan, Mariyang, Migging, Mopom (Adipasi), Palling, Singa, Tuting and Yingkiong. There is total 112 no of villages with a total population of 35320 persons (2011 Census). The project area lies in Yingkiong sub-division in Yingkiong circle on east side of Siang River and Jengging circle on west side of Siang River.

Yingkiong is a junction for the commuters of many villages. Yingkiong is surrounded by Tehsil/villages e.g., Moying, Jengging, Riga, Rumgong towards west side of the river and Gobuk, Mariyang, simong towards east side of the river. The district is inhabited by Adi, Memba, Khamba and Idu Mishmi tribes who have been harmoniously living in the cradle of nature since time immemorial with colourful festivals / rituals like Solung, Aran, Reh, Lossar, Dihang, etc. It is a mountainous region endowed with rich natural resources and biodiversity, deep gorges and fast flowing streams and rivulets, which form the tributaries of the mighty Siang River. It flows through the district running into Indian Territory at a point near Gelling in the Indo-China border.

## 1.6 SOCIO ECONOMIC PROFILE

Upper Siang District is a wild mountainous region and presents a remarkable topographical variety. It is mountainous in the north gradually descending south ward. The district is a part of Inner Himalayas, Middle Himalayas and the Siwalik ranges. As per cartographic analysis of the state, the district can be said to mainly fall under three major physical regions i.e. Middle Tsangpo catchment area, Upper catchment of Siang river, and Yamne river basin. The region is drained by Tsangpo river. The Upper catchment of Siang river extends over Yingkiong circle. The area is covered by dense East Himalayan moist temperate forests. The district is drained by river Siang and its tributaries Yamne and Nyigong.

The socio-economic life of the people of Upper Siang District is very much linked with the forest. Almost 70% of the total forest area of the district is under unclassified forest where local people exercise their customary right. The forest wealth is located in almost inaccessible area of the district.

The forest department has covered an area of about 1085 hectares under afforestation. The department has raised a nursery for plantation, viz. i) Modern Nursery Maint - 50,000 Nos. seedlings ii) Avenue Plantation - 170 Nos. of seedlings The sources of forest revenue in the district includes major and minor forest products namely Timber, Bamboo, Firewood, cane, Toko leaves and other minor Forest products. The department has earned revenue of Rs.61,87,375/- from the Yingkiong Forest Division and Rs.16,000/- from 1500 Kaps of cane during 2009-10.

## 1.7 EXISTING ROAD AND ITS CHARACTERISTICS

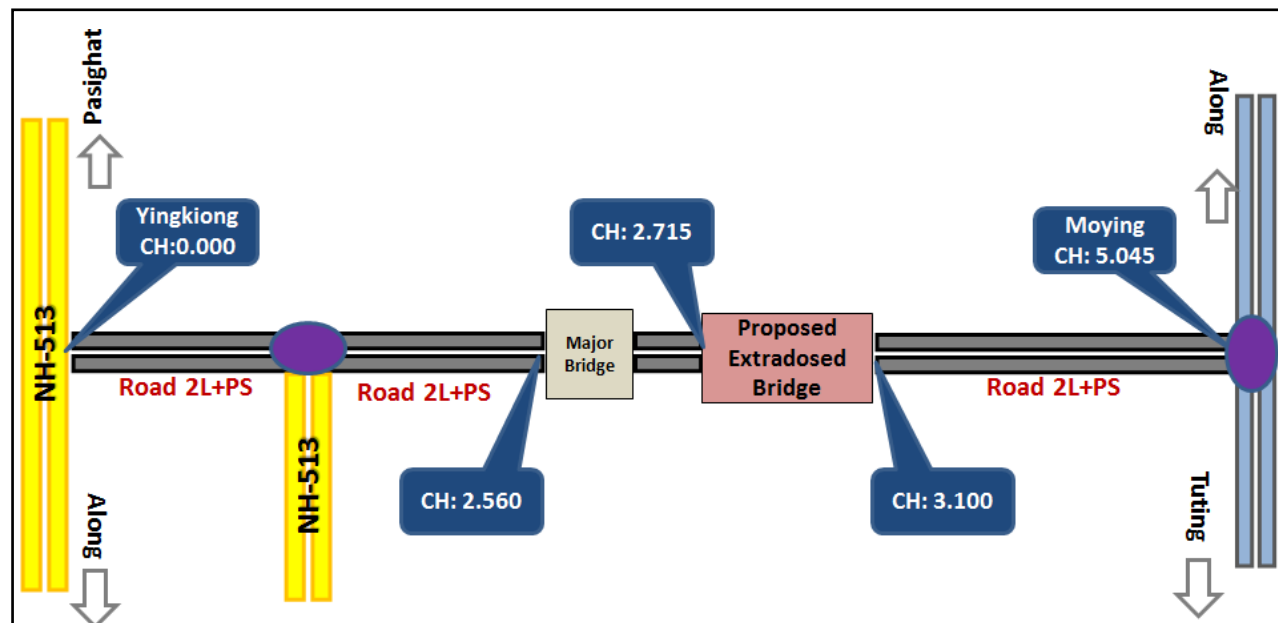
Existing road starts from NH-513 at Yingkiong and terminate on Moying – Tuting road at Moying Junction. At km 3.383 existing Gandhi Bridge across Siang connects the east and west side of the river. The existing road is single lane road constructed by state PWD and RWD. The existing road handed over to BRO.

### 1.7.1 Land

As per the secondary information Existing road is not available. The road was constructed without Land acquisition.

### 1.7.2 Existing Bridges

Stretch	Major Bridges	Minor Bridges	Total No of Bridges	Culverts			
				Box	Slab	Pipe	Total
Yingkiong – Moying	1 (300m Suspension Bridge)	1	2	-			



### 1.7.3 Proposed Bridges

#### ❖ Major Bridge

*Table 1-1: Proposed Major Bridges*

2 lane bridge new-construction	2 lane new bridge to be constructed due to realignment	2 lane bridge to be Re-constructed due to poor Condition of existing bridge/Narrow Width	Total No of Bridges
1	1	0	2

#### ❖ Minor Bridge - Nil

## 1.8 EXTRADOSED BRIDGE

### 1.8.1 Background

During feasibility stage, a multiple span bridge with PSC box girder type superstructure was proposed for 300m long bridge with four piers proposed in the river.

Bridge suggested by the Consultants were discussed and client Officials had apprehension on constructability of high bridge in difficult terrain especially considering the project siting in Seismic Zone V and river morphology/characteristics. Client authorities opined that a signature/Special Bridge Viz. cable stayed bridge, suspension bridge or steel arch bridge of single span between two firm Banks avoiding pier construction in river would be most appropriate bridge consistent with the site conditions. Consultant informed that the RFP does not specify the signature or special bridge which will require specialized and additional resources and additional time and fee for design of Bridge. On BRO instructions, consultant worked out the additional fee and time and submitted the variation proposal. BRO further instructed the consultant to submit GAD and cost of long span bridge based on preliminary calculation to avoid delay in the project. Accordingly, consultant has proposed the long span extradosed bridge without any pier falling in river.

### 1.8.2 Final proposal

The road alignment starts from km 118.8 of AY road at junction of AY-road and NH513 at Yingkiong on east side of Siang River and will connect Moying village through proposed 2-lane 386m (260m+63m+63m) long extradosed bridge over Siang River at km 2+908 (design chainage) and terminate at 93.5 km of Ditte-Dimme-Migging Road at Moying Junction on west side of the river.

In addition to main bridge a 2-Lane 63.5m long major bridge has been proposed at km 2+590 (design chainage) at Yingkiong side approach road. One span of 12m is proposed with

sufficient vertical and lateral clearance from existing road for vehicles movement through this road.

*Table 1-2: Salient features of proposed Extradosed Bridge*

Name of the river	Siang River
Location of Bridge	Start Proposed Chainage: 2+715 (28°39'39.70"N, 95° 0'48.45"E) End Proposed Chainage: 3+101 (28°39'45.63"N, 95° 0'35.93"E)
Length of Bridge	386m
Span arrangement	63m+260m+63m
Design vehicular Loading	3 Lane of Class A or One Lane of class 70R+1 Lane of class A whichever governs. Footpath is considered as carriageway in live load analysis. (As per IRC 6 :2017)
Overall Width	12 m (Functional width) 15m (Structural width)
Carriageway Width	7.5 m
Footpath	1.5 m each side
Type of Superstructure	Box Girder
Depth of Box Girder	4.5 m at Mid 7.5m at Supports
Type of Bearing	POT PTFE
Type of Expansion Joint	Modular Type
Type of Foundation	Open Foundation



## 1.9 COST ESTIMATE

The basic rates of materials at source have been taken from APSOR'2021-22 Government of Arunachal Pradesh.

Table 1-3: Abstract of Cost

ABSTRACT OF COSTS			
S.No.	ITEM	Total Amount (Rs)	Total Amount (Cr)
<b>1</b>	<b>Major Bridge Works</b>		
i	01 Nos New Construction of Major Bridge @ 2+ 590	-	-
	<b>Extradosed Bridge Major Bridge Works</b>		
ii	01 Nos New construction of Major Bridge @ 2+908	-	-
	<b>Base Civil Cost (A)</b>	-	-
	<b>Add 12% GST of Base Civil Cost of (A)</b>	-	-
	Contingencies @ 1% of (A)	-	-
	Supervision Charge @ 3% of (A)	-	-
	Price Escalation @ 5% of (A)	-	-
	Maintenance for 10 years @ 3.75% of A	-	-
	<b>Total Project Cost</b>	-	-

The cost of slope protection work of the hills has not been accounted for keeping in view that it requires geological, geotechnical and geophysical investigations of vulnerable stretches. The analysis of slope stability and protection of slope should be taken as separate project by the BRO.

## 2 PROJECT OVERVIEW

### 2.1 Background

The existing Gandhi Bridge across Siang River at Yingkiong imposes height and width restrictions for freight and transport due to an existing width and loading restricted bridge spanning across Siang River used for communications. The load and width restrictions are considered a major limitation on this stretch of the road network for the passage of oversize freight and Defence force equipment.

Realizing this need, Border Roads Organization have commissioned this Project and assigned the work “Consultancy Services for Feasibility Study, Preparation of Detailed Project Report (DPR) and Providing Preconstruction Services (including Selection of Site, Type of bridge, Sub Soil Investigation, Estimation, Preparation of Tender documents etc.) (Indicative length of Bridge-300 metres & Approach Road -4.50 Kms) over Siang River at Km 93.50 on Ditte-Dimme-Migging Road under 761 BRTF of Project Brahmark in Arunachal Pradesh State” to VKS Infratech Management Pvt. Ltd., Delhi through competitive bidding.

The Project corridor necessitated new 386m (63m+260m+63m) long main bridge.

### 2.2 Project location

The project is located in the Yingkiong town of Upper Siang District of Arunachal Pradesh state. The Proposed Bridge located at Latitude: 28°39'42.60" N & Longitude: 95°00'42.38 E. Yingkiong and Moying village are connected through existing Suspension Bridge (Gandhi Bridge) over Siang River. The project lies in in steep terrain. The existing suspension Bridge Latitude is 28°39'45.28"N & Longitude is 95° 0'42.90"E. The Fig. 1-1 is showing the location of project.

