Ministry of Road Transport and Highways
India

Preparatory Survey for North East Road Network Connectivity Improvement Project (National Highway 208 and 127B)

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NH127B Assam

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JAPAN INTERNATIONAL COOPERATION AGENCY

PADECO Co., Ltd.

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Abbreviations and Acronyms

AAPT	Annual Average Pavement Temperature
AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
ADC	Autonomous District Council
ADT	Average Daily Traffic
AIDC	Assam Industrial Development Corporation
ASCF	Average Seasonal Correction Factor
ASRB	Assam State Road Board
BBIN	Bangladesh - Bhutan - India - Nepal
BC	Bituminous Concrete
BIMSTEC	Bay of Bengal Initiative for Multi-Sectional Technical and Economic Cooperation
BIS	Bureau of Indian Standards
BOQ	Bill of Quantity
BOT	Build-Operate-Transfer
BRDB	Border Roads Development Board
BRGF	Backward Regions
BRO	Border Roads Organization
BTC	Border Trade Centre
CAD	Computer-Aided Design
CAGR	Compound Annual Growth Rate
CBR	California Bearing Ratio
CCEA	Cabinet Committee on Economic Affairs
CDP	Cluster Development Programme
CEO	Chief Executive Officer
CGWB	Ground Water Information Booklet
COVID-19	Coronavirus Disease 2019
CRF	Central Road Fund
CTB	Cement Treated Base
CTFB	Chittagong-Tripura Fold Belt
CTSB	Cement Treated Subbase
CVPD	Commercial Vehicle Per Day

DBB	Design-Bid-Build
DBM	Dense Bituminous Macadam
DPR	Detailed Project Report
EAC	Expert Appraisal Committee
EAP	Externally Aided Project
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EOI	Expression of Interest
EPC	Engineering, Procurement and Construction
ESC	Environment and Social Considerations
GAD	General Arrangement Drawings
GDP	Gross Domestic Product
GHG	Green House Gases
GIS	Geographic Information System
GOI	Government of India
GPS	Global Positioning System
GSB	Granular Sub Base
GSDP	Gross State Domestic Product
GSVA	Gross State Value Added
HDI	Human Development Index
HDM	Highway Development and Management
HFT	Himalayan Frontal Thrust
IAHE	Indian Academy of Highway Engineers
IBP	Indo- Bangladesh Protocol
ICB	International Competitive Bidding
ICD	Inland Container Depot
ICP	Integrated Check Post
IFC	International Finance Corporation
IID	Integrated Infrastructural Development
IIDCS	Integrated Infrastructure Development Centres
IRC	Indian Road Congress
IS	Indian Standards

JBB	Jhama Brick Base
JBSB	Jhama Brick Sub Base
JICA	Japan International Cooperation Agency
LCB	Local Competitive Bidding
LCS	Land Custom Station
LED	Light-emitting Diode
LOS	Level of Service
LVUP	Light Vehicle Underpass
MDONER	Ministry of Development of North Eastern Region
MDR	Major District Road
MHA	Ministry of Home Affairs
MoEFCC	Ministry of Environment, Forest and Climate Change
MoRTH	Ministry of Road Transport and Highways
MRD	Ministry of Rural Development
MSE-CDP	Micro and Small Enterprises - Cluster Development Programme
MVA	Motor Vehicles Agreement
NAAQS	National Ambient Air Quality Standards
NBARD	National Bank for Agricultural and Rural Development
NEC	North Eastern Council
NER	North Eastern Region
NERSDS	North East Road Sector Development Scheme
NESRIP	North- Eastern States Roads Investment Program
NGO	Non-Governmental Organization
NH	National Highway
NHAI	National Highway Authority of India Ltd
NHDP	National Highway Development Project
NHIDCL	National Highway and Infrastructure Development Corporation Limited
NRRDA	National Rural Road Development Agency
NSDP	Net State Domestic Product
ODA	Official Development Assistance
ODR	Other District Road
OSBP	One Stop Border Post
PCU	Passenger Car Unit

PF	Protected Forest
PHF	Peak Hour Factor
PIU	Project Implementation Unit
PMGSY	Pradhan Mantri Gram Sadak Yojana
PPP	Public Private Partnership
PQC	Pavement Quality Concrete
PSC	Pre-Stressed Concrete
PWD	Public Works Department
QAP	Quality Assurance Plan
RAP	Resettlement Action Plan
RCC	Reinforced Cement Concrete
RF	Reserved Forest
RFCTLARR	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act
RFP	Request for Proposal
RIDF	Rural Infrastructure Development Fund
ROB	Road over Bridge
ROW	Right of Way
RR	Rural Road
RSI	Road Side Interview
RSMP	Road Sector Modernization Program
SARDP	Special Accelerated Road Development Programme
SEAC	Expert Appraisal Committee
SEIAA	State Environmental Impact Assessment Authority
SEZ	Special Economic Zone
SH	State Highway
SIA	Social Impact Assessment
SOR	Schedule of Rate
SPV	Special Purpose Vehicle
SVUP	Smaller Vehicle Underpass
TCS	Typical Cross Section
TIDC	Tripura Industrial Development Corporation
TTAADC	Tripura Tribal Autonomous Area District Council
TTC	Travel Time Cost

VDF	Vehicle Damage Factor
VOC	Vehicle Operating Cost
VR	Village Road
VUP	Vehicle Underpass
WB	World Bank
WHO	World Health Organization
WMM	Wet Mix Macadam
WTMP	Work-Zone Traffic Management Plan

Chapter 1. Introduction

1.1 Background of the Project

In India, roads, along with railways, have become a dominant means of domestic transport catering to 85.2% of passenger transport and 62.9% of freights transport. Due to the rise in population and economic growth, the number of registered cars has increased at an annual rate of 11[1]% since 2001, with the number expected to exceed 250 million by 2020. As a result of such increase in the rate of private vehicle ownership, improvement of passenger and cargo transportation efficiency is one of the major issues in India.

In order to resolve this issue, in 2001 Ministry of Road Transport and Highways (MoRTH) implemented a strategy called the "National Highway Development Project" to start road maintenance of areas which included Delhi at the center, Mumbai in the west, Kolkata in the east and Chennai in the southeast - the so called "Golden Rectangular". As of 2015, the construction of the originally planned road section of 7,522km in length was completed, while improvement of the main highway has been in progress.

Though the number of registered vehicles is increasing in the Northeast (annual increase of 10 % as per Basic Statistics of North East Region, North East Council, 2015), much like mainland India, the maintenance of road conditions is lagging behind. In the Northeast states, only 28.5% of the roads are paved (while the national average is 63.4%), only 53% of the national highways have more than two lanes (the national average is 77.9%) and several areas have no slope protection, including disaster prevention and implementation of drainage facilities.

Such poor road conditions contribute to hinder reliable logistics and cause to delay economic development of these states. The GDP per capita (2017-2018) in the Northeast area was 105,044 Indian Rupees (IR) in Tripura, 74,204 IR in Assam, and 81,098 IR in Meghalaya , which is low compared to the national average of 114,958 IR, and indicate the wide gap between the Northeast and the mainland. The Northeast is rich in produce and resources such as coal which makes industries such as mining and high-value added agriculture oroduct of fruit and flowers promising for the regional and economic development of the region. However, due to poor infrastructure and connectivity, such resources take time to go to market. In order to benefit from these resources and encouraging investment, improving road connectivity becomes essential.

This project "Improvement on Road connectivity in Northeast Region (NH 127B in Assam)" focuses on the National Highway 127B in Assam among the overall project "Improvement on Road connectivity in Northeast Region (NH208 and NH 127B). National Highway 127B (NH127B) in Assam is connected to National Highway 31C at Srirampure, which is a part of the East-West Corridors that connects Northeast area and the other areas of India. NH127B also runs from Bhutan to northeast as an international corridor.

Another important connection in the North East Region is National Highway 208 (NH208), which crosses Tripura state and leads to Chittagong, the second largest city and largest port city in Bangladesh. This road should become a road that improves international distribution network. If the route via Sabroom opens, India to Chittagong becomes the new distribution channel which shortens the access. Moreover, the corridor section between Ramgarh (the border in Bangladesh) and Baraiyarhat that connect from Sabroom, has several related projects that can create synergy on connectivity and regional development with this Project. The support on bridge improvement/repair through "Cross-border Road Network Maintenance Project", which is planned to maintain the national highway. The experience of past 4 projects, "Improvement of

[1] Motor Vehicles, Statistical Year Book India 2017

Road Connectivity in Northeast India (phase 1~4)" are highly relevant to this project, and we should provide continuous support and contribution in the Northeast region.

Improving the international network and system leads to improvement of connectivity between inner and outer northeast area and enhances movement of people and products which influences economic property and stability of the region, in line with wide open India-Pacific vision. The objective of this Project is in line with the Three Year Action Agenda: 2017 April ~2020 March that the Government of India (GOI) announced for the country's future development, focusing on connectivity between northeast and the other regions.

Given this background, the Government of India has requested the Japanese Government to implement the Project as Phase 5 in order to establish and improve and NH127B (state of Assam). Therefore, based on this request by the Government of India, the aim of this Survey is to collect relevant information on the purpose, overview, cost, implementation method, management, and environmental and social considerations of this Project, and to collect data for formulation of sector-loan Project.

1.2 Project Overview

Table 1-1: Project Overview

1) Project name	Improvement of Road Connectivity in Northeast Region (NH127B) in Assam
2) The purpose of project	To newly establish and improve roads in Northeast India, from Srirampur to Dhubri in Assam state of National Highway 127B (54km) in order to improve connectivity and contribute to the promotion of economic development of the area.
3) The overview of request by the GOI	1. NH 127B: Partially newly constructing, improving and widening of 2 or 4 lane roads (including bridges, drainage channel bypass etc.) from Srirampur to Dhubri in Assam (approximately 54 km) 2. Consultation service (design and construction management)
4) Counterpart and Relevant Agencies	Counterpart Agencies ・ National Highway and Infrastructure Development Corporation Limited (NHIDCL) - for the component 1, and 2 described in 3) the overview of request by the GOI Relevant Agencies ・ MORTH ・ Ministry of Development of North Eastern Region (MDONER)

Source: JICA Survey Team

1.3 Objectives of the Survey

The survey objectives are as follows:

- To review the DPR and make improvements;
- To confirm/assess project purpose, traffic demand forecast, engineering design, cost, schedule, implementation structure, economic viability, and the like, for JICA loan appraisal;
- To confirm that environmental and social considerations of this Project is in compliance
- with the JICA guidelines.

Chapter 2. Present Conditions of the Survey Areas

2.1 Present Status of Highway Network in the Survey Areas

2.1.1 National Highway Network in North-Eastern States

National Highway in India is expanding rapidly. The total length of all the National Highways is 132,499 km[1], and 13,640.5km is in the North-East Region covering 8 States; Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. Majority of these existing highways are 2-lane roads (one lane in each direction) and developed and maintained by the State Public Works Department (PWD). Highways are expanded to four or more lanes as more traffic flow is expected through the towns. The following figure shows the National Highway Network in the North Eastern Region. Regarding territory and borders, it does not represent the official opinion as JICA Survey Team.

Source: Ministry of Development of North Eastern Region, modified by JICA Survey Team.

Figure 2-1: National Highway Network in the North Eastern Region

The following table shows the total length of National Highway by city in the North Eastern Region.

[1] Ministry of Road Transport and Highways (2019)

Table 2-1: National Highway Number and Length by State in the North Eastern Region

No.	State	National Highway No.	Length (km)
1	Arunachal Pradesh	13, 113, 313, 513, 713, 713A, 15, 115, 215, 315, 415, 515, 315A	2,537
2	Assam	2, 702, 702C, 702D, 6, 306, 8, 208A, 15, 115, 215, 315, 315A, 415, 515, 715, 715A, 17, 117, 117A, 217, 27 E.W., 127, 127A, 127B, 127C, 127D, 127E, 427, 627, 29, 129, 329, 329A, 37	3,909
3	Manipur	2, 102, 102A, 102B, 102C, 202, 702A, 29, 129A, 37, 137, 137A	1,750
4	Meghalaya	6, 106, 206, 217, 127B	1,156
5	Mizoram	2, 102B, 302, 502, 502A, 6, 306, 306A, 108	1,423
6	Nagaland	2, 202, 702, 702A, 702B, 702D, 29, 129, 129A, 229, 329A	1,548
7	Sikkim	10, 310, 310A, 510, 710, 717A, 717B	463
8	Tripura	8, 108, 108A, 108 B, 208, 208A	854
	Total		13,640

Source: Ministry of Road Transport and Highways (2019)

2.1.2 Transport Infrastructure Projects in North-Eastern States

The Ministry of Development of North Eastern Region has taken initiative on developing infrastructure connectivity in a manner which mitigates the constrains on economic development of the region. In addition, for the rapid development of the region, plans and policies were formulated and implemented in collaboration with the Central Ministries and the State Governments. The following table shows major projects in the North Eastern Region.

Table 2-2: Major Infrastructure Project in North Eastern Region

Project	Description
Indradhanush Gas Grid Project	• 1656 Km. North East Gas Pipeline Grid covering all eight States. • Clean and Green NE with use of cleaner fuel. • Boost to Industrial Growth with clean environment
Greenfield Hollongi Airport Capital Connectivity to Arunachal Pradesh	• Estimated Project Cost Rs.955.67 Cr. Work stated and on-going Project. Likely Completion – December, 2022
Railways – Better & Faster Connectivity to NE	• Projects Sanctioned. Doubling – New Bongaigaon to Agthori via Rangia. (142 km at cost of Rs.2042.51 Cr) • Bridges on River Brahmaputra. i. Saraighat Bridge Estimated Cost Rs.888 Cr. ii. Tezpur-Silghat Bridge Estimated cost. Rs.3512 Cr. • Electrification of entire Railway Network in NER (Length 2352 km, estimated cost Rs.2293 Cr)
Connecting NER National Highways	• Awarded 35 Projects (Costing Rs.7707.17 Cr and 536 Km length) • Important Projects (4 Laning of Imphal-Moreh–Pkg I (20 km); Rs.762Cr. Connectivity for India-Myanmar-Thailand Trilateral Highway) • Aizwal Tuipang Pkg -l (57 km); Rs.678 Cr, to provide access to Kaladan MMT Project. • 3 Projects completed in Arunachal Pradesh – 66 Km length. • Hunli to Anini (16 km) NH313 • Singer River to Sizoh Nallah (23 km) NH 513 • Pasighat to Pangin (27 km)

Project	Description
Inland Waterways – Connectivity with Kolkata/Haldia Ports	• Great savings in logistics cost. • Bulk cargo and container movement from Kolkata and Haldia Ports to Pandu (Guwahati) Terminal via Indo- Bangladesh Protocol (IBP) Route • Development of IBP Route in Bangladesh at estimated cost of Rs.305.84 Cr.
2000 MW Lower Subansiri Hydro Power Project	• Work on project stalled since in 2011 due to political agitations and court cases, total expenditure Rs.10,500 Cr till then. • Constant monitoring and follow up at all levels led to clearing of all hurdles in July, 2019. • Commencement in October, 2019 after NGT clearance. • Dam construction is underway and likely to be completed by 2023.

Source: Major Achievements (May 2019- May 2020), Ministry of Development of North Eastern Region

2.2 National and Regional Highway Development

2.2.1 Organizations Related to National Highway Development

The development and implementation of the road network in India are undertaken by both the Central Ministries and the State Governments with the cooperation of various agencies. The Ministry of Road Transport and Highways (MoRTH) is the highest authority for the National Highways (NH). On the other hand, the State Governments are responsible for State Highways (SH), Major District Roads (MDR) and Rural Road (RR), comprised of Other District Roads (ODR) and Village Road (VR). The main implementation agencies are as follows:

- State Public national Highway Authority of India Ltd. (NHAI)
- National Highway Infrastructure Development Corporation ltd. (NHIDCL)
- Border Roads Organization (BRO)
- National Rural Road Development Agency (NRRDA)
- Public Works Department (PWD)
- Local Governments

The North Eastern Council (NEC) in the Ministry of Development of North Eastern Region (MDoNER) and Planning Departments under State Governments perform as coordinators.

The Indian Road Congress (IRC) fulfils the role of the national standard form by sharing knowledge and maintaining the experiences and expertise on the entire range of subjects from roads, bridges, tunnels, to road transportation. In addition, IRC advices on planning and design, legislation and research related with development and maintenance of roads and road transportation. The Indian Academy of Highway Engineers (IAHE) organizes training for engineers and government professionals.

(1) Ministry of Road Transport and Highways (MoRTH)

MoRTH is the highest organization for road networks under the central government. MoRTH administrates road planning, development, administration of the Central Road Fund (CRF), formulation and implementation of road-related policies including research, environmental issues, and automotive norms. Regarding its structure, the ministry is composed of various wings, such as the National Highway Wing, Operations and Project Wing, and Roads Wing, which manage regional offices in each state.

(2) National Highways Authority of India Ltd. (NHAI)

National Highways Authority of India was established by an act of the Parliament, NHAI Act, 1988 “An Act to provide for the constitution of an Authority for the development, maintenance

and management of national highways and for matter connected therewith or incidental thereto", and became operational in 1995, under the administrative control of MoRTH. NHAI is authorized to implement National Highways Development Project (NHDP), India's largest ever Highways Project in a phased manner. It has been entrusted with NHDP, which along with other minor projects, has vested in it 50,329 km of National Highways for development, maintenance, and management.

(3) National Highway Infrastructure Development Corporation Ltd. (NHIDCL)

NHIDCL is a company fully owned by MoRTH. The NHIDCL undertakes surveys, designs, building, operation, maintenance and upgrading of National Highways and roads with strategic importance, including border roads that share international boundaries with neighboring countries. The operation was initiated from 1st January 2015.

(4) Border Roads Organization (BRO)

The Border Roads Organization (BRO) is a road construction executive force, integral to and in support of the army. It began operations in May 1960. The BRO is entrusted with the task of construction and maintenance of roads in the border areas for defense purpose. The roads in the border areas are developed and maintained through funds provided by MoRTH through the Border Roads Development Board (BRDB). In addition to the roads in the border areas, BRO also conducts works entrusted by other ministries and departments.

(5) Ministry of Rural Development (MRD)

MRD is the nodal ministry to manage most of the development and welfare activities in the rural areas, including infrastructure, that cover Other District Roads (ODR) and Village Roads (VR). MRD set up the National Rural Roads Development Agency (NRRDA) to provide operational and management support to the Rural Road development plan programmes; namely, ***Pradhan Mantri Gram Sadak Yojana*** (PMGSY), the Prime Minister's Rural Roads Scheme.

(6) Public Works Department (PWD)

PWD was originally set up by the military in the middle of 1800 under British Rule. Currently, 36 PWDs are assigned under state governments in India and are responsible for construction and maintenance of public infrastructures such as government building, roads, bridges, public transport, drinking water systems and much more. Especially, the principal function of PWD on roads is to develop and manage the state road infrastructure for providing connectivity and efficient transportation. It undertakes construction and maintenance of roads, bridges, culverts in the state.

2.2.2 Development Programs for National Highways

(1) Special Accelerated Road Development Programme for the North-East (SARDP-NE)

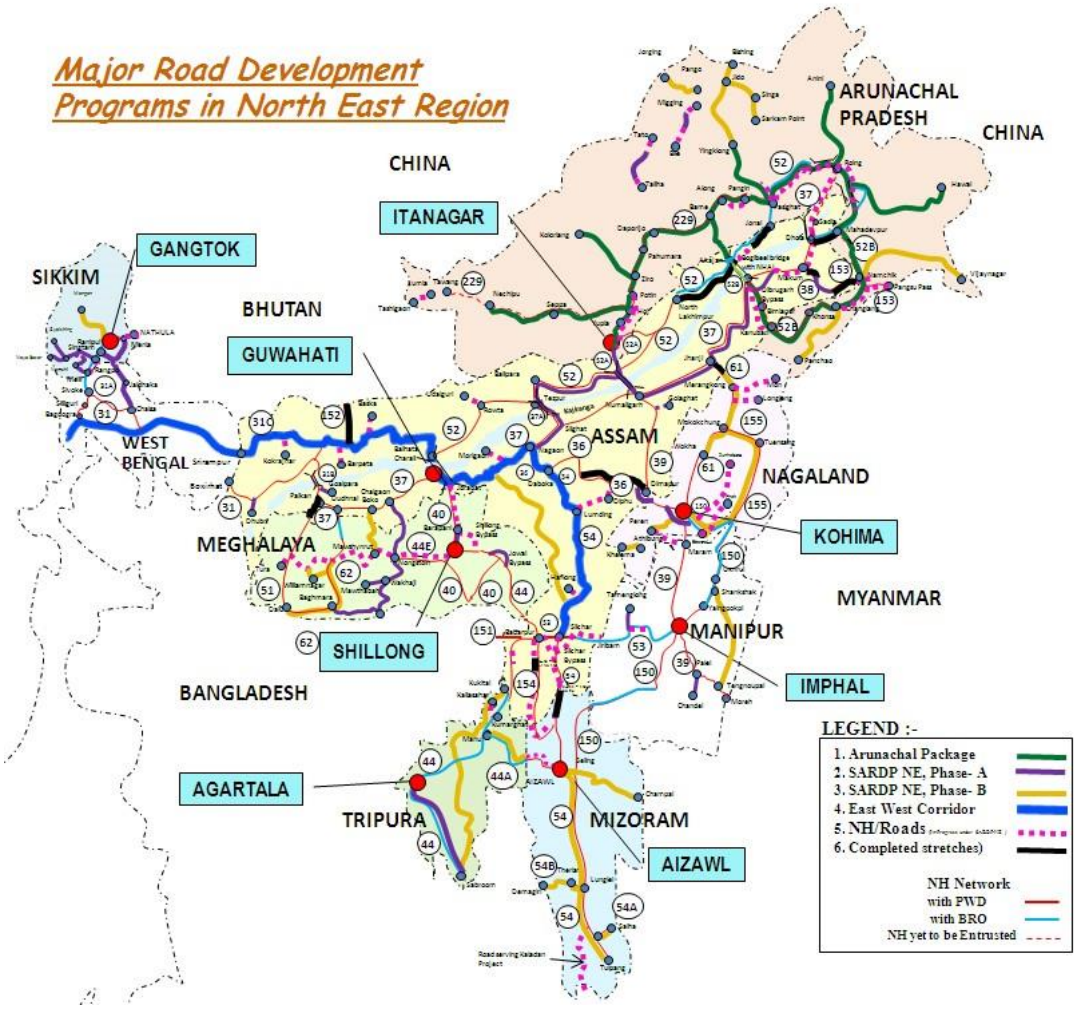
Ministry of Road Transport and Highways has formulated SARDP-NE for enhancing road facilities in the North-East region. Objective of the scheme are upgradation of National Highways connecting State Capitals with 2 or 4 lane roads. Providing connectivity to backward and remote areas of North East region to boost socio-economic development, improving roads of strategic importance in border areas and improving connectivity to neighbouring countries. The scope of the programme has been enlarged from time to time since September 2005.
The SARDP-NE programme has been divided into 3 parts: Phase-A, Arunachal Pradesh Package of Roads and Highways (Arunachal Package), and Phase-B. The details of approvals are as follow:

Table 2-3: Details of NARDP-NE

Phase	Approval for execution		Approved 'in-principle'		Approved for DPR preparation		Total Approved	
	Length (km)	Estimated cost (Rs in crore)	Length (km)	Estimated cost (Rs in crore)	Length (km)	Estimated cost (Rs in crore)	Length (km)	Estimated cost (Rs in crore)
Phase-A	3,213	12,821	886	8,948	-	-	4,099	21,769
Arunachal Package	2,319	11,703	-	-	-	-	2,319	11,703
Phase-B	-	-	-	-	3,723	64	3,723	64
Total	**5,532**	**24,524**	**886**	**8,948**	**3,723**	**64**	**10,141**	**33,536**

Source: Ministry of Development of North Eastern Region (MDoNER, March 2012)

SARDP-NE stagnated for a long time due to the security situation and the lack of implementation capability of executing agencies. In addition, the difficult terrain and delayed land acquisition fell behind the progress. The Modi administration has placed importance on road development in the North-Eastern region and NHIDCL was newly set up under MoRTH in February 2014 to expedite the works. The figure below shows major road development programs in North East Regions.



Source: Ministry of Development of North Eastern Region (MDoNER)

Figure 2-2: Major Road Development Programs in North East Region

(2) National Highway Development Project (NHDP)

The National Highways Development Project (NHDP) has been implemented for the purpose of upgrading, rehabilitating, and widening major highways in India to a higher standard. The project is managed by the National Highway Authorities of India (NHAI) under MoRTH. The NHDP planned a total of 49,260 km of works and constructions of roads and highways to enhance national economic development. The project consists of 7 Phases which were initially planned to be completed in late 2015, but was re-scheduled to finish in early 2018. Subsequently, the unfinished parts of NHDP Project were taken over under a larger Bharatmala Project under the Ministry of Road Transport and Highways. The following table shows the priorities of different Phases of NHDP.

Table 2-4: Priority of different Phases of NHDP

Priority	NHDP Phase	Length (in km)	Present Status	Approval Date	Completion Date
1.	Balance of Phase-I	1,738	Fully awarded	Dec '00	Dec '06
2.	Phase-II	6,736	Award in progress	Dec '03	Dec '09
3.	Phase-III A	4,000	Already identified	Mar '05	Dec '09
4.	Phase-V	6,500	5700 km of GQ 800 km to be identified	Nov '05	Dec '12
5.	Phase-III B	6,000	Already identified	Mar '06	Dec '12
6.	Phase-VII A	Ring roads etc.	To be identified	Dec '06	Dec '12
7.	Phase-IV A	5,000	To be identified	Dec '06	Dec '12
8.	Phase-VII B	Ring roads etc.	To be identified	Dec '07	Dec '13
9.	Phase-VI A	400	Already identified	Dec '07	Dec '14
10.	Phase-IV B	5,000	To be identified	Dec '07	Dec '13
11.	Phase-VII C	Ring roads etc.	To be identified	Dec '08	Dec '14
12.	Phase-VI B	600	To be identified	Dec '08	Dec '15
13.	Phase-IV C	5,000	To be identified	Dec '08	Dec '14
14.	Phase-IV D	5,000	To be identified	Dec '09	Dec '15

Source: The Secretariat for the Committee on Infrastructure

(3) Bharatmala Project

In 2015, Bharatmala Pariyojana (Project), a new umbrella program for the highway sector was established after NHDP reached a certain level of maturity. In order to implement efficiently and effectively, it was necessary to redefine road development and have a macro approach while planning expansion of the national highway network. Therefore, Bharatmala Pariyojana has focused on the new initiatives like development of Border and International connectivity roads, Costal and port connectivity roads, improving efficiency of National Corridors, Economic Corridors, and others. In addition, it has enabled to upgrade the optimizing efficiency of freight and passenger movements across the country by bridging critical infrastructure gaps. The total investment was Rs 535,000 Crore (US$75 billion) for 83,677 km of the new highway constructions. The features of Bharatmala Pariyojana are as follows:

- Improvement in efficiency of existing corridors through development of Multimodal Logistic Parks and elimination of choke point.
- Enhance focus on improving connectivity in North East and leveraging synergies with Inland Waterways.
- Emphasis on use of technology and scientific planning for Project Preparation and Asset Monitoring.
- Delegation of powers to expedite project delivery. Phase-1 to completely by 2022.
- Improvement connectivity in the North East.

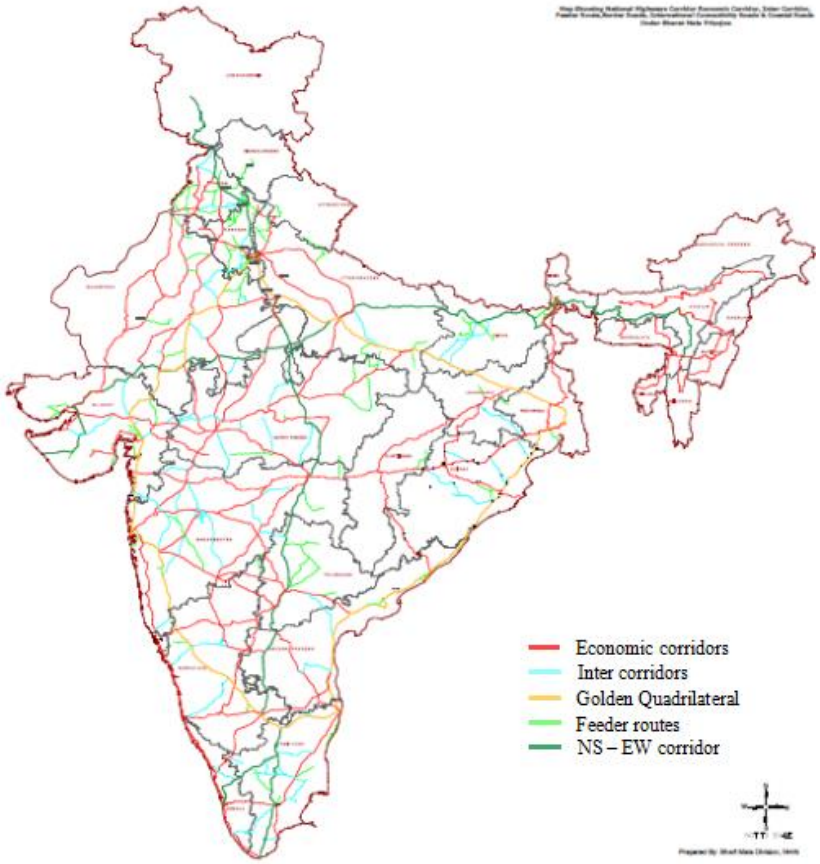
The total length of 34,800 km including 24,800 of new highways and another 10,000km currently under-construction remaining incomplete under NHDP will be constructed in Phase-1 and completed by the end of 2022 as per the initial plan. In addition, the total length of 48,877 km highways will be constructed under Phase-2. After completing Phase-1 of Bharatmala, state road networks will be developed in Phase-2 to comprehensively restructure National Highway Development Project and ensure the National Highway Grid of desirable length.
Under Bharatmala Pariyojana, the total road length of about 5,301km in North Eastern Region have been approved for improvement. Out of this, 3,246km road length has been approved for development of Economic Corridors in the North East[2]. The road network under Bharatmala Project is shown in Figure 2-3. The schemes and estimate costs of Phase-1 is shown in Table 2-5. As of now, Phase-1 is in under construction.

Table 2-5: Schemes and estimate cost of Bharatmala Project Phase-1

Sr. No.	Scheme	Phase-1 Length (km)	Cost (Rs. Crore)
1	Economic Corridors	9,000	120,000
2	Inter-corridor and feeder routes	6,000	80,000
3	National Corridors Efficiency Program	5,000	100,000
4	Border and International connectivity roads	2,000	25,000
5	Coastal and Port connectivity roads	2,000	20,000
6	Expressways	800	40,000
	Sub-total	**24,800**	**385,000**
7	Ongoing Projects, including NHDP	10,000	150,000
	Total	**34,800**	**535,000**

Source: Ministry of Road Transport and Highways

[2] Source: Ministry of Development of North-East Region



Source: Ministry of Road Transport and Highways

Figure 2-3: Road Network under Bharatmala Project

2.2.3 On-going and Planned Road Projects Related to the Survey Roads by International Cooperation

Currently, there are several ongoing and planned road projects in the North-Eastern region funded by international aid agencies.

(1) North East Road Network Connectivity Improvement Project by JICA

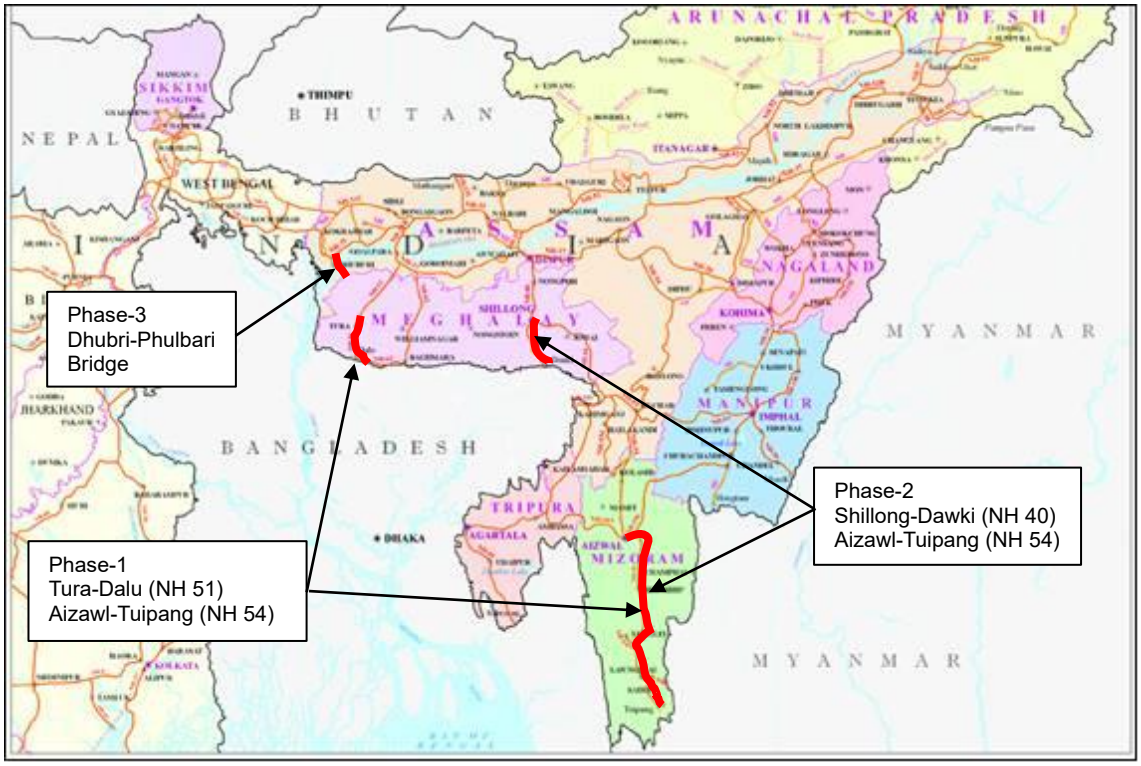
One of the achievements in Joint Statement on Japan and India Vision 2025 issued in 2015 was that ODA loans were provided for the improvement of road network connectivity in north-eastern states of India.

Under these circumstances, the Government of India requested loan assistance to the Government of Japan for the improvement of existing roads, rehabilitation of bridges, and construction of a new bridge. All are National Highways and NHIDCL was considered as the implementing agency. JICA conducted the Preparatory Study for Road Network Improvement in the North-Eastern States and selected priority road sections for Japanese ODA assistance. The descriptions are shown in the below table.

Table 2-6: Road Network Connectivity Improvement Project by JICA

Phase	Date	Description
I	2017 March	Phase 1 focused on improvement of improvement of NH-54 and NH-51 in Mizoram and Meghalaya. NH-54 is located in central Mizoram and the stretch of the targeted section of NH-54 is from Aizawl to Tuipang in Mizoram stretching to 350km. The improvement of NH-54 would enhance the connectivity of the Kaladan Multi Modal Transport Corridor, which connects the northeastern states with the rest of India through Myanmar by roads, inland water transport and marine transport. NH-51 is located in the western part of Meghalaya. The stretch of the targeted section of NH-51 is from Tura to Dalu in Meghalaya with a length of approximately 50km, which connects the Bangladesh border.
2	2018 April	The objective of the Project is to improve the connectivity in North Eastern Region (NER) of India through improving the roads and bridges, thereby promoting regional socio-economic development. The proposal was to construct bypasses for National Highway 40 in Meghalaya and National Highway 54 bypasses in Mizoram, which are the targeted sections in the Project.
3	2018 November	The project involves the construction of a 20 km long two/four-lane bridge (including approach roads of 10 km) connecting Dhubri (on the North Bank) and Phulbari (on the South Bank) with Srirampur on NH-31(C) over the Brahmaputra river in the states of Assam and Meghalaya. It is being implemented by National Highways and Infrastructure Development Corporation Limited on an engineering, procurement and construction basis at an estimated cost of Rs 30 billion. The project, which aims to promote interregional and intra-regional connectivity and boost economic development in the region, is expected to be completed by September 2028.
4	2020 April	The project covers the improvement of the national highway connecting Kailashahar to Kowai in Tripura as well as the construction of a new bypass in Kowai. The average travel time of the target section will be reduced from approximately 205 minutes to approximately 103 minutes, which will lead to expanding the annual average daily traffic, the number of passengers, and the volume of freight. Thus, this project will improve the region's connectivity with other regions, both within and outside the region and country, which is expected to contribute to promoting the economic development in this region.

Source: JICA Survey Team



Source: JICA Study Team

Figure 2-4: Road Network Connectivity Improvement Projects by JICA

(2) Assam State Road Project by the World Bank

The Assam State Roads Project is and Externally Aided Project (EAP) implemented for by the Public Works Roads Department (PWRD) through the Assam State Road Board (ASRB) for improvement of State Highways (SH) and Major District Roads (MDR) in the State. The total project cost is US$ 400 million. It includes US$ 320 loan assistance from the World Bank through the Government of Indi and US$ 80 million Government of Assam State share. The project development objective is to support the Government of Assam to develop and effective, sustainable, and safe state road network to facilitate integration of Assam's economy with rest of India.

The World Bank initiated the Assam State Road Project in 2012, which is planned to continue up to 2019. The project was consisted of 3 components.

1. Road Improvement was conducted for the improvement of priority sections of the secondary roads to improve state connectivity and facilitated regional integration.
2. Road sector modernization and performance enhancement were developed to support implementation of the Road Sector Modernization Program (RSMP) to carry forward and deepen various institutional development initiatives already underway.
3. Road safety management was conducted to support construction of road safety management capacity of related agencies through developing and implementing a multi-sector road safety strategy.

(i) Approval Date (as of board presentation): March 13, 2012
(ii) Closing Date: March 31, 2018, extended until Sep. 2019
(iii) Total Project Cost: US$ 400.00 million

The implementation agency is PWD and 22 packages for improvement and upgradation work, 42 packages for rehabilitation work, and 5 packages for innovative and standardised bridge were sanctioned.

(3) North- Eastern States Roads Investment Program (NESRIP) by ADB

The Government of India has received a loan from the Asian Development Bank (ADB) to finance the cost of implementing the North Eastern States Road Investment Project (NESRIP). NESRIP is a 100% centrally sponsored scheme implemented over a period of 5 years at a revised cost of Rs. 2144.56 crore from the earlier approved cost of Rs. 1353.83 crore for construction/upgradation improvement of 433.7 km long State roads in the North Eastern States of Assam, Manipur, Meghalaya, Mizoram, Sikkim and Tripura along with extension of project period up to August 2022. ADB is providing loan assistance of US$ 200 million in two tranches.

The road survey in the North-Eastern region was conducted in October 2005, which showed that approximately 70 percent roads were poor condition. Then, Detailed Project Report was conducted and submitted in 2008. The Scheme, NESRIP was approved by Cabinet Committee on Economic Affairs (CCEA) in May 2011 to be executed within 5 years.

The main objectives of NESRIP are as follows and the loan details are shown in the table below.

- Increase access within the NER states; aims to improve about 430 km of priority road sections in the six states (vis. Assam, Manipur, Meghalaya, Mizoram, Sikkim and Tripura) in the North Eastern Region (NER) of India.
- Increase access between the NER states and the rest of India and other countries.
- Provide capacity building support to improve management and institutional strengthening.
- Improve road management systems.
- Improve road safety
- Improve environmental and social impact assessments and management practices

Table 2-7: North-Eastern States Roads Investment Program (NESRIP) by ADB

			From	To	Length (km)	Previous Construction Cost (in Crore of Rs.)	Revised Construction Cost (in Crore of Rs.)
Tranche-1	Assam	1	Bilasipara, Dhubri Dist.	Fakiragram (NH 31), Kokrajhar Dist.	16.2	113.77	149.67
		2	Barpeta, Barpeta Dist.	Kalitakuchi, Kamrup Dist.	58.5		
	Meghalaya	3	Grobada, West Garo Hills Dist.	Dalu (NH-51) West Garo Hills	93.4	147.47	187.82
	Sikkim	4	Melli (NH-31), South Sikkim	Nayabazar, South Dist.	9.5	62.92	121.22
		5	Nayabazar, South Sikkim	Namchi, South Sikkim	19.7		
Tranche-2	Assam	6	Tamulpur	Paneri	43	233.13	323.01
		7	Paneri	Udalguri	18.6		
		8	5 Major Bridges		1.08		
	Manipur	9	Tupul (NH-53) Tamenglong Dist.	Bishnupur (NH-150), Bishnupur Dist.	50.8	209.7	388.04
		9a	Thoubal (NH-39), Thoubal Dist.	KasomKhullen, Ukhrul Dist.	47.0125		
	Mizoram	10	Serchhip (NH-45), Serchhip Dist.	Buarpui, Lunglei Dist.	55	123.07	213.57
	Tripura	11	Udaipur (NH-44), South Tripura	Melaghar, West Tripura	20.3	47.01	91.97
Sub-total (Tranche-1)					197.3	324.16	458.71
Sub-total (Tranche-2)					236.01	602.91	1,016.59
Total (Tranche-1 + Tranche-2)					**433.31**	**927.07**	**1,475.30**

Source: JICA Survey Team base on MDoNER

(4) North East Road Sector Development Scheme (NERSDS)

The objectives of the North East Road Sector Development Scheme (NERDS) is to take up rehabilitation/construction of following category of roads (including bridges on the roads) in the North Eastern Region (NER) in order of priority.[3]

(i) Inter-state roads previously built by the North Eastern Council (NEC) and other agencies which are of vital connectivity for one state, but of little importance for the other state and hence remained neglected but with available formation width of roads;
(ii) Roads in socio-politically neglected pockets of NER;
(iii) Roads required for security of strategic viewpoint, not covered in any other programmes; and
(iv) Roads necessary from the viewpoint of market access for agriculture produce and roads of economic importance on fap filling approach

NERSDS was launched during the Financial Year 2015-2016. Three (3) roads were identified and entrusted to National Highways & Infrastructure Development Corporation Limited (NHIDCL) for implementation. The Detailed Project Report (DPR) for the three roads was finalized before taking up the work. The works have since been awarded and are at stages of implementation. The scheme has already been taken up for extension beyond March, 2017 till March, 2020.

[3] Source: Guidelines for administration of north east road sector development scheme (NERDS) https://mdoner.gov.in/dashboard/files/NERSDS.pdf

2.2.4 Other Related Project

North East Special Infrastructure Development Scheme (NESIDS) has been approved by the Government of India as a new Central Sector Scheme on December 15, 2017. Under the scheme guidelines of NESIDS, 100% centrally funding is provided to the State Governments of North Eastern Region for the projects of physical infrastructure relating to water supply, power and connectivity enhancing tourism and social infrastructure relating to primary and secondary sectors of education and health.