**District:** Upper Siang, **Nearest Town:**Yingkiong, **River:** Siang

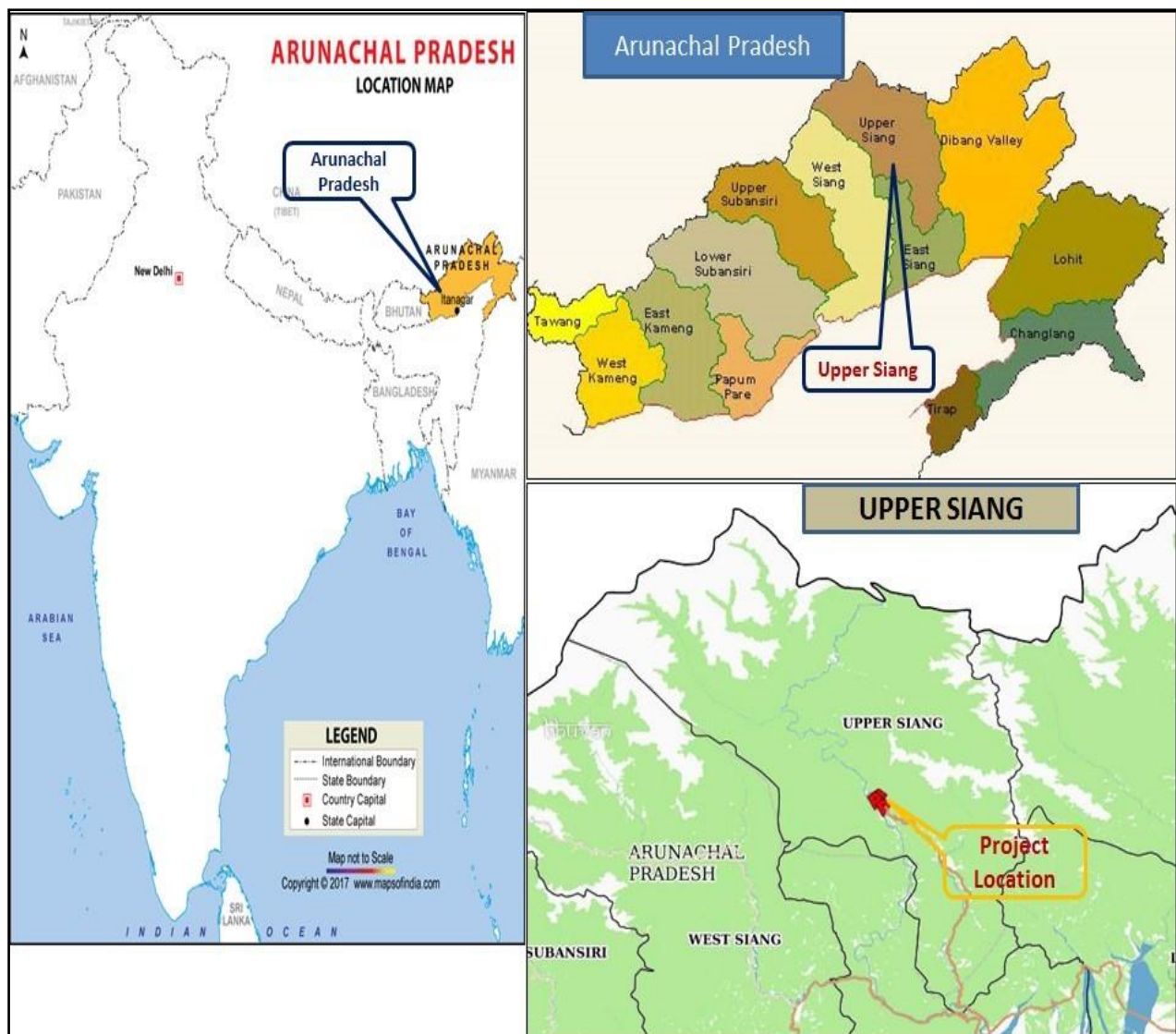


Fig 2-1: Location Map of Project





Fig 2-2: Project Location

## 2.3 Project objectives

- This road bridge is proposed in order to provide better connectivity to heavy vehicles commuting through Yingkiong-Tuting route and to provide easy and quick access to army and paramilitary forces on the Indo-China border in Upper Siang district of Arunachal Pradesh.
- The Project Road Bridge will be life line for local inhabitants of Yingkiong, Tuting, including several other villages of the Yingkiong and Gette, Gobuk, Halleng, Pugging, Simong Janbo Tahsils.

- The proposed bridge connecting Yingkiong to Tuting will shorten the distance from 330km to 150 km for heavy vehicles.
- The proposed Road Bridge will connect the western region of Siang River to NH-513 which will be an alternative route to access the town.
- The project bridge link will enhance the socio- economic profile of the project influence area.

## 2.4 Existing Road Network

The project is located in the Yingkiong town of Upper Siang District of Arunachal Pradesh state. The Proposed Bridge located at Latitude: 28°39'42.60" N & Longitude: 95°00'42.38 E Yingkiong on east side of Siang River and connects Moying village through existing Suspension Bridge (Gandhi Bridge) over Siang River and terminate at 93.5km of Ditte-Dimme-Migging Road at Moying Junction on west side of the river.. The project lies in in steep terrain and altitude varies between 240-500m.

### ➤ NH-513 (East side of Siang River)

NH-513 is of 140km length which starts from its junction with NH-13 near Pasighat connecting Mariyang and terminating at Yingkiong in the State of Arunachal Pradesh. The project roads start at the junction of NH-513 and 118.8 km of AY Road at Yingkiong. This 2 lane National Highway is newly constructed and in a good condition. NH-513 becomes lifeline for the people of Yingkiong, especially for those residing in North & Middle of Upper Siang district. NH-513 facilitates easy movement of essential commodities, health care facilities, etc. round the year.

### ➤ AY Road (East side of Siang River)

Along-Yingkiong (AY Road) Road starts at Along town in west Siang district and connects Yingkiong and terminates at Dimme-Dimme-Migging road.

### ➤ Ditte-Dimme-Migging Road (West side of Siang river)

Ditte-Dimme-Migging road connects Ditte-Dimme village, Moying village, Migging, Tuting and Gelling near china border in upper Siang district. Project road ends at 93.5km km of this road at Moying village junction.

## 2.5 LAND USE

The project area has mixed land use. The open area of land along the project alignment is mainly used for agricultural activities on the valley side and on the hill side at few locations.

*Table 2-1: Land use types of Arunachal Pradesh*

LAND USE TYPES	AREA (IN 000' HA)	PERCENTAGE
Geographical Area	8,374	
Reporting area for land utilization	7,228	100.00
Forests	6,725	93.03
Not available for land cultivation	62	0.86
Permanent pastures and other grazing lands	18	0.25
Land under misc. tree crops and groves	35	0.49
Cultural wasteland	62	0.86
Fallow land other than current fallows	65	0.89
Current fallows	36	0.50
Net area sown	225	3.12

### 3 SOCIO ECONOMIC PROFILE

#### 3.1 Introduction

The main objective of the socio-economic analysis is to provide an overview of the socio-economic status and the relative status of the project influence area within the state. The socio-economic profile of the project influence area of the corridor is required to establish the likely growth prospects which will have a bearing on the road improvements proposed. It gives the present scenario, past performance and the perspective growth of economy, population and urbanization. It also provides an overall view of spatial distribution of economic activities and provides inputs for estimation of future growth in transport demand on the basis of perspective economic growth rates and transport demand elastically. In the light of the above, certain economic parameters are identified for an in-depth study for arriving at realistic traffic growth rates.

#### 3.2 General Features

The study area is located in the Upper Siang district of Arunachal Pradesh, between Latitude 94°–95° North and Longitude 28°–29° East with adjoining border with China on northern region. This delineated study Area has been reviewed comprehensively by consultant team to propose possible alignment corridor. The take-off points at 118.8 km of AY road at junction of AY road and NH-513Y at Yingkiong, on east side of Siang

River, connects Moying village through existing suspension Bridge (Gandhi Bridge) over Siang River and terminate at 93.5km of Ditte-Dimme-Migging-Road at Moying Junction on west side of the Siang River.

The Total Area of this district is 6188 Sq km. It has 3 sub-divisions namely Yingkiong sub-division, Tuting Sub-Division, Mariyang Sub-Division. The district has 11 Administrative Circles namely Geku, Gelling, Jengging, Katan, Mariyang, Migging, Mopom (Adipasi), Palling, Singa, Tuting and Yingkiong. There is total 112 no of villages with a total population of 35320 persons (2011 Census). The project area lies in Yingkiong sub-division in Yingkiong circle on east side of Siang River and Jengging circle on west side of Siang River.

Yingkiong is a junction for the commuters of many villages. Yingkiong is surrounded by Tehsil/villages e.g. Moying, Jengging, Riga, Rumgong towards west side of the river and Gobuk, Mariyang, simong towards east side of the river. The district is inhabited by Adi, Memba, Khamba and Idu Mishmi tribes who have been harmoniously living in the cradle of nature since time immemorial with colourful festivals / rituals like Solung, Aran, Reh, Lossar, Dihang, etc. It is a mountainous region endowed with rich natural resources and biodiversity, deep gorges and fast flowing streams and rivulets, which form the tributaries of the mighty Siang River. It flows through the district running into Indian Territory at a point near Gelling in the Indo-China border.

*Table 3-1: Circle/Tehsils of Upper Siang district*

District	Sub-Division	Circle		Village
UPPER SIANG DISTRICT	Yingkiong Sub-Division.	1	Jengging	13
		2	Yingkiong	7
	Tuting Sub-Division	1	Tuting	20
		2	Gelling	6
		3	Singa	14
		4	Migging	5
		5	Paling	5
	Mariyang Sub-Division	1	Mariang	17
		2	Geku	13
		3	Katan	8
		4	Mopom(Adi Pasi)	4
<b>Total</b>	<b>3</b>	<b>11</b>		<b>112</b>





Fig 3-1: Circle/Tehsil Map of Upper Siang District

### 3.3 DEMOGRAPHY

#### 3.4 Population Upper Siang District of Arunachal Pradesh

As per Census 2011 population of Upper Siang District of Arunachal Pradesh is 35320 it was 33363 in 2001. Its population growth rate over the decade 2001–2011 was 5.77%. Rural and Urban area wise population since 2011 is given below:

Table:3-2: Population Rural & Urban area wise in Upper Siang Distt

Population	2001	2011
Rural	27186	28780
Urban	6177	6540
Total	33363	35320

Table:3-3: Population Growth in India

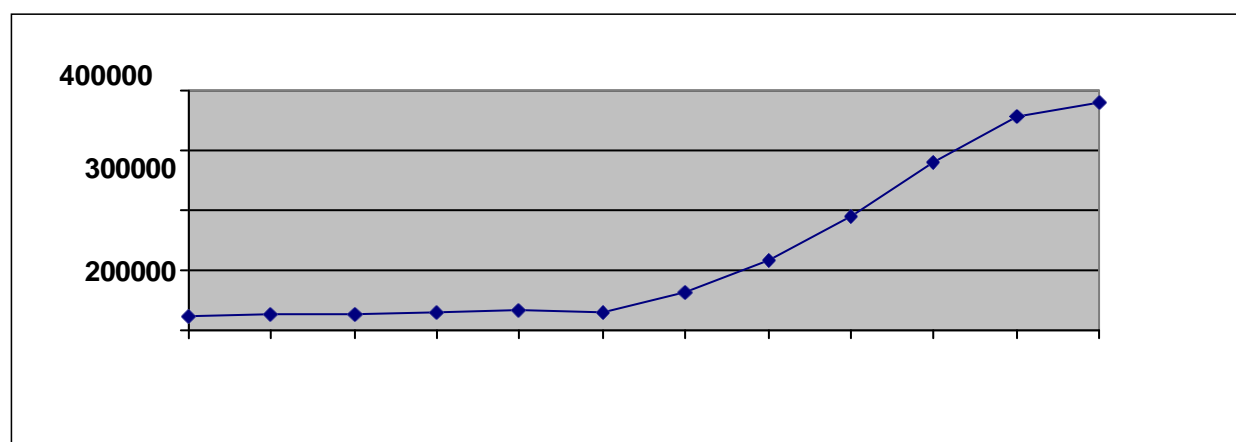
Sl. No.	Details	Population in Lakhs				
		1971	1981	1991	2001	2011
1	Population of India	5,481.60	6,833.29	8,464.21	10,287.37	12,101.93
2	Percentage Growth for 10 Years	24.80	24.66	23.87	21.54	17.64
3	Annual Growth in Percentage	2.48	2.47	2.39	2.15	1.76
4	Density in No. of Persons per Sq. Km	177	216	267	325	382

Table:3-4: Population Growth of Arunachal Pradesh

Sl. No.	Details	Population	
		2001	2011
1	Population of Arunachal Pradesh	1,097,968	1,383,727
2	Percentage Growth for 10 Years	26.21%	26.03%
3	Annual Growth in Percentage	2.621%	2.603%
4	Density in No. of Persons per Sq. Km	13	17

Table:3-5: Population Growth in Upper Siang District of Arunachal Pradesh

Sl. No.	Details	Population				
					2001	2011
1	Population of Upper Siang of Arunachal Pradesh				33363	35780
2	Percentage Growth for 10 Years				20.10	5.77
3	Annual Growth in Percentage				2.1	0.57
4	Density in No. of Persons per Sq. Km				5	5



**Source:** Census 2011 Upper Siang District of Arunachal Pradesh

### 3.5 Rural & Urban Population

An official Census 2011 detail of Upper Siang, a district of Arunachal Pradesh has been released by Directorate of Census Operations in Arunachal Pradesh. Enumeration of key persons was also done by census officials in Upper Siang District of Arunachal Pradesh. In 2011, Upper Siang had population of 35,320 of which male and female were 18,699 and 16,621 respectively. In 2001 census, Upper Siang had a population of 33,363 of which males were 18,057 and remaining 15,306 were females. Upper Siang District population constituted 2.55 percent of total Maharashtra population. In 2001 census, this figure for Upper Siang District was at 3.04 percent of Maharashtra population. There was change of 5.77 percent in the population compared to population as per 2001. In the previous census of India 2001, Upper Siang District recorded increase of 20.10 percent to its population compared to 1991. The 2011 census figures for India indicate that rural population is predominating over urban population. The rural and urban split scenario is depicted in **Table 4.5** for the country, state and PIA.

*Table:3-6: Rural & Urban Population*

Sl. No.	India/ District	Area Sq. km	Total Population	Rural Population	Urban Population	Percentage (%)	
						Rural	Urban
1	India	32,87,000	1,21,01,93,422	83,30,87,662	37,71,05,760	69	31

Sl. No.	India/ District	Area Sq. km	Total Population	Rural Population	Urban Population	Percentage (%)	
						Rural	Urban
2	Arunachal Pradesh	83,743	1,383,727	1,066,358	317,369	77.06 %	22.94 %
3	Upper Siang District of Arunachal Pradesh	6188	35320	28780	6540	81.50	18.50

**Source:** Census 2011 Upper Siang District of Arunachal Pradesh.

### 3.6 Literacy

Average literacy rate of Upper Siang in 2011 were 59.99 compared to 49.78 of 2001. If things are looked out at gender wise, male and female literacy were 66.45 and 52.63 respectively. For 2001 census, same figures stood at 58.71 and 38.79 in Upper Siang District. Total literate in Upper Siang District were 18,195 of which male and female were 10,723 and 7,472 respectively. In 2001, Upper Siang District had 13,424 in its district.

*Table:3-7: Rural/Urban literacy in Upper Siang District of Arunachal Pradesh.*

Category	2001			2011		
	Male	Female	Persons	Male	Female	Persons
Rural				8280 - 62.58%	5438 - 47.51%	13718 -55.59%
Urban				2443 - 84.10%	2034 - 73.96%	4477 -79.17%
Total	7881	5543	13424	10723	7472	18195

Category	2001			2011		
	Male	Female	Persons	Male	Female	Persons
	- 58.71%	- 41.29%	40.23%	58.93%	41.00%	-59.99%

**Source:** Census 2011 Upper Siang District of Arunachal Pradesh.

*Table:3-8: Rural/Urban literacy in of Arunachal Pradesh*

Category	2001			2011		
	Male	Female	Persons	Male	Female	Persons
Rural				67.44%	52.04%	535902 -59.94%
Urban				88.45%	76.66%	230103 -82.93%
Total	303,281 63.83%	181,504 43.53%	484,785 54.34%	439,868 72.55%	326,137 57.70%	766,005 65.38%

*Table:3-9: Rural/Urban literacy in of India*

India		2001			2011		
		Persons	Males	Females	Persons	Males	Females
Total	No. of literates	56,06,87,797	33,65,33,716	22,41,54,081	763638812	434763622	328875190
Percentage	Literacy rate	64.80%	75.30%	53.70%	63.06%	57%	43%
Rural	No. of literates	361,870,817	223,551,641	13,83,19,176	482793835		
	Literacy rate	58.7%	70.7%	46.1%	57.91%	77.15%	57.93%

Urban	No. of literates	19,88,16,980	11,29,82,075	8,58,34,905	280844977		
Percentage	Literacy rate	79.90%	86.30%	72.90%	74.47%	88.76%	79.11%

### 3.7 Work Participation Rate

Total working population of Upper Siang is 17644 which are either main or marginal workers. Total workers in Upper Siang are 17644 out of which 9968 are male and 7676 are female. Total main workers are 14524 out of which male main workers are 8521 and female main workers are 6003. Total marginal workers of Upper Siang are 3120.

*Table:3-10: Workers Participation of Total Workers of Upper Siang District*

	Total	Male	Female
Total Workers	17644	9968	7676
Main Workers	14524	8521	6003
Main Workers Cultivators	8190	3948	4242
Agriculture Labourer	611	340	271
Household Industries	354	225	129
Other Workers	5369	4008	1361
Marginal Workers	3120	1447	1673
Non-Working Persons	17676	8731	8945

**Source:** Census 2011 Upper Siang District of Arunachal Pradesh.

Work Participation rate in Upper Siang as per 2011 is 49.95%, male work participation is 56.49% compared to female work participation of 43.50%. Work Participation rates have increased from rates of 2001. Keeping with the national trend the cultivators have declined in this decade. Number of workers in category of “other workers” has increased from past census. Also, the proportion of marginal workers is

on increase that indicates the acceptance of society as not to depend on public sector alone and engage in other economic activities in these islands.

*Table:3-11: Workers Participation of Total Workers of Arunachal Pradesh*

	<b>Total</b>	<b>Male</b>	<b>Female</b>
Total Workers	587657	350273	237384
Main Workers	478721	301109	177612
Main Workers Cultivators	248120	130008	118112
Agriculture Labourer	20259	11921	8338
Household Industries	4728	2772	1956
Other Workers	205614	156408	49206
Marginal Workers	108936	49164	59772
Non-Working Persons	796070	363639	432431

*Table:3-12: Workers Participation of Total Workers of India*

			<b>Rate %</b>	
	<b>2001</b>	<b>2011</b>	<b>2001</b>	<b>2011</b>
Total Workers	402234724	481743311	39.1	39.8
Rural	309835681	348597535	41.7	41.8
Urban	92399043	133145776	32.3	35.3
Main Workers	313004983	362446420	77.8	75.2
Main Workers Cultivators	127312851	118692640	31.7	24.6



Agriculture Labourer	106775330	144329833	26.5	30
Household Industries	16956942	18336307	4.2	3.8
Other Workers	151189601	200384531	37.6	41.6
Marginal Workers	89229741	119296891	22.2	24.8

Source: Primary Census Abstract for Total population and Houseless Population, 2011 Office of the Registrar General & Census Commissioner, India

### 3.8 Agriculture

Agriculture is the backbone of the economy of the district. The people of this district are mainly dependent upon farming. Thus, this sector has developed significantly during the last decade. The govt. has also emphasised on the growth of agricultural sector by introducing different schemes related to providing trainings on new technology and techniques for scientific farming, mechanization programme of agriculture has been taken up by providing subsidy on machineries and tools. New high yielding varieties of seeds viable for this area has been introduced for taking up new crops and to increase the productivity. A bio fertilizer and bio chemical has been provided to the farmers to encourage them for adopting organic farming. Farmers are also putting their efforts for attaining better yield at low cost of production. Therefore, they are going for double cropping nowadays rather than taking one crop a year resulting a slight increase in cropping intensity. In some places the practice of shifting cultivation still exists but it is being replaced by settled cultivation by the farmers. The main crops of this area are paddy, maize, millet but the farmers are showing interest in growing ginger, potato, pulses and vegetables as subsidiary crops for better earning. The area and production of various crops is given below:

*Table:3-13: Area and Production of various crops in Upper Siang District*

Sl. No.	Name of Crops	Year 2008-09	
		Area (in hect.)	Production (MT)
1	Paddy (TRC)	3300	6270
2	Paddy	3200	5280

Sl. No.	Name of Crops	Year 2008-09	
		Area (in hect.)	Production (MT)
	(Jhum)		
3	Maize	1320	1980
4	Millet	1110	1110
5	Pulses	280	224
6	Ginger	255	1275
7	Sugarcane	130	650
8	Chilly	65	32.5
9	Potato	90	450
10	Oil seeds	40	24
11	Vegetables	280	560
	<b>Total</b>	<b>10070</b>	<b>17855.5</b>

Source : District Agriculture Officer, Upper Siang District, Yingkiong

Table:3-14: Area and Production of various crops in Arunachal Pradesh

Sl. No.	Name of Crops	Area (in hect.)	Production (MT)
1	Paddy (TRC)	133500	367125
2	Paddy (Jhum)		
3	Maize	51100	79205
4	Millet	26790	27460
5	Pulses	13350	14151

Sl. No.	Name of Crops	Area (in hect.)	Production (MT)
6	Ginger	7900	55474
7	Sugarcane	2146	46139
8	Chilly	3645	10498
9	Potato	6200	44950
10	Oil seeds	36570	37097
11	Vegetables	26625	138450

Crop Production Scenario Department of agriculture Government of Arunachal Pradesh

Table:3-15: Area and Production of various crops in India

Sl. No.	Name of Crops	2019-2020	
		Area (in hect.)	Production (MT)
1	Paddy (TRC)	437.8	118.4
2	Paddy (Jhum)		
3	Maize	51100	79205
4	Millet	26790	27460
5	Pulses	13350	14151
6	Ginger	7900	55474
7	Sugarcane	2146	46139
8	Chilly	3645	10498
9	Potato	6200	44950
10	Oil seeds	36570	37097
11	Vegetables	26625	138450

Table:3-16: Area & Production of Horticultural Crops in Upper Siang Dist.t, yr 2009-10

Sl. No.	Name of fruits	Area (in Hectares)	Production (in MT)
1	2	3	4
<b>A.</b>	<b>Temperate/Semi-temperate Fruits</b>		
	Apple	106	0.10
	Pear	30	300.00
	Plum	10	250.00
	Peach	5	125.00
	Walnut	60	Negligible
	Sub Total "A"	<b>211</b>	<b>675.10</b>
<b>B.</b>	<b>Sub-Tropical Fruits</b>		
	Orange	630	1600.00
	Guava	10	200.00
	Pineapple	152	95.00
	Banana	50	500.00
	Ginger	300	450.00
	Others(Large Cardamom)	375	26.00
	Sub-Total "B"	<b>1517</b>	<b>2871.00</b>
	<b>Grand Total ("A" + "B")</b>	<b>1728</b>	<b>3546.10</b>

Source :District Horticultural Officer, Yingkiong

Table:3-17: Land Utilization in Arunachal Pradesh

LAND USE TYPES	AREA (IN 000' HA)	PERCENTAGE
Geographical Area	<b>8,374</b>	
Reporting area for land utilization	<b>7,228</b>	<b>100</b>
Forests	<b>6,725</b>	<b>93.03</b>
Not available for land cultivation	<b>62</b>	<b>0.86</b>
Permanent pastures and other grazing lands	<b>18</b>	<b>0.25</b>
Land under misc. tree crops and groves	<b>35</b>	<b>0.49</b>
Cultural wasteland	<b>62</b>	<b>0.86</b>
Fallow land other than current fallows	<b>65</b>	<b>0.89</b>

LAND USE TYPES	AREA (IN 000' HA)	PERCENTAGE
Current fallows	36	0.5
Net area sown	225	3.12

Source: Land Use Statistics, Ministry of Agriculture, GOI, (2014-15)

### 3.9 Irrigation

In Upper Siang district, out of 131 implemented minor irrigation schemes, only 29 are in progress as on 31<sup>st</sup> March 2010 as shown below:

Sl. No.	Name of the Circle	No. of Minor Irrigation Project		Command area (Hect.)	
		Implemented	In progress	Implemented	In progress
1	Yingkiong	22	3	1609	60.00
2.	Jengging	34	8	2226	160.50
3.	Mariyang	18	6	2040	486.00
4.	Mopon	1	-	225	-
5.	Geku	8	4	839	186.00
6.	Katan	12	2	640	48.00
7.	Tuting	7	2	243	26.00
8.	Gelling	5	2	150	20.00
9.	Singa	3	1	162	11.00
10.	Palling	8	1	431	11.00
11.	Migging	13	-	380	-
	Total	131	29	8945	1008.5

Source :EEPWRD, Yingkiong

### 3.10 Animal husbandry and Veterinary

Upper Siang district is one of the ideal districts for development of livestock and poultry. The local tribal people reared poultry, piggery and semi-domesticated mithun. These are not only important source of food, but also the stock of assets as the lifespan of these animals exceeds a single Jhum production period. Since these animals have natural growth the stock also grows on its own. But the growth of its size would be limited by the availability of food that the animal stock consumes. The mithuns depends extremely on forests. Yet the size of the stock of mithuns had to be kept in check not only to conserve forest but also to protect agriculture crops from being plundered by them. The Animal Husbandry and Veterinary department is the nodal agency for development of livestock and poultry birds in the district. The main role of the department is to provide appropriate

and adequate veterinary aid to the livestock and poultry population. To keep the animal and birds healthy, vaccination against all fatal diseases are done periodically and necessary health coverage are done through treatment. There is vast scope for livestock development including poultry in this district as the climate of the district is suitable.

<b>The number of veterinary institutions in the district as on 31.03.2010 is as shown below:</b>	
1. Veterinary Dispensary	5 Nos. at Yingkiong, Jengging, Mariyang, Geku and Tuting.
2. Veterinary Centres	Total 9 Nos. - 3 Nos. at Jengging, 1 at Mariyang, 2 at Katan, 1 each at Tuting, Gelling and Migging.
3. Cattle upgrading Centres	3 Nos. at Yingkiong, Jengging and Mariyang
4. Cattle breeding farm	1 No. at Tuting
5. Mobile Veterinary Dispensary	1 No. at
6. Govt. Fodder Farm	1 No. at Tuting
7. Dist. Diagnostic Lab.	1 No. at Yingkiong

**Source :** District Statistical Office, Yingkiong

### 3.11 Fishery

The district is rich in various inland fishery resources like rivers, lakes, swamps etc. The area under pisci culture is 50 Hectares and area under paddy cum fish culture is 35 hectares. Upper Siang district has 2 Govt. Fish farm, 499 village fish pond, and water area development is 49.9 hectares and fingerlings distributed is 1,50,000 as on 31.03.2010.

Fish and Fish seed produced in Upper Siang District during the year 2009-10



Sl.No.	Items	Year 2009-10
1	<b><u>Fish Productions</u></b>	- 90MT
	i) Marine fish	
	ii)Inland fish	
2	<b><u>Fish seed production</u></b>	
	i) fry	
	ii) Fingerlings	

Source :DFDO, Yingkiong

The Government established fish seed farms in the district and circle headquarters. To help the farmers, subsidy is given for construction of fish ponds and fish farms. Further to popularize Pisciculture, programme such as farmer's tour and farmers training camps are arranged at Govt. cost. The local farmers are getting help and encouragement from the Govt. to develop water area for constructing fish ponds at low lying areas.