The period of Scheme is 2017-18 to 2019-20. The funds are related in two instalments of 40% and 60%, initially a token amount of Rs. 10 lakh are released and balanced amount of first instalment are released after receipt of letter of award of the work. The following list show the NESIDS for ongoing road and bridge projects in Assam.

Table 2-8: List of ongoing road and bridge projects under NESIDS in Assam

Project name	Date of sanction	Approved cost (Rs. In crore)	Total funds released (Rs. In crore)
Construction of Double Lane Road from Lanka to Umrangso via Diyungmukh, Haflong Tinali and Panimur	3-Sep-19	188.79	67.65
Construction of RCC Bridge No. 3/1 over River Dikhow at Chiripuria Ghat along with road from Chiripuria via Ajanpeer Dorgarh road to NH 37 in Assam	14-Aug-19	17.99	6.76
Construction of RCC Bridge over river Aie at Aie Powali including approach & protection work in Chirang District	14-Feb-19	69.74	27.90
Construction of three lane road over bridge at Jorhat in replacement of Railway LC gate No St-58 on Naali, Jorhat District in Assam during 2018-19	30-Aug-18	67.76	27.10

Note: Ongoing status on July 31, 2020
Source: JICA Survey Team base on MDoNER

2.3 Socio-Economic Conditions

2.3.1 Overview of Survey Areas

The three states covered under this Survey are Assam, Meghalaya, and Tripura. These Survey areas are in the North-Eastern region of India, connected to the mainland with only a narrow strip of land known as the “Chicken’s neck”. Assam, Meghalaya, and Tripura make up three of the popular “Seven Sister” States of India.

Within the North-Eastern region, Assam, Meghalaya, and Tripura are three of the most populated states making up around 84% of the total population while covering approximately 44% of the total North-Eastern region as shown in Table 2-9.

Table 2-9: Population and Area of "Seven Sister" States

North Eastern States	Population (Census 2011)	Population (% share)	Area (Sq. km)	Area (% share)
Arunachal Pradesh	1,382,611	3.07%	83,743	32.83%
Assam	31,169,272	69.30%	78,438	30.75%
Manipur	2,721,756	6.59%	22,327	8.79%
Meghalaya	2,964,001	6.05%	22,429	8.75%
Mizoram	1,091,014	2.43%	21,081	8.26%
Nagaland	1,980,602	4.40%	16,579	6.50%
Tripura	3,671,032	8.16%	10,486	4.11%
TOTAL	**44,980,288**	**100%**	**255,083**	**100%**

Source: Ministry of Development of North Eastern Region

In terms of geographical location, Assam, Meghalaya, and Tripura are of significant importance as these states share borders with Bangladesh, together making up around 40% of the total Indo-Bangladesh border. Among the three, Assam also plays an integral role as the sole gateway connecting North-Eastern India to Mainland India.

Thus, NH127B (Srirampur-Dhubri, Assam and Fakirganj-Tura, Meghalaya), which aims to establish a more efficient connection between Assam and Meghalaya, along with NH208 (Khowai-Sabroom), which would pave way to better connect Bangladesh's biggest port (Chittagong Port) with rest of the North-Eastern region, hold considerable promise for future development of the region.

The main districts within Assam, Meghalaya, and Tripura directly linked to the Survey Corridors are briefly summarised in Table 2-10 and shown in Figure 2-5.

Table 2-10: Districts Directly Linked to the Survey Corridors

Survey Areas	Main Districts	Description
Srirampur-Dhubri , Assam[1]	Dhubri	The Dhubri District shares *intra-state* borders with Goalpara and Bogaigaon districts in the east, Kokrajhar district in the north, and South Salmara-Mankachar district in the south. All these districts are part of the Lower Assam Division which has *inter-state* connections with West Bengal in the west and Meghalaya in the South across the mighty Brahmaputra River. Dubri also shares international borders with Bangladesh in the west. The Dhubri District has a population of almost 2 million and covers an area of 2,176 sq. km. It has one of the highest population densities within Assam with 896 persons per sq. km.
	Kokrajhar	The Kokrajhar District is to the north of Dhubri and has the Chirang District to its east. It shares an inter-state border with West Bengal in the west and an international border of around 88 kms with Bhutan in the north. Kokrajhar covers an area of 3,169 sq. km within Assam and hosts a population of under 1 million.
Fakirganj-Tura, Meghalaya[2]	West Garo Hills	West Garo Hills is located in the western part of the Meghalaya state. It shares intra-state boundaries with East Garo Hills in the east and South Garo Hills in the south-east. West Garo Hills borders the Goalpara district of Assam in the north and north-east and also shares an international border with Bangladesh in the south. West Garo Hills spans across 3,677 sq. km and hosts a population of approx. 471,000.

Survey Areas	Main Districts	Description
Teliamura-Sabroom, Tripura[3]	West Tripura (Khowai & Gomati)	Khowai and Gomati are located on the eastern stretch of the West Tripura District. Khowai is to the north of Gomati and Gomati is connected to South Tripura to its south. The Khowai district shares a border with Bangladesh to its north. Gomati has an area of 1522.8 sq. km. with a population of around 441,500. Khowai is comparatively smaller with an area of 1377.28 sq. km. with a population of approx. 327,600.
	South Tripura	South Tripura is the southern-most tip of the Tripura State. To its north is the West Tripura District and to its south, it shares an international border with Bangladesh. South Tripura covers an area of around 1514 sq. km and has a population of approx. 453,000.

Note: Demographic data as per 2011 Census.
Source: Official websites of: [1]Government of Assam, [2] West Garo Hills, State of Meghalaya, [3] South Tripura District, Gomati District, and Khowai District.

Source: JICA Survey Team

Figure 2-5: Survey Corridor Districts in North-Eastern India

The following sections of this chapter will elaborate on the geographical and socio-economic conditions of Assam, with as much focus as possible on the two main target districts listed above in Table 2-10.

2.3.2 Geographical Conditions in Assam

(1) Physiography

Assam covers an area of 78,438 sq. km., which makes up approx. 30% of the total North-East India region and around 2.4% of the total area of India. Assam is composed of three physiographic divisions, namely, the Brahmaputra Valley at the foot of the Himalaya Range in the north, the Central Assam ranges of Karbi-Anglong and North-Cachar Hills in the middle, and the Barak Valley in the south of Assam.

Nonetheless, Assam is often simply categorized into two regions of Brahmaputra Valley and Barak Valley. The Dhubri and Kokrajhar districts are part of the Brahmaputra Valley - or more specifically, Western Brahmaputra Valley.

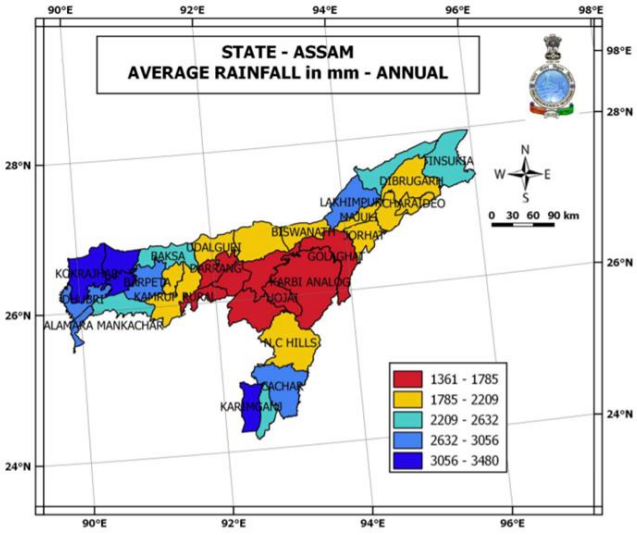
Brahmaputra Valley and Barak Valley both derive their names from the respective rivers flowing in the region, namely, Brahmaputra and Barak rivers. The presence of these two major rivers, along with its many tributaries passing through the valleys, make Brahmaputra Valley and Barak Valley vulnerable to monsoon floods.

(2) Climate

Assam mainly has three seasons of Monsoon, Summer, and Winter. The temperature in summers ranges from 25° Celsius to 40° Celsius while in winters it ranges from 10° Celsius to 25° Celsius. Humidity remains high (usually over 60%) throughout the year.

Assam, in general, experiences heavy rainfall (approx. 2,077.8 mm on average in 2015[4]), especially during Monsoon season (Jun-Sept). In particular, the Survey Corridor districts of Dhubri and Kokrajhar experience an average annual rainfall of approx. 2,688.9 mm and 3,400.5 mm[5], respectively, which is higher than the state average, as evident from Figure 2-4.

In spite of the seasonal flooding, Dhubri and Kokrajhar, much like the rest of Brahmaputra Valley is one of the richest biodiversity zones of the world. The geographical disposition also makes it rich in natural resources, namely, agricultural, water, forest, and mineral.



Source: India Meteorological Department

Figure 2-6: Average Annual Rainfall in Assam

2.3.3 Socio- Economic Conditions in Assam

(1) Demographics

Assam is an integral state within the North-Eastern region, not just due to its geographical disposition, but also because almost 70% of the total population of North-East India live in Assam.

While the general population within Assam is relatively disbursed within the state, Dhubri is still one of the most populated districts with a population density of 896 per Sq. Km., clearly much higher than the state average of 398 per Sq. Km. as shown in Table 2-11**.** Compared to Dhubri, Kokrajhar has half the population size with a much lower population density of 280 per Sq. Km.

In Assam, around 86% of the population live in rural areas. Similarly, within the Dhubri district, 90% of the population live in rural areas. The percentage is even higher for Kokrajhar district which has as much as 94% of rural population (based on 2011 Census). However, if Assam's rural population growth rate between 2001-2011 is compared with that of urban population growth rate (15.47% and 27.89%, respectively), it appears that urban population is growing at a higher rate.

[4] "Assam at a Glace", 2016, Directorate of Economics and Statistics, Government of Assam
[5] Average over the years of 2008-2015 based on data collected by India Mereological Department

Furthermore, with regards to gender disparity, as shown in Table 2-11, despite the proportionate population distribution, gender gap is evident from the comparatively lower literacy rates among women in both the districts as well as Assam as a whole.

Table 2-11: Demographics of Assam (Census 2011)

Area	Population	Area (Sq. Km.)	Population Density	Literacy Rate (%)
Assam[1]	Total: 31,205,576 *Male: 15,939,443* *Female: 15,266,133*	78,438	398 per Sq. Km.	Total: 72.19% *Male: 77.85%* *Female: 66.27%*
Dhubri District[2]	Total: 1,949,258 *Male: 997,848* *Female: 951,410*	2,176	896 per Sq. Km.	Total: 58.34% *Male: 63.10%* *Female: 53.33%*
Kokrajhar District[3]	Total: 886,999 *Male: 452,965* *Female: 434,034*	3,169	280 per Sq. Km.	Total: 66.63% *Male: 73.44%* *Female: 59.54%*

Source: [1]Official State Portal of Assam, [2]Official Website of Government of Assam-Dhubri District, [3]Official Website of Kokrajhar

(2) Economy and Sectoral Distribution

The Gross State Domestic Product (GSDP) of Assam, estimated for 2020-21, is Rs. 409,000 Crore[6]. Between 2011-12 and 2020-21, Assam's annual Compound annual growth rate (CAGR) was 12.36%.

Per Capita Net State Domestic Product (NSDP) for Assam for 2016-17 was Rs. 64,680 which is comparably much lower than the national average of Rs. 103,219 for the same year[7]. Between the period of 2011-12 and 2016-17, per capita NSDP for Assam has grown by approx. 9.47% , however, it still remains much lower than the overall average in India.

The sectoral contribution to Gross State Value Added (GSVA) is shown in Table 2-12 below:

Table 2-12: Sectoral Contribution to GSVA (%) of Assam

Sector	2011-12	2017-18
Primary/Agriculture (and allied activities)	31.88%	28.79%
Secondary/Industry	21.59%	23.37%
Tertiary/Services	46.53%	47.83%

Source: India Brand Equity Foundation

Despite the comparatively decreasing contribution of the agricultural sector to GSDP, the sector remains the most important as Assam's economy is primarily rural in nature and livelihood of 70% of its population is directly dependent on agriculture. This is especially true for the two Survey Corridor districts of Dhubri and Kokrajhar where economy is primarily dependent on agriculture and forest products.

[6] According to India Brand Equity Foundation, an initiative of the Ministry of Commerce & Industry, Government of India

[7] Ministry of Statistics and Programme Implementation, Government of India

2.4 Industrial Development

2.4.1 Overview of Industrial Development in Survey Area

Essentially, the three states are primarily known for its horticulture and agricultural. Assam is particularly renowned for its tea production that makes up 50% of India's overall tea production and captures one-seventh of global tea production having the largest tea growing area in the world.

Apart from tea production in Assam, Meghalaya and Tripura are also known for its agro-food production and forestry. For instance, turmeric produced in Meghalaya is recognized for its high quality while Tripura ranks as the fourth largest producers of natural rubber in India. All states also have vast reserves of minerals and natural gas.

Sericulture, an agriculture allied activity, is also one of the key sectors in Assam and provides employment to a large share of the rural population given its labour-intensive nature of work. Assam has global monopoly in Muga Silk production and also makes up 65% of the overall country's Eri Silk production. As noted under the Handloom policy discussed under 'Advantage Assam'- the Assam Global Investors' Summit, along with Muga Silk, Eri Silk has great potential to be further popularized, especially with the rise of ethical consumerism, as it is a non-violent silk, which means the insects are not killed for the production of the silk.

Advantage Assam (2018), along with other industrial development and investment initiatives and schemes, such as North Eastern Region Vision 2020, Meghalaya Vision 2030, Tripura Industrial Investment Promotion Incentives Scheme (2017), recognize and emphasize the importance of harnessing the potentials of agricultural and agriculture-allied activities within the target states. Furthermore, provided that the region is rich in natural resources such as minerals, herbal plants, and natural gas, industrial development also largely depends on effective utilization of these resources. Some of the "thrust" sectors where investments are directed to drive industrial growth include:

- Agro-food processing and horticulture-based industries
- Herbal plants and forestry related industries, particularly Bamboo and Rubber
- Handloom textile industries, particularly silk
- Mineral based industries
- Hospitality and Tourism industries
- IT related services

The target districts along the Survey Corridors in Assam, Meghalaya, and Tripura share a common characteristic of having a predominant agrarian sector which supports the livelihood of majority of the population within the districts. There are micro and small enterprises which operate within the districts, but supply or production is rather limited.

2.4.2 Current Status of Existing Industries and Planned Development in Assam

As mentioned previously, the Survey Corridor in Assam passes through the Dhubri and Kokrajhar districts. These districts are primarily rural with only micro and small enterprises as most industrial areas/parks are located near Goalpara and Guwahati. Nonetheless, the Survey Corridor districts are gateway to eastern and south-eastern Assam where such industries lie. Dhubri is also in a strategic position to facilitate and benefit from cross-border trade between India and Bangladesh if access to the district is improved.

(1) Dhubri District

According to the Ministry of Industries and Commerce, Government of India, within the Dhubri district there are currently no large-scale industries or medium scale enterprises within the district. However, there are a number of Micro and Small Enterprises which produce agro-based products, textile and garments, jewelry, crafts, mineral-based products, and metal-based products, and that provide services such as repairing, and printing.

There are two manufacturing clusters which are:

(i) Terracotta Cluster at Asharinkandi – produce crafts and pottery.
(ii) Jute Cluster at Bagulamari – produce jute products such as bags, carpets, table mat, etc.

Apart from the above, the district also has an Industrial Estate at Gauripur, however, it is currently occupied by Central Reserve Police Force.

Provided that the Dhubri district shares a border with Northern Bangladesh, a Border Trade Centre (BTC) at Golokganj is currently under construction as an initiative of Assam Industrial Development Corporation (AIDC). This BTC is 9.5 km from the intersection of NH31 and the Survey Corridor NH127B and 21.4 km away from the main Dhubri Town. Similarly, there is also another Border Trade Centre at Mankachar also constructed by AIDC. BTC, Mankachar is approx. 47 km away from Survey Corridor at Tura, Meghalaya. Furthermore, under the provision of Rural Infrastructure Development Fund (RIDF), there is a Marketing Infrastructure, Raniganj which is under construction. Once completed, the facility is anticipated to help promote and market agricultural products.

(2) Kokrajhar District

The Kokrajhar district is known for its reserved forest area which covers 55% of its total geographic area. A part of the Chakrasila Wildlife Sanctuary lies within the district boundaries and is home to the golden langur, which is one of the most endangered species of India.

Due to limited cultivable land, the micro and small enterprises that exist are involved in the production of garments and silk clothing and metal-based projects. Other enterprises are in the service sector. Moreover, under the initiative of AIDC known as the Micro & Small Enterprises - Cluster Development Programme (MSE-CDP), there is an Integrated Infrastructural Development (IID) Scheme underway in Serfanguri, which is approx. 41 km away from the intersection between NH31C and the Survey Corridor at Srirampur.

2.4.3 Impact of Survey Corridors on Future Industrial Development

(1) Overview

While there are regional as well as state level initiatives and policies to boost industrial development within the North Eastern Region, one of the main bottlenecks for hindered industrial growth and expansion in the region has been the lack of inter-regional and inter-state connectivity to overcome its innate characteristic of geographical isolation.

Isolation from Mainland India and lack of connectivity generate several supply-side issues which include limited marketing links, high costs associated with transportation of goods, inability to produce and deliver large orders in time, and operational inefficiency due to lack of access to required resources for production.

As noted in the above section, the target Survey districts within Assam, Meghalaya, and Tripura comprise a rural population whose source of livelihood is primarily through agro-based products, handloom, and hand-made crafts, as well as products based on minerals and metals that are abundantly present in the region.

Despite the hinderances caused due to its geographic disposition, what makes the North Eastern Region unique is also its location. The region shares 98% of its borders with neighboring countries of Bangladesh, Myanmar, Bhutan, and China. The target states of Assam, Meghalaya, and Tripura share its international land borders with Bangladesh. Resultantly, one of the promising means to accelerate as well as promote further industrial development in the target regions is to improve transport infrastructure, primarily roads, which facilitate increase in foreign trade with Bangladesh. It is worth noting that trade between North Eastern India and Bangladesh have long existed, with Bangladesh importing raw resources and in return exporting finished goods. However, such resource-industry trade is often carried out through means of informal trade among individuals living in regions close to land borders while formal trade remains limited due to high logistic costs.

(2) NH127B (Assam)

One of the key infrastructural developments which would substantially promote industrial development within the Survey Corridor districts is the construction of Dhubri bridge. This bridge, which connects Dhubri on the North Bank of the Brahmaputra river with Phulbari on the South Bank, is expected to minimize travel distance between Assam and Meghalaya from roughly 205 km to 19 km, decreasing travel time from 5 hours to only 20 minutes[8].

This Dhubri bridge construction along with the improvement of the Survey Corridor NH127B, would pave way for increase in formal border trade with Bangladesh by increasing accessibility to existing LCSs in Mankachar and Golokganj. It would help establish better marketing linkages for the small and medium enterprises operating in the nearby districts and promote more resource-industry trade, resultantly, adding momentum to the industrial development plans laid out under at the Global Investment Summit in Assam (Advantage Assam).

For instance, the Handloom policy implemented in Assam aims to expand the handloom textile industry given that the sector generates employment for a large number of people, especially women, within the rural areas. There are skilled weavers and artisans within the Survey Corridor and nearby districts and Assam is globally recognized for its silk and jute production. However, some of the biggest hurdles faced by them include inability to supply large orders (primarily raw items) in a timely and cost-effective manner, inability to generate demand beyond their locality or understand the latest market trends due to lack of access to markets, and most importantly, difficulty acquiring materials required to make products such as yarn. Through improved border trade, it would become easy to import products like yarn from Bangladesh and export products like silk, jute, and other raw materials from Assam.

Furthermore, increase in accessibility to LCS Mankachar and LCS Golokganj would not only promote industrial development in nearby districts with small to medium scale enterprises but also enhance logistic efficiency in areas such as Bongaingaon, Goalpara, and Guwahati where large-scale industrial parks exist.

[8] https://www.business-standard.com/article/news-cm/cabinet-approves-dhubri-phulbari-four-lane-bridge-construction-over-river-brahmaputra-119030100396_1.html

Table 2-13 shows the main location points for trade within Assam. It should be noted that ICD, Guwahati is predominantly used for single-direction transportation of tea from Guhawati to Kolkata port[9]. So, the actively used trade point is LCS Sutarkandi in the Karimganj district.

Table 2-13: Assam Trade Points

Sl	States & LCS/ICD etc	2012-13		2013-14		2014-15	
		Export (in Cr)	Import (in Cr)	Export (in Cr)	Import (in Cr)	Export (in Cr)	Import (in Cr)
1	LCS: Mankachar, Dhubri	0.56	2.75	0.68	2.12	4.17	0.31
2	LCS: Golokganj , Dhubri	0	0	0	0	24.8	0
3	LCS: Karimganj steamer & Ferry station, Karimganj	5.71	0.19	2.93	0	8.52	0
4	LCS: Sutarkandi, Karimganj	45.11	54.18	37.44	15.96	50.62	85.09
5	Bonded Warehouse, Guwahati	0	2.58	0	0	0	0
6	Inland Container Depot (ICD): Amingaon, Guwahati	599.9	3.88	771.06	0	313.56	32.34
7	LGB International Airport: Cargo, Guwahati	0	8.95	0	0	0	1.07
	Total	**651.28**	**72.53**	**812.11**	**18.08**	**401.67**	**118.81**

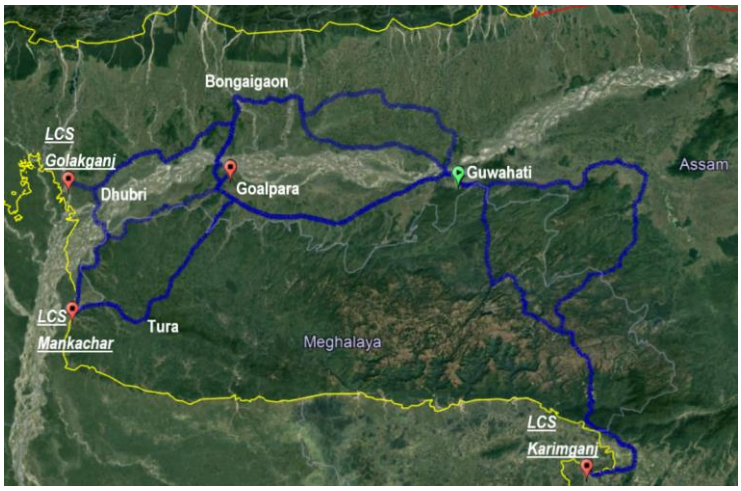
Source: Industries & Commerce, Government of Assam

When comparing the distance between the main industrial districts and the existing LCSs as summarized in Table 2-14 and shown in Figure 2-7, it is evident LCS Golokganj and LCS Mankachar are closer in proximity. With the construction of Dhubri bridge and improvement of the Survey Corridor NH127B, the distance would further decrease.

Table 2-14: Assam Trade Points

	LCS Karimganj	LCS Golokganj	LCS Mankachar
Guwahati	310 km ~ 415 km	270 km	260 km ~370 km*
Goalpara	450 km ~ 500 km*	140 km	160 km ~200 km*

* if passing through route via Bongaigaon
Source: JICA Survey Team



Source: JICA Survey Team

Figure 2-7 Access Routes to Land Custom Stations for Border Trade with Bangladesh

[9] https://www.thehindubusinessline.com/economy/logistics/container-throughput-at-amingaon-icd-likely-to-stay-at-last-years-level/article23093133.ece/amp/

Therefore, promoting border trade would be key to industrial development of Assam as a result of increased international demand, lower time and cost associated with transportation of goods, better access to resources required for expansion of industrial production, and so forth, in line with bilateral trade initiatives such as Indo-Sri Lankan Free Trade Agreement and the aims of enhancing Assam-Bangladesh collaboration as outlined at the Global Investment Summit in Assam (Advantage Assam).

2.5 Cross-Border Logistics Issues/Barriers, Developments, and Recommended Next Steps

2.5.1 Subject Area

The Preparatory Survey for the North East Road Network Connectivity Improvement Project (National Highways 208 and 127B) is covering three highways: (i) NH 208, Khowai-Sabroom, Tripura; (ii) NH 127B, Srirampur-Dhubri, Assam; and (iii) NH 127B, Fakirganji-Tura, Meghalaya. It is (ii) that is the subject of this feasibility study.[10]

2.5.2 Analysis of the Current Situation and Recent Developments

Analysis of the current situation and recent developments related to cross-border logistics in the subject area (which have suppressed regional trade) include the following:

(i) Cross-border movements to/from Bangladesh have generally not been possible due to a lack of trade and transport facilitation arrangements, and therefore cargo from the corridor (as well as Bhutan and Nepal) has had to go through the Chicken's Neck,[11] all the way to Kolkata (or other mainland India ports), 1,700+ km away. However, movements between India and Bhutan are considered "hassle-free".[12]

(ii) For reference, with relation to Bangladesh, the "notified" Golokganj (Assam) LCS[13] is about 22 km (40 minutes) from Dhubri, and the functional Mankachar (Assam) LCS is about 77 km (3 hours and 15 minutes) from Dhubri; with relation to Bhutan, the Jaigaon, West Bengal (India)/Phuentsholing (Bhutan) border point[14] is about 96 km (2 hours) from Srirampur (Assam).[15]

(iii) Restrictions on cross-border transport between India and Bangladesh (e.g., required transshipment at the border) may be addressed by signed and planned international agreements aimed at relieving existing constraints.

   (a) Following a 6 June 2015 bilateral memorandum of understanding, on 25 October 2018, the Ministry of Shipping, Road Transport and Highways, India, and the Ministry of Shipping, Bangladesh signed an agreement to allow the

[10] **Of the subject highways, cross-border logistics are most relevant regarding (i), i.e., NH 208, Khowai-Sabroom, Tripura, between India and Bangladesh, through Sabroom (India)-Ramgarh, Bangladesh). This will be covered in a companion feasibility study report prepared under the preparatory survey,**

[11] The Chicken's Neck is a narrow stretch of land of about 22 km width, located in West Bengal and connecting India's North East with the rest of India, with Nepal and Bangladesh lying on either side of the corridor.

[12] C. E. Testing Company Pvt. Ltd., *NH-127B, Final Detailed Project Report*, Volume I, March 2020, p. 46.

[13] The Golokganj LCS has been listed as "nonfunctional"; it has been mentioned as an LCS only for the purpose of the export of stone boulders, stone chips, and coal from India. https://industries.assam.gov.in/portlet-innerpage/exportable-items-and-border-infrastructure. A Border Trade Centre was opened there in 2015. Generally, immigration and customs facilities at an LCS are rudimentary compared to those at an integrated check post (ICP).

[14] The Land Ports Authority of India has proposed development of an ICP at Jaigaon, which currently is an LCS.

[15] In addition, the distance from Dhubri to Baliyamari Border Haat India-Bangladesh Joint Market is about 90 km. A border *haat* is a maketplace organized by the adjoining countries 1-2 days a week.

transport of goods between Chattogram (Chittagong)[16] Port (and Mongla Port) and India.[17]

(b) The Bangladesh-Bhutan-India-Nepal (BBIN) and Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC)[18] Motor Vehicles Agreements (MVAs) for the Regulation of Passenger, Personal and Cargo Vehicular Traffic are proceeding toward implementation. Under these agreements, approved vehicles would be permitted to enter member states under certain terms and conditions that would reduce transport costs and promote the development of transit and multimodal transport facilities that will increase connectivity and interregional trade (e.g., multiple entry visas would be issued to crew members, *octroi* or local taxes would not be levied unless they are also charged vehicles from the host country, temporary admission of vehicles would be permitted free of customs duties, international road signs and signals would be provided, transport operators would be permitted to open business branches and bank accounts in the neighboring member states). The BBIN MVA was signed by the four states in June 2015 and subsequently ratified by three of the states, although Bhutan has not yet been able to proceed with ratification due to environmental concerns by stakeholders; in the interim, with Bhutan's consent, Bangladesh, India, and Nepal are proceeding toward implementation, having discussed a draft enabling memorandum of understanding and passenger and cargo protocols, in February 2020. The BIMSTEC MVA is still under negotiation, with some states hesitant to move forward. The following box presents the structure of the BBIN MVA.[19] Installation of a tracking system on motor vehicles as well as containers at the cost of the entering vehicle/container is to be introduced for the implementation of the agreement (as per Article III).

(iv) Bangladesh generally imposes restrictions on imports from India, although in December 2019 Bangladesh withdrew import restrictions on nine items from Tripura State.

(iv) A number of constraints are to be addressed in the Master Plan for Transport Connectivity in the BIMSTEC Region, which is at an advanced draft stage; it is to be considered at a virtual meeting of the BIMSTEC Transport Connectivity Working Group in the third quarter of 2020. The plan includes a number of relevant projects, both ongoing and planned, such as development of automated clearance systems and development of advanced logistics (2018-2028), and training in trade facilitation and border management (2018-2028).

[16] Chattogram is the new official name for what was called Chittagong; the new name is closer to the Bangla pronunciation. However, the old name is used for certain proper nouns such as the Chittagong Port Authority and the Chittagong Hill Tracts.

[17] Later developments have included (i) signing of standard operating procedure(s) outlining how goods are to be moved, along which routes, and over what time period, on 5 October 2019; (ii) commencement of transshipment after trial runs in January 2020; and (iii) offering by the Chittagong Port Authority to India of space for cargo handling on a priority basis (although not dedicated space) and priority cargo handling, in 2020. However, agreement still needs to be reached on the administrative fees charged by Bangladesh under this arrangement, and in the longer term Chattogram Port will require significant efficiency and capacity improvements if it is to serve this increased traffic.

[18] The BIMSTEC Member States are Bangladesh, Bhutan, India, Myanmar, Nepal, Thailand, and Sri Lanka.

[19] Pritam Banerjee, *Bangladesh-Bhutan-India-Nepal Motor Vehicles Agreement: Unlocking the Potential for Vibrant Regional Road Freight Connectivity*, CUTS [Consumer Unity and Trust Society] International, July 2015, offered a number of suggestions for improving the BBIN MVA, e.g., independent and periodic authorization of trucks, removal of the requirement for journey-wise permits for authorized trucks driven by authorized drivers, provision of flexibility for changing drivers at the border. Other issues include the lack of mutual recognition of cargo insurance and limitation of use of the agreement for containerized cargo (a limitation that favors larger operators). Bipul Chatterjee and Arnab Ganguly, "Time to Implement the BBIN Motor Vehicles Agreement", *The Economic Times*, 12 February 2020.

Structure of the Bangladesh-Bhutan-India-Myanmar Motor Vehicles Agreement, 2015

Article I:	Definitions
Article II:	Vehicles
Article III:	Permit[s]
Article IV:	Documents Required
Article V:	Passport[s] and Visa[s]
Article VI:	Restrictions
Article VII:	Fees and Charges
Article VIII:	Road Signs and Signals – Compliance with Traffic Laws
Article IX:	Force Majeure
Article X:	Right to Inspect and Search
Article XI:	Insurance
Article XII:	Business Facilitation
Article XIII:	Consultations
Article XIV:	Applicability of Local Laws
Article XV:	Dispute Settlement, Entry and Withdrawal
Article XVI:	Entry into Force, Amendments and Review Mechanism
Article XVII:	Depository
Forms and Annexures	

Source: Motor Vehicles Agreement for the Regulation of Passenger, Personal and Cargo Vehicular Traffic between Bangladesh, Bhutan, India, and Nepal (June 2015)

2.5.3 Recommended Next Steps

Recommended next steps include the following:

(i) The status of the LCS at Golokganj should be upgraded and functionality provided; in addition, the LCS at Mankachar should be improved. Also, the planned ICP at Jaigaon should be developed, e.g., with warehouses, container transshipment facilities, parking, and airport-like immigration facilities.

(ii) The agreement to allow the transport of goods between Chattogram (Chittagong) Port and India should be implemented, and include additional routes.

(iii) The BBIN MVA should be implemented by Bangladesh and India (as well as Nepal), in 2020.[20] Electronic cargo tracking systems should be installed, as per Article III of the MVA.

(iv) A free trade agreement should be developed between India and Bangladesh, perhaps similar to the India-Sri Lanka Free Trade Agreement,[21] to increase bilateral trade along land routes in North East India. In the interim, Bangladesh may consider removing import restrictions in the region, as it has for nine items from Tripura State.[22]

(v) The relevant projects from the BIMSTEC Transport Connectivity Master Plan should be implemented following their planned timescales.

[20] In October 2019, H.E. Sheik Hasina, Prime Minister, Bangladesh, called for early operationalization of the BBIN MVA, even without Bhutan's participation. "Bangladesh PM calls for Operationalizing BBIN Motor Vehicle Agreement with India and Nepal", *DD News*, 27 October 2019.
[21] See, e.g., Bikash Singh, "Initiate a Bilateral Trade Agreement with Bangladesh in Line with the Indo-Sri Lankan FTA: Assam Industry Minister", *The Economic Times*, 12 September 2019.
[22] The nine items on which import restrictions were removed (as of 1 December 2019) were cashew nuts, paper, sugar, generators, broken glass, chocolate, baby wipes, confectionary products, and bitumen.

Chapter 3. Present Conditions and Recommendations for DPR Improvements for NH127B (Srirampur-Dhubri)

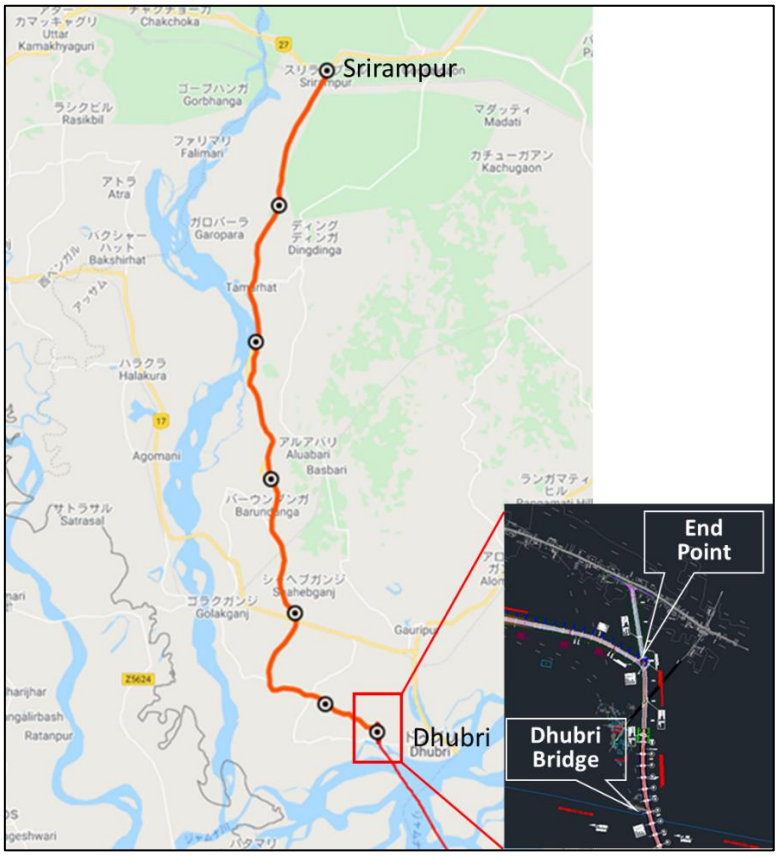
3.1 General

3.1.1 Description of NH127B Assam (Srirampur - Dhubri)

The Survey Road starts from Srirampur on NH-27 (old NH-31 C) to the immediate approach of proposed bridge over Brahmaputra River near Dhubri in the state of Assam. Dhubri District is bounded both by inter-state and international border i.e. West Bengal and Bangladesh in the west, Goalpara and Bogaigoan District of Assam and Garo Hills District of Meghalaya in the east, Kokrajhar District in the north, Bangladesh and state of Meghalaya in the south.

Starting from Srirampur (in the state of Assam), the Survey Road passes through village /localities, Jakobpur, Kambilpur, Malkapur, Kathalguri, Grampur, Bashantipur, Auxiguri, Uzanpetla, MudhaPetla, Alokjhari, Madha Petla, Bhati Petla, Satsaura, Kachakana, Pgla Hat, Barun Danga, Morterjhar, Baniyamari, Balajan, Dhepdheoi, Debdutta Hazdaha 1, Kachari Hat, Debdutta Hazdaha 2, Raja Katli, Kachua Kash,Chanda Khol, Ada Bari and ends at the immediate approach of the proposed bridge over Brahmaputra River near Dhubri.

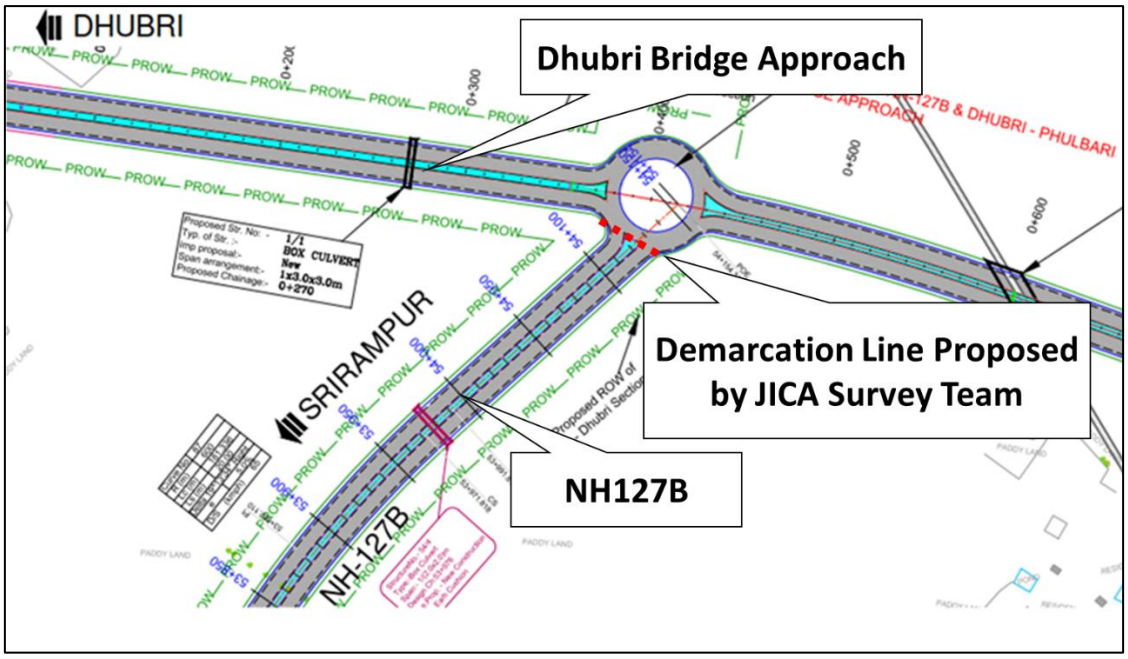
The Survey Road lies in Kokrajhar and Dhubri Districts of Assam. Its terrain is plain. The topography is mostly rural in nature. The land use of the project road stretch is mainly roadside plantation, agricultural area. Some of stretches have settlement and residential structures having rural /semi-urban character. The length of the road is 54.154 km.



Source: JICA Survey Team

Figure 3-1: Locations of NH127B Assam (Srirampur - Dhubri)

JICA Survey Team (JST) has pointed out that there are no demarcation lines between the Project Road and the Dhubri Bridge Project as shown in the figure below.



Source: JICA Survey Team

Figure 3-2: Connecting Point with Dhubri Bridge Project

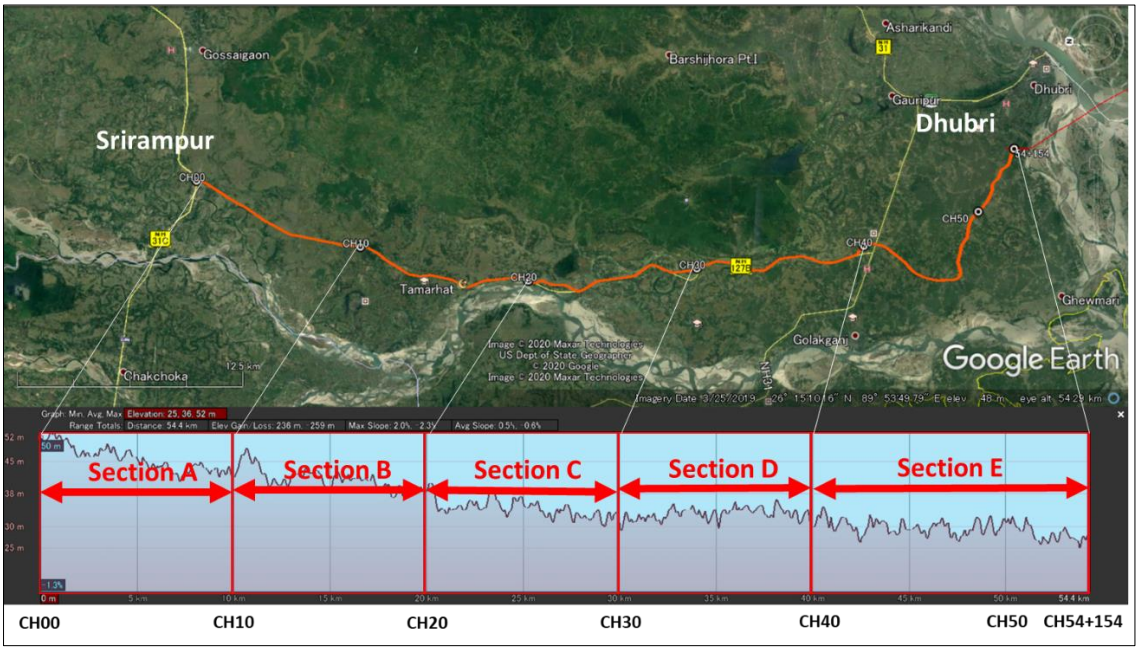
3.2 Present Condition

3.2.1 Present Condition of NH127B Assam (Srirampur - Dhubri)

The Survey Road is currently a single lane /intermediate road. The entire road stretch passes through plain terrain. The topography is mostly rural in nature. The land use of the Survey road stretch is mainly roadside plantation and agricultural. Some of the stretches have settlement and residential structures having rural /semi-urban character. The existing Right of Way (ROW) width along the Study Road has been observed to be around 20m to 30m. The existing ROW does not cater to the provision of 60m ROW for plain road and hence land is required to be acquired.