The major drawback in the development of fishery industry is the lack of good quality fish seeds of quick growing fishes. Some small fish seed farms are available at Yingkiong, Jengging and Tuting.

### 3.12 Transport Network

The Upper Siang District of Arunachal Pradesh is served by two means of transport viz. road ways, and airways.

#### 3.12.1 Road network

The project stretch is located in the Yingkiong town of Upper Siang District of Arunachal Pradesh state. The project stretch starts from 118.8 km of AY road at junction of AY-road and NH513 at Yingkiong on east side of Siang River and connects Moying village through existing Suspension Bridge (Gandhi Bridge) over Siang River and terminate at 93.5km of Ditte-Dimme-Migging Road at Moying Junction on west side of the river.

- NH-513 (East side of Siang River)

NH-513 is of 140km length which starts from its junction with NH-13 near Pasighat connecting Mariyang and terminating at Yingkiong in the State of Arunachal Pradesh. The project roads start at the junction of NH-513 and 118.8 km of AY Road at Yingkiong. This 2 lane National Highway is newly constructed and in a good condition. NH-513 becomes lifeline for the people of Yingkiong, especially for those residing in North & Middle of Upper Siang district. NH-513 facilitates easy movement of essential commodities, health care facilities, etc. round the year.

➤ AY Road (East side of Siang River)

Along-Yingkiong(AY Road) Road starts at Along town in west Siang district and connects Yingkiong and terminates at DimmeDimmeMigging road.

➤ Ditte-Dimme-Migging Road (West side of Siang River)

Ditte-Dimme-Migging road connects Ditte-Dimme village, Moying village, Migging, Tuting and Gelling near China border in upper Siang district. Project road ends at 93.5km km of this road at Moying village junction.

### **3.13 STATE ECONOMY**

#### **3.13.1 GDDP (Gross district Domestic Product) & NDDP (Net district Domestic Product)**

The district is mainly dependent on the agriculture sector. The chief agricultural product in the district is paddy, maize, Mille, etc. orange, pineapple, guava and banana are the main horticulture products of the region. More than half of the population are engaged in agriculture in order to earn their livelihood. The district has also a massive electric power project. The GDDP or Gross District Domestic Product during 2007-08 was Rs. 27,544 lakhs at Current Price and Rs. 9467 lakhs at Constant Prices in the year 1999-2000. The Per Capita Income or NDDP, at factor cost during 2007-08 was Rs. 29,799 at Current Price and Rs. 368 at Constant Prices in the year 1999-2000. The NDDP or Net District Domestic Product during 2007-08 was Rs. 10,966 lakh at Current Price and Rs. 8,294 lakhs at Constant Prices in the year 1999-2000. The Per Capita Income or NDDP, at factor cost during 2007-08 was Rs. 29,799 at Current Price and Rs. 368 at Constant Prices in the year 1999-2000.

#### **Arunachal Pradesh**

The economy of Arunachal Pradesh is mainly sourced by Agriculture. Arunachal Pradesh with a massive 94% rural population, is the largest state in the North-East India. Consequently, the economy of the state is based of agriculture. The state's agrarian economy is sponsored by cultivation of rice, maize, millet, wheat, pulses, sugarcane, ginger, and oilseeds. The soil of Arunachal Pradesh is also appropriate for horticulture and fruit orchards. Amongst fruits grown

here, the major ones are pineapple, orange, lemon, plum, pear, cherries, and peaches. Jhum, the local term for shifting cultivation, which was extensively practiced by tribal groups, is now less practiced.

At current prices, GSDP is estimated at Rs. 2795797 lakhs in 2020-21 (A) as per the estimates provided by Economic and Statistics Department, Govt. of Arunachal Pradesh, as against Rs. 1106269 lakhs in 2011-12 whereas at constant prices, GSDP is estimated at Rs. 1814934 lakhs in 2020-21 (A). It reveals that the growth of GSDP during the years from 2011-12 to 2020-21 is 152.72% at current prices and 64.06% at constant prices. In 2020-21 (A), Net State Domestic Product (NSDP) is estimated at Rs. 2536356 lakhs at current prices and Rs.1610823 lakhs at constant prices as against Rs. 1022946 lakhs in 2011-12. The growth of NSDP during the years from 2011-12 to 2020-21 is 147.95% at current prices and 57.47% at constant prices

At current prices, the Gross State Domestic Product (GSDP) of Arunachal Pradesh is estimated to reach Rs. 299.74 lakh crore (US\$ 4.25 billion) in 2020-21. The state's GSDP will increase at a compound annual growth rate (CAGR) of 10.1% between 2015-16 and 2020-21.

The chart below displays the trend of the gross state domestic product of Arunachal Pradesh at market prices by the Ministry of Statistics and Programme Implementation with figures in billions of Indian Rupees

Year	Gross Domestic Product (Billion ₹)
1980	1.07
1985	2.69
1990	5.08
1995	11.84
2000	17.83
2005	31.88
2010	65.21
2014	155.88

### 3.13.2 Economic profile

Economically, the district is mainly dependent on the agriculture sector. The chief agricultural product in the district is paddy, maize, Mille, etc. orange, pineapple, guava and banana are the main horticulture products of the region. More than half of the population are engaged in agriculture in order to earn their livelihood. The district has also a massive electric power project.

## 4 RECONNAISSANCE SURVEY

### 4.1 DATA COLLECTION

Following are the Primary and secondary data collected during the reconnaissance survey and & Investigation.

#### Primary data

- Terrain Condition
- Structures Inventory

### 4.2 CLIMATE CONDITION

#### 4.2.1 Temperature

Climate in the district is varied as rainfall and temperature differs from place to place. The district experiences temperate and sub-tropical humid set of climatic condition with maximum and minimum temperature recorded in the months of June and December respectively. Maximum and Minimum temperature in the tract during summer and winter vary between 130c -390c and 40°C to 210 c while relative humidity in the area varies from 75 to 91% as envisaged from the records contiguous Upper Subansiri district. The minimum temperature during winter at many places generally goes down below freezing point. Remote localities in the district experience snow fall. The higher reaches in the north remains snow clad. The total snow cover in the district is on the wane due to the global warming phenomena and consequent retreat of glacier.

#### 4.2.2 RAINFALL DATA

Climate in the district is varied as rainfall and temperature differs from place to place. The district experiences temperate and sub-tropical humid set of climatic condition with maximum and minimum temperature recorded in the months of June and December respectively. Maximum and Minimum temperature in the tract during summer and winter vary between 13°C -39°C and 4°C to 21°C while relative humidity in the area varies from 75 to 91% as envisaged

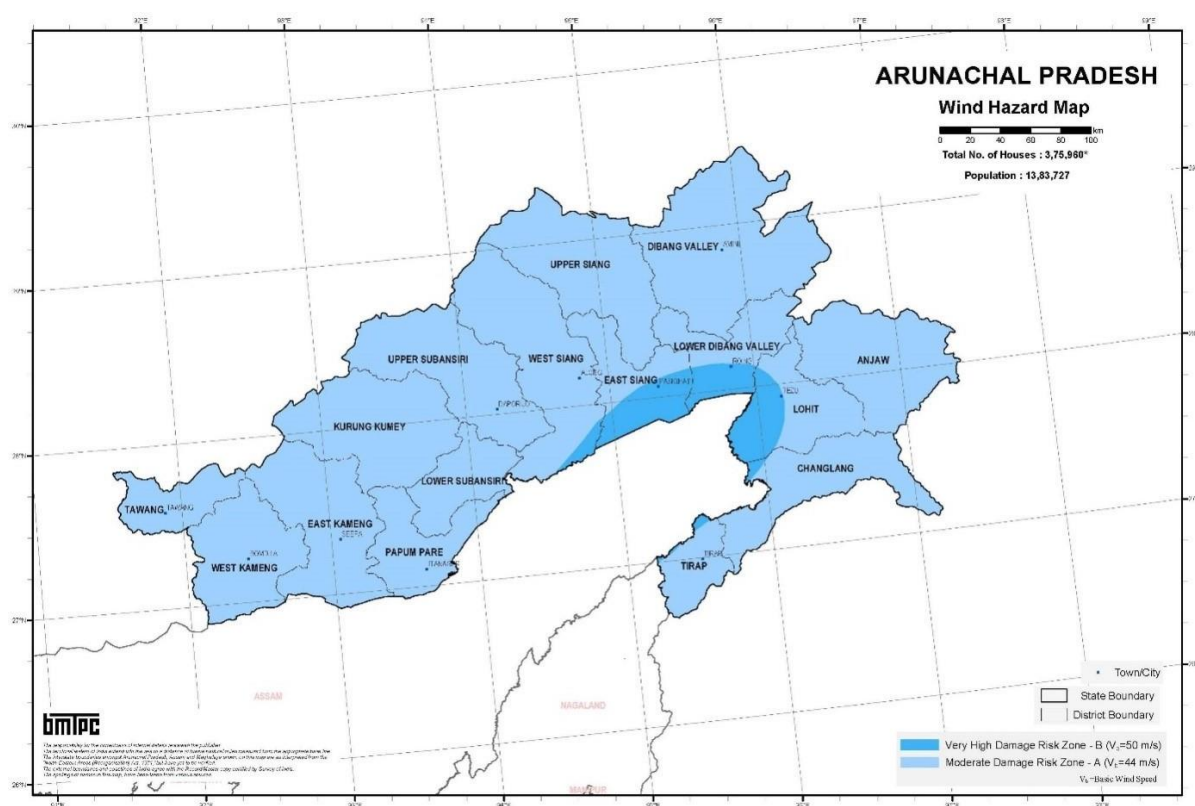
from the records contiguous Upper Subansiri district. Remote localities in the district experience snow fall. Rainfall mainly occurs during the period of April to October.

Table below shows the mean rainfall (mm) and coefficient of variation of the state for the monsoon months, southwest monsoon season and annual during the period 1989-2018. It can be seen that the state gets highest rainfall (30%) of south west monsoon rainfall in July month while the June month get 28% of the south west monsoon rainfall. August and September receive 22 % and 21% of south west monsoon rainfall. Also, more than 64% of annual rainfall receives during the southwest monsoon season only. The variability of monsoon rainfall is 22 % while in annual is 17%.

Table 4-1: Rainfall data of Arunachal Pradesh

Description	June	July	August	September
Mean (mm)	485.6	526.8	389.0	360.9
C V (mm)	30.3	31.0	37.5	34.7

### 4.2.3 Wind



*Fig 4-1: Wind Map of Arunachal Pradesh*

## 4.3 EXISTING BRIDGES INVENTORY& CONDITION

### 4.3.1 Inventory survey

Details of Inventory survey for major, minor bridges have been presented in the annexure of this Volume. Summary of Existing structures is presented in the tabular form.

*Table 4-2: Summary of existing structures*

Major Bridges	Minor Bridges	Total No of Bridges
1	1	2

### 4.3.2 Condition survey

Thorough inspection of the existing structures have been done and details of all structural elements have been taken with their condition including all the parameters given in the Inspection pro-forma of IRC-SP:35-1990. The condition and structural assessment survey of the bridges is presented in the annexure of this Volume.

#### 4.3.2.1 General condition of Major Bridges

There is a single lane existing Suspension Bridge (Gandhi Bridge) in good condition which connects Yingkiong and Ditte-Dimme-Migging Road. Carriageway width of the existing bridge is 4.25m, total deck width is 5.75m and Total length is 300m. The New extradosed bridge is proposed at 94m D/S of this bridge. Detailed proposal of bridges is presented in the annexure of this Volume.





*Fig 4-2: Gandhi Bridge near proposed Bridge site*

#### **4.3.2.2 General condition of Minor Bridges**

There is one single lane existing minor Bridge at Yingkiong side, known as Bailey bridge, which is in good condition. The carriageway width of this bridge is 4.25m and Total length is 15m. This bridge is bypassed due to realignment. Detailed proposal of bridges is presented in the annexure of this Volume.



Fig 4-3: Bailey bridge at Yinkiong side

#### 4.4 GEOTECHNICAL SURVEY AND INVESTIGATION

As observed from the data the subsoil is of good quality and is characterised by weathered rock. The rock so observed is highly to moderately weathered. The stretch is overlaid by soil mixed with gravel, cobbles and boulders of varying depth. Considering the subsoil condition, type of structures and the location of open foundation has been adopted for all structures.

Determination of bearing capacity:

Based on soil characteristics observed  $c$  and  $\phi$  are chosen,

$C=0$  t/sqm  $\phi=35$

degree

Net Ultimate Bearing capacity in case general shear failure is given as:

$$(\quad)$$

Where

C= Cohesion

q= Overburden pressure

B=Width of Foundation

$\gamma$  = Bulk density of soil under foundation = 1.9 t/m<sup>3</sup>

$\gamma_{\text{sub}}$  = Submerged density of soil under foundation = 0.9 t/m<sup>3</sup>

W'=Water table correction

are bearing capacity factors

are shape factors

are depth factors

are inclination factors

**(A) Bearing capacity calculation for foundation for Major Extradosed Bridge of length 386m over Siang river**

Using C=0 t/sqm and  $\phi=35$  degree the bearing capacity factors are

**For**

Width of foundation B=19 m

Length of foundation L = 31 m

Depth of foundation D = 3.0 m

Submerged density of soil under foundation  $\gamma = 0.9$  t/m<sup>3</sup>

Water table correction W' =0.5

Overburden pressure q = 3.0 (Depth) x 0.9 (submerged density) = 2.7 t/sqm

The shape factors are



The Depth factors are

The inclination factors are

Computed Net ultimate bearing capacity =  $438 \text{ t/m}^2$

Using a factor of safety of 3.0, net safe bearing capacity =  $146 \text{ t/m}^2$

**(B) Bearing capacity calculation Foundation for Major Bridge of length 63.5m in approach road of main bridge**

Using  $C=0 \text{ t/sqm}$  and  $\phi=35$  degree the bearing capacity factors are

**For**

Width of foundation  $B=10.7 \text{ m}$

Length of foundation  $L = 12.0 \text{ m}$

Depth of foundation  $D = 3.0 \text{ m}$

Bulk density of soil under foundation  $\gamma = 1.9 \text{ t/m}^3$

Water table correction  $W' = 1$

Overburden pressure  $q = 3.0 \text{ (Depth)} \times 1.9 = 5.7 \text{ t/sqm}$

The shape factors are

The Depth factors are

The inclination factors are

Water table correction  $W' = 1$

Computed Net ultimate bearing capacity =  $560 \text{ t/m}^2$

Using a factor of safety of 3.0, net safe bearing capacity =  $187 \text{ t/m}^2$

**For**

Width of foundation  $B=8.2$  m

Length of foundation  $L = 12.0$  m

Depth of foundation  $D = 3.0$  m

Bulk density of soil under foundation  $\gamma = 1.9$  t/m<sup>3</sup>

Water table correction  $W' = 1$

Overburden pressure  $q = 3.0$  (Depth)  $\times 1.9 = 5.7$  t/sqm

The shape factors are

The Depth factors are

The inclination factors are

Computed Net ultimate bearing capacity  $= 515$  t/m<sup>2</sup>

Using a factor of safety of 3.0, net safe bearing capacity  $= 172$  t/m<sup>2</sup>

**For**

Width of foundation  $B=3.9$  m

Length of foundation  $L = 12.0$  m

Depth of foundation  $D = 3.0$  m

Bulk density of soil under foundation  $\gamma = 1.9$  t/m<sup>3</sup>

Water table correction  $W' = 1$

Overburden pressure  $q = 3.0$  (Depth)  $\times 1.9 = 5.7$  t/sqm

The shape factors are

The Depth factors are

The inclination factors are

Computed Net ultimate bearing capacity =403 t/m<sup>2</sup>

Using a factor of safety of 3.0, net safe bearing capacity =134 t/m<sup>2</sup>

#### 4.5 HYDRAULIC AND HYDROLOGY SURVEY

The area is characterized by deep gorges and fast flowing streams and rivulets. The major rivers of the state are the Siang River and its tributaries. The Siang River flows through the heart of the district running into Indian Territory at a point near Gelling in the Indo-China border. The river then flows southward across the length of the state, cutting a narrow, steep-sided gorge into the mountainous terrain. The Siang River finally emerges onto the northern edge of the Assam plains—near the town of Pasighat joined by the Lohit River a short distance beyond Pasighat, just south of the border between Assam and Arunachal Pradesh. West of the Siang, the Subansiri is the only tributary to cross the main Himalayan ranges. The Kameng and other rivers in the area rise on the southern flanks of the mountains.



Fig 4-4: River Map of Arunachal Pradesh

##### 4.5.1 High Flood Level

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



### *Extradosed Bridge at Km 2+908*

The hydraulic data of existing 300m suspension bridge, located at 94m upstream of the proposed bridge is collected as follows;

HFL : RL 255.00m.

LWL : RL 247.00m

The high flood level for the proposed extradosed bridge is adopted as RL 255.00m and LWL is adopted as RL 247.00 m.

### *Major Bridge at Km 2+590*

HFL : RL 273.50m

## **4.5.2 Discharge calculation**

Discharge at bridge sites have been estimated by following three different methods and design discharge has been fixed as per clause 6.2.1 of IRC:SP:13-2004;

- i. Dickens Formula
- ii. Ryves Formula
- iii. Area Velocity Methods(Mannings Formula)

## **4.5.3 Design discharge for Extradosed Bridge at Km 2+908**

Discharge has been estimated by three different methods summarised as under and design discharge has been fixed as per clause 6.2.1 of IRC:SP:13-2004. For detailed calculations please refer Annexure at end of this report.

S.No.	Method of calculation	Dishcharge in cumecs
1	Dickens Formula	242335
2	Ryves Formula	44615
3	Area Velocity Method (Manning's)	50945

First Highest discharge of above = 2,42,335 m<sup>3</sup>/sec

Second Highest discharge of above = 50,945 m<sup>3</sup>/sec

1.5 times of second highest discharge = 76,417 m<sup>3</sup>/sec

As per clause 6.2.1 of IRC:SP:13-2004

If 1.5\*2nd highest < 1st Highest than adopt 1.5\*2nd highest

If  $1.5 \times 2^{\text{nd}} \text{ highest} > 1^{\text{st}} \text{ Highest}$  than adopt  $1^{\text{st}} \text{ highest}$

Adopted design discharge = **76417 m<sup>3</sup>/sec**

#### 4.5.4 Design discharge for Major Bridge at Km 2+590

Discharge has been estimated by three different methods summarised as under and design discharge has been fixed as per clause 6.2.1 of IRC:SP:13-2004. For detailed calculations please refer Annexure at end of this report.

S.No.	Method of calculation	Discharge in cumecs
1	Dickens Formula	140
2	Ryves Formula	59
3	Area Velocity Method (Manning's)	101

First Highest discharge of above = 140 m<sup>3</sup>/sec

Second Highest discharge of above = 101 m<sup>3</sup>/sec

1.5 times of second highest discharge = 151 m<sup>3</sup>/sec

As per clause 6.2.1 of IRC:SP:13-2004

If  $1.5 \times 2^{\text{nd}} \text{ highest} < 1^{\text{st}} \text{ Highest}$  than adopt  $1.5 \times 2^{\text{nd}} \text{ highest}$

If  $1.5 \times 2^{\text{nd}} \text{ highest} > 1^{\text{st}} \text{ Highest}$  than adopt  $1^{\text{st}} \text{ highest}$

Adopted design discharge = **140 m<sup>3</sup>/sec**

#### 4.5.5 Scour Depth

Maximum scour depth is calculated for the foundations in flowing channel. In case of pier it is  $2 \times d_{sm}$  and in case of abutments it is  $1.27 \times d_{sm}$  which varies in the combination of seismic forces. Since there is no pier and abutment of both bridges in the flowing channel restricting the flow of the channel, calculation of scour depth is not required.

### 4.6 TOPOGRAPHIC SURVEY

#### 4.6.1 Digital Global Positioning System (DGPS control)

At the start of the project road the base point (first GPS station) is tied to a grid system using Dual frequency digital global positioning system to find out the coordinates in WGS-84 series. Based on the coordinates of this base point further plan control points are established. These GPS points are fixed on permanent reference pillars of size 15cm square. They are fixed in

the ground by embedding in C.C up to a depth of 30 cm foundation and they are fixed quite far away from the road so that it will not get disturbed and be available during construction. All GPS control points relate to WGS 84 series (World Geodetic System-84).

#### 4.6.2 Total Station Traverse Control

DGPS control network has been further extended by providing additional total station control points at every 250m intervals by using Leica / Sokkia geodimeter. The residual error within limits have been adjusted and distributed.

#### 4.6.3 Height Control

Height control has been provided by fly-leveling using Digital / Auto levels at the beginning of the project road.

The temporary Bench Marks (TBMs) have been established at 250m interval along the length of the road on Bench Mark pillars of size 15cm x 15cm square and embedded in C.C foundation for 30cm depth. The closing error, if found, within the limit have been adjusted between their Bench mark pillars. List of GPS coordinates and pillars has given in Table.

Table 4-3: GPS & TBM LIST Table

S. NO	EASTING	NORTHING	ELEVATION	CODE
1	697966.952	3169766.621	362.930	GPS1/TBM1
2	697852.304	3169931.633	348.084	GPS1A/TBM2
3	697742.679	3170222.769	349.301	TBM3
4	697665.350	3170480.714	351.050	TBM4
5	697580.025	3170713.198	351.992	TBM5
6	697366.602	3170908.148	348.982	TBM6
7	697198.684	3171077.619	350.554	TBM7
8	697023.329	3171242.579	352.780	TBM8
9	696754.975	3171408.088	336.044	TBM9
10	696725.129	3171701.263	308.843	TBM10
11	696852.661	3171932.356	304.146	TBM11
12	696870.950	3171998.475	295.501	TBM12
13	696770.474	3172204.864	284.198	TBM13
14	696502.198	3172347.106	284.487	TBM14
15	696372.376	3172150.850	301.618	TBM14A
16	696223.707	3172006.992	308.945	TBM15
17	695999.862	3171914.610	326.531	TBM16
18	695930.435	3171692.594	339.514	TBM17
19	695747.791	3171499.302	346.439	TBM18
20	695623.862	3171363.528	347.015	TBM19



S. NO	EASTING	NORTHING	ELEVATION	CODE
21	695559.452	3171138.501	357.601	GPS2/TBM20
22	695471.390	3170898.670	371.782	GPS2A/TBM21



Fig 4-5: Photographs of GPS & TBM Pillars



Fig 4-6: Photographs of GPS & TBM Pillars



## 4.7 MAP COMPILATION

Detail survey has been done for the entire length of the project road for a strip width of 30m on either side. This is carried out using total stations, commencing and closing on existing TBM. The horizontal and vertical disclosures within limits have been distributed within the stretch.

The total station data is downloaded to a computer to generate the drawing on 3D format and MX roads/Civil 3D. Recognized codes and symbols are used with suitable descriptive remarks with data capture and text of coding.

Individual project alignment plans for 2 km lengths are proposed on 1:2000 scales with all survey details noting therein all available structures and detail. Separate layers are used for spot levels and longitudinal and cross section levels.

The survey drawing is attached as annexure of this report.

## 4.8 CADASTRAL SURVEYS

The draft gazette notification No:3 for details of land to be acquired village wise, taluck wise and district wise will be prepared for submission to BRO for necessary notification and acquisition of land.

The project road traverses through the administrative jurisdiction of Upper Siang District in Arunachal Pradesh municipal.

## 4.9 EXISTING ROW

At ground survey no existing row pillar was found. The formation width is 5.0-6.0m and road width is 6.0-8.0m during the reconnaissance survey. As per secondary data/information collected the existing road has been transferred to BRO by PWD. No land acquisition was carried out by state PWD, Yingkiong.

## 4.10 MATERIAL SURVEY

### 4.10.1 Material investigations

Arunachal Pradesh has typical and hard terrain having different altitude, wherein maximum construction material are brought from Assam and utilised in different station located in state. The following sources have been adopted;

- iv. (Bitumen product - Nearby Authorised Dealer is IOCLGuwahati
- v. All steel items/Cement :- Silapathar, Assam (Conforming to relevant IS Codes)

- vi. Bricks :- Kiln in Assam nearest to site of work approved by Govt. of Arunachal Pradesh/BRO
- vii. Aggregate :- At quarry nearby site of work.
- viii. Other items :- Average market rates fixed for all district headquarters of state.
- ix. R.C.C. Hume Pipes :- Naharlagun or nearby source in Assam.

The alternative proposal for cost of aggregates by installing crusher is to be compared with procurement of crushed aggregates from the market and proposal found more economical is to be adopted.

The specifications of materials shall be governed by section 1000 of MoRT&H Specifications for Road and Bridge Works.