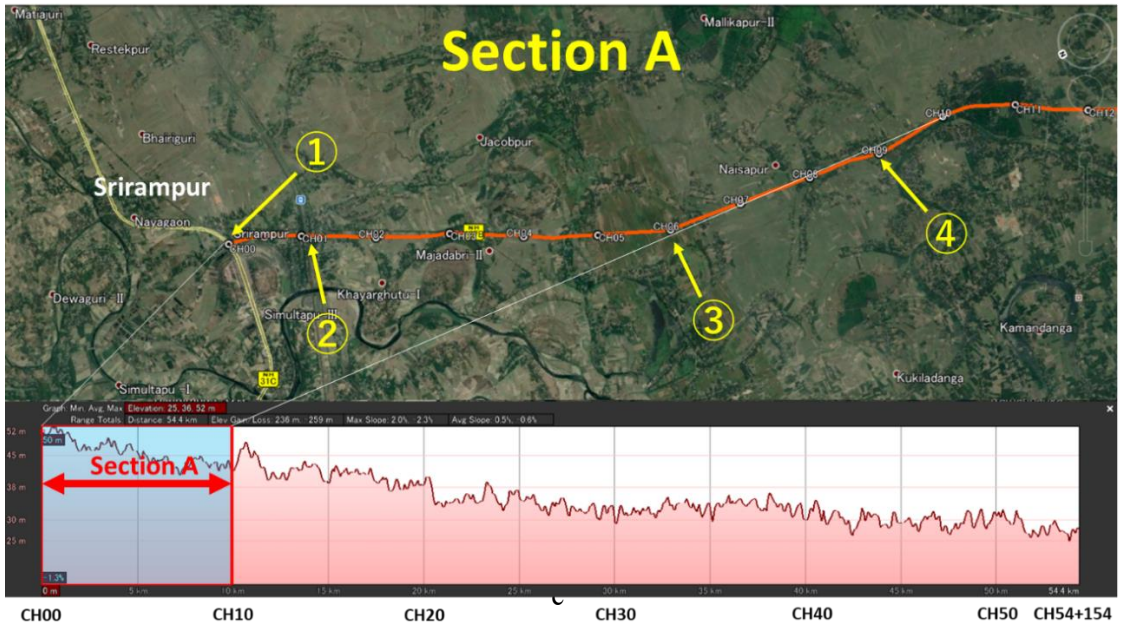
The horizontal alignment of the existing road has some sub-standard and sharp curves including reverse S-curves. Also, there is no proper transition length for most of the horizontal curves including the reverse ones to provide for required super elevation reversal for riding safety and comfort. These deficiencies shall be corrected in fixing the horizontal alignment for the entire Survey road to conform to MoRTH standards.

The present condition of the survey road is indicated in figures from Figure 3-3 through Figure 3-8.



Source: JICA Survey Team

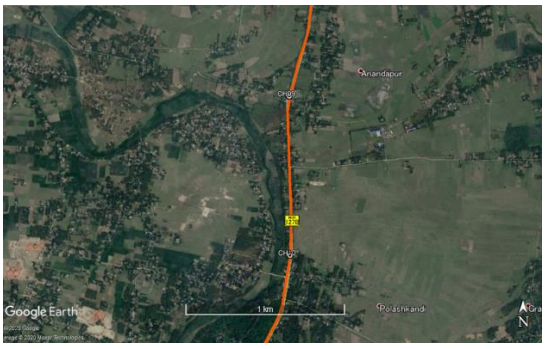
Figure 3-3: Locations of Site Photos (CH00 - CH54+154)



① CH00 Start Point on NH27

② CH02 Railway Crossing

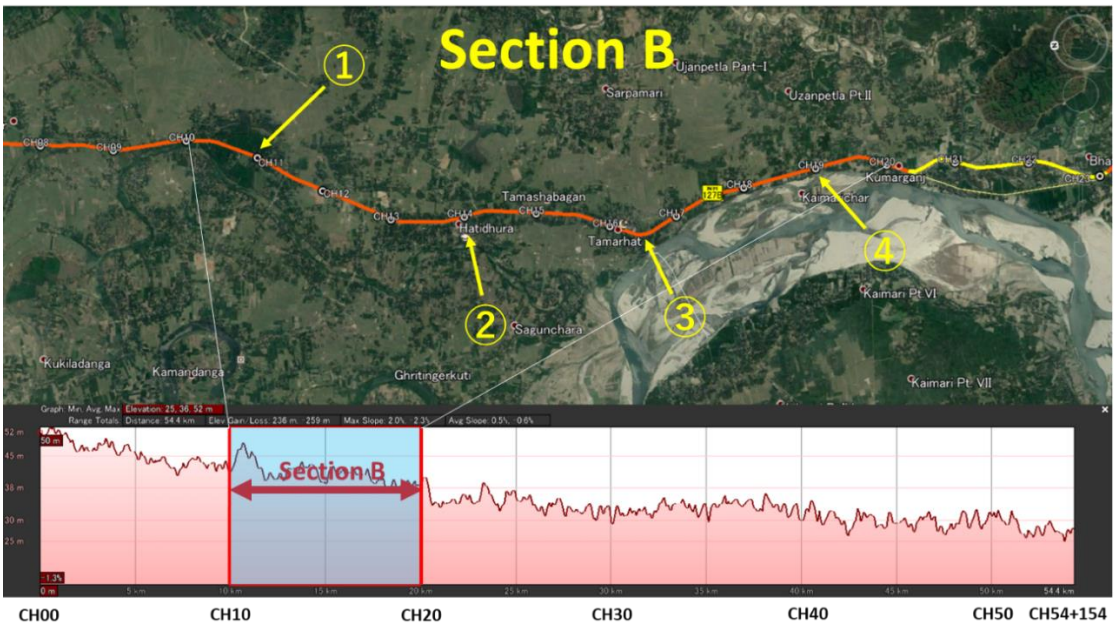
③ CH06 Filaguri-II



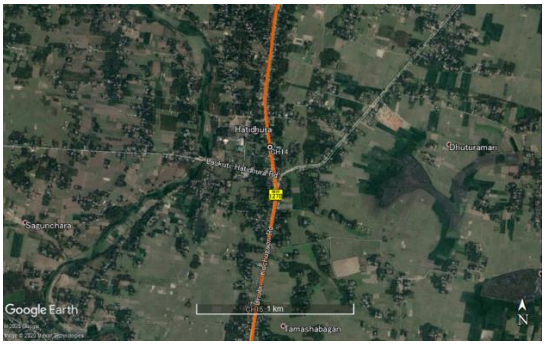
④ CH09 Anandapur

Source: JICA Survey Team

Figure 3-4: Locations of Site Photos in Section A (CH00 – CH10)



① CH11 Pokalagi



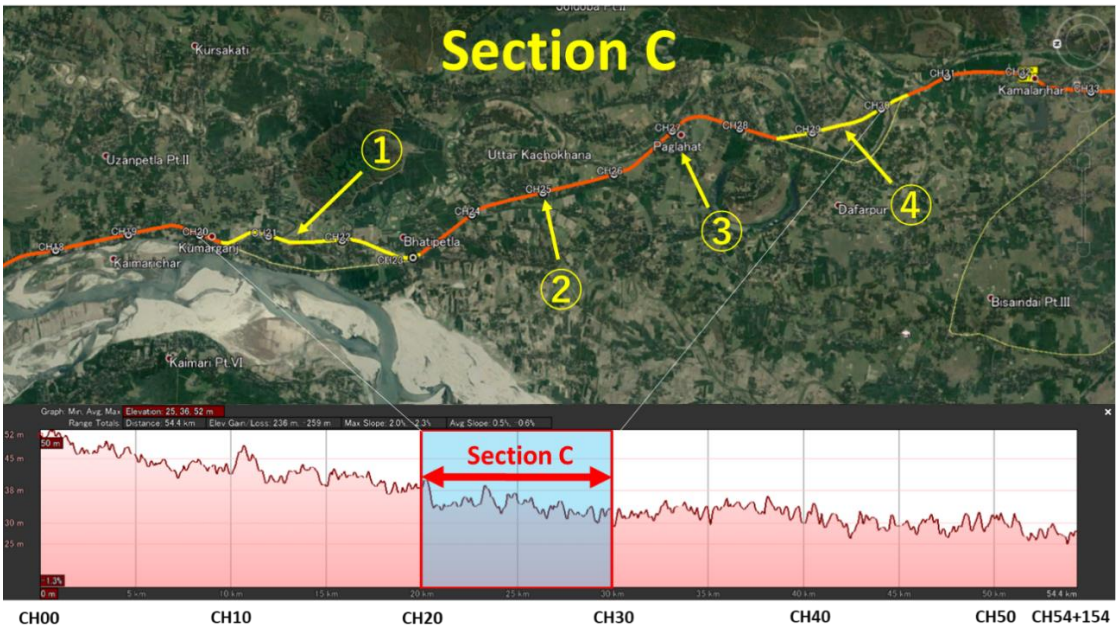
② CH14 Hatidhura

③ CH16 Tamarhat

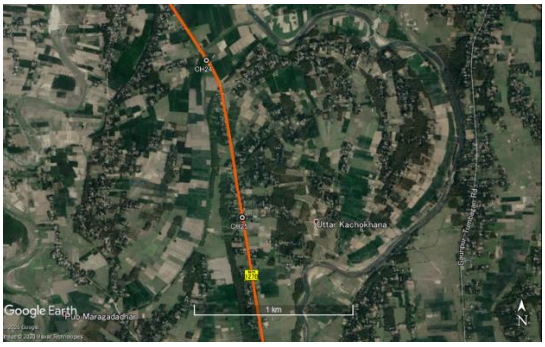
④ CH19 Kaimarichar

Source: JICA Survey Team

Figure 3-5: Locations of Site Photos in Section B (CH10 – CH20)



① CH22 Kumarganj Bypass



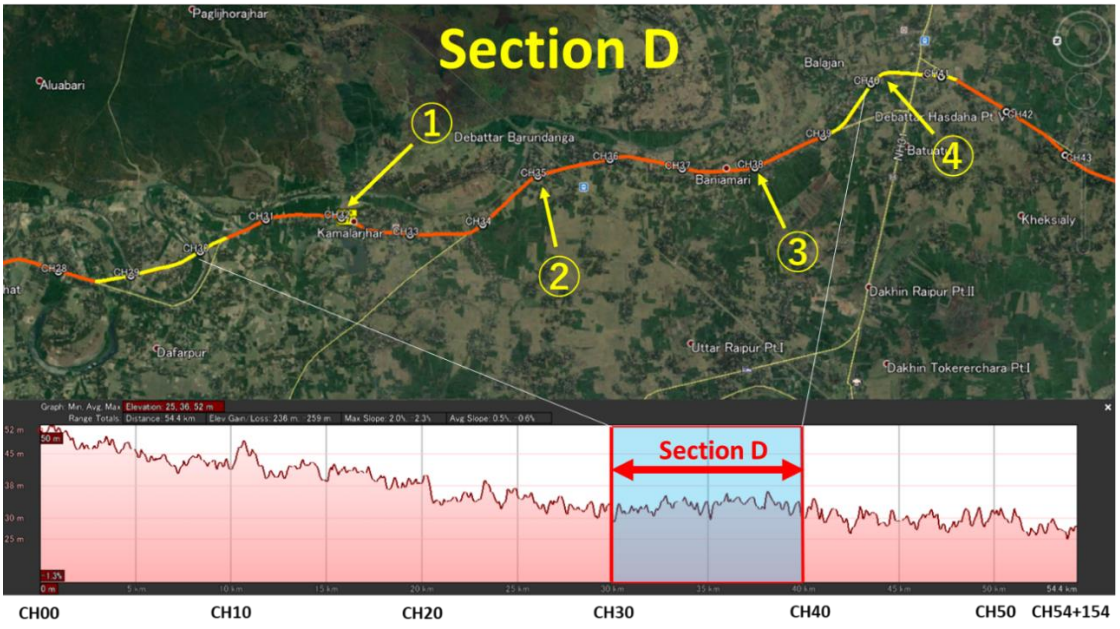
② CH25 Uttar Kachokhana

③ CH27 Paglahat

④ CH30 Sonahat Bypass

Source: JICA Survey Team

Figure 3-6: Locations of Site Photos in Section C (CH20 – CH30)



① CH32 Kumalarjhar

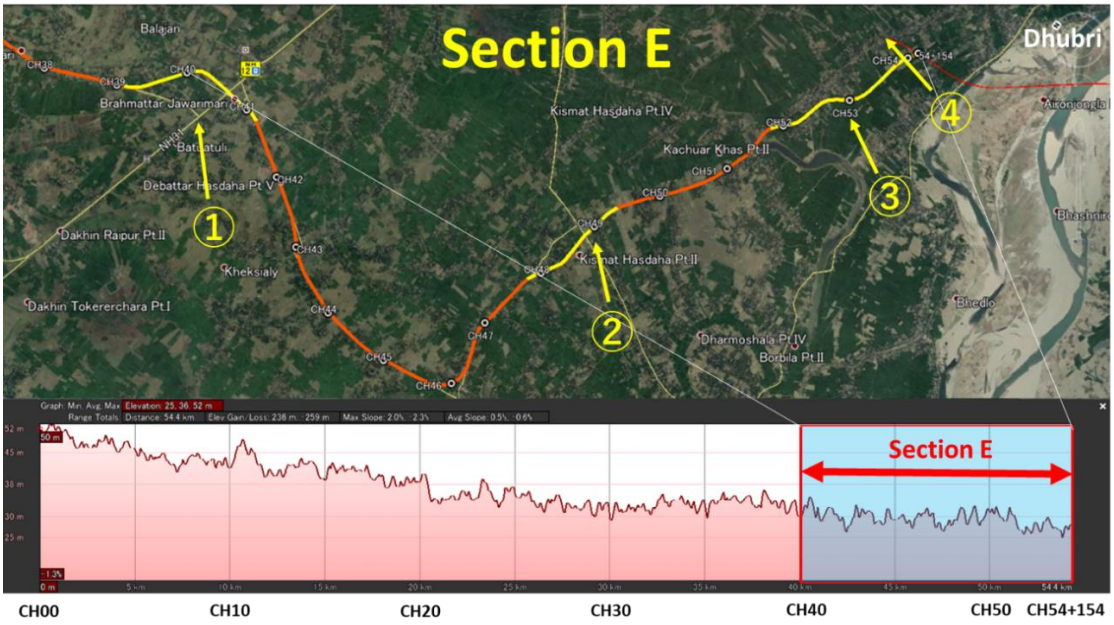
② CH35 Moterjhar

③ CH38 Baniamari

④ CH Saheb ganj bypass

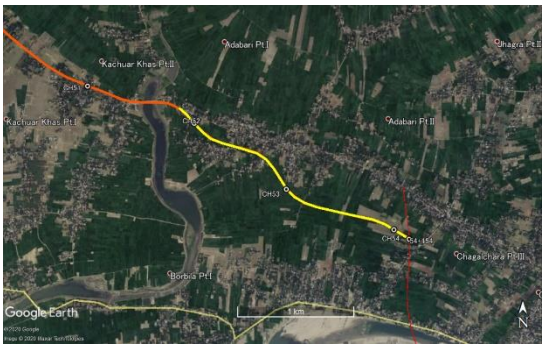
Source: JICA Survey Team

Figure 3-7: Locations of Site Photos in Section D (CH30 – CH40)



① CH40 Balajan Bypass

② CH49 Kismat Bypass



③ CH53 Adabari Bypass

④ CH54 Chagalchara

Source: JICA Survey Team

Figure 3-8: Locations of Site Photos in Section E (CH40 – CH54+154)

3.3 Major Issues of DPR Design and Recommended Solutions

3.3.1 Terrain Classification

IRCSP84-2019[1], Clause 2.9.1 states that the geometric design shall conform to IRC73[2] except as otherwise indicated in this Manual. Demarcation of terrain classification for the Survey Road should be indicated clearly because the terrain classifications govern all the geometric design of the highways.

As per IRC73-1980, Clause 4.1 "the geometric design of a highway is influenced significantly by terrain conditions. Economy dictates choice of different standards for different types of terrain. Terrain is classified by the general slope of the country across the highway alignment for which the criteria given in the Table below should be followed. While classifying a terrain, short isolated stretches of varying terrain should not be taken into consideration."

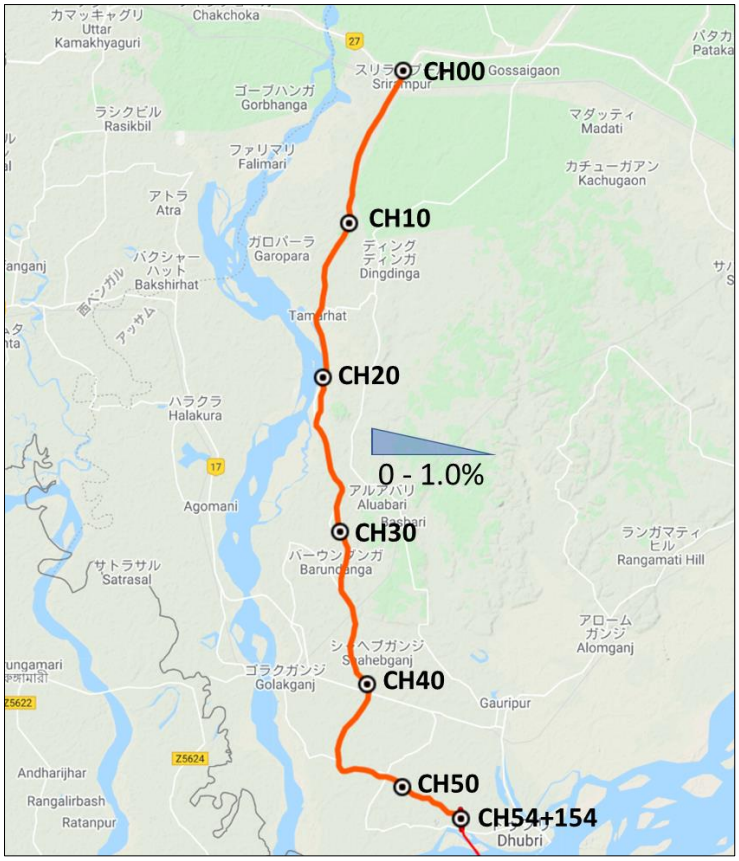
Table 3-1: Terrain Classification as per IRC73-1980

No.	Terrain classification	Per cent cross slope of the country
1	Plain	0 - 10
2	Rolling	10 - 25
3	Mountainous	25 - 60
4	Steep	Greater than 60

Source: JICA Survey Team

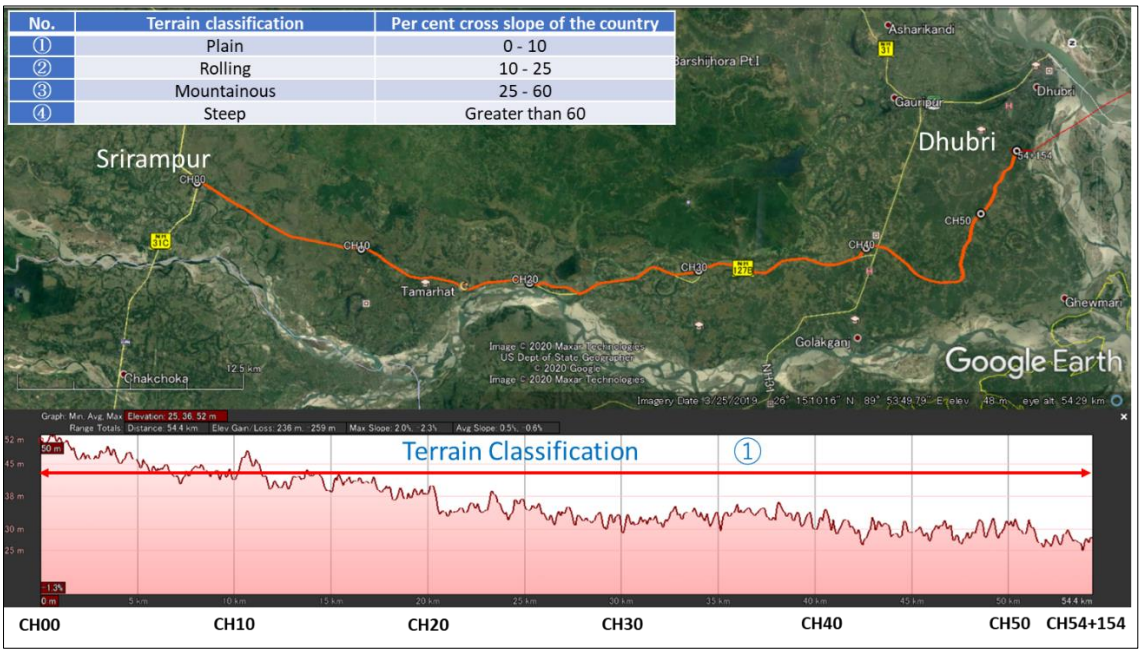
As indicated in Figure 3-9 and Figure 3-10 below, the cross slope of the country across the Survey Road is 0.0% to 1.0% for the entire stretch and should be classified as Plain.

[1] IRCSP84-2019 Manual of Specifications Standards for Four Laning of Highways
[2] IRC73-1980 Geometric Design Standards for Rural (nonurban) Highways



Source: JICA Survey Team

Figure 3-9: Terrain Classification of NH127B Assam (Srirampur - Dhubri)



Source: JICA Survey Team

Figure 3-10: Demarcation of Terrain Classification of NH127B Assam (Srirampur - Dhubri)

3.3.2 Applicable Design Standards

IRCSP84-2019, Clause 1.1 states "This Manual is applicable for Four Laning of Highways through Public Private Partnership (PPP) mode. The general planning aspects laid out in this manual shall be applicable for widening from 2-lane to 4-lane or new construction of 4-lane highways. The scope of the work shall be as defined in the Concession Agreement. This Manual shall be read harmoniously with the intent of the Concession Agreement. The Manual may also be used for non-PPP projects."

IRCSP84-2019, Clause 1.5 states "The version of the Codes, Standards, Specification, etc. notified /published at least 60 days prior to the last date of bid submission shall be considered applicable."

The DPR used IRCSP84-2014[3] for the geometric design of the Survey Road. The main differences between IRCSP84-2014 and IRCSP84-2019 are (1) the width of shoulders and (2) vertical and horizontal clearances as indicated below. These changes shall be applied to the design of road cross-sectional parameters and underpass structures. Table 3-2 and Table 3-3 indicates those differences.

The DPR consultant informed JICA Survey Team by the e-mail dated August 22, 2020 that NHIDCL accepted the application of IRCSP84-2014 to this Project road.

Table 3-2: Width of Shoulders in IRCSP84-2019 and (IRCSP84-2014)

Type of Section	Width of Shoulder (m) in Plain and Rolling Terrain		
	Paved	Earthen	Total
Open country with isolated built up area	2.5 (1.5)	1.5 (2.0)	4.0 (3.5)
Built up area	2.5 (2.0)	-	2.5 (2.0)
Approaches to grade separated structures	2.5 (2.0)	-	2.5 (2.0)
Approaches to bridges	2.5 (1.5)	1.5 (2.0)	4.0 (3.5)

Source: JICA Survey Team

Table 3-3: Vertical and Horizontal Clearances in IRCSP84-2019 and (IRCSP84-2014)

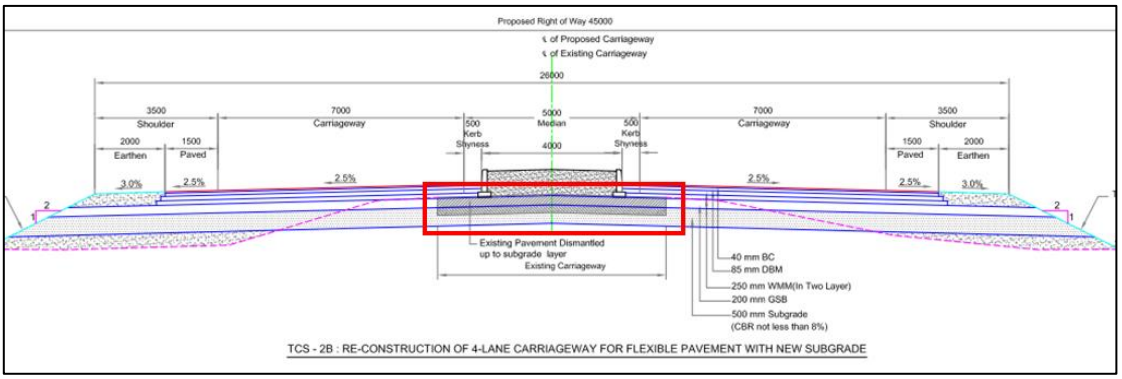
Type of Underpass	Vertical Clearance (m)	Horizontal Clearance (m)
Vehicular Underpass (VUP)	5.5 (5.5)	20.0 (12.0)
Light Vehicle Underpass (LVUP)	4.0 (3.5)	12.0 (10.5)
Smaller Vehicle Underpass (SVUP)	4.0 (3.0)	7.0 (7.0)

Source: JICA Survey Team

3.3.3 Road Design and Typical Cross Sections

The figure below is the typical cross section of "TCS-2B Re-construction of 4-lane Carriageway for Flexible pavement with New Subgrade" in DPR. Some additional descriptions are required about the work on existing road referring to MORTH specifications as shown below.

[3] IRCSP84-2014 Manual of Specifications & Standards for Four Laning of Highways Through Public Private Partnership



Source: JICA Survey Team based on DPR

Figure 3-11: Required Modifications to Typical Cross Section in DPR

MORTH-2013 Specifications for Road and Bridge Works 5th Revision, Clause 305.4.3 Earthwork over Existing Road Surface where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

i) If the existing road surface is of granular type and lies within 1 m of the new formation levels, it shall be scarified to a depth of 50 mm or as directed so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new sub-grade level is compacted to the desired density.

ii) If the existing road surface is of bituminous type or cement concrete and lies within 1 m of the new formation level, the bituminous or cement concrete layer shall be removed completely.

iii) If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be roughened after ensuring that the minimum thickness of 500 mm of sub-grade is available.

3.3.4 Selection of Pavement Types

The survey road is currently a single lane/intermediate road. The bituminous road surface examined by the DPR consultant has been classified into poor due to the presence of potholes, raveling, rutting and patching over the stretch, and failed on visual inspection and BBD test. Some proportions of Dense Bituminous Macadam (DBM) and Water Bound Macadam (WBM) layers are fully exposed. Shoulder drops as well as pavement edge failure are found at many locations. The existing pavement thickness has been found to vary from 100mm to 1000mm. The summary of pavement condition survey is shown in Table 3-4, and the further details are shown in Appendix B-2.

In order to improve the current conditions, the DPR consultant proposed 54.154km of 4-lane carriageway for rehabilitation and up-gradation, which is versus 55.060 km of the existing length as per the survey. The stretch is divided into 5 packages, and most packages are re-construction (42.649 km) or new construction (total 9.534 km) of 4-lane carriageway for flexible pavement. Rigid pavement is proposed 2 locations at built-up areas in the Package-2, and the total length is 1.971km.

The soil and material investigations including field and laboratory tests were conducted during the feasibility study. In addition, the geotechnical investigation and traffic surveys were conducted in Draft Detailed Project Report Stage. Based on these results, further evaluations

through field investigation were conducted by the DPR consultant to propose the pavement types which are in accordance with the Indian provisions.

During the DPR preparation period, trial pits (1m x 1m in size and 1m depth) at every 500m interval along the existing road as well as the proposed alignment were excavated to identify and record the compositions of the individual pavement layers. Total 105 trial pits were excavated, and the summary of layers obtained from trial pits is shown in Table 3-5and Table 3-6.

According to the results from trial pits of both right and left sides, and in addition from Table 3-4, a bituminous surface was not observed from 14+500 km to 39+000km of the survey stretch. The average thicknesses of each layer were observed as follows.

Bituminous surface = 35 mm
Base course + Sub-base course = 415 mm
Subgrade = 560 mm

In addition, brownish grey, 300 mm of clayey silt with sand mixture and 800 mm of subgrade were observed at the trial pits of new alignment from 29+500km to 31+000km of the survey stretch.

Field Density Tests on the sub-grade soil were conducted at each trial pit location and a small quantity of sample was collected for the evaluation of field moisture content. A Dynamic Cone Penetrometer (DCP) test was also performed at subgrade level. Then, soil samples were collected for field and laboratory tests and conducted the soil and material investigation for the pavement design.

Table 3-4: Summary of Pavement Condition Survey

No.	Chanage		Riding Quality		Pavement Condition					Pavement Edge Drop (mm)	Embankment Condition (Good/ Fair/ Poor)	Remarks
	From (km)	To (km)	Speed (km/hr)	Quality (G/F/P/VP)	Craking (%)	Raveling (%)	Potholing (No. and % 100m)	Rut (None/ Moderate/ Severe)	Patching (No. and %100 m)			
1	0+000	0+500	25	P	2	2	5	None		50 mm	G	There are minor cracks.
2	0+500	1+000	25	P	1.76	2	3	None		50 mm	G	
3	1+000	1+500	25	P	1.96	1.2	1.3	None		50 mm	G	
4	1+500	2+000	25	P	1	0.56	0.5	None		50 mm	G	
5	2+000	2+500	25	P	0.6	0.2	0.23	None		50 mm	G	
6	2+500	3+000	25	P	0.2	0.12	0.3	None		50 mm	G	
7	3+000	3+500	25	P	0.8	0.4	0.15	None		50 mm	G	
8	3+500	4+000	25	P	0.24	0.32	0.11	None		50 mm	G	
9	4+000	4+500	25	P	0.16	0.21	0.22	None		50 mm	G	
10	4+500	5+000	25	P	0.15	0.31	0.17	None		50 mm	G	
11	5+000	5+500	25	P	0.56	0.27	0.11	None		50 mm	G	
12	5+500	6+000	25	P	0.2	0.12	0.23	None		50 mm	G	
13	6+000	6+500	25	P	0.13	0.21	0.19	None		50 mm	G	
14	6+500	7+000	25	P	0.24	0.26	0.14	None		50 mm	G	
15	7+000	7+500	25	P	0.24	0.32	0.11	None		50 mm	G	
16	7+500	8+000	25	P	0.2	0.12	0.23	None		50 mm	G	
17	8+000	8+500	25	P	0.15	0.31	0.17	None		50 mm	G	
18	8+500	9+000	25	P	0.13	0.21	0.19	None		50 mm	G	
19	9+000	9+500	25	P	1	0.56	0.5	None		50 mm	G	
20	9+500	10+000	25	P	0.24	0.32	0.11	None		50 mm	G	
21	10+000	10+500	25	P	0.15	0.31	0.17	None		50 mm	G	
22	10+500	11+000	25	P	0.56	0.27	0.11	None		50 mm	G	
23	11+000	11+500	25	P	1	0.15	0.9	None		50 mm	G	
24	11+500	12+000	25	P	0.15	0.33	0.11	None		50 mm	G	
25	12+000	12+500	25	P	0.13	0.21	0.19	None		50 mm	G	
26	12+500	13+000	25	P	0.22	0.32	0.1	None		50 mm	G	
27	13+000	13+500	25	P	0.2	0.12	0.23	None		50 mm	G	
28	13+500	14+000	25	P	0.8	0.4	0.15	None		50 mm	G	
29	14+000	14+500	25	Exposed DBM. The road is fully damaged.				None			G	Pavement condition is very poor.
30	14+500	15+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto

31	15+000	15+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
32	15+500	16+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
33	16+000	16+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
34	16+500	17+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
35	17+000	17+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
36	17+500	18+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
37	18+000	18+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
38	18+500	19+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
39	19+000	19+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
40	19+500	20+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
41	20+000	20+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
42	20+500	21+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
43	21+000	21+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
44	21+500	22+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
45	22+000	22+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
46	22+500	23+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
47	23+000	23+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
48	23+500	24+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
49	24+000	24+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
50	24+500	25+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
51	25+000	25+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
52	25+500	26+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
53	26+000	26+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
54	26+500	27+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
55	27+000	27+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
56	27+500	28+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
57	28+000	28+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
58	28+500	29+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
59	29+000	29+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
60	29+500	30+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
61	30+000	30+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
62	30+500	31+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
63	31+000	31+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
64	31+500	32+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
65	32+000	32+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
66	32+500	33+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
67	33+000	33+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
68	33+500	34+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
69	34+000	34+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
70	34+500	35+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
71	35+000	35+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
72	35+500	36+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
73	36+000	36+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
74	36+500	37+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
75	37+000	37+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
76	37+500	38+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
77	38+000	38+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
78	38+500	39+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
79	39+000	39+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
80	39+500	40+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
81	40+000	40+500	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
82	40+500	41+000	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
83	41+000	41+550	25	Exposed DBM. The road is fully damaged.				None			G	Ditto
84	42+250	42+750	25	P	1	0.56	0.5	None			G	Minor cracks. Carriage way ends are fully
85	42+750	43+250	25	P	2	-	0.1	None			G	There are minor cracks.
86	43+250	43+750	25	P	0.16	0.21	0.22	None			G	Ditto
87	43+750	44+250	25	P	0.15	0.33	0.11	None			G	Ditto
88	44+250	45+750	25	P	0.2	0.12	0.23	None			G	Ditto
89	45+750	45+250	25	P	0.15	0.33	0.11	None			G	Ditto
90	45+250	45+750	25	P	0.2	0.12	0.23	None			G	Ditto
91	45+750	46+250	25	P	0.13	0.23	0.19	None			G	Ditto
92	46+250	46+750	25	P	0.15	0.33	0.11	None			G	Ditto
93	46+750	47+250	25	P	1	0.56	0.5	None			G	Ditto
94	47+250	47+750	25	P	0.2	0.12	0.23	None			G	Ditto
95	47+750	48+250	25	P	0.16	0.21	0.22	None			G	Ditto
96	48+250	49+750	25	P	0.15	0.33	0.11	None			G	Pavement condition is very poor.
97	49+750	49+250	25	P	WMM exposed. Road is fully damaged.						G	Ditto
98	49+250	49+750	25	P	WMM exposed. Road is fully damaged.						G	Ditto
99	49+750	50+250	25	P	0.16	0.21	0.22	None			G	Ditto
100	50+250	50+750	25	P	0.15	0.33	0.11	None			G	Ditto

101	50+750	51+250	25	P	0.13	0.21	0.19	None			G	Ditto
102	51+250	51+750	25	P	0.15	0.33	0.11	None			G	Ditto
103	51+750	52+250	25	P	0.8	0.4	0.15	None			G	Ditto
104	52+250	52+750	25	P	0.2	0.12	0.23	None			G	Ditto
105	52+750	53+250	25	P	1.2	0.2	0.1	None			G	Ditto
106	53+250	53+750	25	P	0.23	0.2	0.12	None			G	Ditto
107	53+750	54+250	25	P	0.13	0.21	0.19	None			G	Ditto
108	54+250	54+750	25	P	0.11	0.02	0.15	None			G	Ditto
109	54+750	55+250	25	P	0.32	0.21	0.11	None			G	Ditto
110	55+250	55+750	25	P	0.31	0.12	0.19	None			G	Ditto
111	55+750	56+250	25	P	1.2	0.2	0.1	None			G	Ditto
112	56+250	56+750	25	P	0.8	0.4	0.15	None			G	Ditto
113	56+750	57+250	25	P	0.4	0.34	0.05	None			G	Ditto
114	57+250	57+750	25	P	0.3	0.13	0.1	None			G	Ditto

Source: JICA Survey Team based on DPR

Table 3-5: Summary of Layers from Trial Pits (Right Hand Side)

Grand Surface <---> Deeper

No.	Chainage RHS (km)	Thickness of Layer (mm)																							Depth of Trial pit (mm)
		Bituminous surface	Base course (WBM)	Layer-1		Sub-base course		Layer-1				Layer-2	Filling sand			Layer-1	Base course (WBM)	PMC	Sub-base course	GSB	Filling sand	Subgrade			
		Bitumen with aggregates	Stone aggregates	Yellowish brown, clayey silt with sand mix. Obs=mica	Brownish grey, clayey silt with sand mix. Obs=mica	Stone +Sand	Sand	Deep grey, silty clay with sand mix, Obs=mica	Yellowish brown, clayey silt with sand mix. Obs=mica	Brownish grey, silty clay/clayey silt with sand mix, Obs=mica	Brownish grey, clayey silt with sand mix. Obs=mica	Brownish grey, silty clay/clayey silt with sand mix, Obs=mica	Filling sand with medium size stone	Sand	Sand +Stone	Brownish grey, clayey silt with sand mix. Obs=mica	Stone	Bitumen with aggregates	Stone +Sand	Stone +Sand	Filling sand	Yellowish brown, silly sand, Obs=mica	Brownish grey, clayey silt with sand mix. Obs=mica	Yellowish brown, clayey silly sand, Obs=mica	
1	0+100	20	200	-	-	100	-	-	-	-		-	-	-	-	-	-	-	-	-	-	680	-	-	1,000
2	1+000	100	200	-	-	100	-	-	-	-		-	-	-	-	-	-	-	-	-	-	600	-	-	1,000
3	2+000	40	200	400	-	30	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	330	-	1,000
4	3+000	40	160	260	-	150	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	390	-	1,000
5	4+000	30	200	-	-	200	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	570	-	1,000
6	5+000	50	160	-	-	200	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	590	-	1,000
7	6+000	30	180	-	-	220	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	570	-	1,000
8	7+000	40	150	-	-	150	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	660	-	1,000
9	8+000	30	200	-	-	250	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	520	-	1,000
10	9+000	40	150	-	-	200	-	150	-	-		-	-	-	-	-	-	-	-	-	-	-	460	-	1,000
11	10+000	40	150	-	-	100	-	-	200	-		100	-	-	-	-	-	-	-	-	-	-	410	-	1,000
12	11+000	60	100	-	-	100	-	-	200	-		-	-	-	-	-	50	-	-	-	-	-	490	-	1,000
13	12+000	30	170	-	-	250	-	-	-	200		-	-	-	-	-	-	-	-	-	-	-	350	-	1,000
14	13+000	30	100	-	-	200	-	-	-	-		-	100	-	-	-	-	-	-	-	-	-	570	-	1,000
15	14+000	20	180	-	-	-	-	-	-	-		-	-	100	-	-	-	-	100	-	-	-	600	-	1,000
16	15+000	-	80	-	-	-	-	-	-	-		-	-	200	-	-	-	-	100	-	-	-	-	620	1,000
17	15+500	-	150	-	250	100	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	500	-	1,000
18	16+550	40	100	-	-	-	-	-	-	-		-	-	200	-	-	-	-	150	-	-	-	510	-	1,000
19	18+000	-	20	-	-	300	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	680	1,000
20	19+000	-	100	-	-	100	-	-	-	-	200	-	-	-	-	-	-	-	100	-	-	-	335	-	835
21	21+000	-	100	-	-	170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	730	-	1,000
22	23+000	-	100	-	-	200	-	-	-	-	-	-	-	-	-	-	100	-	-	50	-	-	550	-	1,000
23	23+500	-	100	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	800	-	1,000
24	24+500	-	80	-	-	150	-	-	-	-	-	-	-	-	-	-	30	-	-	-	200	-	540	-	1,000
25	25+500	-	100	-	-	50	-	-	-	-	-	-	-	100	-	250	-	-	30	-	-	-	470	-	1,000
26	26+500	-	150	-	-	120	-	-	-	-	-	-	-	250	-	-	-	-	-	80	-	-	400	-	1,000
27	27+500	-	100	-	-	150	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	-	600	-	1,000
28	28+500	-	150	-	-	150	-	-	-	-	-	-	-	250	-	-	-	-	100	-	-	-	-	350	1,000
29	31+500	-	100	-	-	100	-	-	-	-	200	-	-	-	-	-	-	-	200	-	-	-	400	-	1,000
30	32+500	-	100	-	-	200	-	-	-	-	-	-	-	50	-	-	-	-	-	100	-	550	-	-	1,000
31	33+500	-	100	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	700	-	1,000
32	34+500	-	100	-	-	200	-	-	-	-	-	-	-	-	-	-	-	50	100	-	-	-	550	-	1,000
33	35+500	-	100	-	-	200	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	500	1,000
34	37+000	-	100	-	-	100	-	-	-	-	-	-	-	-	-	-	150	-	100	-	50	-	500	-	1,000
35	38+000	-	150	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	150	-	-	-	450	-	1,000
36	39+000	-	100	-	-	150	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	550	-	900
37	40+000	40	50	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	710	-	1,000
38	41+000	30	100	-	-	-	-	-	-	-	-	-	-	50	-	-	-	-	-	-	-	-	820	-	1,000
39	42+500	30	120	-	-	-	-	-	-	-	-	-	-	60	-	-	-	-	-	-	-	-	790	-	1,000
40	43+000	30	100	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	100	-	-	-	670	-	1,000
41	44+000	30	100	-	-	-	150	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	620	-	1,000
42	46+000	30	150	-	-	-	100	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	470	-	1,000
43	47+000	50	150	-	-	-	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	-	650	-	1,000
44	48+000	20	100	-	-	100	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	680	-	1,000
45	49+000	20	100	-	-	150	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	530	-	1,000
46	50+000	30	150	-	-	100	-	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	470	-	1,000
47	51+000	40	100	-	-	100	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	660	-	1,000

Source: JICA Survey Team based on DPR

Table 3-6: Summary of Layers from Trial Pits (Left Hand Side)

Grand Surface <---> Deeper

No.	Chainage RHS (km)	Thickness of Layer (mm)																																Depth of Trial pit (mm)
		Bituminous surface	Base course (WBM)	Layer-1			Base course (WBM)	Sub-base course		Layer-1		Layer-2		Filling sand			Base course (WBM)	Layer-1		Sub-base course	Layer-3	GSB	Layer-1	GSB	Filling sand	Subgrade								
		Bitumen with aggregates	Stone aggregates	Yellowish brown, clayeysilt with sand mix. Obs=mica	Yellowish brown, siltysand. Obs=mica	Brownish grey, clayeysilt with sand mix. Obs=mica	Stone aggregates	Stone +Sand	Sand	Yellowish brown, clayeysilt with sand mix. Obs=mica	Brownish grey, clayeysilt with sand mix. Obs=mica	Brownish grey, silty clayclayey silt with sand mix. Obs=mica	Brownish grey, clayeysilt with sand mix. Obs=mica	Filling sand with medium size stone	Sand	Sand +Stone	Stone	Yellowish brown, clayeysilt sand mix. Obs=mica	Brownish grey, clayeysilt with sand mix. Obs=mica	Stone +Sand	Deep grey, clayeysilt with sand mix. Obs=mica	Stone +Sand	Brownish grey, clayeysilt with sand mix. Obs=mica	Stone +Sand	Filling sand	Yellowish brown, sillysand, Obs=mica	Brownish grey, clayeysilt with sand mix. Obs=mica	Yellowish brown, clayeysilty sand, Obs=mica	Brownish grey, silty clayclayey silt with sand mix. Obs=mica	Deep grey, clayey siltsilty clay with sand mix. Obs=mica	
1	0+500	80	200	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	620	-	-	-	-	1,000
2	1+500	30	250	100	-	-	100	-	-	-	-	-	50	-	-	-	-	-	-	30	100	-	-	-	-	-	-	340	-	-	1,000
3	2+500	30	250	50	-	-	-	40	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	530	-	-	-	1,000
4	3+500	30	30	240	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	620	-	-	-	1,000
5	4+500	20	200	-	-	-	-	200	-	-	-	-	-	-	150	-	20	-	-	-	-	-	-	-	-	-	410	-	-	-	1,000
6	5+500	20	180	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	-	-	-	1,000
7	6+500	40	100	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	660	-	-	-	1,000
8	7+500	40	150	-	-	150	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	610	-	-	-	1,000
9	8+500	60	150	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	590	-	1,000
10	9+500	40	100	-	-	-	-	150	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	410	-	-	-	-	1,000
11	10+500	30	60	-	250	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	510	-	-	-	1,000
12	11+500	40	200	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	510	-	1,000
13	12+500	30	120	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	650	-	-	-	1,000
14	13+500	40	100	-	-	-	-	150	-	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	560	-	-	-	1,000
15	14+500	-	60	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-	-	-	-	-	-	50	-	-	690	-	-	-	1,000
16	16+000	-	80	-	-	-	-	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	740	-	-	-	1,000
17	17+000	40	100	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	170	-	-	-	-	-	-	390	-	-	-	1,000
18	17+500	-	250	-	-	-	-	200	-	-	-	-	-	-	100	-	60	60	-	-	-	-	-	-	-	-	330	-	-	-	1,000
19	18+500	-	100	-	-	-	-	-	-	-	-	-	-	-	200	-	100	-	100	100	-	-	-	-	-	-	400	-	-	-	1,000
20	19+500	-	200	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	550	-	-	-	1,000
21	20+000	-	100	-	-	-	-	100	-	-	300	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	400	-	-	-	1,000
22	20+500	50	100	-	-	-	-	200	-	-	200	-	-	-	-	-	-	-	-	50	-	-	-	-	-	-	-	-	-	400	1,000
23	21+500	-	100	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	100	-	-	-	-	-	-	500	-	-	-	1,000
24	22+500	20	100	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	780	-	-	-	-	1,000
25	24+000	-	100	-	-	-	-	100	-	300	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	400	-	-	-	1,000
26	25+000	-	100	-	-	-	-	100	-	-	-	-	-	-	150	-	-	-	-	50	-	-	-	-	-	-	600	-	-	-	1,000
27	26+000	-	150	-	-	-	-	100	-	-	-	-	-	-	200	-	-	-	-	50	-	-	-	-	-	-	500	-	-	-	1,000
28	27+000	-	200	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	-	-	-	-	1,000
29	28+000	-	100	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	100	-	-	-	-	-	-	550	-	-	-	1,000
30	29+000	-	100	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	750	-	-	-	1,000
31	32+000	-	100	-	-	-	-	100	-	-	-	-	-	-	200	-	-	-	-	-	-	50	-	-	-	-	550	-	-	-	1,000
32	33+000	-	100	-	-	-	-	100	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	600	-	-	-	1,000
33	34+000	-	200	-	-	-	-	100	-	-	-	-	-	-	50	-	-	-	-	-	-	50	100	30	-	-	-	-	-	470	1,000
34	35+000	-	100	-	-	-	-	100	-	-	-	-	-	-	100	-	-	-	-	100	-	-	-	-	-	-	600	-	-	-	1,000
35	36+000	-	100	-	-	-	-	200	-	-	100	-	-	-	-	-	-	-	-	50	-	-	-	-	-	-	550	-	-	-	1,000
36	36+500	-	100	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	700	-	-	-	1,000
37	37+500	-	100	-	-	-	-	150	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	650	-	-	-	1,000
38	38+500	-	100	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	200	-	-	-	-	-	-	600	-	-	-	1,000
39	39+500	-	100	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	50	-	-	-	-	-	-	550	-	-	-	1,000
40	40+500	30	100	-	-	-	-	100	-	-	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	710	-	-	-	1,000
41	41+500	40	100	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	760	-	-	-	1,000
42	42+500	40	100	-	-	-	-	-	-	-	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	800	-	-	-	1,000
43	44+500	30	100	-	-	-	-	-	100	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	570	-	1,000
44	45+000	30	160	-	-	-	-	-	-	-	-	-	-	-	80	100	-	-	-	-	-	-	-	-	-	-	-	-	630	-	1,000
45	45+500	30	150	-	-	-	-	-	-	-	-	-	-	-	100	400	-	-	-	-	-	-	-	-	-	-	-	-	320	-	1,000
46	46+500	30	100	-	-	-	-	100	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	570	-	1,000
47	47+500	20	100	-	-	-	-	80	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	700	-	1,000
48	48+500	20	100	-	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	680	-	1,000
49	49+500	30	100	-	-	-	-	100	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	480
50	50+500	30	100	-	-	-	-	200	-	-	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	620	-	1,000
51	51+500	30	100	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	570	-	1,000
52	52+000	30	100	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	570	-	1,000

Source: JICA Survey Team based on DPR

The field and laboratory tests were conducted on the collected soil samples from the trial pits and assessed the pavement composition. The purpose of the investigation and the conducted tests are shown in Table 3-7, and the list of adopted testing codes is shown Table 3-8. Soil classification was conducted according to the Indian Classification System as detailed in IS 1498. Procedures for investigations, sampling and testing of soils and other construction materials are in accordance with MoRTH Specifications wherever applicable to determine their suitability. The Laboratory test results are shown in Appendix F-1, and the summary of some soil test results is shown in Table 3-9.

Table 3-7: Purpose and Tests for Soil Investigation

Purpose	Conducted Tests on site and in the laboratory
To determine the characteristic and strength of the subgrade	In-situ density of the subgrade Field moisture content to determine Field Dry Density DCP (Dynamic Cone Penetration) tests Modified Proctor Tests Classification (grain size and Atterberg Limits) of subgrade soil Laboratory CBR (both un-soaked and 4-day soaked) at 3 energy levels
To determine the pavement condition	Visual inspection
To evaluate the suitability of borrow material for use in construction of embankment and/or subgrade	Grain size Modified proctor test Liquid and plastic limits CBR at 3 energy levels
To locate the quarries and testing of stone aggregate as available to evaluate their suitability for use in construction of pavement	Sieve Analysis Flakiness and Elongation index Specific gravity and water absorption Aggregate impact value

Source: JICA Survey Team based on DPR

Table 3-8: Testing Codes Adopted

Type of Test	**Method**
Field dry density using sand replacement method	IS 2720 Part 28
Moisture content determination	IS 2720 Part 2 (section I)
Atterberg limits	IS 2720 Part 5
Sieve analysis - Natural soils - Rock aggregate	 IS 2720 Part 4 IS 2386 Part 1
Compaction test (Heavy Compaction)	IS 2720 Part 8
CBR and Swell (Soaked and unsoaked at three energy levels for sub-grade)	IS 2720 Part 16
Free swell index	IS 2720 Part 40

Source: JICA Survey Team based on DPR

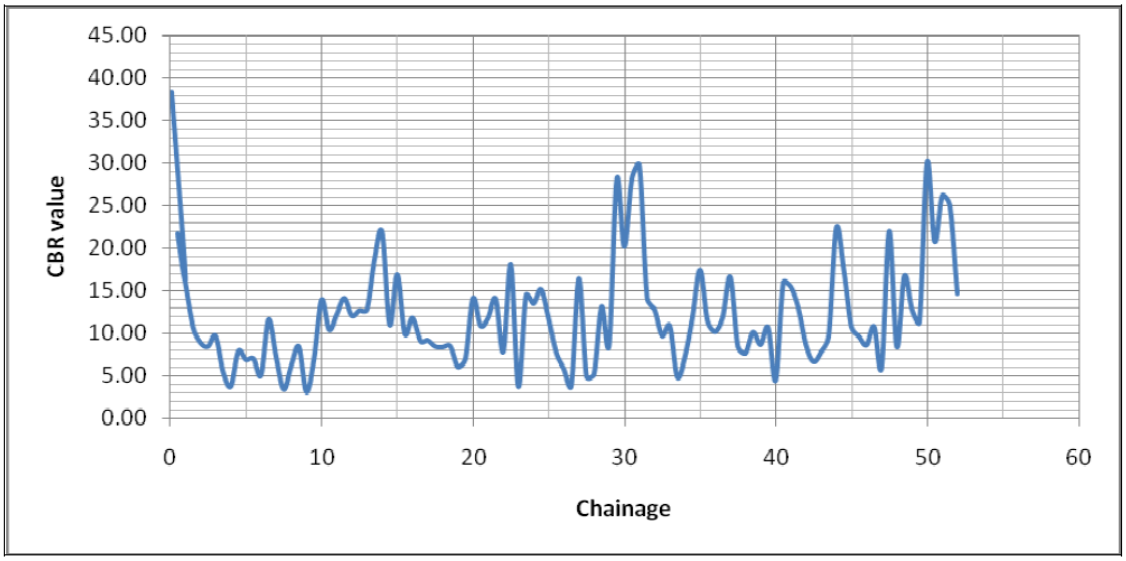
Table 3-9: Summary of Soil Test Results

Type of Test	Unit	Minimum	Maximum	Average
California Bearing Ratio (CBR at 97% MDD)	%	3.07	38.31	20.69
Maximum Dry Density	gm/cc	1.60	2.07	1.83
Optimum Moisture Content	%	10.46	19.80	15.13
Liquid Limit (LL)	%	22.00	53.00	37.50
Plastic Limit (PL)	%	18.00	34.00	26.00
Plasticity Index (PI)	%	1.00	21.00	11.00

Source: JICA Survey Team based on DPR

(1) Design CBR

The CBR values of the subgrade are used to evaluate the subgrade strength of roads and pavements and are one of the most important parameters in determining the structural pavement design and composition of the layers. The obtained CBR values of the existing subgrades showed significant variation along the individual project corridors, and the fluctuation range was from 3.07% to 38.31%. The variation of CBR along the survey stretch is given in the figure below, and CBR values in trial pits are shown in Appendix F-1.



Source: DPR

Figure 3-12: CBR on Km 0.000 to Km 54.523

CBR values of subgrade soil varies along the proposed alignment. In accordance with IRC 37-2012, CBR values are arranged in ascending order and percentage greater than equal to each of the values has been calculated. 90th percentile CBR is recommended in the guidelines as well as IRC 37-2012, and it should be adopted for the design of high volume roads such as Expressways, National Highways, State Highways and Urban Roads, assumed the design traffic of 20 msa or more.

Since the difference of the CBR values is found significant between the CBR value of new subgrade and the CBR of existing embankment soil, the design should be based on effective CBR as per Clause 5.2 of IRC 37-2012 (page-11). Accordingly, the effective CBR of subgrade comes 8% from the Fig 5.1 of IRC 37-2012, and the design CBR for the survey stretch is considered 8%.

Moreover, it is observed from DCP test results exhibited in Appendix F-2 that, the degree of field compaction of existing subgrade varies from 69.1% to 96.2%. As such, existing soil of the subgrade needs to be loosened and recompacted in layers up to 500mm depth, so that the density may be achieved at a minimum of 97% of maximum dry density (MDD) in the field.

Similarly, the underneath soil of subgrade in the survey stretch where CBR is found less than 8%, the existing soil shall be replaced with either suitable borrow area soil or it will be stabilized with lime.

(2) Pavement Design Standard and Methodology

The pavement design for the road was conducted based on cumulative number of standard axles and the CBR of the subgrade. The composition of pavement has been recommended keeping in view the construction and maintenance costs. In accordance with IRC SP 84-2014[4] and IRC 37-2012[5], the design life of 15 years for the flexible pavement is applied. Similarly, a design life period of 30 years as per IRC 58-2011[6] is applied for the rigid pavement adopted in the congested built up area.

A flexible bituminous pavement is applied for the new bypass carriageway, widening areas of existing carriageway, junctions and any existing pavement where the replacement of existing pavement is necessary to improve the structural condition.

In order to calculate the design traffic in cumulative number of standard axle, the survey stretch was divided into 2 homogeneous sections; Section-1 is from 0+000km to 38+990km and Section-2 is from 38+990km to 54+523km. The axle load survey was conducted for 24 hours at Srirampur. The design traffic for the design period were calculated by applying the following parameters shown in the table below.

Table 3-10: Parameter for Design Traffic (msa)

Homogeneous Section	A Initial traffic	D Lane Distribution Factor	F Vehicle Damage Factor (VDF)	n Design Life (year)	r Annual Growth Rate (%)	N Design Traffic (msa)
Section-1 (0+000km - 38+990km)	461	0.5	3.37	15	0.05	6
Section-2 (38+990km - 54+523km)	1145	0.75	3.37	15	0.05	23

Source: JICA Survey Team based on DPR

As per Clause 5.4.1 in IRC SP 73-2015 as well as IRC SP 84-2015, it is stated that flexible pavement shall be designed for a minimum design period of 15 years, subjected to the condition that design traffic shall not be less than 20 msa (=million standard axles). Therefore, the design traffic of 20 msa is adopted for the flexible pavement design on Section-1 (0+000km-38+990), instead of 6msa.

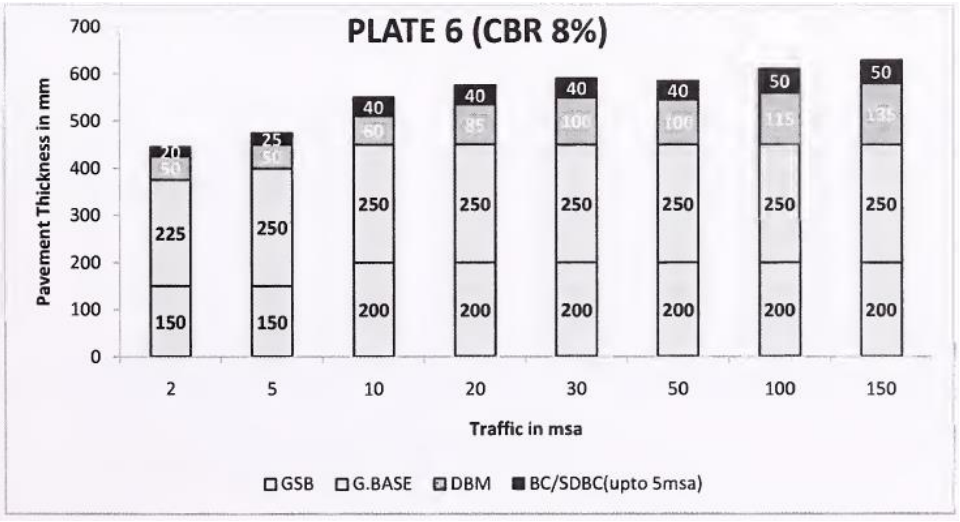
(3) Design of Bituminous pavement with Granular Base and Granular Sub-base

DPR consultant prepared necessary data to determine the pavement thickness design:

Design CBR = 8%
Design Traffic = 20msa (Section-1) and 23msa (Section-2)

From the above conditions, Plate-6 of the pavement design catalogues in IRC 37-2012 (page-27) is adopted and shown in the figure below. The recommended thicknesses are listed in Table 3-11.

[4] IRC SP 84-2014: Manual of Specifications & Standards for Four Laning of Highways through Public Private Partnership
[5] IRC 37-2012: Guidelines for The Design of Flexible Pavements
[6] IRC 58-2011: Guidelines for The Design of Plain Jointed Rigid Pavements for Highways



Source: IRC 37-2012

Figure 3-13: Catalogue for Pavement Thickness as per IRC 37-2012

Table 3-11: Pavement Thickness from IRC 37-2012

Homogeneous Section	Design CBR (%)	Design Traffic (msa)	BC (mm)	DBM (mm)	WMM (mm)	GSB (mm)	Total Thickness (mm)
0+000km - 39+990km	8	20	40	85	250	200	575
39+990km - 54+523km	8	23	40	85	250	200	575

Source: JICA Survey Team based on DPR

The Total pavement thickness was 575 mm. The DPR consultant recommends the re-construction in the stretches where the poor pavement surfaces of extensive cracking, raveling, rutting, and potholes are located. For these areas, the new pavement thickness of Bituminous Concrete (BC)=40mm, Dense Bituminous Macadam (DBM)=85mm, Wet Mix Macadam (WMM) in two layer=250mm and Granular Sub-base (GSB)=200mm shall be provided on existing portion. The pavement construction starts after removal of existing pavement layer up to the required depth in the profile design.

The pavement design as per IRC 37-2012 is based on the mechanical pavement design principle which has evolved from theoretical, laboratory and pavement performance studies on Indian pavement materials and pavements constructed in India. In IRC 37-2012, for analysis, bituminous layer with VG30 bitumen and an annual average pavement temperature (AAPT) of 35 Celsius have been applied.

On the other hand, for pavement overlays, the deflection criteria are considered. The existing pavement where the condition of the subgrade allows can be strengthened by an overlay of bituminous material as per IRC 81[7]. Simultaneously, deficiencies should be corrected for the entire survey road to conform to MoRTH Standards, since the strengthening of the carriageways as required to maintain the level of service over the design period is considered.

[7] IRC 81-1997 Guidelines for Strengthening of Flexible Road pavements using Benkelman Beam Deflection Technique

3.3.5 Width of ROW

DPR states that the existing ROW width along the Survey Road has been observed to be around 20m to 30m. However, the existing ROW does not cater to the provision of 60m ROW for plain road and hence land is required to be acquired.

IRCSP84-2014, Clause 2.3 states "A minimum Right of Way (ROW) of 60 m should be available for development of a 4-lane highway. The Authority would acquire the additional land required, if any. The land to be acquired shall be indicated in Schedule 'B' of the Concession Agreement. The consideration for planning, design and construction described in Para 1.13 shall apply."

The design of ROW in DPR is summarized in the table below, which follows 60 m ROW in principle and adjusting ROW flexibly to deal with the cases of open area exceptional and built-up areas. The lengths of each ROW are 17.5 km for 60 m width, 29.6 km for 45 m width and 7.0 km for 30 m respectively.

Table 3-12: Width of ROW in DPR

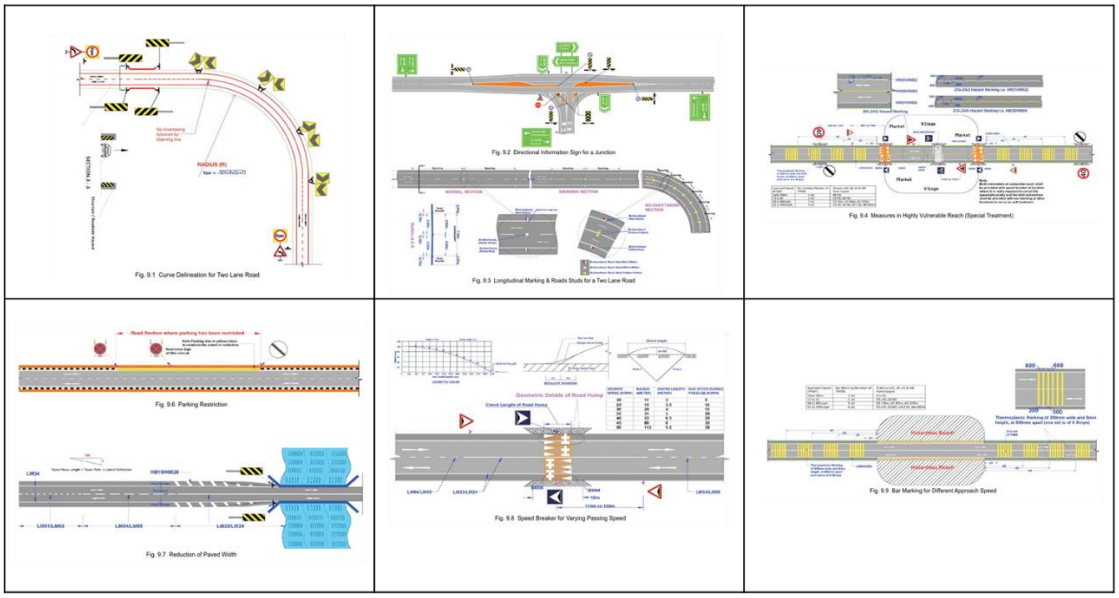
Open Area		Bypass / New Alignment		Built-up Area	
Normal	Exceptional	Normal	Exceptional	Normal	Exceptional
60 m	45 m	60 m	-	45 m	30 m

Source: JICA Survey Team

3.3.6 Safety Measures in Road Design and Construction

(1) Road safety measures for mountainous roads with poor visibility

The Particular Specification for this survey work states "although the previous road sections are in the mountainous terrain with sight obstructions, road safety measures were not fully designed. Therefore, adequate facilities necessary for road safety (guardrail, mirror, etc.) shall be included in the preliminary design. Specifications and standards of IRC, however, carry standardized drawings to apply to the sections where road safety measures are required such as sections with small radius curves (mostly smaller than 1000 m) and neighbouring to markets and villages. Therefore, the design of road safety facilities for curves is usually simplified in preliminary design, which seems to have given the impression of inadequate road safety measures for previous survey road sections. The figures below are some examples of the standardized drawings from IRCSP73-2018.



Source: JICA Survey Team base on IRCSP73-2018

Figure 3-14: Samples of Standardized Drawings of Road Safety Facilities from IRCSP73-2018

(2) Management of Safety for Construction Work

India has well organized guidance for the management of safety for construction work. There is an act as the base, which stipulates responsibility and education/training. Regarding safe execution by the type of work, there are Indian Standards (IS) equivalent to JIS in Japan. Handbook on Construction Safety Practices carries structured ISs. IRC provides guidance for road projects. The table below is the comparison between the relevant Indian regulations the Guidance for the Management of Safety for Construction Works on Japanese ODA Projects.

Table 3-13: Comparison between Japanese Guidance and Relevant Indian Regulations

The Guidance for the Management of Safety for Construction Works on Japanese ODA Projects		Indian Regulations		
		The Building and Other Construction Workers' (Regulation of Employment and Consitions of Service) Central Rules 1998	Handbook on Construction Safety Practices (First Reprint September 2007)	IRCSP73-2018 Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder (Second Revision)
Chapter 1 General Rules				
	1.1 Purpose	O		
	1.2 Scope of Application	O		
	1.3 Plans for Safety Management	O		
	1.4 Roles and Responsibilities of Project Stakeholders	O		
Chapter 2 Basic Policies for Safety Management				
	2.1 Basic Principles of Safety Management			O
	2.2 Compliance with Relevant Laws and Regulations			O
	2.3 PDCA for Safety Management			
Chapter 3 Contents of the "Safety Plan"				
	3.1 Composition of the Safety Plan			
	3.2 Basic Policies for Safety Management			
	3.3 Internal Organizational Structure for Safety Management			O
	3.4 Promotion of the PDCA Cycle			
	3.5 Monitoring		O	O
	3.6 Safety Education and Training	O		O
	3.7 Voluntary Safety Management Activities			
	3.8 Sharing Information	O		O
	3.9 Response to Emergencies and Unforeseen Circumstances	O		O
Chapter 4 Contents of the "Method Statements on Safety"				
	4.1 Composition of the "Method Statements on Safety"			
	4.2 Applicable Standards for the "Technical Guidance for Safe Execution of Works"		O	
Chapter 5 Technical Guidance for Safe Execution (by the Type of Work)				
	5.1 Excavation Work	O	O	
	5.2 Pile Foundation Work	O	O	
	5.3 Formwork and Form Shoring System Work	O	O	
	5.4 Reinforcing Bar Work		O	
	5.5 Concrete Work	O	O	
	5.6 Work over Water	O		
	5.7 Demolition Work	O	O	
	5.8 Work where there is danger of oxygen deficiency	O		
	5.9 Slinging Work	O	O	
Chapter 6 Technical Guidance for Safe Execution (by the Type of Accident)				
	6.1 Measures for Prevention of Fall Accidents		O	
	6.2 Measures for Prevention of Accidents Involving Flying or Falling Objects	O		
	6.3 Measures for Prevention of Accidents Involving Collapse of Structures.	O		
	6.4 Measures for Prevention of Accidents Involving Construction Machinery		O	
	6.5 Measures for Prevention of Explosion Accidents	O	O	
	6.6 Measures for Fire Prevention	O		O
	6.7 Measures for Prevention of Public Accidents			O
	6.8 Measures for Prevention of Traffic Accidents	O		O
	6.9 Protective Gear	O		O

Source: JICA Survey Team

3.3.7 Measures to Minimize Construction Period

The survey road region falls in a long period monsoon zone starting from May through October (about six months every year). It is effective to plan as much works as possible during the monsoon season to minimized construction period. Precast method is one of the works suitable for that purpose because all the operations from molds assembly, rebars arrangement, cement concrete pouring, and quality control can be performed indoors. During the monsoon, by fabricating and stocking road furniture such as side drains and box culverts, works during dry seasons can be expedited.

The precast method for road appurtenances is nothing new and commonly used in many countries. However, it is very seldom to find a company that produces road appurtenances with the precast method and sells them in the Indian market. Some road construction contractors have started to introduce the precast method by building their own fabrication yards near their road construction project sites. The pictures below show the practice of the precast method adopted for road construction project of NH44 in 2016 in Meghalaya.

Molds and rebars	Quality control	Site placement

Source: JICA Survey Team

Figure 3-15: Precast method Adopted for the Construction of NH44

3.3.8 Measures to Widen Road in Difficult Conditions

The road construction and social activities are the integral part of road network development. Improving and expanding the roadway network while keeping road traffic is critical to economic development as well as the quality of life and, these activities create work zones in the network. The road work zones are areas of conflict between normal operating traffic, construction workers, road building machineries and construction traffic. Therefore, planning an efficient and effective Work Zone Traffic Management (WTMP) is crucial for successful operations.

IRCSP55-2014 sets out the guidelines for planning WTMP including a) provide safety for road users and workers, b) minimized hindrance or delay to road users, c) provide clear and positive guidance to road users, d) ensure roadside safety maintenance, e) ensure that planners and decision makers have the necessary knowledge, and f) provide good public relations. As indicated in Figure 3-16, planning effective lighting devices, clear message signs, and proper protection barriers for working zones helps to enhance the effectiveness of WTMP by providing proper warnings.

Source: IRCSP55-2014

Figure 3-16: Types of Warning Devices in IRCSP55

3.3.9 Measures to Protect Slope of Embankment

NH127B Srirampur−Dhubri is planned in the alluvial plain, and consists of embankments and bridges over the entire section.

According to DPR, in the rural areas, high embankments are designed due to few land use restrictions, while in built-up areas land use is so restricted, and retaining walls and reinforced earth retaining walls (RE retaining walls) are designed.

Retaining walls are applied for the lower embankments with less than approximately 10 m hight, and RE retaining walls are applied for the embankments with higher than approximatedly10 m hight. And stone pitching work is proposed for the slope protection of the embankments.

Regarding the embankment slope protection methods mentioned above, there are no major problems in DPR design. Adequacy of applied countermeasures is examined and described below on gradient of embankment slope, selection of slope protection measures, and selection of locations where slope protection work.

(1) Gradient of Embankment Slope

According to IRC:SP:84-2014 “Manual of Specifications & Standards”, the gradient of embankment is described as “Side slopes shall not be steeper than 2H : 1V unless soil is retained by suitable retaining structure”. Based on this manual, the gradient of 2H : 1V is adopted in DPR. In Japan, incidentally, the gradient of 1.5H : 1V to 2H : 1V is common for embankment slope. From this perspective, there are no problems in DPR design.

(2) Selection of Slope Protection Measure of Embankments

NH127B (Srirampur−Dhubri) is planned along the Gangadhar River which is the tributary of the Brahmaputra River. Besides, Assam is a region with heavy rainfall, floods frequently occur, and river banks and road embankments are easily damaged by river erosion.

The Retaining wall and the RE retaining wall are the structures those have resistance against river erosion, so there are less problems for slope protection. However, the embankments close to river require some countermeasures for slope protection.

Vegetation, concrete block pitching, stone pitching, and gabion works are general for slope protection of embankments. Among them, vegetation is not applicable for road embankments close to river and river banks because vegetation is easy to be eroded. Stone pitching among above measures is selected in DPR.

Gabion works are common in India for protection against river erosion. However, gabion works are as costly as concrete block pitching. The slope of embankments is basically stable with the adopted gradient of 2H: 1V, so it is thought that costly gabion works are not necessary.

The cost of concrete block pitching is about four times more expensive than stone pitching because concrete is costly in India. In addition, the maintenance and repair of stone pitching are easy compared with those of concrete block pitching. Moreover, stone pitching can be a friendly countermeasure for environment.

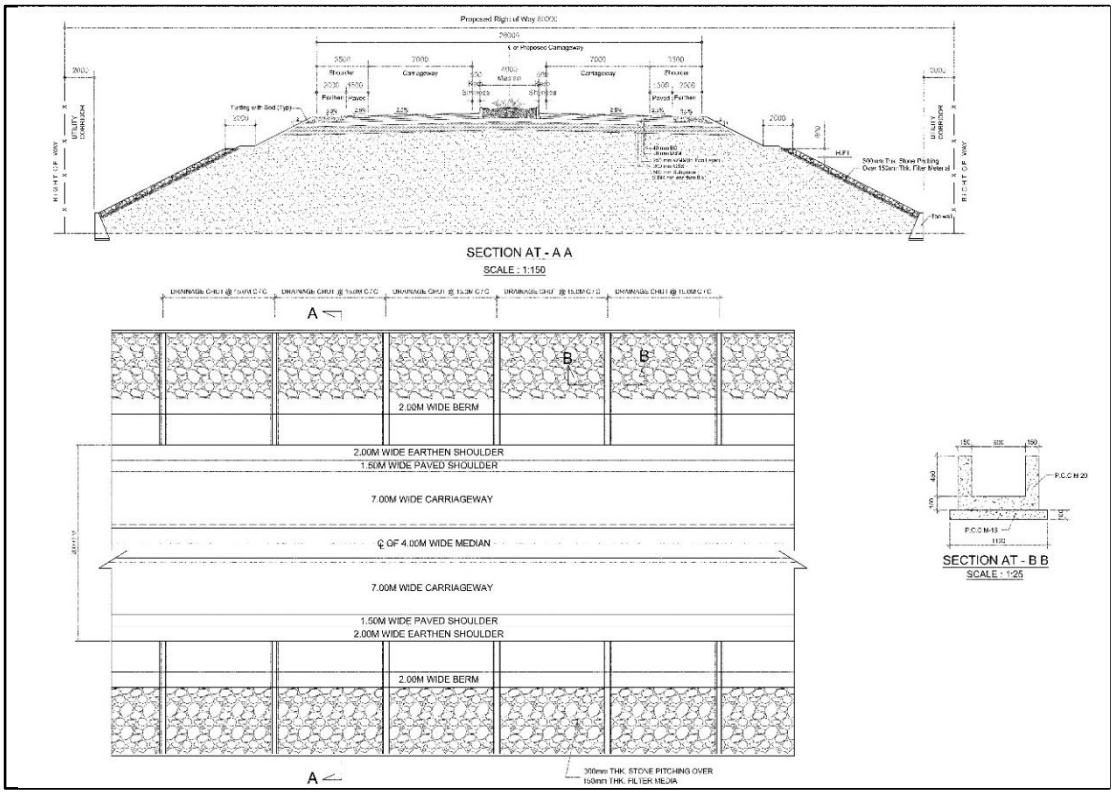
For the above reasons, the stone pitching which DPR has proposed is considered to be appropriate method for slope protection of embankments.

(3) Selection of Stone Pitching Locations

The stone pitching is planned in the following locations,

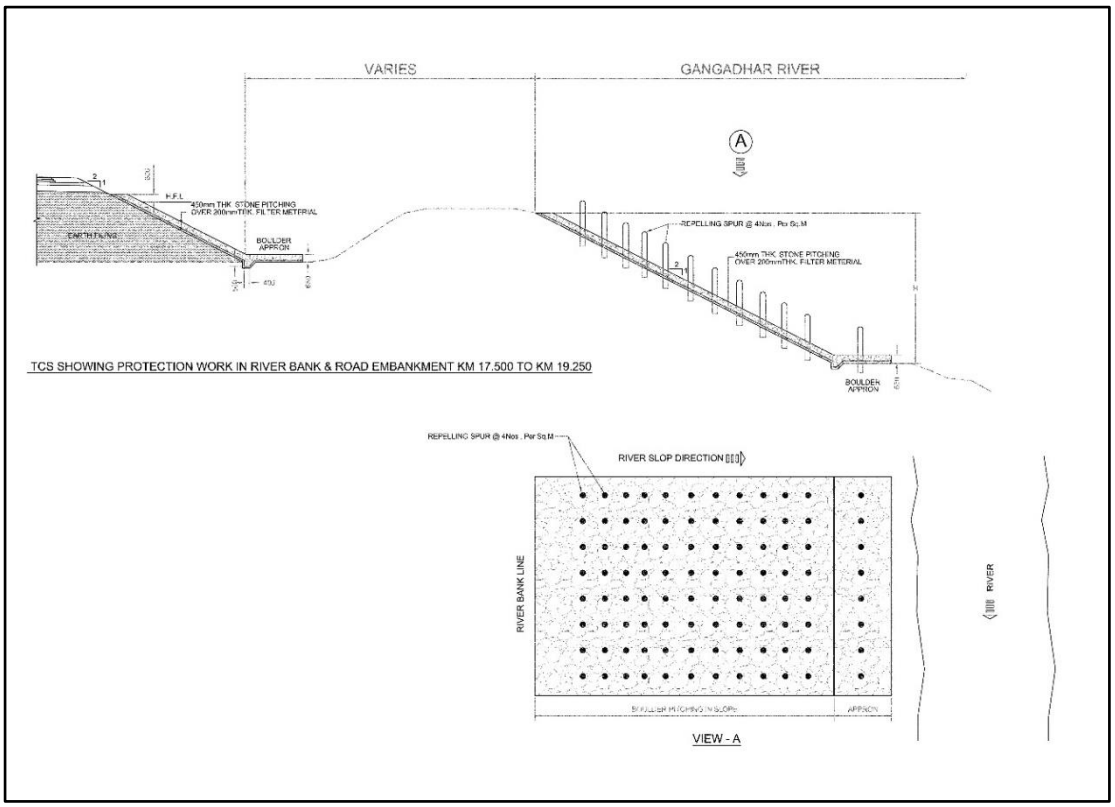
- Road embankments close to river
- River banks close to high road embankments
- River banks around bridge abutments

In case of high embankment close to river, stone pitching is planned both in embankment and in riverbank. The example of stone pitching in the high embankment close to river is shown in Figure 3-17, and the examples of stone pitching both in road embankment and river bank is shown in Figure 3-18.



Source: DPR, Drawing Volume–IV, Package–V

Figure 3-17: Stone Pitching in Embankment Close to River



Source: DPR, Drawing Volume–IV, Package– II

Figure 3-18: Stone Pitching Both in Road Embankment and River Bank

3.3.10 Bridge Plan

(1) Design Standards

All structures shall be designed in accordance with the relevant Codes, Standards, Specifications, Special Publications (i.e. IRC SP 73-2018 for two-lane carriageway or IRC SP84-2019 for 4-lane carriageway respectively) and Guidelines of the IRC. Construction of all culverts, bridges and grade separated structures shall confirm to MORTH Specifications for Road and Bridge Woks. (refer to Figure 3-14.)

However, it is confirmed by the DPR Consultant that NHIDCL has decided to follow IRC SP 84-2014 instead of 2019 for the Assam portion.

Table 3-14: List of Major Design Standards

Code No.	Titles
THE INDIAN ROADS CONGRESS	
IRC:5-2015	Standard Specifications and Code of Practice for Road Bridges, Section I - General Features of Design
IRC:6-2017	Standard Specifications and Code of Practice for Road Bridges Section II - Loads and Load Combinations (Seventh Revision) Amendment No.1 July 2017
IRC:22-2015	Standard Specifications and Code of Practice for Road Bridges, Section VI - Composite Construction
IRC:24-2010	Standard Specifications and Code of Practice for Road Bridges Section V - Steel Road Bridges
IRC:40-2002	Standard Specifications and Code of Practice for Road Bridges, Section IV - Brick, Stone and Block Masonry
IRC:45-1972	Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges
IRC:78-2014	Standard Specifications and Code of Practice for Road Bridges Section VII - Foundations and Substructure
IRC:83-2015	Standard Specifications and Code of Practice for Road Bridges Section IX Bearings Part I Metallic Bearings (First Revision)
IRC:83-2018	Standard Specifications and Code of Practice for Road Bridges Section IX Bearings Part II Elastomeric Bearings
IRC:83-2018	Standard Specifications and Code of Practice for Road Bridges Section IX Bearings Part III POT, POT-cum-PTFE, PIN and Metallic Guide Bearings
IRC:83-2014	Standard Specifications and Code of Practice for Road Bridges Section IX Bearings Part IV Spherical and Cylindrical
IRC:87-2018	Guidelines for Formwork, Falsework and Temporary Structures (First Revision)
IRC:89-1997	Guidelines for Design and Construction of River Training and Control Works for Road Bridges
IRC:112-2011	Code of Practice for concrete road bridges
IRC:SP:13-2004	Guidelines for the Design of Small Bridges and Culverts (First Revision)
IRC:SP:18-1978	Manual for Highway Bridge Maintenance Inspection
IRC:SP-33-1989	Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures
IRC:SP:35-1990	Guidelines for Inspection and Maintenance of Bridges
IRC:SP:42-2014	Guidelines of Road Drainage
IRC:SP:69-2011	Guidelines Specifications for Expansion Joints (First Revision)
IRC:SP:73-2015	Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder (First Revision)
IRC:SP:73-2018	Manual of Specifications and Standards for Two Laning of Highways with Paved Shoulder (Second Revision)

Code No.	Titles
IRC:SP-84-2014	Manual of Specifications and Standards for Four Laning of Highways (Second Revision)
IRC:SP-87-2019	Manual of Specifications & Standards for Six Laning of Highways (Second Revision)
IRC:SP:114-2018	Guidelines for Seismic Design of Road Bridges
IRC:SP:115-2018	Guidelines for Design of Integral Bridges
MINISTRY OF ROAD TRANSPORT & HIGHWAYS	
MORTH-2013	Specifications for Road and Bridge Works (Fifth Revision)

Source: JICA Survey Team

(2) Design Loads

The design loads and stresses shall be as per IRC:6 appropriate for the width of carriageway, velocity of stream, location, altitude, environment, etc.

All new structures shall be designed for the condition when footpath is used as carriageway. And this is confirmed in the additional calculation by the DPR Consultant. The raised footpaths shall be provided in built-up areas, while the footpath portion may be provided at the same level as the bridge carriageway and separated by crash barrier in non built-up areas.

All the components of the structures shall be designed for a service life of 100 years except appurtenances like crash barriers, wearing surface and rubberized components in expansion joints and elastomeric bearings. All the requirements to achieve durability and serviceability shall be implemented.

Major load conditions are as follows:

- Live load: IRC:6, Clause 204
  - CLASS 70R (WHEELED, TRACK)
  - Class A
- Live load combination: IRC:6, Clause 204.3
  5.3m <= Carriageway Width < 9.6m
  - 2 lanes of 70R (WHEELED)
  - 2 lanes of Class A

  9.6m <= Carriageway Width < 13.1m
  - 1 lane of 70R (WHEELED) + 1 lane of Class A
  - 3 lanes of Class A
- Impact load: IRC:6, Clause-208
- Temperature: IRC:6, Clause 215
- Seismic force: IRC:6, Clause 219
  - Seismic Zone of bridge location: V (IRC:6, Clause 219, Fig 18)
  - Zone factor, Z:0.36 (IRC: 6, Clause 219, Table 6)
  - Seismic important factor of structure: 1.2 (IRC: 6, Clause 219, Table 8)
- Wind: IRC: 6, Clause 209
- Earth pressure: IRC: 6, Clause 214

(3) Carriageway Configuration

All new bridges shall have a footpath on the left side of the traffic direction. The carriageway width of the bridge shall be the distance between face to face of crash barrier/raised kerb. Full carriageway and paved shoulders of approaches should continue on the bridge. Additionally, 0.5m width for shyness should be provided on either side. RCC crash barrier shall be provided between footpath and carriageway and pedestrian guard rail at the outer edges of the bridge. Typical cross sections of a new bridge with footpath (no service road bridge) for a 4-lane Project Highway are given in Figure 3-19.

The width of median in the culvert and bridge portion shall, as far as possible, be kept same as that in the approaches. In case width of median is different from that of approach section due to site constraints, transition of 1 in 30 shall be provided near approaches for guiding vehicular traffic.