## 5 DESIGN BASIS AND STANDARDS

### 5.1 BRIDGE AND STRUCTURES

#### 5.1.1 General

The Design Standards and the loading have been considered as per the requirements laid down in the manual of standard specification for two laning of highways, latest editions of IRC/IS codes of practices & standards specifications, and guidelines of Ministry of Surface Transport. Additional technical references have been used wherever the provisions of IRC/IS codes are found inadequate

#### Following IRC/IS codes used in the design

Code No.	Title
IRC: 5- 2015	Standard Specification & Code of practice for Road Bridges. Section I General Features of Design (Seventh Revision)
IRC: 6- 2017	Standard Specification & Code of practice for Road Bridges. Section II Loads & Stresses (Fourth Revision)
IRC: 22- 2015	Standard Specification & Code of practice for Road Bridges, Section: VI-composite construction (Limit State Design) Third Revision
IRC: 24- 2010	Standard Specification & Code of practice for Road Bridges, Steel Road Bridges (Limit State Method) Third Revision.
IRC: SP:73-2018	Manual Of Specifications And Standards For Two Laning Of Highways With Paved Shoulder
IRC: 78-2014	Standard Specification & Code of practice for Road Bridge. Section VII Foundation & Substructure (First Revision)
IRC: 83- 2002	Standard Specification & Code of practice for Road Bridges. Section IX Bearing, Part-III POT, POT-CUM-PTFE, PIN Metallic Guide Bearings.
IRC: 112 – 2011	Code of Practice for Concrete Road Bridges may be used in place of IRC: 18 & IRC: 21
IS-6403-1981	Code of Practice for the determination of Bearing Capacity
IRC: SP:13-2004	Guidelines for the Design of small Bridges and Culverts
IRC: SP:35-1990	Guidelines for inspection and maintenance of Bridges.
IRC: SP:40-1993	Guidelines on Techniques for strengthening and rehabilitation of Bridges.
IRC: SP:65-2015	Guidelines for Design and Construction of Segmental bridges

Code No.	Title
IRC: SP:66-2005	Guidelines for the Design of Continuous Bridges
IRC: SP:105-2015	Explanatory Handbook to IRC:112-2011 Code of practice for concrete Road Bridges
IS:14268-1995	Uncoated stress relieved low relaxation seven ply strand for pre-stressed concrete specification

### 5.1.2 Concrete

Concrete grade have been mentioned in the respective drawings of structures.

### 5.1.3 Reinforcing Steel

The grade of steel reinforcement is Fe 500 for HYSD bars.

### 5.1.4 Bearings

POT-PTFE Bearings have been proposed for Steel and Extradosed PSC Box Girder bridge. These bearings shall be designed and supplied by the approved manufacturers.

Tar paper bearing has been proposed for major bridge for 12m RCC span at km 2+590

### 5.1.5 Expansion Joints

Strip seal expansion joint have been proposed.

### 5.1.6 Wearing course

In accordance with the provision of MORT&H Specifications clause 2702.1.2, the wearing coat shall consist of a coat of mastic asphalt of 25 mm thick over 40 mm thick asphaltic concrete.

### 5.1.7 Design Loads

Design has been done based on the following loads.

#### Dead Loads

Unit weight of different construction materials has been taken as per IRC: 6-2017.

#### Super Imposed Dead Load

Wearing Coat : 65mm thick asphaltic concrete with total weight of 0.2 t/sq.m

Crash barriers : From design (i.e. 1.0 t/m per side)

#### Live Loads

All the new structures have been designed for no. of lanes associated with 12m deck width for Bridges/structures. Impact factors, longitudinal forces, centrifugal forces for bridges on curves, etc. are as per IRC: 6-2017.

Design live loads are:

3 lanes of class A vehicle or

2 lanes of class A vehicle + 1 lane of 70R vehicle

Live load analysis has been carried out considering footpath as carriageway.

### **Seismic forces**

The structures falls in Zone V of the Seismic Zonal map of India. The seismic force on the piers due to the deck is estimated using the response spectrum method as per the guide lines of IRC. The seismic acceleration coefficient is estimated considering the following values for the parameters as:

$$Z = 0.36$$

$$R \text{ (for Pier-Columns)} = 3.0$$

(For other structural elements the value of R is as per latest revision note of IRC: 6-2017)

$$I = 1.2 \text{ as per Table-8 of IRC: 6-2017}$$

In the estimation of the longitudinal seismic forces, only the dead load and SIDL of the deck is considered. For the transverse effect, 20% of live load is considered. For RCC-foundation design an additional factor of 1.35 is considered.

### **Wind forces**

Lateral wind forces have been calculated in accordance with the provisions of IRC: 6-2017.

### **Earth pressure**

Lateral forces due to earth pressure for the design of abutments and retaining walls have been calculated as per IRC: 6-2017. Properties of backfill material shall take as per IRC: 78-2014, Appendix-6.

All abutments & return walls have been designed for a live load surcharge equivalent to 1.2m earth fill.

### **Temperature**

Effect of temperature difference within the superstructure has been considered in design in accordance with Clause-215 of IRC 6:2017.

## 6 IMPROVEMENT PROPOSAL

### 6.1 BRIDGE AND STRUCTURES

#### 6.1.1 General

The proposed structures have been finalized based on detailed inventory, condition survey, Horizontal Alignment, vertical profile, geotechnical information, hydrological study etc.

#### 6.1.2 Proposed width of structures

##### a) Bridges

Cross sectional width of bridge will be adopted as per IRC: SP:48-1998 and MoRTH circular No. RW/NH/33044/2/88-S&R (B) dt 21th October 2009. The proposed cross section is shown in figure below;

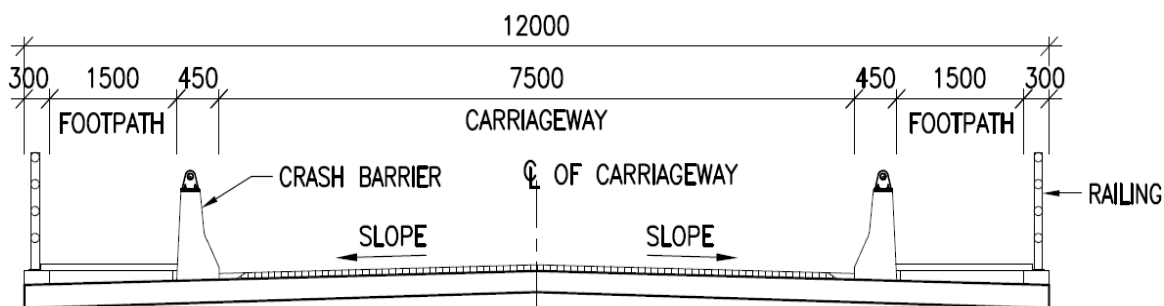


Fig 6-1: Proposed Bridge Cross Section with Footpath

#### 6.1.3 Proposal of Bridges

Detailed proposal for Major/Minor bridges and culverts is presented in Annexure of this volume. Summary of the proposal is presented in the following table;

Table 6-1: Proposed Major Bridges

2 lane bridge new-construction	2 lane new bridge to be constructed due to realignment	2 lane bridge to be Re-constructed due to poor Condition of existing bridge/Narrow Width	Retain/Widening		Total No of Bridges
			Existing 2 Lane Retained	Widening of existing bridge to 2-lane	
1	1	0	0	0	2

Table 6-2: Proposed Minor Bridges

2 lane bridge new-construction	2 lane bridge to be constructed due to realignment	2 lane bridge to be Re-constructed due to poor Condition of existing bridge/Narrow Width	Retain/Widening		Total No of Bridges
			Existing 2 Lane Retained	Widening of existing bridge to 2-lane	
Nil					

#### 6.1.4 Proposal of main Extradosed Bridge over Siang River

2-Lane 386m (260m+63m+63m) long extradosed bridge over Siang river is proposed at 94m D/S of existing suspension bridge (Gandhi Bridge). The main span is kept 260m to avoid construction of pier/pylon in Siang river.

##### a) Superstructure:

An extra-dosed bridge employs a structure that combines the main elements of both a pre-stressed box girder bridge and a cable-stayed bridge. The name comes from the word extradosed, the exterior or upper curve of an arch, and refers to how the "stay cables" on an extra-dosed bridge are not considered as such in the design, but are instead treated as external pre-stressing tendons deviating upward from the deck. In this concept, they remain part of (and define the upper limit of) the main bridge superstructure. Compared to a cable-stayed or cantilever-girder bridge of comparable span, an extra-dosed bridge uses much shorter stay-towers or pylons than the cable-stayed bridge and a significantly shallower deck/girder structure than used on the girder bridge. This arrangement results in the typical extra-dosed "look" of a fan of low, shallow-angle stay cables, usually with a pronounced "open window" region extending from the sides of each tower.

##### b) Deck:

Deck shall consist of cast-in-situ segmental box sections. The deck shall be constructed by balanced cantilever technique.

##### c) Foundation:

Open foundation for pylons and abutments is proposed due to sufficient safe bearing capacity of soil.

##### d) Pylon:

The height of the pylon above the deck is 26m. The pylons could be constructed by slip form method being constructed in upward direction from bottom.

### e) Stay Cables:

The stay cable shall consist of a large number of strands with each strand having galvanized high tensile wires. The number of strands will depend on the stay cable force obtained from the superstructure analysis. The stay cables shall be connected to the main girders of the deck at bottom and to the steel anchorage boxes at the top of the Pylon. There will be one such anchorage box for each pair of stay cables.

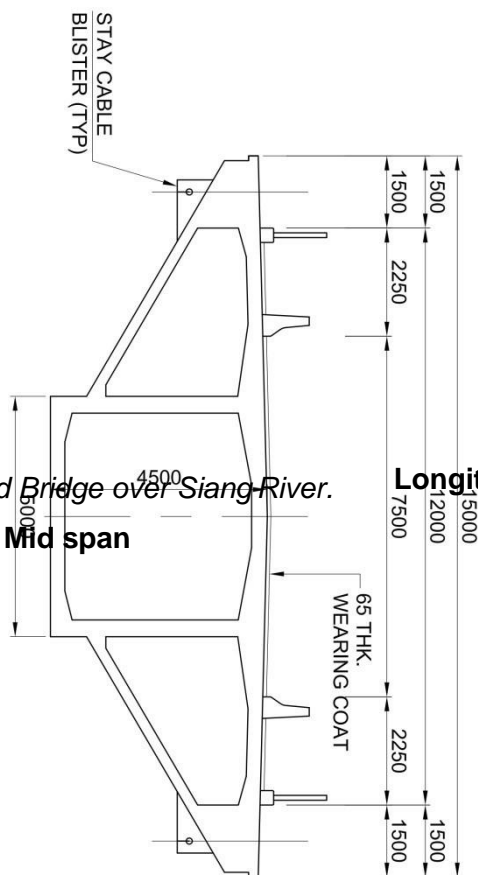
*Table 6-3: Salient features of Main extradosed Bridge*

Name of the river	Siang River
Location of Bridge	Start Proposed Chainage: 2.+715 (28°39'39.70"N, 95° 0'48.45"E) End Proposed Chainage: 3+101 (28°39'45.63"N, 95° 0'35.93"E)
Length of Bridge	386m
Span arrangement	63m+260m+63m
Design vehicular Loading	3 Lane of Class A or One Lane of class 70R+1 Lane of class A whichever governs. Footpath is considered as carriageway in live load analysis. (As per IRC 6 :2017)
Overall Width	12 m (Functional width) 15m (Structural width)
Carriageway Width	7.5 m
Footpath	1.5 m each side
Type of Superstructure	Box Girder
Depth of Box Girder	4.5 m at Mid 7.5m at Supports
Type of Bearing	POT PTFE
Type of Expansion Joint	Modular Type
Type of Foundation	Open Foundation

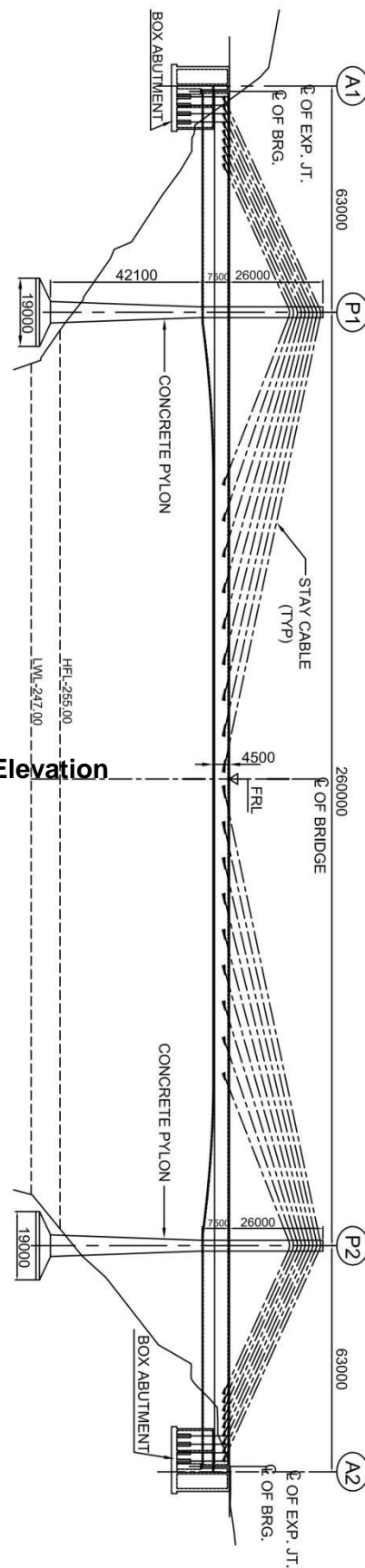


nt of proposed Extradosed Bridge over Siang River.