Cross section for bridges, culverts and other structures shall be followed as per the following:

(a) Reconstruction/ New construction
- Total Width = 28.0m
- Carriageway Width = 19.0 m (2x9.5m)
- Footpath width = 3.0m (2x1.5m)
- Width of Crash Barrier = 2.0m (4x0.5m)
- Width of Kerb +Railing = 1.0m (2x0.5m)
- Width of Median = 3.0m (1x3.0m)

(b) Existing Bridge retained, additional 2 lane bridge proposed:
- Total Width = 12.50m
- Carriageway Width = 9.50m
- Footpath width = 1.5m (1x1.5m)
- Width of Crash Barrier = 1.0m (2x0.5m)
- Width of Kerb + Railing = 0.5m (1x0.5m)

(c) ROB (Road Over Bridge)
- Total Width = 28.9m
- Carriageway Width = 19.0 m (2x9.5m)
- Footpath width = 3.0m (2x1.5m)
- Width of Crash Barrier = 2.0m (4x0.5m)
- Width of Kerb +Railing = 0.9m (2x0.45m)
- Width of Median = 4.0m (1x4.0m)

(d) VUP/LVUP(Vehicular Underpass/Light Vehicular Underpass)
- Total Width = 25.00m
- Carriageway Width = 19.0m (2x9.5m)
- Width of Crash Barrier = 2.0m (4x0.5m)
- Width of Median = 4.0m (1x4.0m)

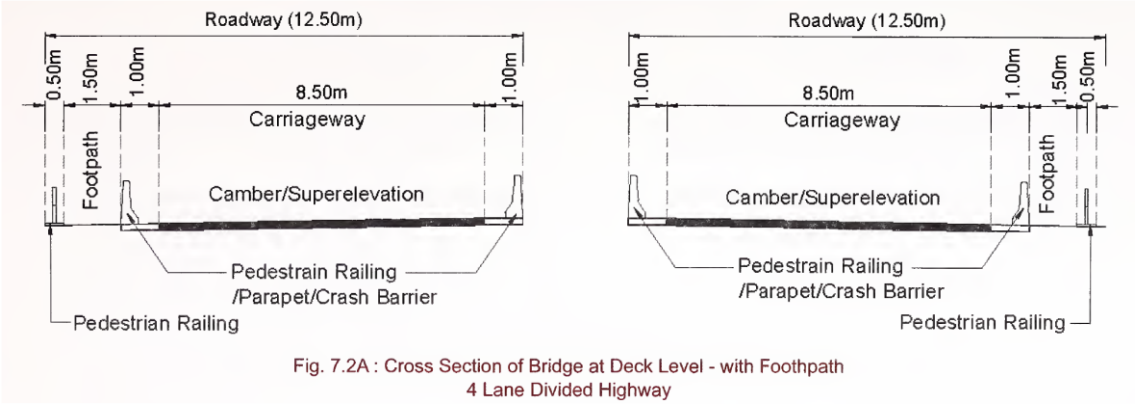


Fig. 7.2A : Cross Section of Bridge at Deck Level - with Foothpath
4 Lane Divided Highway

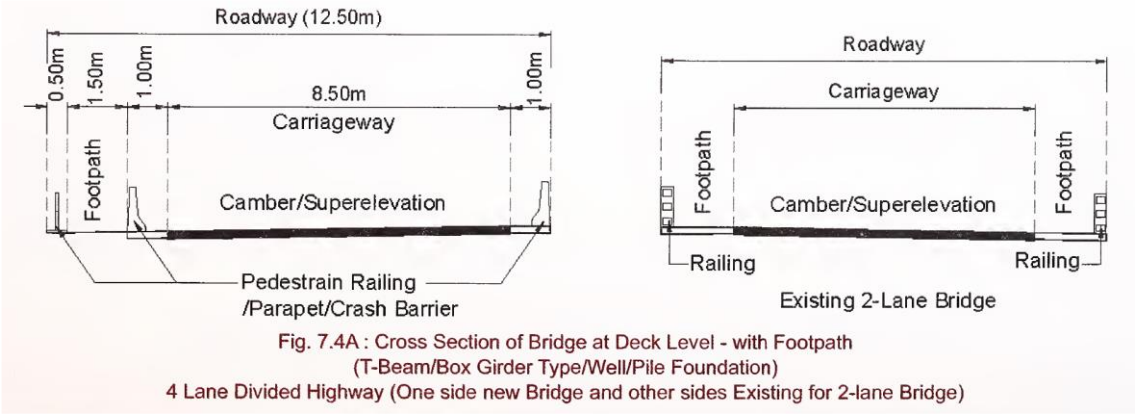


Fig. 7.4A : Cross Section of Bridge at Deck Level - with Footpath
(T-Beam/Box Girder Type/Well/Pile Foundation)
4 Lane Divided Highway (One side new Bridge and other sides Existing for 2-lane Bridge)

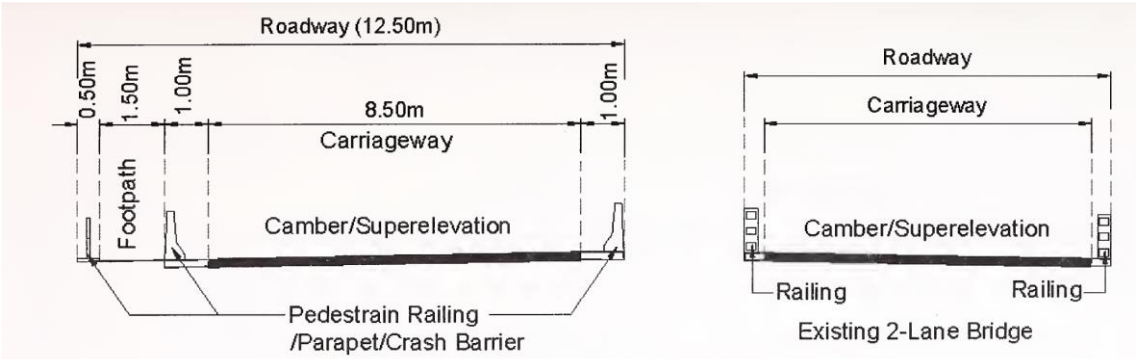


Fig. 7.4B : Cross Section of Bridge at Deck Level - without Footpath
(T-Beam/Box Girder Type/Well/Pile Foundation)
4 Lane Divided Highway (One side new Bridge and other sides Existing for 2-Lane Bridge)

Source: IRC SP84-2014

Figure 3-19: Carriageway Configuration

(4) Classification of Existing Bridges

All the existing bridges which are structurally distressed shall be reconstructed as new bridges. The 3 bridges at CH 43+100, CH 47+289 and CH 48+167 are classified into reconstructed.

The wearing course, bearings and rubberized component of expansion joints which are damaged or older than 15 years in the existing bridge shall be removed and replaced and all repair and rehabilitation required shall be carried out. The existing 4 bridges at CH 24+001, CH30+408, CH44+645 and CH 51+536 are retained with repair and added with 2 lane bridges.

If the width of additional widening for the existing bridge is 1.0 m (0.5 m on each side) or less, the widening of the structure may be dispensed with and traffic shall be guided with the help of crash barriers in a transition of 1 in 20 on either side approaches.

The bridges having 2-lane carriageway particularly those with T-beam/Box type superstructure with well/pile foundation, which are in sound condition, may be retained and proper transition between approach and bridge shall be provided. The width of the new structures constructed on the other side of the existing bridge shall be as specified in the new bridges.

Details of existing bridge are given in Bridge Inventory in Appendix B-4.

There are 9 bridges on the Survey Road stretch out of which 1 minor bridge location has been omitted due to realignment. 3 existing minor bridges (including 2nos wooden bridges) have been proposed for reconstruction, while widening with 5 new 2 lane bridges (4 minor bridges + 1 major bridge) has been proposed. Additional 4 new minor bridges have been proposed on the realignment with consideration of smooth traffic flow and safety issue, 3 VUPs, 1 LVUP and 3 ROBs are also proposed. Then there are 19 bridges on the route.

Table 3-15: List of Bridges in Assam

Chainage	Span Length (m)	Bridge Length (m)	Existing Bridge	Under Bridge	Structure Type	Measures
1+044	3X37.28m+ 1x76.08m +3x37.28m	***300***	-	ROB	Composite (RDSO)+ Bow String +Composite (RDSO)	New
7+241	4mx4mx4cell	16	4cell	Open Land	4mx4.066mx4cell	Retain + Add 2 lanes
21+140	2x18m	39	-	River	RCC T-Beam	New at realignment
21+871	2x18m	39	-	River	RCC T-Beam	New at realignment
24+001	2x12m	25	2x12m	Nallah	Int. Slab	Retain w Repair + Add 2 lanes
28+974	2x24m	51	-	River	RCC T-Beam	New at realignment
30+050	3x18m	59	-	River	RCC T-Beam	New at realignment
30+408	1x21m	21	1x19.6m	Open Land	RCC T-Beam	Retain w Repair + Add 2 lanes
35+355	1x25.92m+ 1x25.08m+1x37.28m +1x25.08m +1x25.92m	***139***	-	ROB	RCC T-Beam+ Composite (RDSO) +RCC T-Beam	New
39+700	1x15m	15	-	VUP	Int. Slab	New
40+637	1x25.92m+ 2x37.28m+ 1x76.08m +22.92m	***199***	-	ROB	RCC T-Beam+ Composite (RDSO)+ Bow String +RCC T-Beam	New
43+010	4mx6mx3cell	27	2cell	Open Land	6mx4mx3cell	Reconstruction
44+645	1x41m	41	1x40.8m	Pond	PSC T-Beam	Retain w Repair + Add 2 lanes
47+289	2x15m	31	Wooden	Ditch Land	Int. Slab	Reconstruction
48+167	1x24m	26	Wooden	Ditch Land	RCC T-Beam	Reconstruction
48+810	1x15m	15	-	VUP	Int. Slab	New
51+536	2x41m	***82***	2x42m	River	PSC T-Beam	Retain w Repair + Add 2 lanes
52+353	1x15m	15	-	VUP	Int. Slab	New
53+191	1x15m	15	-	LVUP	Int. Slab	New

Source: JICA Survey Team based on DPR

(5) Length of Bridges

The length of bridge is strongly affected by the waterway which is calculated according to the design discharge based on maximum flood discharge of 50 years return cycle.

According to IRC:SP:13-2004, "Guidelines for the Design of Small Bridges and Culverts", discharges can be estimated in three different ways, i.e. 1) empirical and rational formulae for peak run-off from catchment, 2) from the conveyance factor and slope of the stream and 3) from flood marks on the sites. The values obtained should be compared. The highest of these values should be adopted as the design discharge Q, provided it does not exceed the next highest

discharge by more than 50 per cent. Sound economy requires that the structure should be able to pass easily floods of a specified frequency (once in 50 years) and that extraordinary and rare floods should pass without causing excessive damage to the structure or the road.
If the required linear waterway (L) is less than the economical span length, it has to be provided in one single span. When L is more than the economical span length (S), the number of spans (N) required is tentatively found from the following relation: L = NS

Since N must be a whole number (preferably odd) S has to be modified suitably. In doing so it is permissible to adopt varying span lengths in one structure to keep as close as possible to the requirements of economy and to cause the least obstructions to the flow.

It is distinguished from the plan drawings that the under-bridge situations are "Open Land" of 3 bridges at CH7+241, CH30+408 and CH43+100, "Pond" of 1 bridge at CH44+645 and "Ditch Land" of 2 bridges at CH47+289 and CH48+167. It is strongly recommended to confirm the reasons to decide the bridge lengths when site visit is possible.

Table 3-16: Bridge Length in Assam

No.	Chainage	Discharge (cu.m)	Regime width (m)	Bridge Length (m)
1	1+044	ROB	-	300
2	7+241	Open Land	-	16
3	21+140	107.48	34.924	39
4	21+871	112.20	34.070	39
5	24+001	42.88	22.008	25
6	28+974	144.95	46.240	51
7	30+050	231.76	52.884	59
8	30+408	Open Land	-	21
9	35+355	ROB	-	139
10	39+700	VUP	-	15
11	40+637	ROB	-	199
12	43+010	Ditch Land	-	27
13	44+645	Pond	-	41
14	47+289	Ditch Land	-	31
15	48+167	Ditch Land	-	26
16	48+810	VUP	-	15
17	51+536	250.04	75.910	82
18	52+353	VUP	-	15
19	53+191	LVUP	-	15

Source: JICA Survey Team based on DPR

(6) Vertical Clearance

The vertical clearance at the underpass shall not be less than the values given in the table.

Table 3-17: Vertical Clearance for Underpass

Type	Clearance (m)
1) Vehicular Underpass (VUP)	5.5
2) Light Vehicular Underpass (LVUP)	4.0
3) Smaller Vehicular Underpass (SVUP)	4.0

Source: IRC SP 73-2018 & SP 84-2019, 2.10

The vertical clearance is determined by calculating minimum clearance from the river as shown below.

Table 3-18: Discharge and Vertical Clearance as per IRC: SP13-2004

Discharge in cu.m/sec	Minimum vertical clearance （mm）
Upto 0.30	150
Above 0.3 and upto 3	450
Above 3 and upto 30	600
Above 30 and upto 300	900
Above 300 and upto 3000	1200
Above 3000	1500

Source: IRC: SP13-2004, Table 12.1

Above said calculation results are summarized in Figure 3-19. The 4 bridges at CH 21+140, CH 28+974, CH 30+050 and CH 51+536, cannot be confirmed as per vertical clearance because the heights of girders are not shown in the drawings. All the bridges but abovementioned 4 bridges satisfy the required clearance.

Table 3-19: Vertical Clearance in Assam

No.	Chainage	Discharge (cu.m)	Minimum Vertical Clearance (m)	H.F.L. (m)	Vertical Clearance (m)
1	1+044	ROB	-	-	8.307
2	7+241	Open Land	-	39.938	3.059
3	21+140	107.48	0.900	32.351	1.188
4	21+871	112.20	0.900	31.951	1.388
5	24+001	42.88	0.900	32.000	1.227
6	28+974	144.95	0.900	30.698	1.188
7	30+050	231.76	0.900	29.996	2.590
8	30+408	Open Land	-	-	-
9	35+355	ROB	-	-	8.095
10	39+700	VUP	-	-	5.968
11	40+637	ROB	-	-	8.306
12	43+010	Ditch Land	-	28.912	-
13	44+645	Pond	-	-	-
14	47+289	Ditch Land	-	28.839	-
15	48+167	Ditch Land	-	28.923	-
16	48+810	VUP	-	-	5.700
17	51+536	250.04	0.900	26.270	4.415
18	52+353	VUP	-	-	7.668
19	53+191	LVUP	-	-	5.037

Source: JICA Survey Team based on DPR

3.3.11 Drainage Plan

(1) Issue of Drainage of NH127B Assam

Due to a new coronavirus infection, it is not possible to go to the site and survey. Therefore, the issues were confirmed based on the DFR created by the DPR consultant. Although the report prepared by DPR is incomplete, we reviewed the drawings and reports currently available and conducted an interview with a DPR consultant to confirm the issues. The main problems are shown below. .

1) Major issues of DPR

A) Type of Culvert
As the width of the road will increase with the improvement of the road, all cross drainage will be renovated or newly constructed. The existing cross-drainage culverts used slab culverts, pipe culverts, and box culverts, but with the improvement of this road, they are all box culverts. Considering the workability, it is necessary to consider the adoption of precast PIPE culvert and box culvert.

B) Box culvert cross-section dimensions
In the design of DPR consulting, three types of box culverts are adopted, W2.0m×H2.0m, W2.0m×H3.0m, and W3.0m×H3.0m, due to this road improvement. Currently, there is no basis for determining the size because the flow rate calculation sheet is not currently available. Currently requested DPR to obtain flow rate calculation sheet. If available, we will review the results. If it is not available, we will conduct a hearing with a local consultant to confirm the rationale.

C) Installation location of new waterway
Since the 127B ASSAM route passes through a flat area, it is a road that uses embankments in many sections. Therefore, the embankment will divide the land, and many new box culverts will be installed. The rationale for the location of the new box culvert is not clear. Conducted interviews with local consultants and confirmed the grounds.

2) Recommended solutions

A) Type of Culvert
The culvert method adopts a format suitable for the location. In particular, the characteristics of the area (construction efficiency, economic efficiency, availability of materials) will be comprehensively examined and determined.

If available locally, consider the use of precast materials in consideration of the shortened construction period and ease of construction.

B) Box culvert cross-section dimensions
Obtain the capacity calculation sheet from DPR, check the required cross-sectional size determined by the capacity and the shape and size of the box culvert to be installed, review whether it is an appropriate cross-section, and determine the cross-sectional size

C) Installation location of new waterway
Since it is not possible to conduct a field survey, Hearing will be conducted from the DPR consultant, and the adequacy of the installation site will be examined.

(2) Design Standards

The standard used in this design are as follows. This standard is the latest standard.

Therefore, the use of this standard is appropriate.

Table 3-20: Design Standards

Code No.	
THE INDIAN ROADS CONGRESS	
IRC:SP:13-2004	Guidelines for the Design of Small Bridges and Culverts (First Revision)
IRC:SP:13-2004	Guidelines for the Design of Small Bridges and Culverts
IRC:SP-42-1994	Guidelines on road drainage"
MINISTRY OF ROAD TRANSPORT & HIGHWAYS	
MORTH-2013	Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion

Source: JICA Survey Team based on DPR

(3) Classification of Existing Culverts

There are 55 nos. of existing culvert on the Survey Road. There are 28 Nos. of existing pipe culvert and 41 nos., of existing Slab Culvert and 1 no. widening of pipe.

Table 3-21: Classification of Existing Culverts in Assam

		NH127B Assam (Srirampur-Dhubri)
EXISTING Culvert （Total）		55
	Pipe Culvert	28
	Slab Culvert	25
	Box Culvert	1
	Fully Chocked Culvert	1
	Widening of Pipe	0

Source: JICA Survey Team based on DPR

A list of existing culverts is shown below.

Table 3-22: List of Culverts in Assam (1)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
1	1.943	1+946	Slab	1×2.0m
2	2.997	2+992	Pipe	3×φ1.0m
3	3.384	3+378	Slab	1×3.0m
4	4.325	4+322	Slab	1×3.0m
5	4.328	5+760	Pipe	2×φ1.0m
6	5.768	6+059	Pipe	2×φ1.0m
7	6.080	6+221	Pipe	2×φ1.0m
8	6.231	6+723	Pipe	2×φ0.9m
9	7.860	7+850	Slab	1×1.7m
10	8.068	8+058	Pipe	2×φ1.0m
11	10.921	10+909	Pipe	1×φ1.1m
12	11.838	11+825	Pipe	2×φ0.9m
13	12.170	12+099	Slab	1×1.5m
14	12.248	12+177	Pipe	2×φ1.0m
15	12.745	12+675	Pipe	2×φ1.0m
16	12.922	12+851	Pipe	2×φ1.0m

Source: JICA Survey Team based on DPR

Table 3-23: List of Culverts in Assam (2)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
17	13.825	13+800	Slab	1×1.3m
18	14.814	14+837	Slab	1×0.7m
19	16.288	16+310	Slab	1×2.3m
20	16.447	16+469	Slab	1×1.0m
21	17.816	17+538	Slab	1×2.1m
22	25.545	25+156	Pipe	1×φ0.6m
23	25.763	25+374	Slab	1×0.8m
24	26.538	26+147	Slab	1×0.9m
25	27.181	26+785	Slab	1×0.9m
26	27.895	27+494	Pipe	1×φ0.8m
27	28.270	27+870	Slab	1×0.8m
28	32.181	31+339	Box	1×2.0×1.5m
29	32.743	31+902	Pipe	1×φ0.8m
30	33.849	33+013	Slab	1×0.9m
31	34.548	33+717	Slab	1×0.9m
32	34.643	33+809	Slab	1×1.0m
33	37.191	36+382	Pipe	1×φ0.9m
34	38.435	37+626	Pipe	1×φ0.9m
35	40.379	39+172	Slab	1×2.25m
36	unknown	39+500	Slab	unknown
37	unknown	**39+505**	**Slab**	unknown
38	unknown	39+500	unknown	unknown
39	unknown	39+800	unknown	unknown
40	unknown	39+795	unknown	unknown
41	unknown	39+800	unknown	unknown
42	unknown	40+310	unknown	unknown
43	unknown	40+250	unknown	unknown
44	unknown	40+193	unknown	unknown
45	41.792	41+083	Slab	1×1.5m
46	42.904	42+191	Pipe	1×φ0.9m
47	43.195	42+482	Pipe	2×φ0.8m
48	43.983	43+268	Slab	1×2.8m
49	44.502	43+788	Slab	1×1.5m
50	44.688	43+974	Slab	1×1.5m
51	44.936	44+222	Slab	1×3.0m
52	46.041	45+325	Slab	1×2.5m
53	46.081	45+370	Pipe	1×φ0.8m
54	47.666	46+856	Pipe	1×φ0.8m
55	unknown	49+250	unknown	unknown
56	49.473	50+485	Pipe	1×φ0.9m
57	51.329	50+611	Pipe	1×φ0.9m

Source: JICA Survey Team based on DPR

Box culverts that are no longer used due to the review of road alignment are as follows.

Table 3-24: Existing Culverts Not Required in Assam

Sl No.	Survey Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
1	21.101	Slab	1×2.000
2	39.604	Pipe	1 × 1.200
3	40.578	Pipe	1 × 1.000
4	42.360	Pipe	1 × 0.900
5	53.269	Pipe	3 × 0.900
6	53.913	Slab	1 × 1.000
7	54.615	Pipe	1 × 0.900
8	54.782	Pipe	1 × 0.900
9	55.150	Slab	1 × 1.200
10	55.616	Slab	1 × 2.100
11	56.900	Pipe	1 × 1.000
12	57.800	Pipe	1 × 0.900
13	57.877	Box	1 × 1.000
14	57.922	Pipe	1 × 0.900
15	58.092	Pipe	1 × 0.900
16	59.528	Slab	1 × 1.000
17	60.708	Slab	1 × 1.000
18	62.54	Slab	1 × 2.000
19	62.72	Box	1 × 1.5000
20	63.03	Pipe	1 × 1.000
21	75.05	Pipe	2 × 1.200
22	114.75	Slab	1 × 1.000
23	127.67	Slab	1 × 5.700
24	132.59	Pipe	2 × 0.900

Source: JICA Survey Team based on DPR

Chapter 4. Traffic Survey, Analysis and Forecast

4.1 General

This Chapter summarizes the main points and assumptions based on the review of the Detailed Project Report (DPR) on the Survey Corridors prepared by relevant DPR Consultants[1]. This Chapter is based on the DPR for NH127B Srirampur-Dhubri, Assam.

Based on the review of the DPRs, the JICA Survey Team have proposed certain revisions to the traffic projections which are discussed at the end of this chapter.

4.2 Survey Road Network / Sections

The NH127B corridors covered under this Survey are as shown in Figure 4-1 and further described in Table 4-1.

Source: JICA Survey Team (based on DPR)

Figure 4-1: Survey Corridor Map for NH127B (Assam)

Table 4-1: Survey Road Network and Sections

State	Survey Road Network		Target Length (km)
Assam	Srirampur-Dhubri	The target road starts at Srirampur in the Kokrajhar district and extends down to approach of the proposed bridge over Brahmaputra river in the Dhubri district.	54.154 (as per DPR)

Source: JICA Survey Team

The proposed "Dhubri bridge" across Brahmaputra river which connects the two sections of NH127B in Assam and Meghalaya has not yet been constructed (2028 planned completion). After construction of this bridge, it is assumed that traffic will be diverted from alternate routes, such as NH31 (Assam), that currently use the existing Goalpara Bridge to cross over between Assam and Meghalaya. Therefore, it is worth noting that the viability of the traffic forecast presented for these two Survey Corridors also depend on successful completion of this bridge.

4.3 Traffic Survey

For the Survey Corridor NH127B Assam, primary surveys were carried out by DPR Consultants through manual counting to analyze the characteristics and volume of existing traffic, travel pattern of each vehicle on the Survey Corridors, influential zones, and other data essential for

[1] DPR for NH127B (Srirampur-Dhubri, Assam) was prepared by CETEST Engineering Consultants

projection of future traffic. The types of surveys conducted along the chainage shown in Figure 4-2 were:

- Classified Traffic Volume Count Survey
- Origin-Destination Survey
- Turning Movement Survey
- Axle Load Survey

Source: JICA Survey Team

Figure 4-2: Chainage along the Survey Corridors

Reconnaissance survey was undertaken to identify homogenous sections along the Survey Corridor and appropriate locations for these primary surveys. Table 4-2 summarize the details of the surveys undertaken at designated locations on the Survey Corridors in Assam.

Table 4-2: Traffic Surveys at NH127B, Assam

Type of Survey	Location	Survey Dates	Survey Duration
Classified Traffic Volume Count Survey	On NH-31C near Srirampur at CH 0+000Km.	18/12/2015 (Fri) to 24/12/2015 (Thu)	24 Hour x 7 days
	Near Tamarhat at CH 15+500Km	17/12/2015 (Thu) to 23/12/2015 (Wed)	
	On NH 31 near CH 40+000Km		
	Near Chowmore at CH 57+000Km		
Origin-Destination Survey [Random sample,	On NH 31C Near Srirampur at CH 0+000Km	21/12/2015 (Mon)	24 Hour x 1 days
	2 Km Towards Dhubri along NH31	19/12/2015 (Sat)	

15% sample size]	from CH 40.00Km of NH-127B		
Turning Movement Survey	Srirampur (CH 0.000Km), 4-legged.	24/12/2015 (Thu)	12 Hour x 1 day
	On NH31 at CH 40+000Km, 3-legged.	18/12/2015 (Fri)	
Axle Load Survey	On NH-31C near Srirampur at CH 0+000Km	21/12/2015 (Mon)	24 Hour x 1 days
	Near Tamarhat P.S CH 15+200Km	23/12/2015 (Wed)	
	2 Km Towards Dhubri along NH31 from CH 40.00Km	19/12/2015 (Sat)	

Source: DPR by CETEST Engineering Consultants

Based on the above survey results, this Chapter discusses the following analysis and calculations undertaken by the DPR Consultants:

- Average Daily Traffic (ADT) - calculated by DPR Consultants taking simple average of the 7-day traffic data collected through Classified Traffic Volume Count Survey.
- Daily Traffic Variations, Hourly Traffic Variations, and Peak Hour Factor (PHF) - analyzed to understand temporal variations.
- Annual Average Daily Traffic (AADT) - calculated after applying Average Seasonal Correction Factor (ASCF) based on petrol and diesel sales figures of the regions' gas stations. AADT also took into consideration the potential diverted traffic from existing alternate route.
- O-D Survey - carried out by DPR Consultants (for NH127B) through Road-Side Interview (RSI) to identify influential zones and travel patterns.
- Passenger Car Unit (PCU) - converted from heterogenous traffic to comparable traffic data based on IRC:64-1990. PCU used for this calculation are shown in Table 4-3.

Table 4-3: PCU Factors

Vehicle Type		PCU Factor
Two Wheeler		0.50
Car/Jeep/ Van/Taxi/ Auto		1.00
Bus	Mini	1.50
	Standard	3.00
LCV		1.50
Truck	2-Axle	3.00
	3 -Axle	3.00
	Multi-Axle	4.50
Agricultural Tractor	With Trailer	4.50
	Without Trailer	1.50
Cycle		0.50
Cycle Rickshaw		2.00
Hand Cart		3.00
Animal Drawn Vehicle		8.00 (Bullock Cart) 4.00 (Horse)

Source: DPR

4.4 Traffic Survey Results

4.4.1 Classified Traffic Count Survey Analysis

(1) Observed Traffic Volume

Table 4-4 summarizes the Average Daily Traffic (ADT) along NH127B Srirampur-Dhubri, Assam. The traffic count data has been taken from the DPR but aggregate calculations have been corrected.

Table 4-4: Average Daily Traffic (NH127B, Assam)

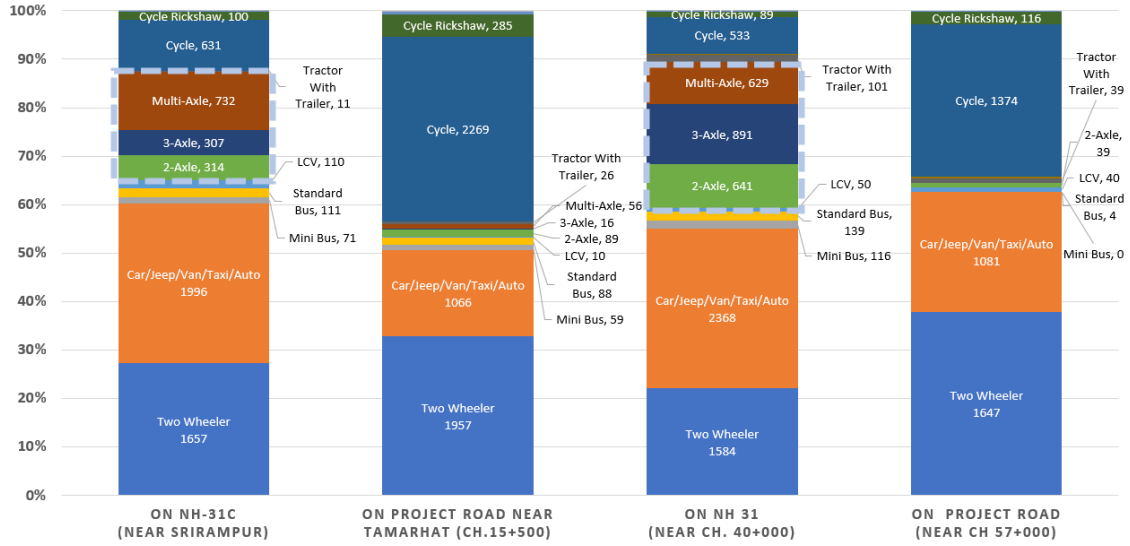
Vehicle Type	ON NH-31C (Near Srirampur)	On project road Near Tamarhat (CH.15+500)	ON NH 31 (Near CH. 40+000)	On project road (Near CH 57+000)
Two Wheeler	1657	1957	1584	1647
Car/Jeep/Van/Taxi/Auto	1996	1066	2368	1081
Mini Bus	71	59	116	0
Standard Bus	111	88	139	4
LCV	110	10	50	40
2-Axle	314	89	641	39
3-Axle	307	16	891	1
Multi-Axle	732	56	629	0
Tractor With Trailer	11	26	101	39
Tractor Without Trailer	2	2	21	13
Cycle	631	2269	533	1374
Cycle Rickshaw	100	285	89	116
Hand Cart	15	29	5	6
Bullock Cart	1	1	1	0
Horse Cart	1	11	5	0
Total Motorized Vehicles (No.)	**5311**	**3369**	**6540**	**2864**
Total Non Motorized Vehicles (No.)	**748**	**2595**	**633**	**1496**
Total Commercial Vehicle per day (No.)	**1658**	**346**	**2588**	**136**
Total Motorized Vehicles (PCU)	**8639**	**3099**	**11739**	**2292**
Total Non Motorized Vehicles (PCU)	**573**	**1844**	**488**	**937**
Total PCU per day	**9211**	**4943**	**12226**	**3229**

Source: CETEST Engineering Consultants (calculations revised by the JICA Survey Team)

On NH127B Assam, maximum traffic of 12,226 PCU per day is observed at Ch. 40+000 where NH31 meets the Survey Corridor with minimum traffic of 3,229 PCU per day at Ch. 57+000 near the proposed Dhubri Bridge.

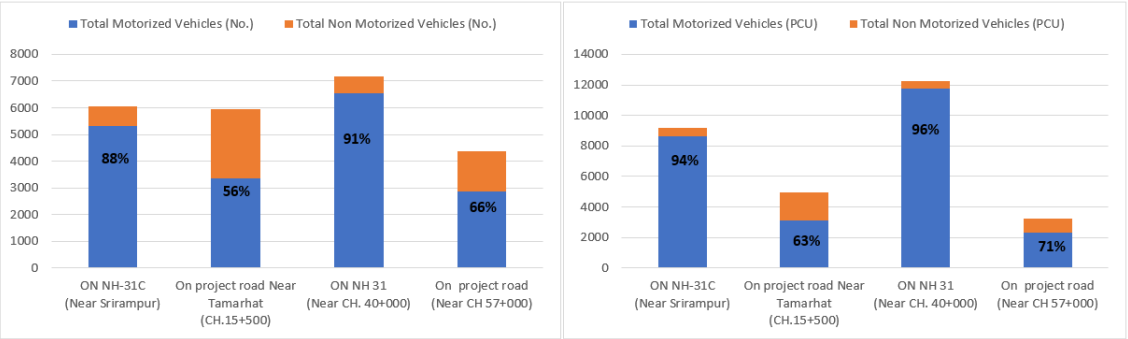
(2) Characteristic of the Traffic

Figure 4-3 shows the vehicle types along NH127B Srirampur-Dhubri, Assam. On the Survey Corridor itself (at Ch. 15+500 and Ch. 57+000) approx. 90% of the traffic is made up of small and private vehicles (i.e. Two Wheeler and Car/ Jeep/ Van/ Taxi/ Auto) and Cycle. However, at locations where the Survey Corridor intersects with existing roads of NH31C and NH31, the vehicle distribution changes with up to approx. 30% of the traffic comprising trucks. From Figure 4-4, it is evident that there is a notable difference in the proportionate share of motorized vehicles and non-motorized vehicles between the Survey Corridor and the intersecting roads NH31C and NH31.



Source: JICA Survey Team

Figure 4-3: Vehicle Types on NH127B Assam



Source: JICA Survey Team

Figure 4-4: Motorized Vehicles vs. Non-Motorized Vehicles on NH127B Assam

4.4.2 Daily and Hourly Traffic Variations, Peak Hour Factor (PHF), and Average Seasonal Variation Factor (ASVF)

(1) Daily and Hourly Traffic Variations

Traffic on NH127B (Assam) fluctuates by the day and hour but this variation has been accounted for by conducting the traffic count survey over a continuous 7-day period. It can be observed that traffic is active during the day but is very low during the night, particularly between the 9:00 pm to 5:00 am window.

(2) Peak Hour Factor (PHF)

The Peak Hours for NH127B Assam are shown in Table 4-5. The PHF range of approx. 9% ~10% indicate that traffic is spread over substantial duration of time during the day.

Table 4-5: Peak Hour Factor for NH127B Assam

Count Location (127B, Assam)	Peak hour	Peak Traffic Volume (PCU)*	PHF (%)
On project road Near Tamarhat (CH.15+500)	10:00 am ~ 11:00am	501	10.13%
On project road (Near CH 57+000)	10:00 am ~ 11:00am	291	9.01%

Source: Estimated by the JICA Survey Team

(3) Average Seasonal Variation Factor (ASVF)

ASVF to generate AADT was calculated by DPR Consultants based on annual petrol and diesel sales figures from fuel stations along the Survey Corridor near the survey locations.

ASVF for NH127B Assam was estimated as 0.93 for petrol operated vehicles and 1.05 for diesel operated vehicles for all locations along the Survey Corridor.

4.4.3 Annual Average Daily Traffic (AADT)

AADT for NH127B Assam is shown in Table 4-6.

Table 4-6: AADT on Homogeneous Sections of NH127B Assam

Vehicle Type	Homogeneous Section 1 (Ch. 0+000km to Ch. 38.990)	Homogeneous Section 2 (Ch. 38+990 Km. to Ch.54+154 Km.)
Two Wheeler	1825	1535
Car/Jeep/Van/Taxi/Auto	1055	1070
Mini Bus	62	0
Standard Bus	92	4
LCV	10	42
2-Axle Truck	93	41
3-Axle Truck	16	1
Multi-Axle	58	0
Tractor With Trailer	28	41
Tractor Without Trailer	2	13
Cycle	1357	1374
Cycle Rickshaw	285	116
Hand Cart	29	6
Bullock Cart	1	0
Horse Cart	11	0
Total Motorized Vehicles (No.)	**3241**	**2747**
Total Non Motorized Vehicles (No.)	**1683**	**1496**
Total Commercial Vehicle per day (No.)	**361**	**142**
Total PCU per day	**4456**	**3180**

Source: CETEST Engineering Consultants (calculations revised by the JICA Survey Team)

4.5 Traffic Projection Methodology

4.5.1 Existing Traffic Data

Existing traffic data is from December 2015 for NH127B Srirampur-Dhubri, Assam as collected by the DPR Consultants. Due to the ongoing global pandemic, the JICA Survey Team is unable to collect more recent traffic data, and for now, traffic analysis is reviewed based on latest data collected by DPR Consultant.

4.5.2 Homogeneous Sections

Two homogenous sections were identified by CETEST Engineering Consultants for NH127B Srirampur-Dhubri, Assam as follows:

- Homogeneous Section I: Km 0+000 (Srirampur) to Km 38+990
- Homogeneous Section II: Km 38+990 to Km 54+154 (near Dhubri)

Homogeneous Section I is taken from the DPR by CETEST Engineering Consultants while Homogeneous Sections II are taken from the DPR by Technocrats Advisory Services.

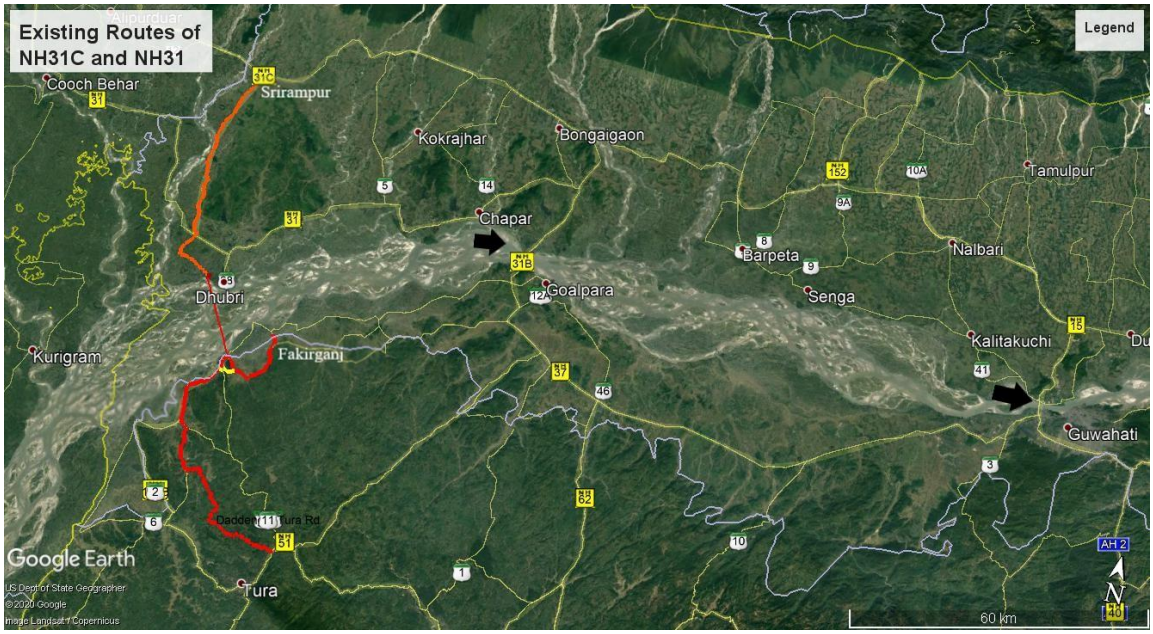
4.5.3 Consideration/ Assumptions by DPR Consultants

(1) Diverted Traffic based on O-D Survey Analysis

O-D survey for Assam was undertaken by CETEST Engineering Consultants at the intersection of NH 31C near Srirampur at CH 0+000Km and at 2 Km towards Dhubri along NH31 from CH 40.00Km.

One of the main observations was that traffic from west side of NH127B (i.e. Delhi, Luckhnow, Patna, etc.) was coming into Assam through NH31C while traffic from south-west side of NH127B (i.e. Kolkata, Gholapak, Harirampur, etc.) were coming into Assam through NH31C and NH31.

As Assam connects mainland India with North-Eastern India, currently a lot of traffic on NH31C and NH31 goes through Assam and crosses over Goalpara or Guwahati to enter other states like Meghalaya and Tripura as shown in Figure 4-5.



Source: JICA Survey Team

Figure 4-5: Existing Routes of NH31C and NH31

Based on the traffic survey, it can be observed that approx. 90% or more traffic along the current NH127B corridor is small and private vehicles or cycles. However, based on the O-D survey results from the intersections of NH31C and NH31, it is assumed that the completion of NH127B Assam would provide a viable alternate route to traffic, particularly trucks, coming from Mainland India (primarily from south-west region such as Kolkata, Gazole, Harirampur, etc,) to North-East India.

More traffic on NH31 is estimated to be diverted to NH127B given that NH127B could serve as a more efficient route to south and south-west regions of the Survey Corridor such as Guwahati, Shillong, Agartala, Nagaland, etc. Accordingly, certain proportion of the existing traffic on NH31 and NH31C are estimated to be diverted to the Km. 40+000 to Km. 57+000 section of NH127B Assam as given in Table 4-7.

Table 4-7: Diverted Traffic Percentage on NH127B Assam

Vehicle Type	Homogeneous Section 2 (Ch. 38+990 Km. to Ch.54+154 Km.)	
	Probable diverted traffic NH31C -> NH127B	Probable diverted traffic NH31 -> NH127B
Car/Jeep/Van/Taxi/Auto	5%	30%
Mini Bus	9%	77%
Standard Bus	10%	77%
2-Axle Truck	12%	59%
3-Axle Truck	3%	57%
Multi-Axle	3%	67%
Others	0%	0%

Source: CETEST Engineering Consultants

After applying the above assumption of traffic diversion, AADT in 2015 (base year) for Homogeneous Section 2 for NH127B Assam can be estimated as shown below in Table 4-8.

Table 4-8: AADT for NH127B Assam with Diverted Traffic

Vehicle Type	Homogeneous Section 2 (Ch. 38+990 Km. to Ch.54+154 Km.)					
	[A] ON NH127B	[B] ON NH31C	[C] Probable diverted traffic NH31C -> NH127B	[D] ON NH31	[E] Probable diverted traffic NH31 -> NH127B	[A]+[C]+[E] Total expected traffic
Two Wheeler	1535	1545	0	1477	0	1535
Car/Jeep/Van/Taxi/Auto	1070	1976	99	2344	703	1872
Mini Bus	0	75	7	121	93	100
Standard Bus	4	116	12	145	112	128
LCV	42	115	0	52	0	42
2-Axle Truck	41	329	39	671	396	476
3-Axle Truck	1	322	10	932	531	542
Multi-Axle	0	767	23	658	441	464
Tractor With Trailer	41	11	0	106	0	41
Tractor Without Trailer	13	2	0	22	0	13
Cycle	1374	631	0	533	0	1374
Cycle Rickshaw	116	100	0	89	0	116
Hand Cart	6	15	0	5	0	6
Bullock Cart	0	1	0	1	0	0
Horse Cart	0	1	0	5	0	0
Total Motorized Vehicles (No.)	**2747**	**5258**	**190**	**6528**	**2276**	**5213**
Total Non Motorized Vehicles (No.)	**1496**	**748**	**0**	**633**	**0**	**1496**
Total Commercial Vehicle per day (No.)	**142**	**1737**	**91**	**2707**	**1573**	**1806**
Total PCU per day	**3180**	**9411**	**396**	**12545**	**5944**	**9520**

Source: CETEST Engineering Consultants

(2) Traffic Growth Rate

The traffic projection by DPR Consultant is based on a growth rate of 5% as per IRC:37-2012. This 5% has been applied for all vehicle types from 2015 to 2035 (i.e. after end of design life), and regardless of 2-lane or expected 4-lane configuration of the Survey Corridor. The base year has been taken as 2015 and 2020 has been assumed as the year of road opening.

4.6 Traffic Projection in DPR

Based on the above traffic growth rates and expected diversion, the traffic projections for each homogeneous section along the Survey Corridor estimated by the DPR Consultant are shown below in Table 4-9.

Table 4-9: Traffic Projections by DPR Consultant for NH127B Assam

Year	NH127B Assam (DPR by CETEST Engineering Consultants)			
	Section 1 (Ch. 0+000km to Ch. 38.990)		Section 2 (Ch. 38+990 Km.~ Ch.54+154 Km.)	
	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2015	5837	4912	6711	9523
Road Opening 2020	7449	6269	8565	12154
2025	9507	8001	10931	15512
2030	12134	10211	13951	19797
2034 (Design life end)	**14749**	**12412**	**16958**	**24064**
2035	15486	13032	N/A	N/A

Source: CETEST Engineering Consultants (compiled by JICA Survey Team)

4.7 Revisions by the JICA Survey Team

4.7.1 Revision of Traffic Growth Assumptions

The JICA Survey Team has used the aforementioned AADT as base figures to generate revised projections for future traffic. The base year is taken as 2015 (i.e. year surveys were conducted).

2023 is taken as the estimate year of road opening of NH127B, therefore, traffic on NH127B Assam portion (Ch. 38+990 km~Ch.54+154 km) for this year has been increased to include diverted traffic from NH31C and NH31 to NH127B Assam.

For NH127B Assam, the following traffic projection scenarios have been generated by the JICA Survey Team:

- **Alternate Scenario 1 (Optimistic version)** – EDMAC Engineering Consultant (DPR Consultant for NH127B Meghalaya) has provided elasticity figures for not just Meghalaya but also Assam. Therefore, these figures have been used by the JICA Survey Team to generate comparable traffic projections for Assam.
- **Alternate Scenario 2 (Conservative version)** – With the understanding that the traffic projection under Scenario 1 is on the optimistic side, a more conservative traffic projection has been generated using traffic growth rates used for estimating traffic projection for JICA Preparatory Survey for Dhubri Bridge.

4.7.2 Revised Traffic Growth Rates

Traffic growth rates used by the JICA Survey Team for revised traffic projections are provided as follows.

Traffic Growth Rates for Scenario 1 for NH127B Assam

Traffic growth trend and elasticity value (based on regression analysis) for NH127B Assam was extracted from the DPR prepared by EDMAC Engineering Consultant as summarized in Table 4-10. Then, the traffic growth rate for motorized vehicles for Assam was estimated as shown in Table 4-11 (i.e. in accordance with the trend given in "Road Development Plan, Vision 2021" by MoRTH, GoI). 2% growth rate was used for non-motorized vehicles.

Table 4-10: Traffic Growth Trend and Elasticity for NH127B Assam

Mode	Economic Indicator	Assam		
		Trend Growth (%)	Elasticity Value (%)	Traffic Growth Rate (%)
2 Wheeler	PCI	12.73	10.62	**12.00**
3 Wheeler	PCI	11.20	9.80	**11.00**
Cars/Jeep	PCI	13.29	11.12	**12.00**
Bus	Population	5.61	5.36	**5.00**
Truck	NSDP	7.47	7.17	**7.00**
LCV/LCV Mini	NSDP	16.09	12.98	**15.00**

Source: JICA Survey Team based on DPR by EDMAC Engineering Consultant

Table 4-11: Estimated Traffic Growth Rate for NH127B Assam (Scenario 1)

Period	2 Wheeler	3 Wheeler	Car / Jeep	Bus	Truck			
					2 Axle	3 Axle	M Axle	LCV
Up to 2016	12.00	11.00	12.00	5.00	5.00	7.00	7.00	15.00
2017 -2021	11.00	10.00	11.00	4.00	4.00	6.00	6.00	14.00
2022 – 2026	10.00	9.00	10.00	3.00	3.00	5.00	5.00	13.00
2027 – 2031	9.00	8.00	9.00	2.00	2.00	4.00	4.00	12.00
Beyond 2031	8.00	7.00	8.00	1.00	1.00	3.00	3.00	11.00

Source: The JICA Survey Team

Traffic Growth Rates for Scenario 2 for NH127B Assam

Below Table 4-12 shows the growth rates for motorized vehicles which are similar to those used in the JICA Preparatory Survey for Dhubri Bridge (2% growth rate was used for non-motorized vehicles).

Table 4-12: Estimated Traffic Growth Rate for NH127B Assam (Scenario 2)

Period	2 Wheeler	3 Wheeler	Car / Jeep	Bus	Truck			
					2 Axle	3 Axle	M Axle	LCV
Up to 2016	8.60	3.30	9.80	5.70	5.90	5.90	4.90	7.20
2017 -2021	8.60	3.30	9.80	5.70	5.90	5.90	4.90	7.20
2022 – 2026	7.10	2.80	7.80	4.80	4.80	4.80	4.00	5.90
2027 – 2031	5.90	2.30	6.70	3.90	4.00	4.00	3.40	5.00
Beyond 2031	4.80	1.70	5.60	2.90	3.30	3.30	2.80	4.10

Source: The JICA Survey Team (based on estimation used for Dhubri Bridge Preparatory Survey)

4.7.3 Revised Traffic Projections

For NH127B Assam, as noted previously, two alternate scenarios have been prepared. Assuming 2023 as the road implementation year, diverted traffic from NH31C and NH31 have been included in addition to the estimated traffic on NH127B.

Based on the traffic forecast in Scenario 1 (optimistic version), the road sections near Dhubri Bridge (i.e. Ch.38+990Km to Ch.55+154Km near Dhubri in Assam) is where a higher proportion of the traffic is expected to be accumulated.

When comparing the traffic forecast of Scenario 2 (conservative version) with that estimated by the DPR Consultant, Scenario 2 shows a smaller traffic volume in Section 1 and a slightly larger traffic volume in Section 2 of NH127B Assam.

Table 4-13: Revised Traffic Forecasts for NH127B Assam

Year	NH127B Assam (Scenario 1)			
	Section 1 (Ch. 0+000km to Ch. 38.990)		Section 2 (Ch. 38+990 Km.~ Ch.54+154 Km.)	
	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2015	4924	4456	4243	3180
2020	7211	6262	6279	4676
Road Opening 2023	9064	7678	12382	16476
2025	10566	8809	14658	19271
2030	15280	12278	21125	26386
2035	21584	16811	29120	34094
2040	30574	23212	40403	44530
Year	NH127B Assam (Scenario 2)			
	Section 1 (Ch. 0+000km to Ch. 38.990)		Section 2 (Ch. 38+990 Km.~ Ch.54+154 Km.)	
	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2015	4924	4456	4243	3180
2020	6768	6012	5858	4400
Road Opening 2023	8095	7116	11234	15470
2025	9078	7927	12743	17456
2030	11776	10143	16664	22385
2035	14744	12566	20802	27310
2040	18379	15516	25854	33184

Source: JICA Survey Team

4.7.4 Further Revision Possibility

NH127B Assam

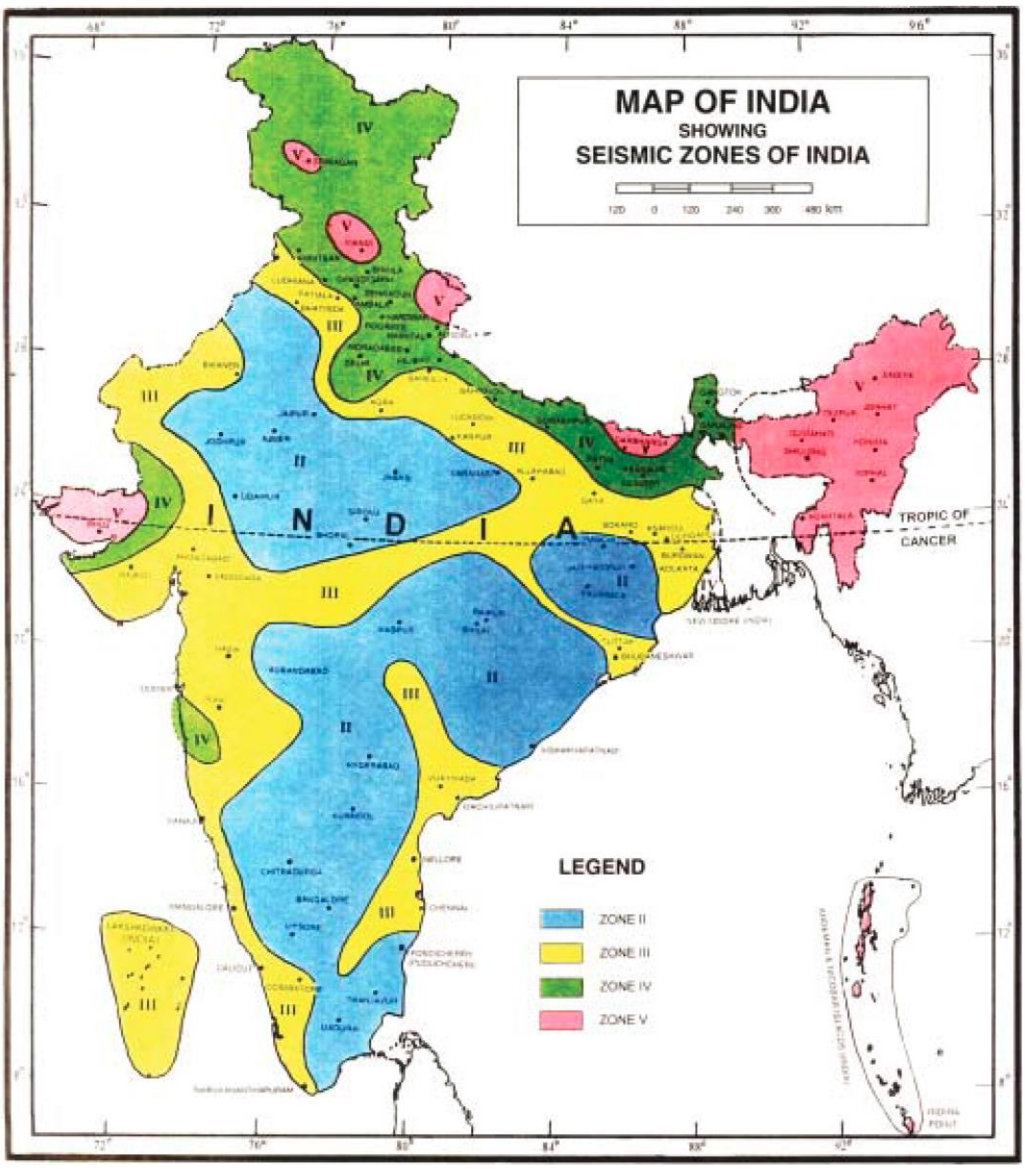
As shown in Table 4-7**,** diversion from NH31/31C can be expected, however, the diversion ratio could be revised, though there is no reference material other than the DPR for now.

There is no updated traffic volume in this region after the base year 2015. If updated traffic counting could be obtained, the base year and traffic forecast could be revised accordingly. Furthermore, the Dhubri Bridge opening could further influence traffic on NH127B Assam.

Chapter 5. Preliminary Design of NH127 (Srirampur-Dhubri)

5.1 Natural Condition Surveys

Natural condition surveys are bases of the engineering design and the preventive measures against natural hazards such as cyclone, heavy monsoon followed by devastating flood, landslide, and earthquake, etc. The main code for earthquake resistant design of structures is IS 1893 2002 (part 1 to part 5) published by the Bureau of Indian Standards, which provides seismic zone map (Figure 5-1) dividing India into 4 seismic zones in terms of zone factors (part 1) and specifies seismic design force. Seismic design of road structures (mainly highway bridges), is covered in two codes, namely, IS 1893 part 3 (Bridges and Retaining Walls) and IRC 6-2017 clause 219 (Seismic Force). The entire North-eastern region of India, where the project roads of NH127 B lies, falls in zone V which is most prone to earthquake hazards. Figure 5-1 shows seismic zones of India and the entire North-eastern region is coloured red as zone V:



Source: IS 1893 (Part1) 2002

Figure 5-1: Seismic Zones of India

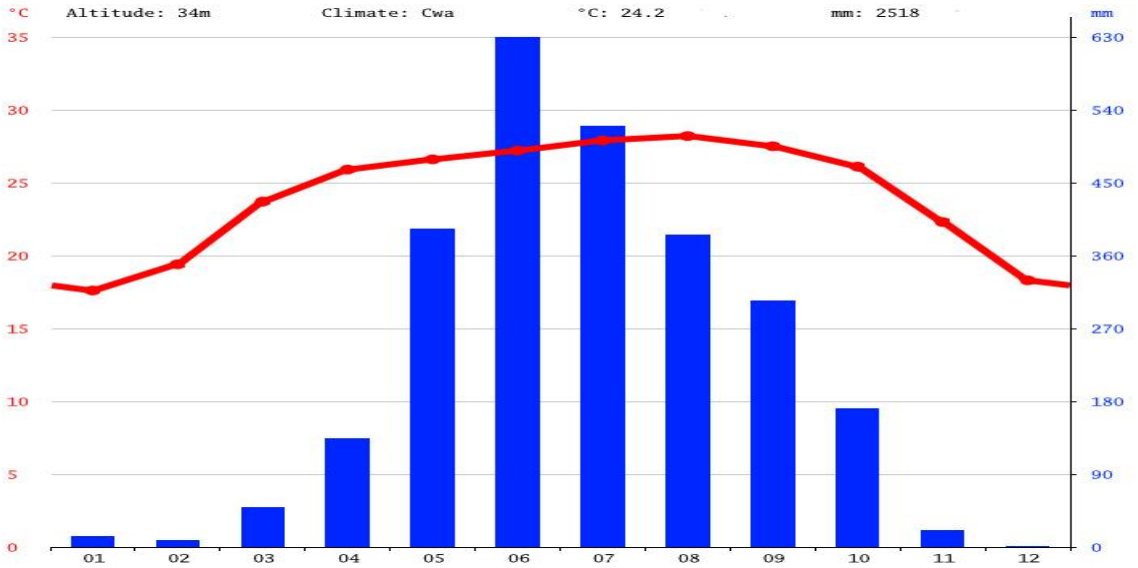
5.1.1 Meteorological and Hydrological Surveys

(1) General

The study area has a warm and temperate climate and is categorized as Cwa (i.e., temperate, dry winter, hot summer) in the Köppen-Geiger climate classification.[1] It has seasonal monsoon rains, which historically have caused dastrous flooding of the Brahmaputra River and its tributaries, particularly in the plain terrain traversed by NH127B.

(2) Meteorological Conditions

The monsoon season is from July to September. Annual average precipitation is 2,518 mm at Dhubri. The annual average temperature is 24.2°C. Figure 5-2 presents average monthly precipitation and temperatures at Dhubri.



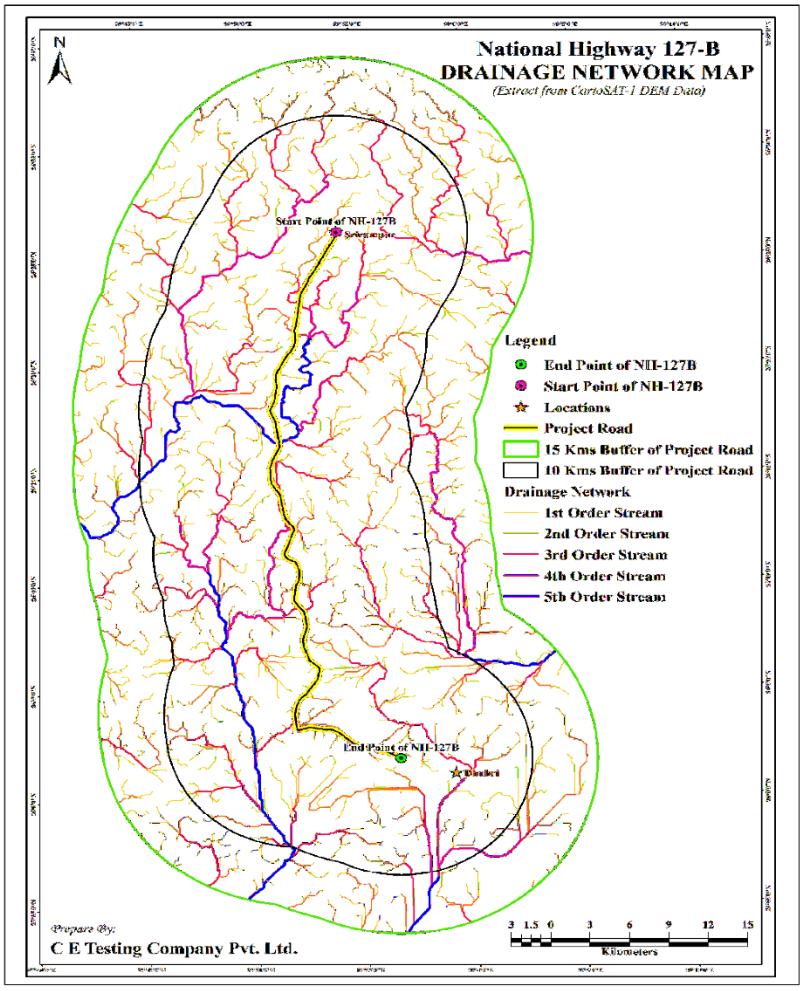
Source: climate-data.org

Figure 5-2: Average Monthly Precipitation and Temperatures at Dhubri

(3) Hydrological Survey

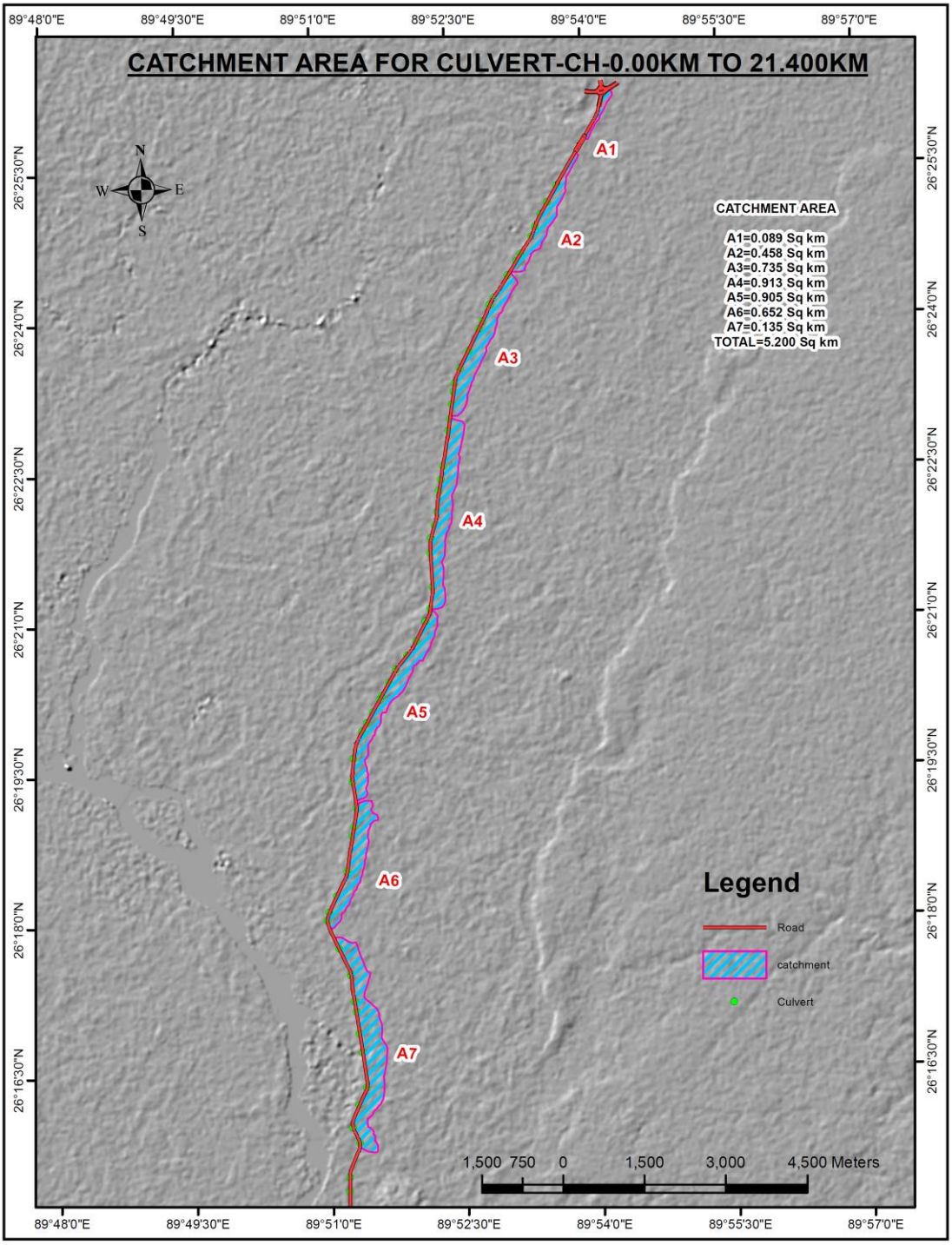
Pursuant to IRC SP-13-2004 and IRC SP-42-2014, a hydrological survey was conducted to obtain design data for bridges and drainage facilities during floods. First, drainage network map for the project road was obtained through satellite imagery. Second, the flooding parameters were studied with topographic maps. The necessary parameters are (i) the catchment area, (ii) tributary length, and (iii) differences in elevation along the road. In addition, rainfall intensity and the return period represented by an isopluvial map, were used to calculate the flood discharge volume, detail of which is described in Section 5.2.6 Discharge Design. Figure 5-3 presents the drainage network map NH-127B, Figure 5-4 presents an example of catchment area, of which full data is provided in Appendix C-1, and Figure 5-5 presents the isopluvial map in the study area.

[1] The most frequently used climate classification system is that of Wladimir Köppen, presented in its latest version 1961 by Rudolf Geiger.



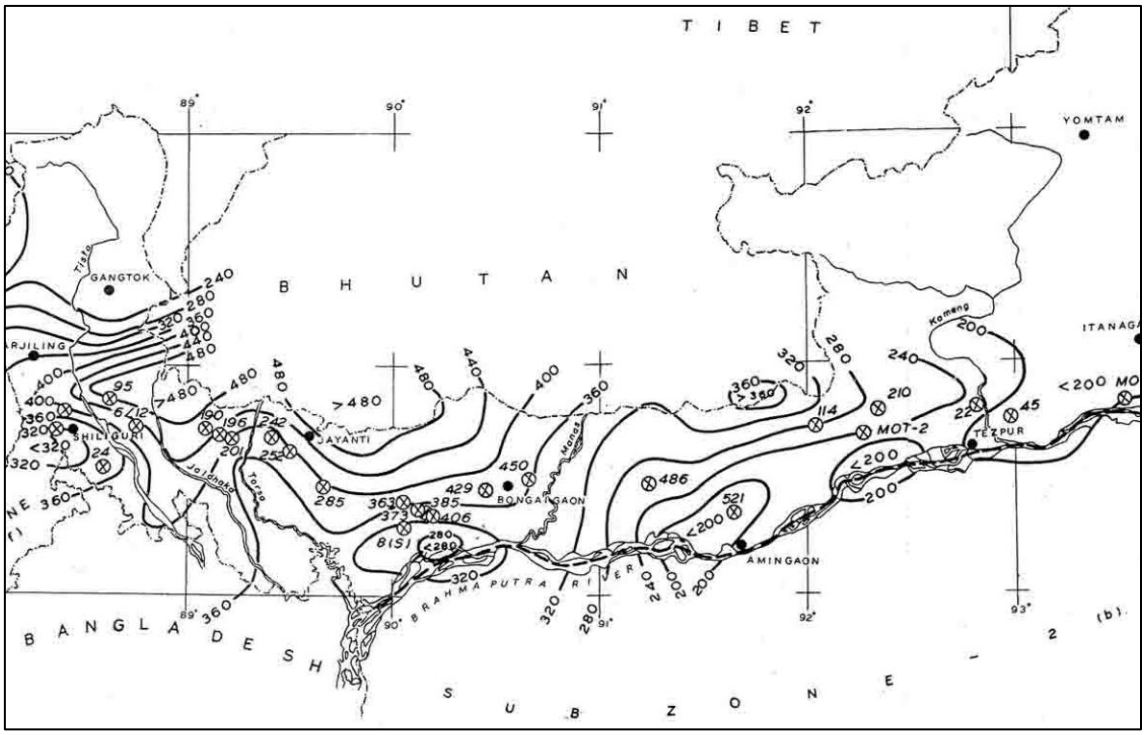
Source: DPR by CETEST Engineering Consultants

Figure 5-3: Drainage Network Map NH127B



Source: D by CETEST Engineering Consultants

Figure 5-4: An Example of Catchment Area



Source: Flood Estimation Report for North Brahmaputra sub Zone 2(a) by Central Water Commission

Figure 5-5: Is Isopluvial Map

5.1.2 Topographic Survey

(1) General

The project road starts from Srirampur and traverses plain terrain and ends at the immediate approach of the planned bridge over the Brahmaputra River near Dhubri. The survey area lies in the Kokrajhar and Dhubri districts of Assam. The design road length is 54.154 km.

(2) Review of the DPR Survey

The JICA Study Team has not yet conducted a site survey due to COVID-19-related travel constraints. However, topographic survey data including computer-aided design (CAD) files from the DPR consultant were received and reviewed by the Team. The following data provide horizontal control points and the horizontal alignment as partially extracted from the DPR. Specifically, Table 5-1 presents a list of GPS pillars, Table 5-2 presents a list of temporary benchmarks, Table 5-3 presents a list of reference pillars and Table 5-4 presents a horizontal alignment report. Full topographic survey data is provided in Appendix A-1 and A-2.

Table 5-1: List of GPS Pillars

1. GPS PILLARS LIST OF NH-127B				
SL NO.	**GPS NO.**	**EASTING**	**NORTHING**	**RL**
1	GPS-10+8	786241.019	2917374.486	40.162
2	GPS-10+8A	786145.974	2917333.584	39.995
3	GPS-15A	785037.925	2913792.136	37.413
4	GPS-15B	785009.157	2913624.313	36.561
5	GPS-20	785315.036	2909106.993	34.930
6	GPS-20A	785430.888	2909103.163	35.148
7	GPS-25	785261.558	2904999.720	35.207
8	GPS-25A	785327.330	2905033.840	31.832
9	GPS-30	785759.906	2899573.948	32.842
10	GPS-30	785759.906	2899573.948	32.842
11	GPS-30A	785659.477	2899487.043	32.869
12	GPS-35	786891.205	2895259.459	31.365
13	GPS-35A	787019.658	2895112.249	31.987
14	GPS-40	787587.866	2890751.259	31.029
15	GPS-40A	787614.979	2890663.832	29.609
16	GPS-45	787016.705	2887666.149	30.089
17	GPS-45A	786912.905	2887704.163	29.613
18	GPS-5+350	787193.337	2922677.367	44.000
19	GPS-5+5	787124.947	2922506.576	42.774
20	GPS-51	791852.928	2883372.991	33.410
21	GPS-51A	791984.837	2883370.406	30.907
22	PGPS-0A	789615.510	2927398.154	49.731
23	PGPS10+8	786244.755	2917358.958	40.344
24	PGPS-15B	784997.088	2913511.016	37.110
25	PGPS-20	785308.812	2909107.951	35.143
26	PGPS-30	785791.872	2899544.006	33.115
27	PGPS-5+0	787365.461	2922971.319	44.917
28	PGPS-5+0A	787319.597	2922915.131	43.428

Source: DPR by CETEST Engineering Consultants

Table 5-2: List of Temporary Benchmarks (TBM)

2. LIST OF TBM OF NH-127B				
SL NO.	**TBM NO.**	**EASTING**	**NORTHING**	**RL**
1	TBM0	789607.178	2927430.656	48.253
2	TBM0A	789597.038	2927370.491	50.039
3	TBM1	789207.873	2926430.946	49.046
4	TBM11+2	785896.528	2916835.930	39.290
5	TBM13+3	785022.693	2914671.237	38.522
6	TBM14+0A	785099.786	2914288.192	37.464
7	TBM14+2	785060.254	2913824.267	37.367
8	TBM15+2	784909.736	2912900.269	37.015
9	TBM16+2	784608.272	2911935.357	37.076
10	TBM17+2	784946.276	2911268.091	35.450
11	TBM23+3	784955.480	2905491.653	34.142
12	TBM26+2	785727.874	2902936.938	33.383
13	TBM27+0	786107.972	2902426.363	33.634
14	TBM27+3	786391.786	2901818.248	32.672
15	TBM28+3	786076.889	2900972.317	32.490
16	TBM29+D	786265.275	2899709.713	31.298
17	TBM29+D1	786238.091	2899682.328	31.812
18	TBM3+5	788052.236	2924290.153	45.015
19	TBM32+0	786824.661	2898168.449	32.561
20	TBM33+2	786508.920	2896724.454	32.514
21	TBM34+2	786451.885	2895854.110	32.069
22	TBM36+0	787258.296	2894516.355	32.431
23	TBM37+1	787287.199	2893254.434	31.732
24	TBM38+1	787122.725	2892243.852	31.238
25	TBM40+0	787585.706	2890784.620	30.851

Note: A temporary benchmark is a fixed point with a known elevation used for level control during construction works and surveys.
Source: DPR by CETEST Engineering Consultants

Table 5-3: List of Reference Pillars

3. REFERENCE PILLARS LIST OF NH-127B				
SL NO.	**PILLAR NO.**	**EASTING**	**NORTHING**	**RL**
1	P0+0	789607.254	2927289.458	48.826
2	P0+1	789561.420	2927132.625	48.753
3	P0+2	789499.403	2926896.772	47.805
4	P0+3	789370.513	2926695.664	47.798
5	P1+0	789242.914	2926475.793	48.075
6	P1+1	789128.996	2926244.128	47.400
7	P1+2	788991.534	2926038.011	46.675
8	P1+3	788874.680	2925808.319	46.711
9	P10+0	786505.049	2918145.667	40.808
10	P10+1	786471.596	2917887.496	40.363
11	P10+2	786392.799	2917655.689	40.757
12	P10+3	786285.811	2917422.781	40.581
13	P11+0	786181.133	2917207.009	40.187
14	P11+1	786027.331	2916995.022	40.302
15	P11+2	785870.630	2916800.455	39.324
16	P11+3	785747.452	2916590.368	38.905
17	P12+0	785650.458	2916395.055	38.898
18	P12+1	785524.068	2916178.204	39.170
19	P12+2	785414.648	2915960.847	38.480
20	P12+3	785288.389	2915742.987	38.885
21	P13+0	785145.390	2915480.459	38.514
22	P13+1	785073.638	2915242.333	38.490
23	P13+2	785037.736	2914996.949	38.283
24	P13+3	785013.844	2914739.428	37.899
25	P14+0	785062.892	2914459.272	38.075
26	P14+1	785108.072	2914194.423	37.936
27	P14+2	785074.168	2913916.595	37.345
28	P15+0	784987.779	2913462.393	37.248
29	P15+1	784964.314	2913206.016	36.957
30	P15+2	784925.409	2912962.936	37.018
31	P15+3	784830.428	2912730.551	36.907
32	P16+0	784710.494	2912497.290	36.993
33	P16+1	784616.041	2912270.830	36.934
34	P16+2	784567.369	2912031.852	36.855
35	P17+0	784659.364	2911860.225	36.857

Source: DPR by CETEST Engineering Consultants

Table 5-4: Horizontal Alignment Report

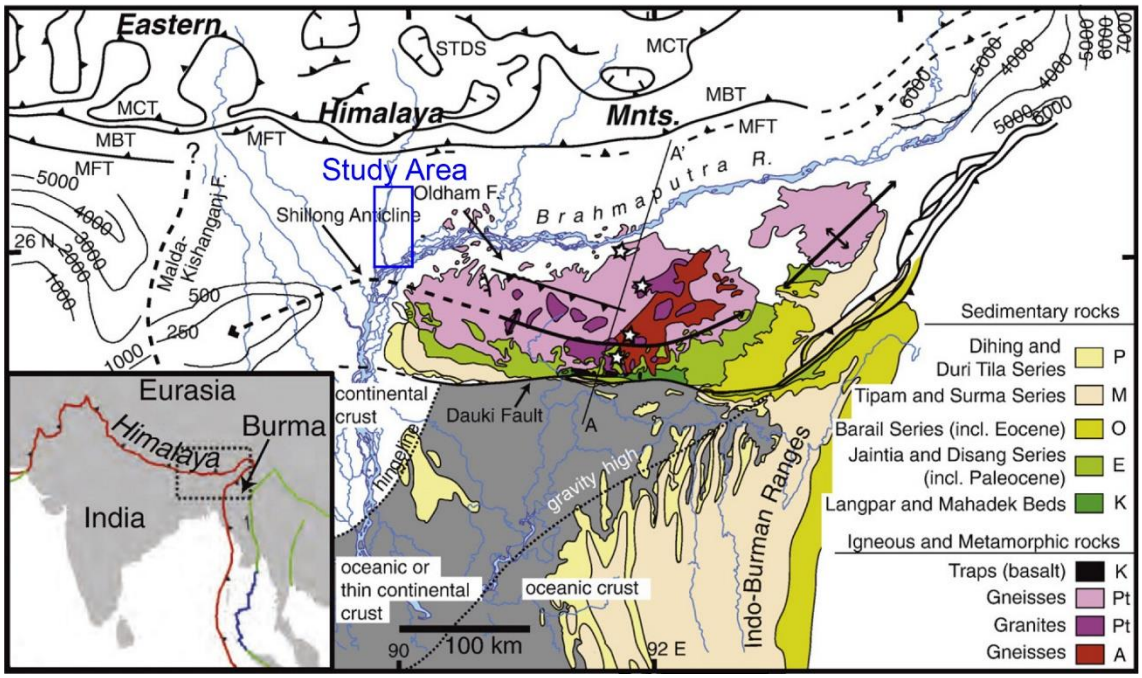
HIP/CURVE NO.	DEFLECTION ANGLE			ELEMENT	START			END			LENGTH (m)	CHORD LENGTH (m)	BEARING (dd mm ss)	RADIUS (m)	HAND OF ARC	SUPERELEVATION (%)	DESIGN SPEED	EXTRA WIDENING
	DEG	MIN	SEC		CHAINAGE (m)	EASTING	NORTHING	CHAINAGE (m)	EASTING	NORTHING								
				Start	0	789622.982	2927389.238	319.092	789552.883	2927077.941	319.092							
				Transition	319.092	789552.883	2927077.941	414.092	789529.098	2926986.005		95						
1	6	17	23.59	Arc	414.092	789529.098	2926986.005	468.982	789509.189	2926934.884		54.89		500	Right	5	100	--NA--
				Transition	468.982	789509.189	2926934.884	563.982	789464.53	2926851.078		95						
				Straight	563.982	789464.53	2926851.078	1868.816	788814.746	2925719.542	1304.834		S 29^51'59.71" W					
2	1	38	18.56	Arc	1868.816	788814.746	2925719.542	1926.01	788786.978	2925669.544		57.194		2000	Left	Normal Camber	100	--NA--
				Straight	1926.01	788786.978	2925669.544	2641.242	788448.685	2925039.374	715.231		S 28^13'41.15" W					
				Transition	2641.242	788448.685	2925039.374	2721.242	788412.429	2924968.079		80						
3	3	24	53.28	Arc	2721.242	788412.429	2924968.079	2757.001	788398.631	2924935.094		35.76		600	Left	5	100	--NA--
				Transition	2757.001	788398.631	2924935.094	2837.001	788373.322	2924859.22		80						
				Straight	2837.001	788373.322	2924859.22	2872.364	788362.88	2924825.434	35.362		S 17^10'25.90" W					
				Transition	2872.364	788362.88	2924825.434	2967.364	788331.982	2924735.639		95						
4	5	55	40.94	Arc	2967.364	788331.982	2924735.639	3019.096	788309.655	2924688.999		51.732		500	Right	5	100	--NA--
				Transition	3019.096	788309.655	2924688.999	3114.096	788259.089	2924608.62		95						
				Straight	3114.096	788259.089	2924608.62	3202.858	788209.469	2924535.023	88.762		S 33^59'17.14" W					
				Transition	3202.858	788209.469	2924535.023	3237.858	788190.016	2924505.926		35						
5	1	57	31.92	Arc	3237.858	788190.016	2924505.926	3289.141	788162.584	2924462.6		51.283		1500	Left	3	100	--NA--
				Transition	3289.141	788162.584	2924462.6	3324.141	788144.602	2924432.573		35						
				Straight	3324.141	788144.602	2924432.573	4036.317	787781.088	2923820.158	712.176		S 30^41'32.38" W					
				Transition	4036.317	787781.088	2923820.158	4076.317	787760.48	2923785.876		40						
6	2	48	0.29	Arc	4076.317	787760.48	2923785.876	4134.962	787728.503	2923736.723		58.645		1200	Right	3.7	100	--NA--
				Transition	4134.962	787728.503	2923736.723	4174.962	787705.512	2923703.991		40						
				Straight	4174.962	787705.512	2923703.991	4270.406	787650.22	2923626.194	95.445		S 35^24'08.16" W					
				Transition	4270.406	787650.22	2923626.194	4365.406	787597.685	2923547.087		95						
7	3	24	51.79	Arc	4365.406	787597.685	2923547.087	4395.202	787583.583	2923520.844		29.796		500	Left	5	100	--NA--
				Transition	4395.202	787583.583	2923520.844	4490.202	787546.607	2923433.377		95						
				Straight	4490.202	787546.607	2923433.377	4528.809	787532.708	2923397.36	38.606		S 21^06'06.06" W					
				Transition	4528.809	787532.708	2923397.36	4568.809	787518.1	2923360.123		40						
8	2	25	57.84	Arc	4568.809	787518.1	2923360.123	4619.76	787497.97	2923313.321		50.951		1200	Right	3.7	100	--NA--
				Transition	4619.76	787497.97	2923313.321	4659.76	787480.986	2923277.107		40						
				Straight	4659.76	787480.986	2923277.107	5835.046	786976.044	2922215.819	1175.287		S 25^26'39.39" W					
				Transition	5835.046	786976.044	2922215.819	5930.046	786937.98	2922128.819		95						
9	6	52	39.99	Arc	5930.046	786937.98	2922128.819	5990.066	786920.881	2922071.324		60.02		500	Left	5	100	--NA--
				Transition	5990.066	786920.881	2922071.324	6085.066	786905.217	2921977.663		95						
				Straight	6085.066	786905.217	2921977.663	6612.354	786834.747	2921455.105	527.288		S 7^40'49.09" W					
10	0	5	12.9	Arc	6612.354	786834.747	2921455.105	6616.147	786834.243	2921451.346		3.793		2500	Left	Normal Camber	100	--NA--
				Straight	6616.147	786834.243	2921451.346	7066.022	786774.796	2921005.416	449.876		S 7^35'36.19" W					
11	0	50	13.87	Arc	7066.022	786774.796	2921005.416	7095.246	786770.723	2920976.478		29.223		2000	Right	Normal Camber	100	--NA--
				Straight	7095.246	786770.723	2920976.478	7397.249	786726.446	2920677.738	302.003		S 8^25'50.06" W					
12	1	7	5.34	Arc	7397.249	786726.446	2920677.738	7436.28	786720.347	2920639.187		39.031		2000	Right	Normal Camber	100	--NA--
				Straight	7436.28	786720.347	2920639.187	7709.565	786675.013	2920369.688	273.286		S 9^32'55.39" W					
13	1	8	17.21	Arc	7709.565	786675.013	2920369.688	7749.293	786668.812	2920330.448		39.728		2000	Left	Normal Camber	100	--NA--
				Straight	7749.293	786668.812	2920330.448	8110.491	786615.981	2919973.134	361.198		S 8^24'38.19" W					
14	3	12	31.43	Arc	8110.491	786615.981	2919973.134	8222.497	786602.709	2919861.932		112.006		2000	Left	Normal Camber	100	--NA--
				Straight	8222.497	786602.709	2919861.932	8483.861	786579.012	2919601.645	261.364		S 5^12'06.76" W					
				Transition	8483.861	786579.012	2919601.645	8563.861	786569.992	2919522.171		80						
15	2	27	0.39	Arc	8563.861	786569.992	2919522.171	8589.519	786565.429	2919496.924		25.657		600	Right	5	100	--NA--
				Transition	8589.519	786565.429	2919496.924	8669.519	786546.054	2919419.322		80						
				Straight	8669.519	786546.054	2919419.322	8908.493	786483.029	2919188.808	238.975		S 15^17'29.12" W					
				Transition	8908.493	786483.029	2919188.808	9018.493	786458.381	2919081.68		110						
16	4	43	48.39	Arc	9018.493	786458.381	2919081.68	9055.643	786454.548	2919044.739		37.15		450	Left	5	100	--NA--
				Transition	9055.643	786454.548	2919044.739	9165.643	786456.678	2918934.833		110						
				Straight	9165.643	786456.678	2918934.833	9868.701	786498.917	2918233.045	703.058		S 3^26'39.56" E					
				Transition	9868.701	786498.917	2918233.045	9913.701	786500.946	2918188.094		45						
17	6	5	4.05	Arc	9913.701	786500.946	2918188.094	9966.798	786498.931	2918135.061		53.097		500	Right	5	80	--NA--
				Transition	9966.798	786498.931	2918135.061	10011.798	786493.496	2918090.394		45						
				Straight	10011.798	786493.496	2918090.394	10253.602	786460.693	2917850.826	241.803		S 7^47'48.32" W					
				Transition	10253.602	786460.693	2917850.826	10328.602	786447.442	2917777.059		75						
18	3	58	36.47	Arc	10328.602	786447.442	2917777.059	10349.424	786441.374	2917757.145		20.822		300	Right	5	80	0.60
				Transition	10349.424	786441.374	2917757.145	10424.424	786411.236	2917688.523		75						
				Straight	10424.424	786411.236	2917688.523	10945.634	786181.956	2917220.453	521.209		S 26^05'50.99" W					
				Transition	10945.634	786181.956	2917220.453	11035.634	786140.188	2917140.762		90						

Source: DPR by CETEST Engineering Consultants

5.1.3 Geological Survey

The geological survey in the field was not carried out because we could not visit India due to COVID-19 epidemic. The geology in the target area is mentioned based on collected literatures.

NH127B (Srirampur−Dhubri) is planned in the alluvial plain which has been formed by the Brahmaputra River and its tributaries. The geological map in the target area and its surrounding region is shown in Figure 5-6.



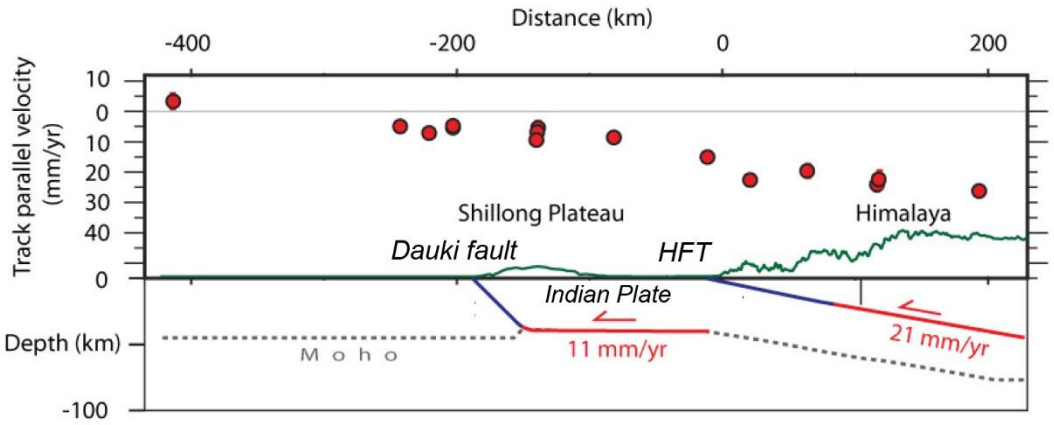
Source: Marin K. Clark and Roger Bilham, Miocene rise of the Shillong Plateau and the beginning of the end for the Eastern Himalaya. Earth Plannet. Sci. Lett., 2008, doi:10.1016/j.epsl.2008.01.045
Note: The target area is shown in blue rectangle.

Figure 5-6: Geological Map in the Target Area and its Surrounding Region

The target area is located at the southern lowland of the Himalayan Frontal Thrust (in general, it is called Himalayan Frontal Thrust and abbreviated as HFT: it is the same as MFT in Figure 5-6). This forms the boundary fault between Indian plate and Eurasia plate.

The Dauki fault, which is a reverse fault inclined to the north with the strike parallel to HFT, is distributed in the south of HFT. The northern side was uplifted by the activity of the Dauki fault, and accordingly the Shillong Plateau was formed, while the southern side is a lowland called "Sylhet Trough". The Brahmaputra River, though originally flowed straight towards the south from Himalayan mountains, has changed the flow towards the west by the uplift of Shillong Plateau.

The cross section, which traverses the Shillong Plateau with North−South direction, is shown in Figure 5-7.



Source: W. Yu and K. Sieh, *Active Tectonic Features That Pose ba Seismic Threat to Bangladesh, Comprehensive Disaster Management Programme*, Dhaka, 2013

Figure 5-7: Cross Section of the Shillong Plateau with North−South Direction

The thin solid lines and Arabic numerals in Figure 5-6 represent the depth of basement rocks. In the other words, it is the thickness of sediments. The Precambrian basement rocks (Indian plate) is exposed in the Shillong Plateau, and in the western region of the Shillong Plateau, the basement rocks are located in the shallow depth. The depth of basement rocks gradually become deeper towards the north. The depth of basement rock near the HFT become more than 5,000 m.