**Cross section at Mid span**



**Longitudinal Elevation**



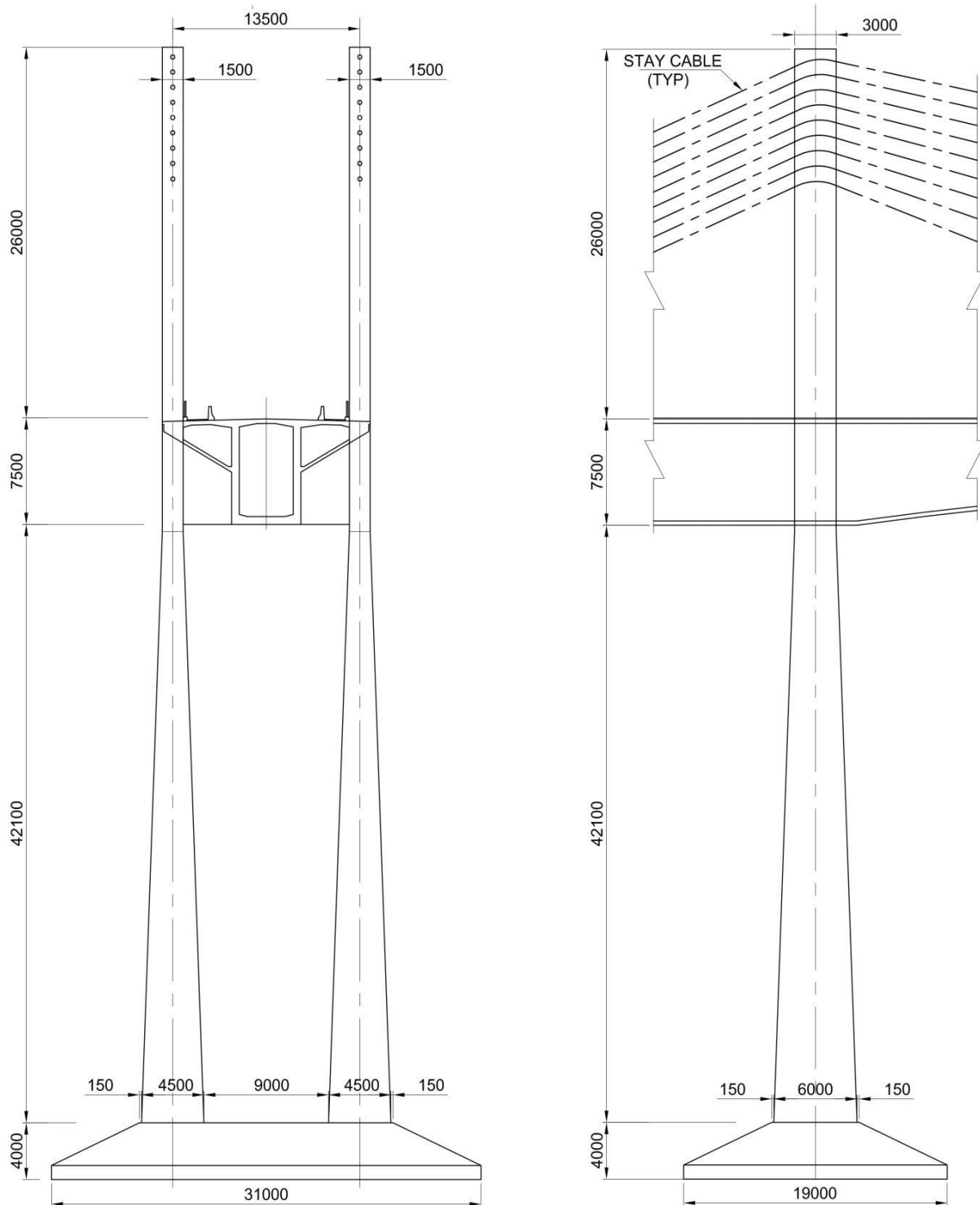


Fig 6-3: Front and side elevation of Pylon of Extradosed Bridge over Siang River.

### 6.1.5 Proposal of Major Bridge in approach of Main bridge at Yingkiong side approach road

2-Lane 63.5m long major bridge has been proposed at km 2+590 at Yingkiong side approach road. One span of 12m is proposed with sufficient vertical and lateral clearance from existing road for vehicles movement through this road.

*Table 6-4: Salient features of Major Bridge at km 2+590*

Location of Bridge	Design Chainage: km 2+590
Length of Bridge	63.5m (c/c Exp. Joint)
Span arrangement	51.5m+12m (c/c exp. Joint)
Design vehicular Loading	3 Lane of Class A or One Lane of class 70R+1 Lane of class A whichever governs. Footpath is considered as carriageway in live load analysis. (As per IRC 6 :2017)
Overall Width	12 m
Carriageway Width	7.5 m
Footpath	1.5 m each side
Type of Superstructure	Steel I girder and RCC Deck for for 51.5m span and RCC Solid slab for 12m span
Depth of superstructure	Girder depth 2.255m for 51.5m span, 0.225m decks slab RCC solid slab depth of 0.9m for 12m span
Type of Bearing	POT PTFE for 51.5 m steel span Tar paper bearing for RCC Solid slab
Type of Expansion Joint	Strip seal type
Type of Foundation	Open Foundation

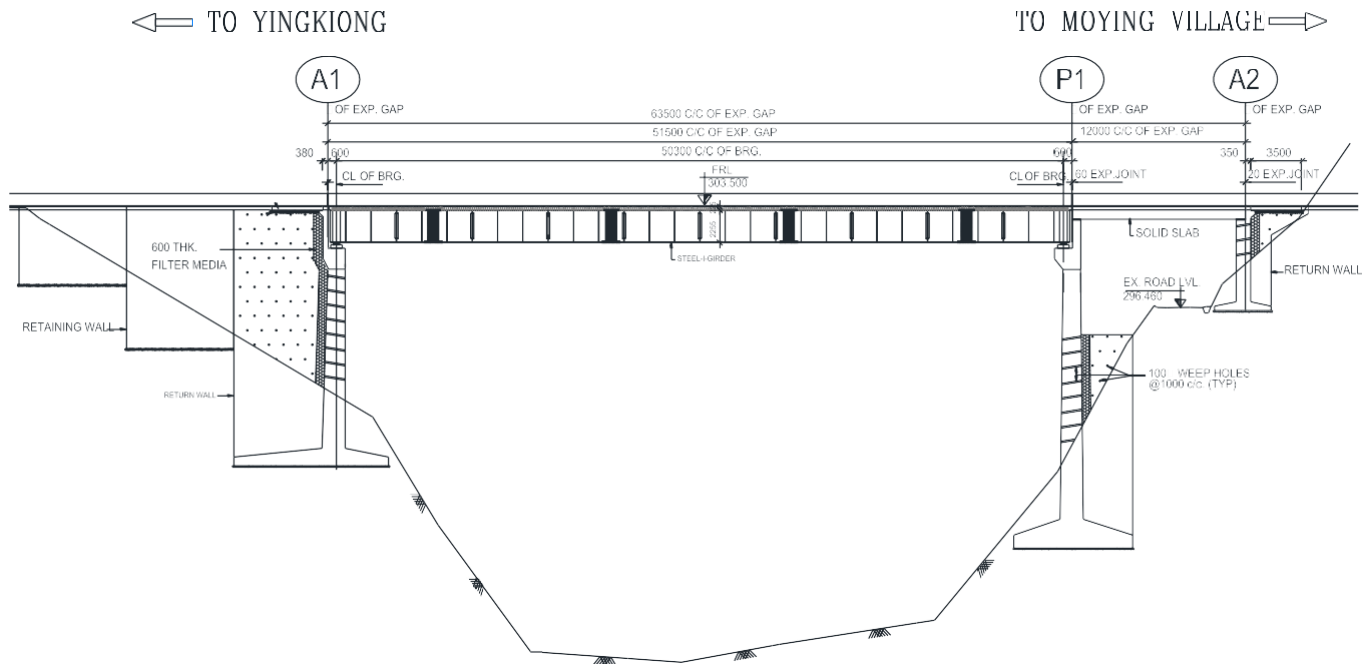


Fig 6-4: General arrangement of proposed Major Bridge at km 2+590 at Yingkiong side.

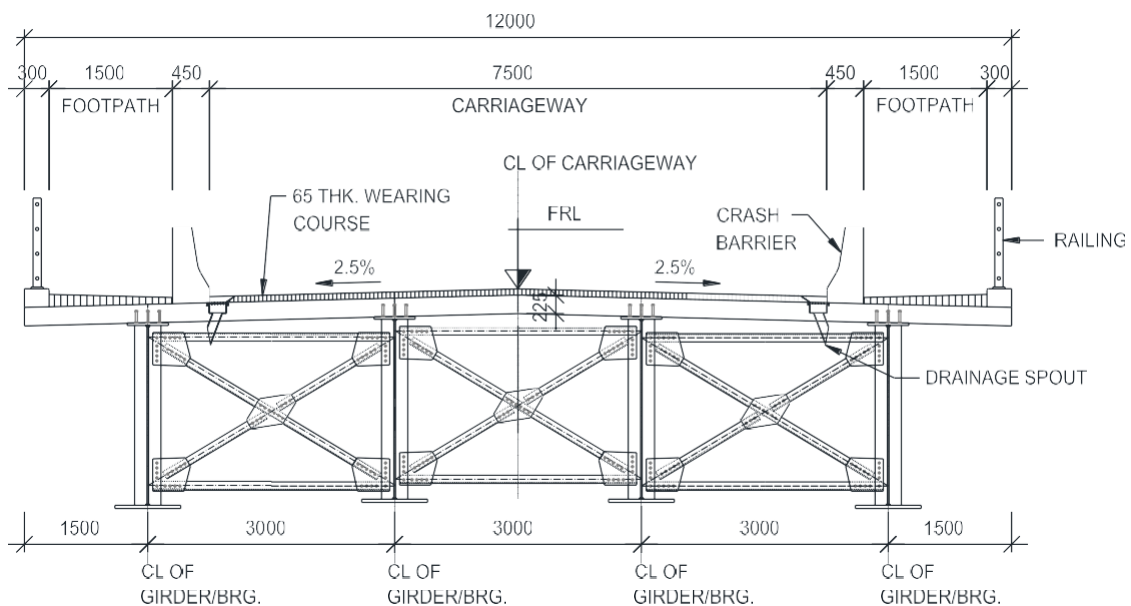


Fig 6-5: Cross section at Mid span of Steel span.

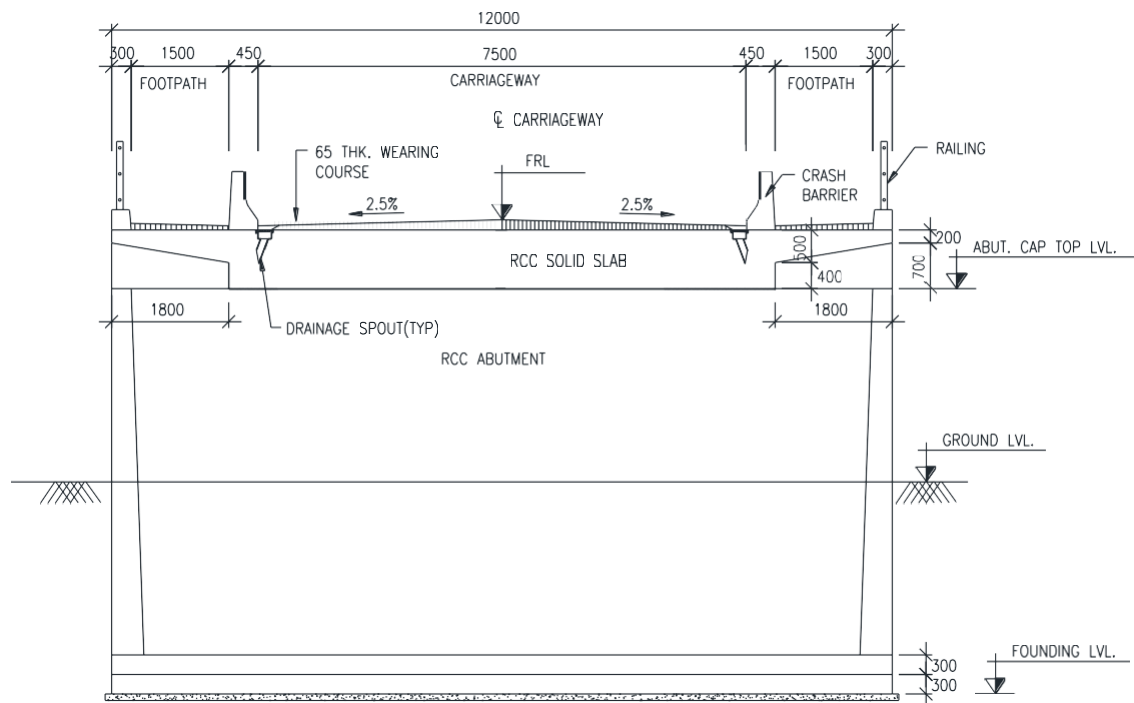


Fig 6-6: Cross section at Mid span of RCC Slab.

## 7 COST ESTIMATE

### 7.1 GENERAL

The cost of the road project has been estimated taking into account quantities and rates of various items. Quantities have been derived from the cross-sections prepared at various significant locations for stretches involving major changes in geometrics and structures. This cost estimate covers cost of Road components such as earthwork for embankment, sub-base, base courses and bituminous surface courses for flexible payment

Cost of Bridge components such as culverts, minor and medium bridges, and major bridges have been included in cost estimates.

Cost of Traffic components have been incorporated in the estimate along with road appurtenances such as km stones, pavement marking and sign boards etc.

Provisions for contingencies, quality control and construction supervision have been made as per communicated guidelines.

For this Feasibility Project Report, the cost of the project has been arrived at after weighing the cost of all the above components based on preliminary design, unit rates and unit costs.

### 7.2 Assumption for Rate Analysis

1. This Rate analysis is based on PWD APSOR 2021. Carriage has been accounted separately as per actual rate given.
2. The rate for completed item at the site of work has inclusive of basis rate of materials plus the actual carriage cost of materials from source/approved quarry to the site of work. The carriage cost of each category of materials has worked out with the carriage charge attached with this SOR prepared for both plain and hill road parameters based on status of road in hilly Himalayan region of Arunachal Pradesh.
3. The Basic materials incorporated in this PWD APSR-2021 are confirming to IRC Standard/MORTH specification. The scheduled rate (Roads and Bridges) 2021 in now brought out purely for calculating cost of the projects by details estimates.
4. The rate analysis for haulage of materials has been made in terms of tonne-kilometer (t.Km) for ease of adoption depending upon the lead in km and load in tonnes.
5. The rate analysis for loading and unloading has been given both by manual and mechanical means. Means of loading/unloading appropriate to the work and site is to be adopted.



6. Overhead Charges 20% for Bridge, Contractor's profit 10% adopted in the rate of PWD APSR 2021 (Bridge)
7. GST 12% has to be added on Civil cost

### 7.3 Plants and Equipment

- i. The rate of Plants and Equipment has been taken from PWD APSOR-2021
- ii. Output of plant/equipment is considered for the compacted quantities
- iii. The usage charges for machines included ownership charge, cost of repair and maintenance including replacement of tyres and running and operating charges which includes crew, fuel and lubricants.

### 7.4 Materials

- i. Quantities of materials considered in the rate are approximate for the purpose of estimating and include normal wastages. Actual consumption would have to be on mix design.
- ii. Arunachal Pradesh has typical and hard terrain having different altitude, wherein maximum construction materials are brought from Assam and utilized in different station located in state. Hence, to maintain the uniformity in rates, it is decided to prepared the PWD APSR-2021 without considering any lead on materials and aggregates. The transportation cost shall be included in the estimate as per distance from the source of procurement of materials/aggregates. The following sources has been adopted in the rate analysis.
- iii. The Contractor will make his own arrangements for borrowing earth. However, compensation for earth taken from private land has been included in the rate for construction of embankments with borrowed earth.
  - Bitumen has been taken from Guwahati, Assam, which is approx. 696km from the proposed alignment.
  - Steel and cement has been taken from Silapathar, Assam, which is approx. 235 km from the proposed alignment.
  - Aggregates has been taken from the Simar quarry in Yingkiong, Arunachal Pradesh , Which is approx. 15km from the site of work.
  - Other items : Average market rates fixed for all district headquarters of state.
  - Coarse sand are locally available, lead is approx. 20 Km.
  - Earth are locally available, lead is approx. 2-3 km from the site of work.

## 7.5 Labour

The average market rate has been adopted which are workable in the state.

Table 7-1: Abstract of Cost

ABSTRACT OF COSTS			
S.No.	ITEM	Total Amount (Rs)	Total Amount (Cr)
<b>1</b>	<b>Major Bridge Works</b>		
<i>i</i>	01 Nos New Construction of Major Bridge @ 2+ 590	-	-
	<b>Extradosed Bridge Major Bridge Works</b>		
<i>ii</i>	01 Nos New construction of Major Bridge @ 2+908	-	-
	<b>Base Civil Cost (A)</b>	-	-
	<b>Add 12% GST of Base Civil Cost of (A)</b>	-	-
	Contingencies @ 1% of (A)	-	-
	Supervision Charge @ 3% of (A)	-	-
	Price Escalation @ 5% of (A)	-	-
	Maintenance for 10 years @ 3.75% of A	-	-
	<b>Total Project Cost</b>	-	-

# ANNEXURES

## HYDRAULIC CALCULATION FOR HIGH LEVEL EXTRADOSED BRIDGE AT Km 2+908

**Calculation of discharge for extradosed bridge over Siang River at Chainage 2+908 Km**  
**Yingkiong, Upper Siang, Arunachal Pradesh**
**1.0 Data**

Design Chainage	2+908 km
HFL	255.00 m
Bed level	201.3 m
Energy slope (Fall of river)	0.001
Catchment Area	298000 Sq km (CWC Report)
	29800000 Hectare

**2.0 Discharge estimation by Dickens Formula**

$$Q = \frac{M^2 C}{1000}$$

**Where**

<b>Q</b>	=	The peak run-off in M <sup>3</sup> /s
<b>M</b>	=	Catchment area in sq. km
<b>C</b>	=	11-14 Where annual Rainfall is 60-120cm 14-19 Where annual Rainfall is more than 120cm 22 in Western Ghats

<b>M</b>	=	298000 Sq km
<b>C</b>	=	19 Considered
<b>Q</b>	=	242335 m <sup>3</sup> /sec

**3.0 Discharge estimation by Ryves Formula**

$$Q = \frac{M^2 C}{1000}$$

**Where**

<b>Q</b>	=	The peak run-off in M <sup>3</sup> /s
<b>M</b>	=	Catchment area in sq. km
<b>C</b>	=	6.8 for areas within 25 km of the coast 8.5 for areas between 25 km and 160 km of the coast 10 for limited areas near the hills

<b>M</b>	=	298000 Sq km
<b>C</b>	=	10 Considered
<b>Q</b>	=	44615 m <sup>3</sup> /sec

#### 4.0 Discharge estimation by Area velocity Method (Manning's Formula)

$$V = \frac{1}{n} \times R^{2/3} \times S^{1/2}$$

$V$  = Velocity of stream  
 $n$  = Rugosity Coefficient = 0.055  
 $S$  = Slope = 0.00100  
 $P$  = Wetted Perimeter = 265.00 m  
 $A$  = Flow Area = 8666.00 m<sup>2</sup>  
 $R = A/P$  (Hydraulic Radius) = 32.702  
 $V = \frac{1}{n} R^{2/3} S^{1/2} = 5.88 \text{ m/sec}$   
 Discharge  $Q = V \times A = 50945 \text{ m}^3/\text{sec}$

#### 5.0 Fixing Design Discharge

Summary of Discharge from different methods

S.No.	Method of calculation	Discharge in cumecs
1	Dickens Formula	242335
2	Ryves Formula	44615
3	Area Velocity Method (Manning's)	50945

First Highest discharge of above = 242335 m<sup>3</sup>/sec  
 Second Highest discharge of above = 50945 m<sup>3</sup>/sec  
 1.5 times of second highest discharge = 76417 m<sup>3</sup>/sec  
 As per clause 6.2.1 of IRC:SP:13-2004  
 If 1.5\*2nd highest < 1st Highest than adopt 1.5\*2nd highest  
 If 1.5\*2nd highest > 1st Highest than adopt 1st highest

Adopted design discharge **76417 m<sup>3</sup>/sec**

#### 6.0 Scour Depth

Maximum scour depth is calculated for the foundations in flowing channel. In case of pier it is 2\*dsm and in case of abutments it is 1.27\*dsm which varies in the combination of seismic forces. Since there is no pier and abutment in the flowing channel restricting the flow of the channel, calculation of scour depth is not required.



HYDRAULIC CALCULATION FOR HIGH LEVEL BRIDGE AT Km  
2+590

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**Calculation of discharge for high level bridge at Chainage 2+590 Km  
Yingkiong, Upper Siang, Arunachal Pradesh**

**1.0 Data**

Design Chainage	2+590 km
HFL	273.5 m
Bed level	272.03 m
Energy slope (Fall of river)	0.105
Catchment Area	14.3 Sq km
	1430 Hectare

**2.0 Discharge estimation by Dickens Formula**

$$Q = \frac{M^2}{C}^{3/4}$$

**Where**

<b>Q</b>	=	The peak run-off in M <sup>3</sup> /s
<b>M</b>	=	Catchment area in sq. km
<b>C</b>	=	11-14 Where annual Rainfall is 60-120cm 14-19 Where annual Rainfall is more than 120cm 22 in Western Ghats
<b>M</b>	=	14 Sq km
<b>C</b>	=	19 Considered
<b>Q</b>	=	140 m <sup>3</sup> /sec

**3.0 Discharge estimation by Ryves Formula**

$$Q = \frac{M^2}{C}^{2/3}$$

**Where**

<b>Q</b>	=	The peak run-off in M <sup>3</sup> /s
<b>M</b>	=	Catchment area in sq. km
<b>C</b>	=	6.8 for areas within 25 km of the coast 8.5 for areas between 25 km and 160 km of the coast 10 for limited areas near the hills
<b>M</b>	=	14.3 Sq km
<b>C</b>	=	10 Considered
<b>Q</b>	=	59 m <sup>3</sup> /sec

#### 4.0 Discharge estimation by Area velocity Method (Manning's Formula)

V	=	$\frac{1}{n}$	x	$R^{2/3}$	x	$S^{1/2}$	
V	=	Velocity of stream					
n	=	Rugosity Coefficient			=	0.055	
S	=	Slope			=	0.10455	
P	=	Wetted Perimeter			=	20.03	m
A	=	Flow Area			=	18.25	m <sup>2</sup>
R	=	A/P	(Hydraulic Radius)		=	0.911	
V	=	$\frac{1}{n}$	$R^{2/3}$	$S^{1/2}$	=	5.53	m/sec
Discharge	Q	=	V x A		=	101	m <sup>3</sup> /sec

#### 5.0 Fixing Design Discharge

Summary of Discharge from different methods

S.No.	Method of calculation	Discharge in cumecs
1	Dickens Formula	140
2	Ryves Formula	59
3	Area Velocity Method (Manning's)	101

First Highest discharge of above = 140 m<sup>3</sup>/sec

Second Highest discharge of above = 101 m<sup>3</sup>/sec

1.5 times of second highest discharge = 151 m<sup>3</sup>/sec

As per clause 6.2.1 of IRC:SP:13-2004

If 1.5\*2nd highest < 1st Highest than adopt 1.5\*2nd highest

If 1.5\*2nd highest > 1st Highest than adopt 1st highest

**Adopted design discharge** 140 m<sup>3</sup>/sec

#### 6.0 Scour Depth

Maximum scour depth is calculated for the foundations in flowing channel. In case of pier it is 2\*dsm and in case of abutments it is 1.27\*dsm which varies in the combination of seismic forces. Since there is no pier and abutment in the flowing channel restricting the flow of the channel, calculation of scour depth is not required.

INVENTORY & CONDITION SURVEY FOR BRIDGES

Road Name: Yinkiong to Moying  
Section :

Road No.:  
Date of survey:

Annexure-1

Sl.NO	Bridge No.	Location (Km.)	Name of River Bridge	Year of Construction	Number of Spans	Span Arrangement (Expansion Joint to Expansion Joint) (m)	Clear Spans	Length of Bridge face to Face of Abutments (m)	High level or Submissible	Clear road way width between Kerbs (m)	Total Outer width of bridge (m)	Width of Footpath (m)	Super Structure						Details of Wearing coat		Sub Structure				Pier Foundation		Abutment Foundation		Protection Work		Skew Angle (Degree)	Vertical Clearance (Below bottom of deck Slab)(m)	Road Formation Level (m)	Direction of Flow	Present Condition of Bridge					Clear Water-Way (m)	Design of Loading	High Flood level (HFL) *	Lowest Water Level (LWL) *	Design Discharge (cum) *	Maximum Design Velocity (m/sec) *	Remarks			
													Gradient	Type	Type of Bearing	Thickness of Slab / Girder (m)	Material of Slab	Handrail Parapet Thickness & Height (m)	Type	Thickness (m)	Thickness			Height of pier & Abutment (m)	Materials Used		Type	Material	Type	Material					Bed	Approach													
																					Type	Top	Bottom		Abutment	Pier																							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	
1		2+787	Siang Tributry	-	1	15.0	14.00	14	High level	4.8	5.0	-	0.00	Steel	-	1.00	Steel Plate	1.2m	-	-	RCC			2.2	RCC	-	-	-	Oper	RCC	-	-	0	2.2	-	L-R	Good	NA	p	F	P	12.0	-	-	-	-	-	-	Bailey Bridge
2		3+383	Siang River	2018	1	300.0	298.70	298.7	High level	4.3	6.1	0.90	0.00	Steel	-		Steel Plate	1.50	-	-	Steel			5.00	Steel Pylon	-	-	-	Oper	RCC	-	-	0	5.0	-	L-R	Good	NA	G	G	G	300.0	-	-	-	-	-	-	Suspension Bridge