5.1.4 Road inventory Survey

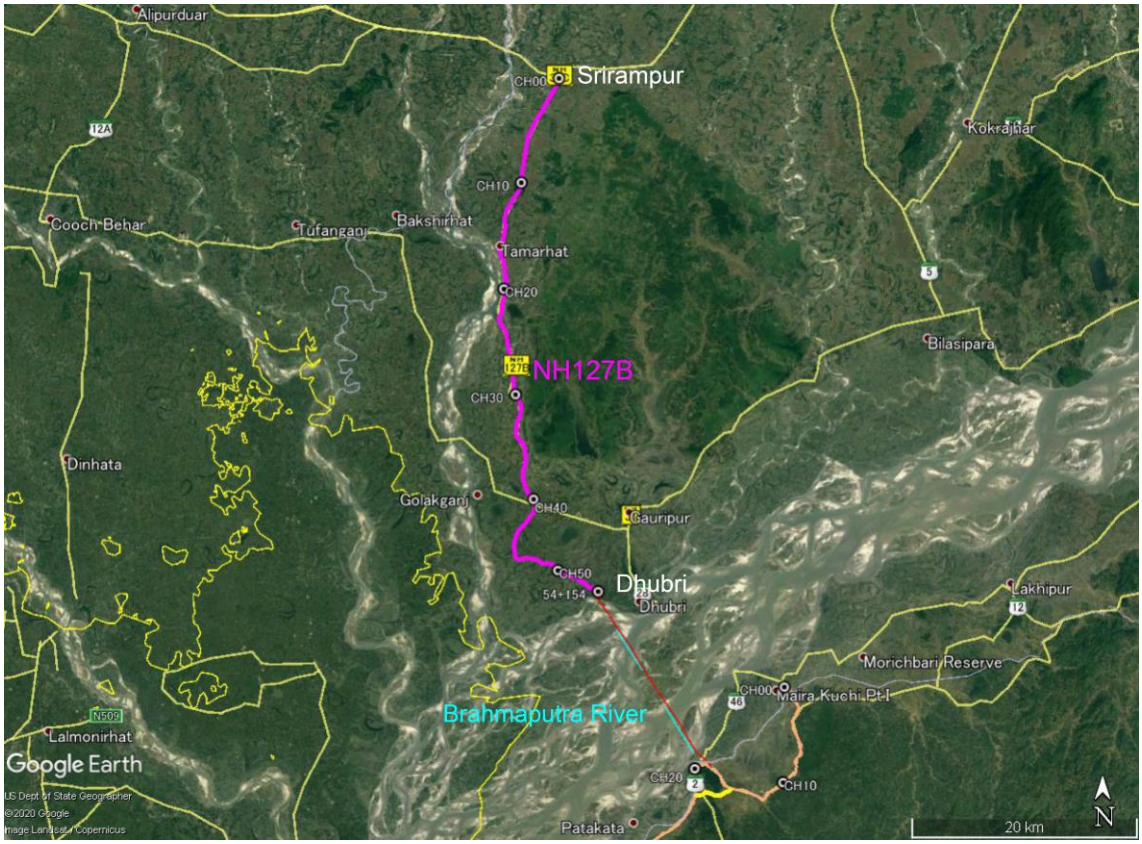
(1) Background of the Survey

The JICA Survey Team has not yet conducted a site survey due to COVID-19 travel constraints, and therefore at this time the Team relied on the study in the DPR, which has been referred to in this Draft Final Report.

(2) Overview of the Road Inventory Survey

The project road extends from Srirampur on NH27 (the former NH31C) at Chainage 0.000 km to the immediate approach of a proposed bridge over the Brahmaputra River near Dhubri at chainage 55.700 km. The total length of the road is about 57.750 km (as per the road inventory). The project road connects Meghalaya State with the proposed bridge over the Brahmaputra River in Assam. The road traverses the villages Srirampur, Jakobpur, Kambilpur, Malkapur, Kathalguri, Grampur, Bashantipur, Auxiguri, Uzanpetla, Mudha Petla, Alokjhari, Bhati Petla, Satsaura, Kachakana, Pagla Hat, Barun Danga, Morterjhar, Baniyamari, Balajan, Dhepdheoi, Debdutta Hazdaha 1, Kachari Hat, Debdutta Hazdaha 2, Raja Katli, Kachua Kash, Chanda Khol, and Ada Bari. The land adjacent to the project road is predominantly agricultural, with low-lying pasture land and sparse settlements, rural and semiurban in character. Figure 5-8 presents a location map of NH127B, along which, the road inventory survey was conducted to:

- prepare an inventory of the existing road structures and assess their condition;
- Identify the existing structures to be abandoned, upgraded, or retained, in accordance with the latest design standards and loading requirements of the traffic; and
- Identify where new structures will be required.



Source: JICA Survey Team

Figure 5-8: Location Map of NH127B

The DPR consultant has carried out an inventory survey along the project road NH127B, conforming to IRC SP19 2001. This main report presents extracted summaries of major inventories, while full inventory lists are provided in the Appendix B-1 to B-3 Major inventory items are (i) a road inventory, (ii) pavement conditions, (iii) a culvert inventory, and (iv) a bridge inventory. Each is summarized below.

(1) Road Inventory

The DPR consultant carried out a road inventory survey along the project road NH127B conforming to IRC SP19 2001. A road inventory survey is to identify details of utility services and other physical features. It was observed that the vertical alignment of the road is quite flat except at a few bridge and culvert locations. The existing formation height of the project road generally varies from 2 to 5 m and is higher at the approaches to bridges. Extracted road inventory data is presented in Table 5-5, while the full data is provided in Appendix B-1 Road Inventory.

(2) Pavement Condition

A pavement condition survey was carried out to identify pavement distress (e.g., cracking, raveling, potholing, patching, rutting) along the entire project road. Extracted pavement condition data is presented in Table 5-6, while the full data is provided in Appendix B-2 Pavement Condition.

(3) Culvert Inventory and Condition

There are 55 culverts along the project road, of which 28 are pipe culverts, 25 are slab culverts, 1 is a box culvert, and 1 is fully choked. Extracted culvert inventory and condition data is presented in Table 5-7, while the full data is provided in Appendix B-3 Culvert Inventory and Condition.

(4) Bridge Inventory and Condition

There is one major bridge and eight minor bridges along the project road, with major bridges defined as exceeding 60 m in length and minor bridges as being from 6 m to 60 m long. Extracted culvert inventory and condition data is presented in Table 5-8, while the full data is provided in Appendix B-4 Bridge Inventory and Condition.

Table 5-5: Extracted Road Inventory Data

From Km	To	Terrain (Plain/Rolling/Hilly)	Land Use (Builtup/Agrt/Forest/Industrial/Barren)	Name of the Village/ Town	Formation Width (m)	CARRIAGEWAY			SHOULDER			Embankment Height	Sub-mergence	Details of Cross Roads			Remarks
						TYPE* (BT/CC/GR/ER)	Width (m)	Condition ** (G/F/P/VP)	TYPE* (BT/CC/GR/ER)	Width (m)	Condition ** (G/F/P/VP)			Location (Km)	Road No. (Km)	Carriageway Width (m)	
0.000	0.500	Plain	Builtup	Srirampur	7	BT	4	P	ER	1.5	P	2		0.100		2.500	Left side Village Road
														0.100		3.000	Right side Village Road
														0.315		3.000	Left side Village Road
														0.450		3.000	Right side Village Road
0.500	1.000	Plain	Builtup	Srirampur	7	BT	4	P	ER	1.5	P	2		0.850		3.000	Left side Village Road
1.000	1.500	Plain	Barren	Srirampur	6	BT	4	P	ER	1	P	3		1.200		3.000	Left side Village Road
														1.200		3.000	Right side Village Road
1.500	2.000	Plain	Agri	Srirampur	5.8	BT	3.8	P	ER	1	P	3		1.690		2.500	Left side Village Road
														1.700		3.750	Right side PMGSY
2.000	2.500	Plain	Agri	Jakobpur	6.5	BT	4.5	P	ER	1	P	3					
2.500	3.000	Plain	Agri	Jakobpur	6.2	BT	4.2	P	ER	1	P	3					
3.000	3.500	Plain	Agri	Jakobpur	8	BT	5	P	ER	1.5	P	3					
3.500	4.000	Plain	Agri	Jakobpur	8	BT	5	P	ER	1.5	P	2					
4.000	4.500	Plain	Agri	Jakobpur	6	BT	4	P	ER	1	P	2		4.000		3.750	Right side PMGSY
4.500	5.000	Plain	Agri	Jakobpur	6.2	BT	4	P	ER	1.1	P	3		4.600		2.500	Left side Village Road
														4.700		2.500	Left side Village Road
														4.700		3.750	Right side PMGSY
5.000	5.500	Plain	Agri	Jakobpur	6	BT	4	P	ER	1	P	1.5		5.050		3.750	Right side PMGSY
5.500	6.000	Plain	Agri	Jakobpur	6	BT	4	P	ER	1	P	1.5					
6.000	6.500	Plain	Agri	Kambilpur	6	BT	4	P	ER	1	P	1.5					
6.500	7.000	Plain	Agri	Kambilpur	6	BT	4	P	ER	1	P	1.5		6.840		2.500	Left side Village Road

Abbreviation: PMGSY = Pradhan Mantri Gram Sadak Yojana (program launched to provide connectivity to unconnected habitations)
Source: CETEST Engineering Consultants

Table 5-6: Extracted Pavement Condition

Chainage		Pavement Composition			Shoulder		Riding Quality		Pavement Condition					Pavement Edge Drop (mm)	Embankment Condition (Good/ Fair/Poor)	Road Side Drain (NE/ PF/ F)***	Remarks
From (Km)	To (Km)	Composition	Type*	Thickness	Composition	Condition	Speed (kph)	Quality (G/F/P/ VP)	Cracking (%)	Raveling (%)	Potholing (No. and % 100 m)	Rut (None/ Moderate/Severe)	Patching (No. and % 100 m)**				
0+000	0+500	Surface	BT		ER	P	25	P	2	2	5	NONE		50MM	G		Minor cracks
		Binder															
		Base															
		Sub-base															
		Subgrade															
0+500	1+000	Surface	BT		ER	P	25	P	1.76	2	3	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
1+000	1+500	Surface	BT		ER	P	25	P	1.96	1.2	1.3	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
1+500	2+000	Surface	BT		ER	P	25	P	1	0.56	0.5	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
2+000	2+500	Surface	BT		ER	P	25	P	0.6	0.2	0.23	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
2+500	3+000	Surface	BT		ER	P	25	P	0.2	0.12	0.3	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															

Chainage		Pavement Composition			Shoulder		Riding Quality		Pavement Condition					Pavement Edge Drop (mm)	Embank-ment Con-dition (Good/ Fair/Poor)	Road Side Drain (NE/ PF/ F)***	Remarks
From (Km)	To (Km)	Composi-tion	Type*	Thick-ness	Compo-sition	Condi-tion	Speed (kph)	Quality (G/F/P/ VP)	Cracking (%)	Raveling (%)	Potholing (No. and % 100 m)	Rut (None/ Moder-ate/Se-vere)	Patching (No. and % 100 m)**				
3+000	3+500	Surface	BT		ER	P	25	P	0.8	0.4	0.15	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
3+500	4+000	Surface	BT		ER	P	25	P	0.24	0.32	0.11	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
4+000	4+500	Surface	BT		ER	P	25	P	0.16	0.21	0.22	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															
4+500	5+000	Surface	BT		ER	P	25	P	0.15	0.31	0.17	NONE		50MM	G		
		Binder															
		Base															
		Sub-base															
		Subgrade															

Source: CETEST Engineering Consultants

Table 5-7: Extracted Culvert Inventory and Conditions

No.	Location (km)	Type of Structures (Pipe/ Slab/ Box/ Arch)	Thickness of Slab (M)	Span Arrangement (No. x Length) (M)	Total Length (M.)	Direction of Flow	Carriage-way Width (M)	Width of Culvert (M)	Details of Protection Works		Condition of Various Features of Culvert					Height above Bed Level		Presence of Scour	Adequacy of Waterway	Remarks
									Type	Condition	Pipe/Slab/Box/Arch	Head Wall	Wing Wall	Return Wall	Parapet/ Handrail	U/S Side (M)	D/S Side (M)			
1	1.900	SC	0.350	1 X 2.0	2.80	R>L	5.000	5.600	-	-	F	-	P	-	P	1.80	1.90	No	Yes	
2	3.000	HP	-	3 Nos. 1000 Dia	6.300	R>L	12.100	12.900	-	-	F	F	-	-	F	3.20	3.30	No	No	Earth Cushion
3	3.400	SC	0.300	N/V	4.200	R>L	5.000	5.600	-	-	NOT VISIBLE					1.10	1.00	No	No	
4	4.300	SC (Prev)	NOT VISIBLE		2.000	R>L	5.100	5.700	-	-	NOT VISIBLE					-	-	No	No	Dismantling (old structure in dkew)
5	4.301	HP	-	2 Nos. 1000 Dia	4.200	R>L	9.200	10.000	-	-	F	F	-	-	-	1.90	2.60	No	Yes	Earth Cushion (newly Constructed in place of Old SC)
6	5.800	HP	-	2 Nos. 1000 Dia	4.200	R>L	9.300	9.700	-	-	F	F	-	-	-	1.70	1.71	No	Yes	Earth Cushion
7	6.100	HP	-	2 Nos. 1000 Dia	4.500	R>L	9.300	9.900	-	-	F	F	-	-	-	1.50	2.30	No	Yes	Earth Cushion
8	6.300	HP	-	2 Nos. 1000 Dia	3.800	R>L	6.900	7.700	-	-	F	P	-	-	-	1.80	2.10	No	Yes	Earth Cushion
9	6.800	HP	-	2 Nos. 1000 Dia	4.400	R>L	9.200	10.000	-	-	F	F	-	-	-	1.58	1.60	No	Yes	Newly Constructed in Place of Old
10	6.803	HP	-	2 Nos. 1000 Dia	-	R>L	6.600	7.200	-	-	P	P	-	-	-	1.38	1.40	No	No	Dismantling
11	7.900	SC	0.400	1 X 1.7	2.500	R>L	6.000	6.800	-	-	P	-	-	-	P	1.80	1.850	No	No	
12	8.100	HP	-	2 Nos. 1000 Dia	3.700	R>L	6.600	7.200	-	-	F	P	-	-	P	1.800	1.820	No	Yes	
13	11.100	HP	-	1 No. 1000 Dia	6.200	R>L	9.000	9.800	-	-	F	F	-	-	F	1.590	1.600	No	No	Border Position of Kokrajhar and Dhubri Districts
14	12.080	HP	-	2 Nos. 800 Dia	4.500	R>L	9.400	10.200	-	-	F	F	-	-	F	1.790	1.800	No	Yes	
15	12.300	SC	0.400	1 X 1.5	2.700	R>L	7.600	8.400	Wing Wall	F	F	-	F	-	F	1.100	1.200	No	Yes	Widened 1.80 m, Both Sides
16	12.420	HP	-	2 Nos. 1000 Dia	4.700	R>L	9.400	10.300	-	-	F	F	-	-	F	2.300	2.310	No	Yes	

Source: CETEST Engineering Consultants

Table 5-8: Extracted Bridge Inventory and Condition

Surveyed by :

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)	SUPERSTRUCTRE						DETAIL OF WEARING		SUB STRUCTURE					
												GRADIENT	TYPE	TYPE OF BEARING	DEPTH OF SLAB & GIRDER(m)	MATERIAL OF SLAB & GIRDER	HANDRAIL PARAFET THICKNEES & HEIGHT (m)	TYPE	THICKNEES (m)	TYPE	THICKNESS (M)		HEIGHT OF PIER & ABUTMENT (m)	MATERIAL USED	
																					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
1	7.300	Nallah	-	4.0X4.0X4.0	18.00M.	4.0M.	16.90M.	HL	7.70M	8.50M	N/A	-	RCC BOX	N/A	0.50M	RCC	0.25 X 1.00M	BC	-	WALL	0.55	0.55	4.00M	RCC	RCC

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 LOADING	HIGH FLOOD LEVEL (H.F.L)	LOWEST WATER LEVEL (L.W.L)	DESIGN DISCHARGE (Cu.m.)	MAXIMUM DESIGN VELOCITY (m/sec)	REMARKS
TYPE	MATERIAL	TYPE	MATERIAL	BED	APPROACH					ABUTMENTS	PIERS	SUPERSTRUCTURE	BEARINGS	PARAPET							
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
-	-	-	-	Slab	Return Wall	No	4.00M	-	R>L	G	G	G	-	-	16.00M	-	-	Dry	-	-	Newly Constructed

INVENTORY & CONDITION SURVEY FOR BRIDGES

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)	SUPERSTRUCTRE						DETAIL OF WEARING		SUB STRUCTURE					
												GRADIENT	TYPE	TYPE OF BEARING	DEPTH OF SLAB & GIRDER(m)	MATERIAL OF SLAB & GIRDER	HANDRAIL PARAFET THICKNEES & HEIGHT (m)	TYPE	THICKNEES (m)	TYPE	THICKNESS (M)		HEIGHT OF PIER & ABUTMENT (m)	MATERIAL USED	
																					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
1	24.400	MASAR RIVER	Approx 7 Years Ago	2	12.00M	-	-	HL	7.70M.	8.30M	N/A	-	RCC SLAB	N/A	0.800M.	RCC	Crash Barrier 0.30X1.00M.	BC	-	WALL	-	-	2.00M ABUTMENT	RCC	RCC

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 LOADING	HIGH FLOOD LEVEL (H.F.L)	LOWEST WATER LEVEL (L.W.L)	DESIGN DISCHARGE (Cu.m.)	MAXIMUM DESIGN VELOCITY (m/sec)	REMARKS
TYPE	MATERIAL	TYPE	MATERIAL	BED	APPROACH					ABUTMENTS	PIERS	SUPERSTRUCTURE	BEARINGS	PARAPET							
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
PILE	RCC	PILE	RCC	-	Return Wall	No	4.70M	-	R>L	G	G	G	-	-	-	-	3.00M ABOVE LBL	0.10M ABOVE LBL	-	-	Newly Constructed Scouring happened Pier Pile Exposed

Source: CETEST Engineering Consultants

5.1.5 Slope Inventory Survey

To observe river erosion of river banks and road embankments was planned in the field. However, the surveys could not be performed because we could not visit India due to COVID-19 epidemic. Instead of the field survey, the positional relationship of road embankment and river was confirmed on the Google Earth images.

5.2 Preliminary Design

5.2.1 Review of DPR

The Assam Public Works Department (PWD) NH (National Highways) Works serves as an executing agency of the Ministry of Road Transport and Highways (MORTH), New Delhi, which has implemented the Consultancy Services for Feasibility Study and Preparation of Detailed Project Report for Construction and Upgradation of the Newly Declared NH127B (Assam section), starting from Srirampur on NH27 (the former NH31C) at Chainage 0.00 Km to the Immediate Approach of [the] Proposed Bridge over [the] Brahmaputra River near Dhubri at Chainage 55.700 Km to NH Standards.

The Assam PWD NH Works engaged C.E. Testing Company Pvt. Ltd. (CETEST) as the consultant to prepare the DPR for the proposed improvement and upgradation of the roadway. Recently the project has been taken over and being executed by the National Highways and Infrastructure Development Corporation Limited (NHIDCL).

The JICA Survey Team conducted an initial review of the DPR. The Team prepared a questionnaire based on an initial review and sent it to the DPR consultants and conducted a web meeting to exchange views. The questionnaire is summarized in Table 5-9.

Table 5-9: Questionnaire on the DPR for NH127B Assam (Srirampur-Dhubri)

Items	Questions & Requests	Suggestions /recommendations	Reply/comments by DPR consultants
Geometric Design Standard	IRCSP73-2015 is used.	As per IRCSP73, 1.5, "Latest version of the Codes, Standards, Specifications, etc. notified /published at least 60 days prior to the last date of bid submission shall be considered applicable. Therefore, IRCSP73-2018 shall be used.	As this is a 4-lane road, 4 lane manual IRC SP 84:2014 is used instead of two-lane manual IRC SP 73 :2018. The decision of 4 lane has been taken in October 2018. Hence, IRC SP 84:2014 is used instead of IRC SP 84:2019.
Alignment	A line of demarcation with the Dhubri Bridge.	A line of demarcation with the Dhubri Bridge is not designed.	Ch. 54.154 is the end point of NH-127B (Assam Part) and shown in the referred drawing.
Terrain Classification	Demarcation of terrain classification is not designed.	As per IRC73-1980, "Terrain is classified by the general slope of the country across the highway alignment."	This is very well understood that the project stretch falls in the plain terrain and the design has been done accordingly.
Design Speed	The stretches with minimum design speed shall be indicated in Schedule 'D'.	As per IRCSP73, "Such stretches where design speed other than ruling speed is to be adopted shall be indicated as deviation in Schedule 'D' of the Concession Agreement." DPR, however, fails to indicate the sections of 80 km/h.	Agreed. It would be included in Schedule D.
Cross Sectional Parameters	Shoulder widths do not comply with IRCSP73.	The shoulder widths in DPR do not comply with IRCSP73-2018.	The DPR has been prepared for 4 Lanning, TCS has been adopted as per SP 84 2014 (Manual for 4 Lanning).
Desirable minimum radius of horizontal curves	Curves smaller than the desirable minimum shall be indicated in Schedule 'D'.	As per IRCSP73, the radius of horizontal curves shall not be less than the desirable 400 m except for sections as indicated in Schedule 'D'. DPR fails to indicate.	Agreed. It would be included in Schedule D.
Gradients (1)	Gradients flatter than 0.3% are observed.	As per IRCSP42, a minimum longitudinal gradient of 0.3 percent is considered essential in most conditions. DPR uses even 0.0%.	0.3% minimum gradient is applicable for flexible pavement for proper drainage of rainwater. This is a built-up area and both side drain has been provided. In-grade 1.372% & out -grade 2.5% already considered in this stretch. Cross camber of 2.5% as per codal provision has been provided to take care the rainwater.

Items	Questions & Requests	Suggestions /recommendations	Reply/comments by DPR consultants
Gradients (2)	Broken back gradients are observed.	Curves in the same direction, separated by short tangents known as broken back curves, should be avoided as far as possible. It causes visual discontinuities in the profile resulting in unsafe driving speed disruption.	Broken back curve has been introduced just before first ROB to avoid the raising of FRL in the market area and reduce the approach length of ROB. Broken - Back effect has been catered by providing minimum straight length of 38m (i.e. more than 10s travel distance which is 28m).
Bypass alignment	Bypass alignment option study is missing.	Bypass alignment option study shall be conducted for remaining two bypasses.	Bypass alignment is final. Option study was earlier submitted at feasibility stage and DPR has been prepared based on approved alignment.

Source: JICA Survey Team based on DPR

5.2.2 Road Geometric Design

(1) Design Speed

IRC73-1980, Section 5, states that "choice of design speed depends on the function of the road as well as terrain conditions. It is the basic parameter that determines all other geometric design features. The design speed should preferably be uniform along a highway, but variations in terrain may make changes in speed unavoidable. In such a case, it is desirable that the design speed is not changed abruptly, but gradually with the introduction of successive sections of increasing/decreasing design speed so that road users are conditioned to the change by degrees."

IRCSP84-2014, 2.2, stipulates design speed as indicated in Table 5-10. Clause 2.2.1 provides that short stretches (less than 1 km) of varying terrain traversed by the road are not to be taken into consideration when determining the terrain classification of a specified highway section.

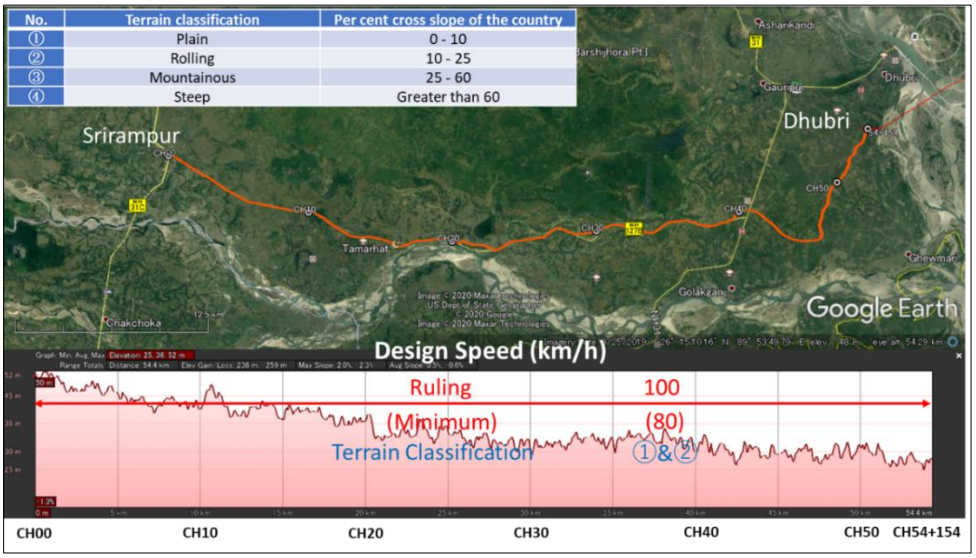
Clause 2.2.2 provides that in general the ruling design speed should be adopted for the various geometric design features of a road. Minimum design speed is to be adopted only where site conditions are restrictive and adequate land width is not available. Such stretches where design speed other than ruling speed is to be adopted are to be as indicated as deviations in Schedule D of a Concession Agreement.

Figure 5-9 shows the design speed (km/h) for NH127B Assam (Srirampur-Dhubri).

Table 5-10: Design Speed as per IRCSP84-2014

Nature of Terrain	Cross Slope of the Ground	Design Speed (km/h)	
		Ruling	Minimum
Plain and Rolling	Up to 25 per cent	100	80
Mountainous and Steep	More than 25 per cent	60	40

Source: JICA Survey Team based on IRCSP84-2014



Source: JICA Survey Team based on DPR

Figure 5-9: Design Speed (km/h) for NH127B Assam (Srirampur- Dhubri)

Table 5-11 presents an excerpt from the DPR for the section between CH8+563 and CH12+980. As per IRCSP84-2014, the ruling design speed is to be adopted for the various geometric design

features of the road. Minimum design speed is to be adopted only where site conditions are restrictive and adequate land width is not available. Stretches where design speed other than the ruling speed is to be adopted are to be indicated as deviations in Schedule D of a Concession Agreement. However, the DPR does not indicate the stretches with minimum design speed deviations to be shown in Schedule D. In response to the comment by JICA Survey Team, the DPR consultant wrote "Agreed. It would be included in Schedule D."

Table 5-11: Design Speeds in the DPR for NH127B Assam (Srirampur-Dhubri)

Detailed Project Report for Construction & up-gradation of the newly declared NH-127 B — Final Detailed Project Report, Geometric Design

HORIZONTAL ALIGNMENT REPORT

HIP/CURVE NO.	HIP		ELEMENT	START	END	LENGTH (m)	CHORD LENGTH (m)	RADIUS (m)	HAND OF ARC	SUPERELEVATION (%)	DESIGN SPEED	EXTRA WIDENING
	EASTING	NORTHING		CHAINAGE (m)	CHAINAGE (m)							
15	786567.98	2919509.499	Arc	8563.861	8589.519		25.657	600	Right	5	100	--NA--
			Transition	8589.519	8669.519		80					
			Straight	8669.519	8908.493	238.975						
			Transition	8908.493	9018.493		110					
16	786455.702	2919063.289	Arc	9018.493	9055.643		37.15	450	Left	5	100	--NA--
			Transition	9055.643	9165.643		110					
			Straight	9165.643	9868.701	703.058						
			Transition	9868.701	9913.701		45					
17	786501.348	2918161.524	Arc	9913.701	9966.798		53.097	500	Right	5	80	--NA--
			Transition	9966.798	10011.798		45					
			Straight	10011.798	10253.602	241.803						
			Transition	10253.602	10328.602		75					
18	786444.753	2917766.996	Arc	10328.602	10349.424		20.822	300	Right	5	80	0.6
			Transition	10349.424	10424.424		75					
			Straight	10424.424	10945.634	521.209						
			Transition	10945.634	11035.634		90					
19	786133.206	2917129.042	Arc	11035.634	11062.912		27.279	550	Right	5	100	--NA--
			Transition	11062.912	11152.912		90					
			Straight	11152.912	11430.183	277.271						
			Transition	11430.183	11490.183		60					
20	785840.397	2916749.167	Arc	11490.183	11567.763		77.58	800	Left	5	100	--NA--
			Transition	11567.763	11627.763		60					
			Straight	11627.763	12980.414	1352.651						

CETEST Engineering Consultants — Doc No: CET/3636/PWD-Assam (NH)/127B/FDPR Revision: R1 March 2020 Page: 7

Source: Detailed Project Report

(2) Extra Width of Pavement and Roadway

IRC38-1988,[2] Clause 6.1.1, states that extra widening is necessary:
… when vehicles negotiate a curve, the rear wheels generally do not follow the same track as that of the front wheels. When the curve is not superelevated, the rear wheels track inside the front wheels. On superelevated curves, the relative position of the wheel tracks depends upon the speed and consequently upon the amount of friction developed for equilibrium. The greater the speed, the rear wheels assume a position farther out. So, with excessive speeds the rear wheels may track outside the front wheels. Therefore, widening of the pavement is necessary to provide for this change in the overall track width required for travel at various speeds.

IRCSP84-2014, Clause 2.7.2, states that: "On horizontal curves with [a] radius up to 300 m, width of pavement and roadway in each carriageway shall be increased as per the table below [see Table 5-14 of this report]."

[2] IRC38-1988, Guidelines for [the] Design of Horizontal Curves for Highways and Design Tables.

Table 5-12: Extra Width of Pavement and Roadway in Each Carriageway

Radius of Curve	Extra Width
75-100 m	0.9 m
101-300 m	0.6 m

Source: JICA Survey Team (based on IRCSP84-2014)

The DPR consultant revised the values of Extra Width based on the comment from JICA Survey Team in their submission dated August 22, 2020 as shown Table 5-13.

Table 5-13: Revised Extra Width in the Submission on August 22, 2020

HORIZONTAL ALIGNMENT REPORT

NORTHING	CHAINAGE (m)	END EASTING	END NORTHING	LENGTH (m)	CHORD LENGTH (m)	BEARING (dd mm ss)	RADIUS (m)	HAND OF ARC	SUPERELEVATION (%)	DESIGN SPEED	EXTRA WIDENING
2917140.762	11062.912	786125.651	2917117.683		27.279		550	Right	5	100	--NA--
2917117.683	11152.912	786071.815	2917045.593		90						
2917045.593	11430.183	785899.911	2916828.043	277.271		S 38^18'53.72" W					
2916828.043	11490.183	785863.306	2916780.507		60						
2916780.507	11567.763	785820.63	2916715.756		77.58		800	Left	5	100	--NA--
2916715.756	11627.763	785791.38	2916663.373		60						
2916663.373	12980.414	785146.751	2915474.207	1352.651		S 28^27'41.32" W					
2915474.207	13100.414	785094.957	2915366.092		120						
2915366.092	13134.475	785084.759	2915333.604		34.061		400	Left	5	100	--NA--
2915333.604	13254.475	785065.473	2915215.286		120						
2915215.286	13597.833	785027.236	2914874.064	343.358		S 6^23'37.75" W					
2914874.064	13677.833	785020.097	2914794.399		80						
2914794.399	13757.808	785021.832	2914714.502		79.975		600	Left	5	100	--NA--
2914714.502	13837.808	785032.424	2914635.222		80						
2914635.222	14188.286	785086.542	2914288.948	350.477		S 8^52'57.58" E					
2914288.948	14283.286	785098.227	2914194.708		95						
2914194.708	14343.979	785098.187	2914134.051		60.694		500	Right	5	100	--NA--
2914134.051	14438.979	785086.377	2914039.827		95						
2914039.827	15052.669	784990.813	2913433.623	613.69		S 8^57'30.69" W					
2913433.623	15085.653	784985.892	2913401.009		32.983		2500	Left	Normal Camber	100	--NA--
2913401.009	15430.177	784936.737	2913060.009	344.524		S 8^12'09.36" W					
2913060.009	15525.177	784920.22	2912966.495		95						
2912966.495	15574.364	784906.285	2912919.343		49.187		500	Right	5	100	--NA--
2912919.343	15669.364	784869.317	2912831.873		95						
2912831.873	16290.937	784609.333	2912267.284	621.572		S 24^43'30.89" W					
2912267.284	16365.937	784580.847	2912197.96		75						
2912197.96	16555.184	784582.499	2912011.842		189.248		300	Left	5	80	0.60
2912011.842	16630.184	784612.211	2911943.035		75						
2911943.035	17391.436	784942.842	2911257.333	761.252		S 25^44'32.37" E					
2911257.333	17511.436	784989.447	2911146.884		120						
2911146.884	17531.499	784994.88	2911127.572		20.063		400	Right	5	100	--NA--
2911127.572	17651.499	785012.69	2911009.022		120						
2911009.022	17798.785	785027.267	2910862.46	147.285		S 5^40'47.09" E					
2910862.46	17919.214	785042.785	2910743.053		120.429		2000	Left	Normal Camber	100	--NA--
2910743.053	18923.836	785202.19	2909751.158	1004.622		S 9^07'47.26" E					
2909751.158	18932.739	785203.583	2909742.365		8.902		2000	Right	Normal Camber	100	--NA--
2909742.365	19508.878	785292.467	2909173.123	576.14		S 8^52'29.14" E					
2909173.123	19598.878	785301.09	2909083.662		90						
2909083.662	19654.786	785293.79	2909028.346		55.908		255	Right	5	80	0.60
2909028.346	19744.786	785262.257	2908944.184		90						
2908944.184	20222.996	785068.444	2908507.01	478.21		S 23^54'32.93" W					
2908507.01	20312.996	785036.911	2908422.848		90						
2908422.848	20446.982	785039.811	2908290.429		133.986		255	Left	5	80	0.60
2908290.429	20536.982	785074.998	2908207.728		90						
2908207.728	20632.975	785117.707	2908121.76	95.993		S 26^25'05.07" E					
2908121.76	20722.975	785152.894	2908039.059		90						
2908039.059	20852.447	785156.832	2907911.033		129.473		255	Right	5	80	0.60
2907911.033	20942.447	785126.793	2907826.326		90						
2907826.326	21208.39	785023.329	2907581.335	265.942		S 22^53'42.29" W					
2907581.335	21263.39	785003.102	2907530.202		55						
2907530.202	21367.302	784982.419	2907428.667		103.912		400	Left	5	80	--NA--
2907428.667	21422.302	784981.032	2907373.696		55						

Source: DPR

(3) Cross Fall/Camber

IRCSP84-2014, Clause 2.8.1, states that: "The crossfall on straight sections of road carriageway, paved shoulders and paved portion of median shall be 2.5 per cent for bituminous surface and 2.0 per cent for cement concrete surface."

Clause 2.8.2 states that: "The crossfall shall be unidirectional for either side carriageway sloping towards the shoulder in straight reaches and towards the lower edge on horizontal curves. The camber on the existing road shall be modified to unidirectional crossfall."

Clause 2.8.3 states that: "The crossfall for earthen shoulders on straight portions shall be at least 0.5 per cent steeper than the slope of the pavement and paved shoulder subject to a minimum of 3.0 per cent. On super elevated sections, the earthen portion of the shoulder on the outer side of

the curves shall be provided with reverse crossfall of 0.5 per cent so that the earth does not drain on the carriageway and the storm water drains out with minimum travel path."

Clause 2.9.3 states that: "Super elevation shall be limited to 7 per cent if radius of curve is less than the desirable minimum. It shall be limited to 5 per cent if the radius is more than desirable minimum and also at section where Project Highway passes through an urban section or falls on a major junction."

JICA Survey Team checked and acknowledged that the design of cross fall/camber in DPR is appropriate.

(4) Horizontal Alignment

IRC73-1980, Chapter 9, provides general guidelines for designing horizontal alignments. Important aspects are summarized in the following text.

(a) Consistent Application of Design Elements

Uniformity of design standards is one of the essential requirements of a road alignment. In each section there must be consistent application of a design element to avoid unexpected situations for the drivers. For example, a short sharp curve in an otherwise good alignment is bound to act as an accident-prone spot if the designer is not vigilant.

(b) Flowing Line of the Horizontal Alignment

Generally, the horizontal alignment should be fluent and blend well with the surrounding topography. A flowing line that conforms to natural contours is aesthetically preferable to one with long tangents slashing through the terrain.

(c) Length of Tangent Sections

Tangent sections exceeding 3 km in length should be avoided as much as possible. As a general rule, sharp curves should not be introduced at the end of long tangents since these can be extremely hazardous. Short curves give the appearance of kinks, particularly for small deflection angles, and should be avoided.

(d) Avoidance of Broken-Back Curves

Curves in the same direction separated by short tangents, known as broken-back curves, should be avoided as far as possible in the interest of aesthetics and safety, and replaced by a single curve. If this is not feasible, a tangent length corresponding to 10 seconds' travel time must be at least be ensured between the two curves.

(e) Radii of Horizontal Curves

IRCSP84-2014, Clause 2.9.4, states that: "The desirable minimum and absolute minimum radii of horizontal curves for various classes of terrain are given in the table below [see Table 5-16 and Figure 5-11 of this report]. The radius of horizontal curves for various terrain conditions shall not be less than the desirable values given in the table except for sections as indicated in Schedule 'D'. For such sections, [the] radius shall not be less than the absolute minimum." In response to the comment by JICA Survey Team, the DPR consultant wrote "Agreed. It would be included in Schedule D."

(f) Absolute Minimum Radius

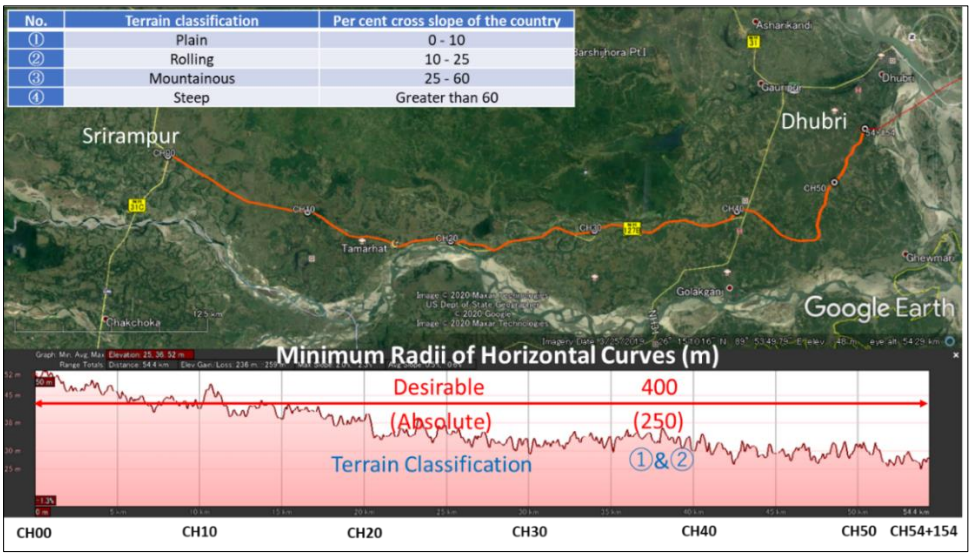
IRC73-1980, Clause 9.4.2, describes the use of minimum radius as follows: "On new roads, horizontal curves should be designed to have the largest practicable radius, generally more than the values corresponding to the ruling design speed. However, absolute minimum values based on minimum design speed might be resorted to if economics of construction or the site conditions

so dictate." Table 5-14 and Figure 5-10 of this report present the absolute minimum radius by type of terrain.

Table 5-14: Minimum Radii of Horizontal Curves as per IRCSP84-2014

Nature of Terrain	Desirable Minimum Radius	Absolute Minimum Radius
Plain and Rolling	400 m	250 m
Mountainous and steep	150 m	75 m

Source: JICA Survey Team based on IRCSP84-2014



Source: JICA Survey Team based on DPR

Figure 5-10: Desirable and Absolute Minimum Radii of Horizontal Curves (m)

(g) Number of Curves Smaller than the Minimum Radius

There are 16 curves in the DPR design that are smaller than Desirable Minimum Radius and JICA Survey Team created the list and requested the DPR consultant to acknowledge it. The details of the curves are provided in Appendix C-2: Number of Horizontal Curves Smaller than Minimum Radius in the DPR for NH127B Assam (Srirampur-Dhubri). Table 5-15 shows the number of horizontal curves in the DPR smaller than the minimum radius.

Table 5-15: Number of Curves in the DPR Smaller than the Minimum Radius

Type of Minimum Radius	Desired Minimum Radius	Absolute Minimum Radius
Radius (m)	Plain 400 m / Mountainous 150 m	Plain 250 m / Mountainous 75 m
Applicability	Applicable with Justifiable Reason	Absolutely not Applicable
Number of Small Curves	**16**	**0**

Source: JICA Survey Team based on DPR

(5) Sight Distance

Visibility is an important requirement for the safety of travel on roads. For this reason, it is necessary that sight distance of an adequate length for different situations be provided to permit drivers sufficient time and distance to control their vehicles so that chances of accidents are minimized.

IRCSP84-2014, Clause 2.9.5, states that: "The safe stopping sight distance and desirable minimum sight distance for divided carriageway[s] for various design speeds are given in the table below [see Table 5-18 of this report]. The vertical design, especially at grade change location, such as VUP/LVUP [vehicular underpass / light vehicular underpass], ROB [road over bridge], bridge locations shall be done using Intermediate Sight Distance (Desirable Minimum Sight Distance). The minimum of safe sight distance shall be available throughout."

Table 5-16: Safe Sight Distances as per IRCSP84-2014

Design Speed (km/h)	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m)
100	180	360
80	130	240
60	90	180
40	45	90

Source: JICA Survey Team based on IRCSP84-2014

The diagram in Figure 5-11 below gives set-back distance for safe stopping sight distance as per IRCSP66-1976. The lines for 60 km/h and 50 km/h are added by JICA Survey Team.

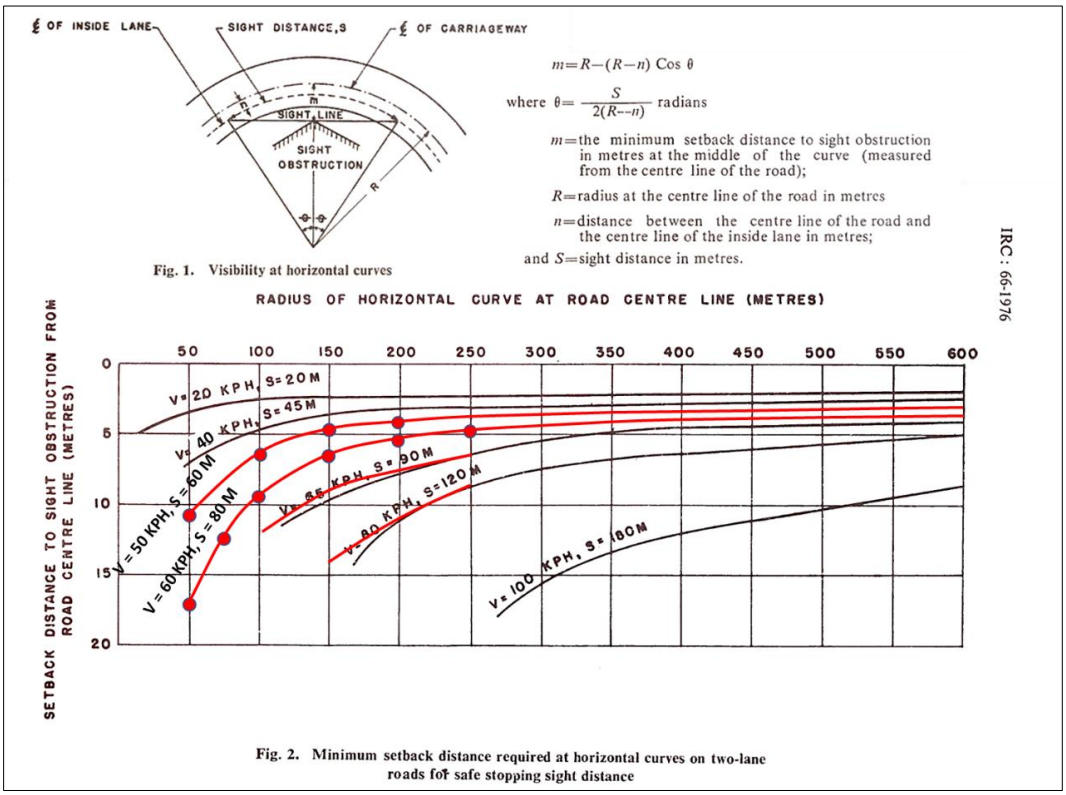


Fig. 2. Minimum setback distance required at horizontal curves on two-lane roads for safe stopping sight distance

Source: JICA Survey Team based on IRCSP66-1976

Figure 5-11: Setback Distance for Safe Stopping Sight Distance as per IRC66-1976

(6) Vertical Alignment

IRC73-1980, Chapter 10, provides general guidelines for designing vertical alignments. Important aspects are summarized in the following text.

(a) No Change in Grade within 150 m

The vertical alignment should provide for a smooth longitudinal profile consistent with the category of the road and the lay of the terrain. Grade changes should not be too frequent as to cause kinks and visual discontinuities in the profile. Ideally, there should be no change in grade within 150 m.

(b) No Short Valley Curves

A short valley curve within an otherwise continuous profile is undesirable since this tends to distort the perspective view and is hazardous.

(c) No Broken-Back Curves

Broken-back grade lines, i.e., two vertical curves in the same direction separated by a short tangent, should be avoided due to the poor appearance; preferably they should be replaced by a single long curve.

(d) Culverts and Minor Bridges with the Same Profile as the Road

Decks of small cross-drainage structures (i.e., culverts and minor bridges) should follow the same profile as the flanking road section, without any break in the grade line.

(e) Limit of the Increase in Elevation

The increase in elevation over a length of 2 km is not to exceed 100 m in mountainous terrain and 120 m in steep terrain.

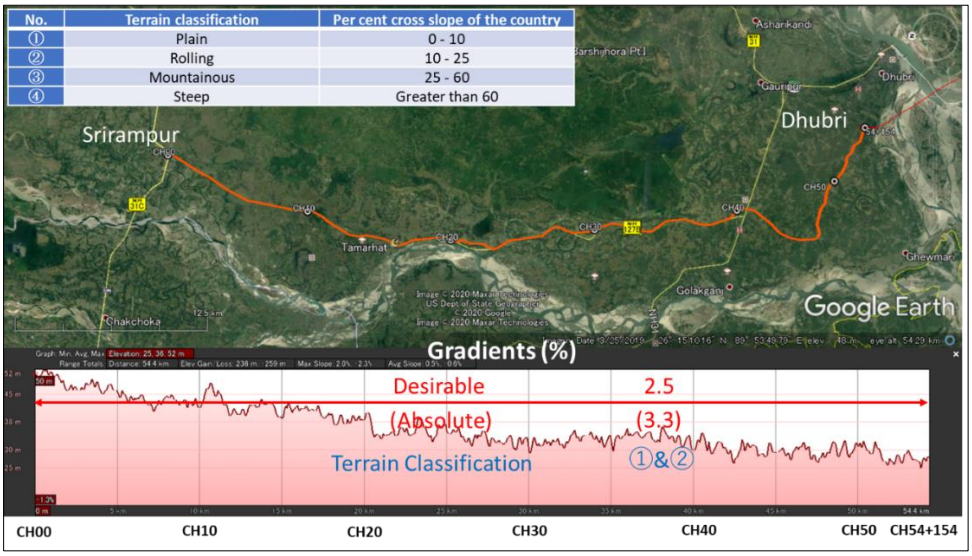
IRCSP84-2014, Clause 2.9.6, states that: "The vertical alignment should provide for a smooth longitudinal profile. Grade changes should not be too frequent as to cause kinks and visual discontinuities in the profile and grade change shall not be allowed within 150 m….. The ruling and limiting gradients are given in the table below [see Table 6-18 and Figure 6-13 in this report]. Ruling gradients shall be adopted as far as possible. Limiting gradients shall be adopted in difficult situations and for short length."

IRCSP42-2014, Clause 4.4.1, states that: "With a view to facilitate quick removal of rainwater, [the] longitudinal profile of the road normally is not designed flat. When the road is provided with kerbs as in the case of urban scenario[s], flat surface[s] can result in [a] collection of large quantity of water on the road. To avoid this situation a minimum longitudinal gradient of 0.3 percent is considered essential in most conditions."

Table 5-17: Gradients as per IRCSP84-2014

Nature of Terrain	Ruling Gradient	Limiting Gradient
Plain and Rolling	2.5%	3.3%
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

Source: JICA Survey Team based on IRCSP84-2014



Source: JICA Survey Team based on DPR

Figure 5-12: Ruling and Limiting Gradients (%)

* * *

Two points to be observed regarding vertical alignment design in DPRs are set out below.

① A longitudinal gradient of less than 0.3% is to be observed (see Table 5-18). Special consideration is required for the design of drainage.

In response to the comment by JICA Survey Team, the DPR consultant has verified their design by stating "0.3% minimum gradient is applicable for flexible pavement for proper drainage of rainwater. This is a built-up area and both side drain has been provided. In-grade 1.372% & out - grade 2.5% already considered in this stretch. Cross camber of 2.5% as per codal provision has been provided to take care the rainwater."

Table 5-18: Sections with Gradients Less Than 0.3%

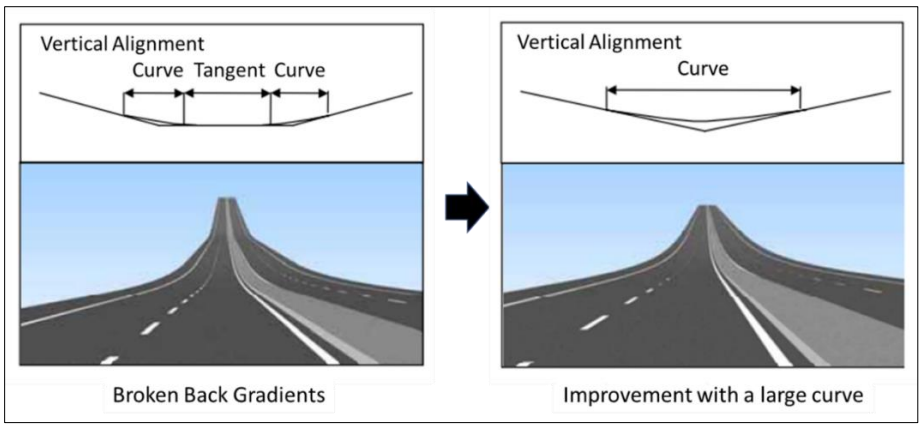
VERTICAL ALIGNMENT REPORT

CURVE NO.	IP		TYPE OF CURVE	CURVE LENGTH	M VALUE	START		END		GRADIENT	
	CHAINAGE	LEVEL				CHAINAGE	LEVEL	CHAINAGE	LEVEL	IN	OUT
1	111.056	49.026	Sag	130	0.223	46.056	49.918	176.056	49.025	-1.372	-0.002
2	329.308	49.023	Sag	230	0.719	214.308	49.025	444.308	51.898	-0.002	2.5
3	724	58.89	Hog	340	-1.062	554	54.64	894	58.89	2.5	0
4	1364	58.89	Hog	340	-1.063	1194	58.89	1534	54.64	0	-2.5
5	1832.129	47.187	Sag	240	0.768	1712.129	50.187	1952.129	47.259	-2.5	0.06
6	2053	47.319	Hog	60	-0.02	2023	47.301	2083	47.258	0.06	-0.204
7	2251	46.915	Sag	60	0.021	2221	46.976	2281	46.94	-0.204	0.082
8	2448	47.077	Hog	60	-0.016	2418	47.052	2478	47.036	0.082	-0.136
9	2693	46.744	Sag	60	0.017	2663	46.785	2723	46.773	-0.136	0.097
10	2849	46.895	Hog	60	-0.02	2819	46.866	2879	46.842	0.097	-0.176
11	3141	46.381	Sag	60	0.025	3111	46.434	3171	46.428	-0.176	0.156
12	3293	46.618	Hog	80	-0.058	3253	46.556	3333	46.449	0.156	-0.421
13	3532	45.611	Sag	60	0.037	3502	45.737	3562	45.633	-0.421	0.075
14	3695	45.733	Hog	60	-0.03	3665	45.711	3725	45.637	0.075	-0.319
15	3836	45.283	Sag	60	0.029	3806	45.379	3866	45.305	-0.319	0.073
16	4001	45.404	Hog	60	-0.021	3971	45.382	4031	45.341	0.073	-0.209
17	4171	45.049	Sag	60	0.023	4141	45.112	4201	45.077	-0.209	0.094
18	4387	45.252	Hog	60	-0.031	4357	45.224	4417	45.158	0.094	-0.313
19	4486	44.942	Sag	80	0.082	4446	45.067	4526	45.147	-0.313	0.511
20	4600	45.525	Hog	120	-0.131	4540	45.218	4660	45.308	0.511	-0.362
21	4794	44.822	Sag	60	0.036	4764	44.931	4824	44.859	-0.362	0.122
22	4923	44.979	Hog	70	-0.039	4888	44.936	4958	44.865	0.122	-0.325
23	5128	44.313	Sag	60	0.022	5098	44.41	5158	44.303	-0.325	-0.035
24	5229	44.278	Hog	60	-0.01	5199	44.288	5259	44.228	-0.035	-0.168
25	5367	44.046	Hog	60	-0.009	5337	44.096	5397	43.958	-0.168	-0.294
26	5632	43.267	Sag	60	0.03	5602	43.355	5662	43.3	-0.294	0.11
27	5760	43.408	Hog	60	-0.018	5730	43.375	5790	43.37	0.11	-0.127
28	5912	43.215	Sag	60	0.022	5882	43.253	5942	43.264	-0.127	0.163
29	6059	43.455	Hog	60	-0.023	6029	43.406	6089	43.414	0.163	-0.138
30	6386	43.003	Hog	60	-0.01	6356	43.044	6416	42.92	-0.138	-0.276
31	6582	42.463	Sag	60	0.022	6552	42.546	6612	42.468	-0.276	0.017
32	6724	42.487	Hog	100	-0.042	6674	42.479	6774	42.328	0.017	-0.318
33	6940.244	41.799	Sag	120	0.187	6880.244	41.99	7000.244	42.358	-0.318	0.931

Source: JICA Survey Team based on DPR

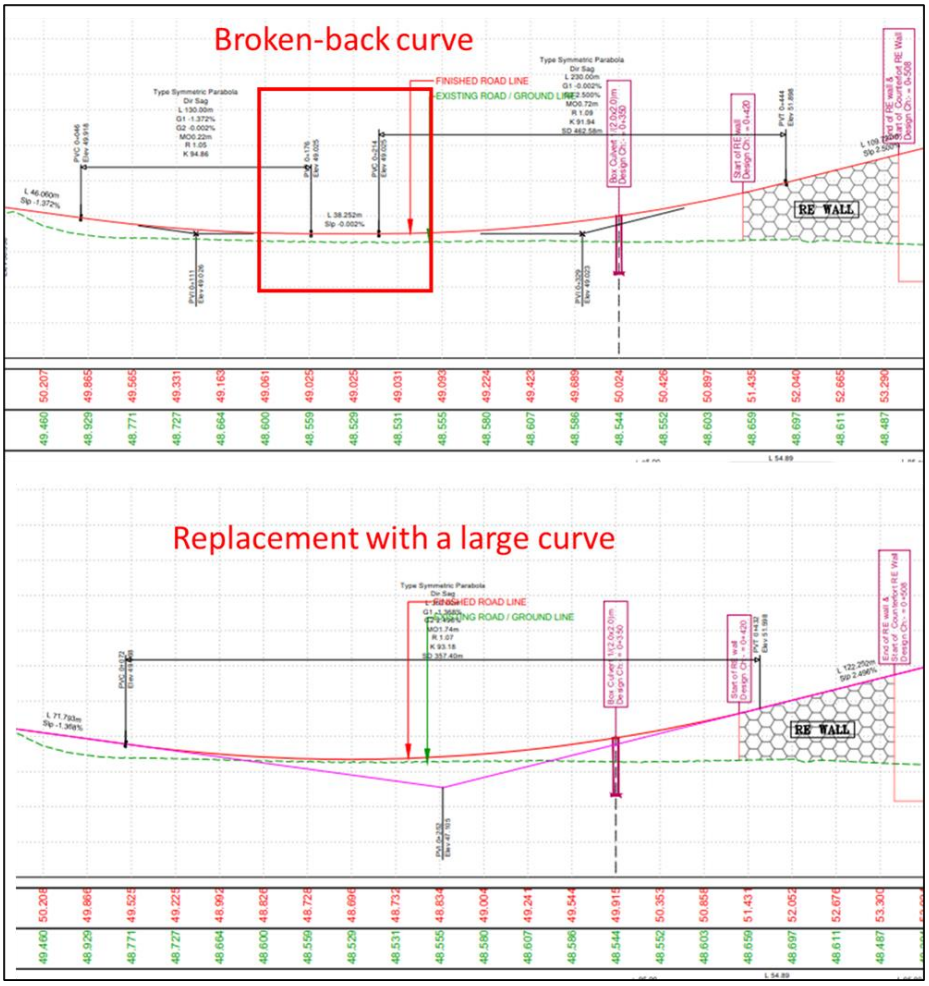
② Vertical alignments with broken-back curves should be avoided.

Curves in the same direction, separated by short tangents known as broken-back curves, should be avoided as much as possible. They cause visual discontinuities in the profile resulting in disruption of safe driving speeds. There is a broken-back curve at CH0+200 of the Project road. It can be improved by replacing the two curves with a large curve as indicated in Figure 5-13. In response to the comment by JICA Survey Team, the DPR consultant revised DPR design as shown in Figure 5-14.



Source: JICA Survey Team based on DPR

Figure 5-13: Suggestions for Improvement of Broken-Back Curve



Source: JICA Survey Team based on DPR

Figure 5-14: Removal of Broken-Back Curves

5.2.3 Bridges and Structures Design

(1) Superstructure Design

Each site has its own unique conditions affecting the choice of the type of bridge structure for optimum performance, economy, and a maintenance-free design life. The choice of a particular span arrangement and the type of structure depends upon several factors such as site characteristics, the type of subsoil strata, the height and length of the bridge, design and construction aspects, the availability of construction materials, construction technology, and the construction timeframe.

The most economical structure type is usually selected corresponding to the span length. The ranges of span lengths within which a particular type of superstructure can be economical along with other considerations such as the type of foundation are shown in IRC: SP 54-2000, as summarized in Table 5-19.

The bridge with its span length less than 25m is often applied RCC-T Girder, and if it exceeds 25m, PSC-T Girder is often applied. If the span length is 50m or more, PSC-Box Girder is often applied. As for viaduct across the railway, composite structure is often applied for shortening construction period and economic efficiency.

The design of reinforced and prestressed concrete superstructures is to follow IRC:112. The design of steel and steel-concrete composite superstructures are to conform to IRC:24 and IRC:22, respectively. The design and specifications of bearings is to follow IRC:83 (Parts I-IV). Expansion joints are to conform to IRC SP:69. Approach slabs are to be provided for all bridges and grade-separated structures as per Clause 217 of IRC:6 and Section 2700 of the MORTH Specifications. However, only one ROB at CH 1+044 has no approach slab. The wearing coat is to conform to Section 2700 of the MORTH Specifications.

Table 5-19: Particular Type of Superstructure

No.	Type of Superstructure	Span Length (m)
1	RCC single or multiple boxes	1.5-15
2	Simply-supported RCC slabs	3-10
3	Simply-supported RCC T-Beam	10-25
4	Simply-supported PSC girder bridges	25-45
5	Simply-supported RCC voided slabs	10-15
6	Continuous RCC-voided slabs	10-20
7	Continuous PSC-voided slabs	15-30
8	RCC box sections, simply supported balanced cantilever continuous	25 to 50
9	PSC box sections, simply supported balanced cantilever	35 to 75
10	PSC cantilever construction/continuous	75 to 150
11	Cable-stayed bridges	200 to 500
12	Suspension bridges	500 onwards

Abbreviations: PSC = Pre-Stressed Concrete, RCC = Reinforced Cement Concrete
Source: Indian Road Congress: SP 54-2000

However, when an economical span arrangement and type of structure is decided upon, it has to be ensured that the required infrastructural facilities, design and construction capabilities, specialized materials, and other requirements are available.

The type and span arrangement should provide for maximum riding comfort and involve minimum inspection and maintenance during the service life of the structure. A continuous superstructure with fewer bearings and expansion joints if not unsuitable otherwise should be preferred over simply supported spans. An integral concept is preferred for small bridges and

culverts in which the substructures and superstructure are made without joints (i.e., a monolithic structure).

As per the 3 ROBs, DPR Consultant has gotten approval of General Arrangement Drawings (GAD) with those span arrangements. Those detailed design and drawings will be taken care by EPC contractor, authority Engineer and NHIDCL through their mutual consultation.

As per one minor bridge, 3 VUPs and 1 LVUP at CH 24+001, CH 39+700, CH 48+810, CH 52+353 and 53+191, integral slab bridges are adopted in order to eliminate expansion joints.

RCC T-Beam Bridges of 2 x 18m at CH 21+140 and CH 21+871 shall be considered as PSC T-Beam Bridge of 1 x 36m. And RCC T-Beam Bridge of 3 x 18m at CH 30+050 shall also be considered as PSC T-Beam Bridge of 2 x 27m. According to DPR Consultant, EPC Contractor has the liberty of bridge type and span arrangement at the bidding though the bridge length is determined.

It is strongly recommended to figure the required lengths of contraction and expansion on the drawings for EPC Contractor to estimate the costs easily.

All bearings are to be easily accessible for inspection, maintenance, and replacement. Suitable permanent arrangements are to be made for inspection of bearings from the bridge deck. The drawings of bearings are to include the layout plan showing the exact location on top of the pier and abutment cap and the type of bearings (i.e., fixed/free/rotational) at each location along with notes for proper installation. The bearings should cater for movement in both longitudinal and lateral directions.

Only 3 ROBs at CH 1+044, CH 35+355 and CH 40+637 have the permanent arrangements though other bridges have nothing for bridge inspection which are necessary to be furnished with permanent arrangement or maintenance plans for bearing inspection, maintenance, and replacement.

It is strongly recommended to figure the required bearing capacity and longitudinal and transverse movements for the EPC Contractor to estimate the costs easily.

For aesthetics, attention should be focused on producing a clean, simple, well-proportioned structural form. In most cases, achieving the desired visual quality may add little to the overall cost of the structure. Aesthetic considerations should play an important role even in minor bridges since bridge parapets are the among the most visible parts and should harmonize with the surroundings.

(2) Dimensions of Superstructures in Assam

The JICA Survey Team reviewed Drawings Part-B: Structural Drawings and summarized the structural dimensions as shown in Table 5-20.

The engineering, procurement, and construction (EPC) contractor is to be considered at the construction stage with the approval of the Authority Engineer. The following issues are to be considered:

- The fabrication yard and transport route need to be considered for PSC-T and RCC-T girders.
- Detailed arrangements need to be considered for attaching pipes (e.g., water pipes, electric cables) on bridges.

Table 5-20: Dimensions of Superstructures in Assam

No.	Chainage	Type	Strength	Span (S)	Height (H)	S/H	Girder width (m)	Web thickness	Reinforce-ment
1	1+044	Composite (RDSO)+ Bow String +Composite (RDSO)	M30	36.000	2.037	17.7	-	-	-
			M45	74.004	-	-	-	-	-
			M30	36.000	2.037	17.7	-	-	-
2	7+241	4mx4.066mx4cell	M30	4.000	0.400	10.0	-	-	-
3	21+140	RCC T-Beam	M30	18.000	1.700	10.6	0.625	0.325	-
4	21+871	RCC T-Beam	M30	18.000	1.700	10.6	0.625	0.325	-
5	24+001	Int. Slab	M30	11.050	0.750	14.7	12.500	12.500	-
6	28+974	RCC T-Beam	M30	24.000	2.300	10.4	0.625	0.325	-
7	30+050	RCC T-Beam	M30	18.000	1.700	10.6	0.625	0.325	-
8	30+408	RCC T-Beam	M30	21.000	2.100	10.0	0.625	0.325	-
9	35+355	RCC T-Beam+ Composite (RDSO) +RCC T-Beam	M30	24.000	2.300	10.4	0.625	0.325	-
			M45	-	-	-	-	-	-
			M30	24.000	2.300	10.4	0.625	0.325	-
10	39+700	Int. Slab	M30	14.100	0.750	18.8	10.500	0.500	-
11	40+637	RCC T-Beam+ Composite (RDSO)+ Bow String +RCC T-Beam	M30	24.000	2.419	9.9	0.625	-	-
			M30	36.000	2.037	-	-	-	-
			M45	74.004	-	-	-	-	-
			M30	21.000	2.119	9.9	0.625	-	-
12	43+100	4mx3mx2cell	M30	4.000	0.400	10.0	-	-	-
13	44+645	PSC T-Beam	M45/M40	38.800	3.000	12.9	0.850	0.300	19S12.7BL
14	47+289	PSC T-Beam	M45	27.800	1.975	14.1	0.850	0.300	19S12.7BL
15	48+167	RCC T-Beam	M30	24.000	2.300	10.4	0.625	0.325	-
16	48+810	Int. Slab	M30	14.100	0.750	18.8	10.500	10.500	-
17	51+536	PSC T-Beam	M45/M40	38.800	3.000	12.9	0.850	0.300	19S12.7BL
18	52+353	Int. Slab	M30	14.100	0.750	18.8	10.500	10.500	-
19	53+191	Int. Slab	M30	14.100	0.750	18.8	10.500	10.500	-

Abbreviations: PSC = Portland slag cement, RCC = reinforced cement concrete, RDSO= Research Designs and Standards Organization, Int. Slab= integral slab bridge
Source: JICA Survey Team based on DPR

(3) Substructure Design

The design of substructures is to conform to IRC 78-2014.

Piers in streams and channels should be located so as to meet navigational clearance requirements and minimally interfere with flood flow. In general, piers should be placed parallel to the direction of stream currents during flooding. Piers in other locations (e.g., viaducts, land spans) should be follow the requirements for crossing obstacles.

The multicolumn piers of bridges across rivers are not adopted. As carrying floating debris, trees, or timber, they should be braced throughout the height of the piers with a diaphragm wall with a minimum thickness of 200 mm when adopted.

Abutments should be designed and dimensioned to retain the earth from the approach embankment. The abutments should be designed to withstand earth pressure in normal conditions in addition to load and forces transferred from the superstructure. In addition, any load acting on the abutment itself, including self-weight, should be considered.

The JICA Survey Team reviewed Drawings Part-B: Structural Drawings and summarized the dimensions as shown in Table 5-21.

Table 5-21: Dimensions of Substructures in Assam

No.	Chainage	Type	Abutment						Pier					
			Dimensions		Pile				Dimensions		Pile			
			H (m)	T (m)	Nos.	Dia. (m)	L (m)	S (m)	H (m)	T (m)	Nos.	Dia. (m)	L (m)	S (m)
1	1+044	4 Column Type	11.400	1.500	-	-	-	-	11.400	φ1.500	-	-	-	-
		4 Column Type	-	-	-	-	-	-	11.400	φ1.500	-	-	-	-
		4 Column Type	11.400	1.500	-	-	-	-	11.400	φ1.500	-	-	-	-
2	7+241	Culvert	-	-	-	-	-	-	-	-	-	-	-	-
3	21+140	1m Semi-Circular Type	3.700	1.200	6	1.200	18.000	3.600	6.200	1.000	6	1.200	18.000	3.600
4	21+871	1m Semi-Circular Type	4.700	1.200	8	1.200	16.000	3.600	7.500	1.000	6	1.200	17.000	3.600
5	24+001	900mm Wall Type	3.786	1.000	8	1.200	17.000	3.600	4.156	0.900	6	1.200	18.000	3.600
6	28+974	1m Semi-Circular Type	3.400	1.200	12	1.200	22.000	3.600	5.600	1.000	9	1.200	22.000	3.600
7	30+050	1m Semi-Circular Type	4.800	1.200	8	1.200	21.000	3.600	7.300	1.000	6	1.200	25.000	3.600
8	30+408	1200mm Wall Type	3.600	1.200	8	1.200	15.000	3.600	-	-	-	-	-	-
9	35+355	4 Column Type	9.400	1.500	8	1.200	22.000	3.600	8.800	φ1.500	8	1.200	22.000	3.600
		4 Column Type	-	-	-	-	-	-	8.800	φ1.500	8	1.200	22.000	3.600
		4 Column Type	9.400	1.500	8	1.200	22.000	3.600	8.800	φ1.500	8	1.200	22.000	3.600
10	39+700	900mm Wall Type	7.769	0.900	6	1.200	19.000	3.600	-	-	-	-	-	-
11	40+637	4 Column Type	10.000	φ1.500	8	1.200	19.000	3.600	10.000	φ1.500	8	1.200	19.000	3.600
		4 Column Type	-	-	-	-	-	-	10.000	φ1.500	8	1.200	19.000	3.600
		4 Column Type	-	-	-	-	-	-	11.086	φ1.500	12	1.200	19.000	4.100
		4 Column Type	10.315	φ1.500	8	1.200	19.000	3.600	10.000	φ1.500	8	1.200	19.000	3.600
12	43+100	Culvert			-	-	-	-		-	-	-	-	-
13	44+645	1200mm Wall Type	5.600	1.200	12	1.200	18.000	3.600	-	-	-	-	-	-
14	47+289	1200mm Wall Type	4.500	1.200	8	1.200	18.000	3.600	-	-	-	-	-	-
15	48+167	1200mm Wall Type	4.300	1.200	8	1.200	12.000	3.600	-	-	-	-	-	-
16	48+810	900mm Wall Type	7.784	0.900	6	1.200	14.000	3.600	-	-	-	-	-	-
17	51+536	1m Semi-Circular Type	6.400	1.200	12	1.200	24.000	3.600	6.300	1.000	9	1.200	31.000	3.600
18	52+353	900mm Wall Type	9.468	0.900	8	1.200	18.000	3.600	-	-	-	-	-	-
19	53+191	900mm Wall Type	6.837	0.900	8	1.200	15.000	3.600	-	-	-	-	-	-

Source: JICA Survey Team based on DPR

(4) Soil Conditions and Foundation Types

The design of foundations is to conform to IRC 78-2014. The design of open foundations is to conform to IRC 78-2014 (or IRC SP13-2004 in the case of small bridges and culverts). The design of pile foundations is to follow IRC 78-2014, while the design of well foundations is to follow IRC:78-2014.

The embedment of foundations in soil is to be based on assessment of the anticipated scour. Foundations may be taken down to a comparatively shallow depth below the bed surface provided good bearing stratum is available and the foundation is protected against scour. The minimum depth of open foundations requires the soil stratum to have adequate bearing capacity but is to not be less than 2.0 m below the scour level.

The rock stratum with ultimate crushing strength of 12.5 MPa (megapascals) or N value of 50 or more requires about 0.6 m into rock, and with 2.5 MPa or N value 10 does 1.5 m.

Well foundations supporting the superstructure located in deep water channels are properly selected in the shapes, sizes, and types with considerations of the size of the abutment and pier to be accommodated, the need to affect streamline flow, the possibility of using pneumatic sinking, the anticipated depth of the foundation, and the nature of strata to be penetrated.

Pile foundations transmit the load of a structure to subsurface strata by the resistance developed from the bearing at the toe, or the skin friction along the surface, or both. The piles may be required to carry uplift and lateral loads in addition to direct vertical load.

The JICA Survey Team reviewed Drawings Part-B: Structural Drawings and summarized the dimensions as shown in Table 5-22.

Table 5-22: Soil and Foundation in Assam

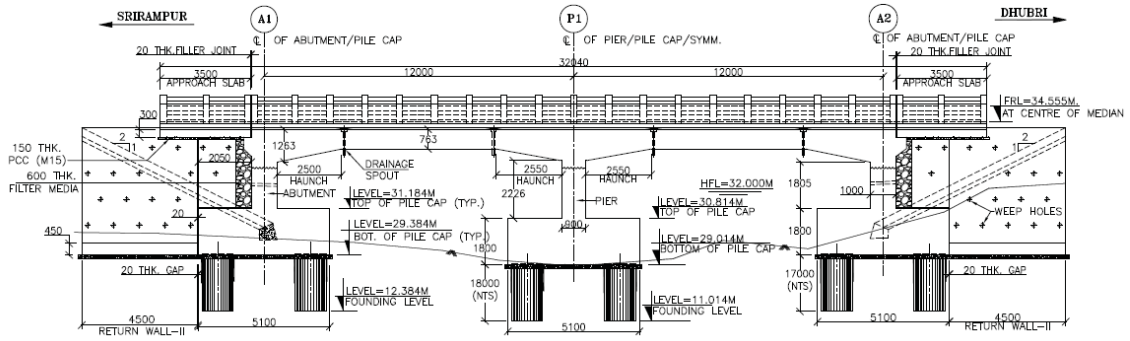
No.	Chainage	Formation height at bottom of pile cap (TYP.)	SPT N-value at bottom of pile cap	Number of boring surveys	Type of foundation
1	1+044	43.654	43	9	Open
		43.654	17		Open
		43.654	24		Open
2	7+241	38.485	12	1	Open
3	21+140	26.621	8	2	φ1200, CIS, L=18m
4	21+871	25.121	8	2	φ1200, CIS, L=16-17m
5	24+001	26.940	9	2	φ1200, CIS, L=15-16m
6	28+974	25.523	6	2	φ1200, CIS, L=22m
7	30+050	22.768	4	3	φ1200, CIS, L=21-25m
8	30+408	28.387	8	1	φ1200, CIS, L=15m
9	35+355	29.822	6	4	φ1200, CIS, L=18-22m
		30.375	9		φ1200, CIS, L=18-22m
		29.822	8		φ1200, CIS, L=18-22m
10	39+700	29.831	-	1	φ1200, CIS, L=19m
11	40+637	26.611	9	4	φ1200, CIS, L=19m
		26.584	16		φ1200, CIS, L=19m
		26.584	8		φ1200, CIS, L=19m
		26.626	38		φ1200, CIS, L=19m
12	43+010	25.626	-	1	Open
13	44+645	24.813	4	2	φ1200, CIS, L=18m
14	47+289	23.740	6	1	φ1200, CIS, L=18m
15	48+167	23.476	10	1	φ1200, CIS, L=12m
16	48+810	27.951	-	×	φ1200, CIS, L=14m
17	51+536	21.705	5	3	φ1200, CIS,L=24-31m
18	52+353	24.651	-	×	φ1200, CIS, L=18m
19	53+191	25.478	-	×	φ1200, CIS, L=15m

Abbreviation: CIS = Cast-in-Situ
Source: JICA Survey Team based on DPR

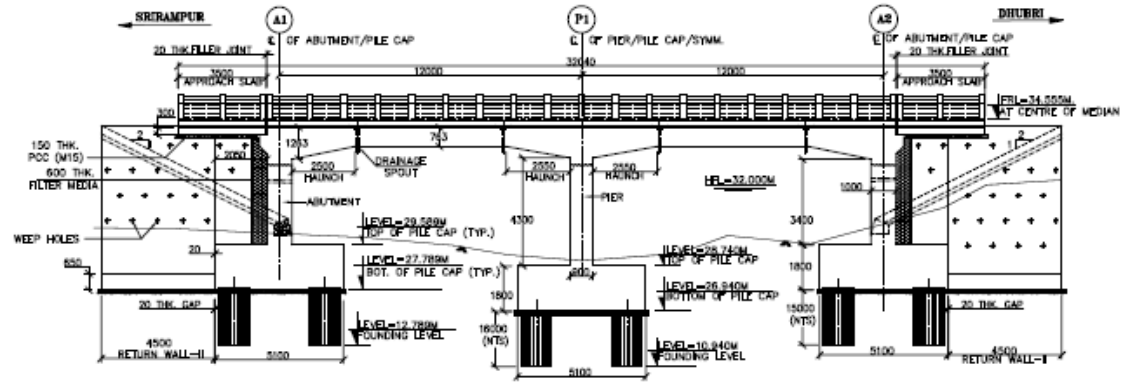
It is suggested that the bore holes shall be shown in LOCATION PLAN because their locations cannot be identified on the General Arrangement Drawings. However, DPR Consultant insists that all bore hole location plans are included in geotechnical investigation reports.

It is pointed out that bottoms of pile caps are higher than maximum scour level in most of bridges. And DPR Consultant explains that protection works are provided at all abutment locations and that piles have been designed for the additional cantilever/overhang length.

It is suggested the pile caps of the bridge at CH 24+001 to be lowered in its altitude so as not to hinder the water flow. And DPR Consultant replies to comply with that.



Source: DPR Drawings as of May 1, 2020



Source: DPR Drawings as of September 2, 2020

Figure 5-15: Bridge at CH 24+001

(5) Scouring

The depth of foundation depends on the maximum recorded quantum of water or flood discharge that passes through the river or the channel over which the bridge is proposed and as such the design discharge is important not only for economic considerations but also for safety and stability considerations. Therefore, the design discharge, which might be the recorded discharge during the past 50-100 years, is to be ascertained carefully. There are various methods for the estimation of flood discharges, as listed below:

1) The Catchment-Runoff Method from rainfall and other characteristics of the catchment using empirical formulae or by the Rational Method;
2) A method based on the hydraulic characteristics of the stream (e.g., conveyance factors, slope of the stream);
3) A method based on recorded flood discharges near the bridge site.

Scour depth has to be considered in the design of pile foundation. Also, the lateral and vertical load capacity of piles has been calculated with due consideration of probable scour and pile overhang.

The JICA Survey Team reviewed the DPR and summarized the scour depth calculation results in Table 5-23. The formula in the hydraulic calculation comply with the Catchment-Runoff Method in confirmation of flood records and IRC SP 13-2004.

Table 5-23: Scour Depth in Assam

No.	Chainage	Discharge (cu.m/sec)	Max. Scour Level(m)	Bottom of Pile Cap(m)	Depth (m)
1	1+044	ROB	-	43.654	-
2	7+241	Open Land	-	38.485	-
3	21+140	107.48	25.61	26.621	1.008
4	21+871	112.20	23.96	25.121	1.159
5	24+001	42.88	27.03	29.014	1.980
6	28+974	144.95	23.95	25.523	1.575
7	30+050	231.76	20.39	22.768	2.375
8	30+408	Open Land	-	28.387	-
9	35+355	ROB	-	29.822	-
10	39+700	VUP	-	29.831	-
11	40+637	ROB	-	26.611	-
12	43+100	Open Land	-	26.895	-
13	44+645	Pond	-	24.813	-
14	47+289	Ditch Land	-	23.564	-
15	48+167	Ditch Land	-	23.557	-
16	48+810	VUP	-	27.951	-
17	51+536	250.04	19.28	21.705	2.429
18	52+353	VUP	-	24.651	-
19	53+191	LVUP	-	25.478	-

Source: JICA Survey Team based on DPR

As per 6 bridges at CH 21+140, CH 21+871, CH 24+001, CH 28+974, CH 30+408 and CH 51+536, the Protection Works are to be furnished as the bottoms of pile cap are not enough deeper than the max scour levels.

(6) Protection Works

River training and protection works are to be provided wherever required to ensure the safety of bridges and their approaches. The design of various types of river training and protection works is to be in accordance with IRC 89-1997. Also, the construction of river training works is to conform to MORTH Specifications.

Protection works for the major bridges will be provided following the methods for existing bridges. IRC:89-1997 presents details for the protection works, as follows.

- Return walls of required length will be provided in all bridges and culverts to stop the spilling of earth into the waterway.
- Flooring will be provided over both sides of the pile cap of bridges to guard against deterioration of the foundation.
- Peripheral cut-off walls around base raft of culverts and boulder apron on both upstream and downstream sides will be provided to reduce the scouring.
- The perimeter cut-off walls will also increase the effective depth of foundation in addition to their protective function.

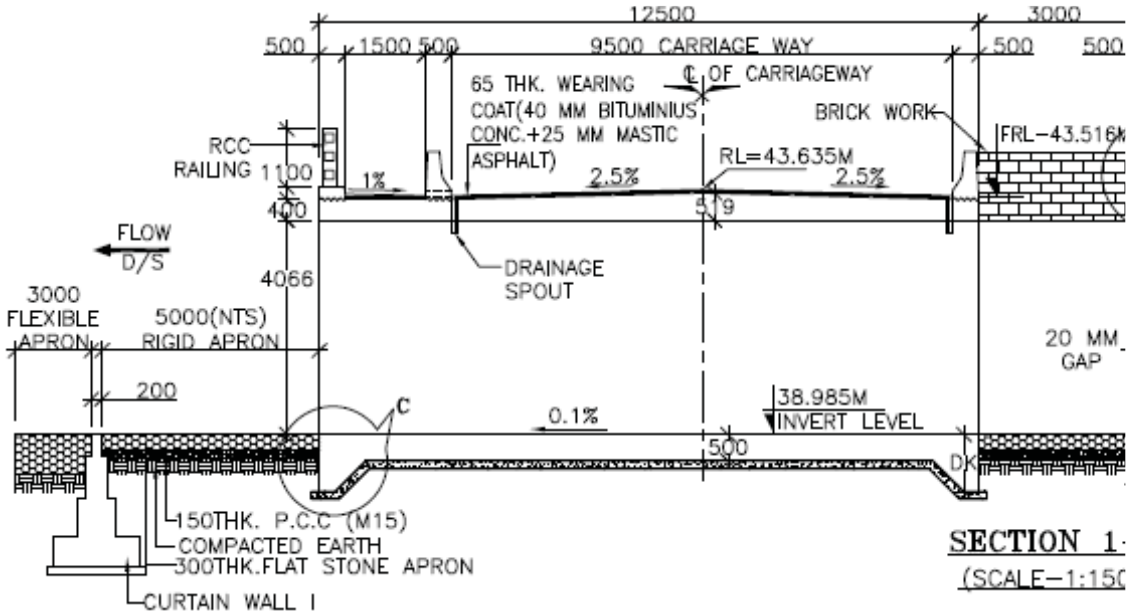
By the time of preparing the Draft Final Report, the JICA Survey Team would like to listed the protection works, as shown in Table 5-24.

Table 5-24: Protection Works in Assam

No.	Chainage	Return wall	Flooring	Curtain wall
1	1+044	-	-	-
2	7+241	W5500 X H4966	Rigid/Flexible Apron	H2500
3	21+140	W3500 X H4055	Boulder Pitching (1:1.5)	-
4	21+871	W3500 X H4055	Boulder Pitching (1:1.8)	-
5	24+001	W4500 X H2188	Stone Pitching Slope (1:2)	-
6	28+974	W3520 X H4400	Boulder Pitching (1:1.5)	-
7	30+050	W3500 X H5155	Floor Protection (1:1.5)	-
8	30+408	W3500 X H4344	Boulder Pitching (1:1.8)	-
9	35+355	-	-	-
10	39+700	-	-	-
11	40+637	-	-	-
12	43+100	W4980 X H3400	Rigid/Flexible Apron	H2500
13	44+645	W9350 X H8893	Floor Protection (1:2)	-
14	47+289	W3750 X H3700	Boulder Pitching (1:1.5)	-
15	48+167	W3500 X H5300	Floor Protection (1:2)	-
16	48+810	W1150 X H6000	-	-
17	51+536	W4000 X H7900	Floor Protection (1:1.5)	-
18	52+353	W6700 X H7668	-	-
19	53+191	W6700 X H6987	-	-

Source: JICA Survey Team based on DPR

Culverts at CH 7+044 and CH 43+100 are accompanied with rigid aprons and curtain walls in addition to cut-off-walls.



Source: DPR Drawings as of May 1, 2020

Figure 5-16: Culvert at CH 7+044

5.2.4 Slope Protection of Embankment

Retaining wall, reinforced earth retaining wall (RE retaining wall), and stone pitching are planned for slope protection measures of road embankments and river banks. The heights of retaining wall are classified into 2.0 m, 3.5 m, and 6.0 m and the total length becomes 4,273 m (Table 5-25). The total length of RE retaining wall is 4,913 m.

The total length of stone pitching is 6,128 m for road embankments (Table 5-27), 2,306 m for the river banks (Table 5-28), and 844.632 m for the river banks around bridge abutments (Table 5-29), respectively.

Table 5-25: Quantity of Retaining Wall

Classification	Package	Length (m)
Height 2.0m	II	849
	III	460
	IV	923
	V	1,485
	Total	3,717
Height 3.5m	I	401
Height 6.0m	III	155

Source: JICA Study Team based on DPR

Table 5-26: Quantity of Reinforced Earth Retaining Wall

Package	Length (m)
I	1,360
III	1,425
IV	1,880
IV (service road)	248
Total	4,913

Source: JICA Study Team based on DPR

Table 5-27: Quantity of Stone Pitching (Road Embankment)

Package	Chainage		RHS/LHS	Length (m)
	From	To		
II	17500	19250	both	3,500
V	51590	52150	both	1,120
	53400	54154	both	1,508
	Total			6,128

Source: JICA Study Team based on DPR

Table 5-28: Quantity of Stone Pitching (River Bank)

Package	Chainage		RHS/LHS	length (m)
	From	To		
II	17500	19250	RHS	1,750
	26549	26950	LHS	401
III	30630	30785	LHS	155
	Total			2,306

Source: JICA Study Team based on DPR

Table 5-29: Quantity of Stone Pitching (Bridge Abutment)

Package	Location of Bridge	Length (m)
I	7241	61.680
II	21140	61.240
	21871	67.988
	24001	70.280
III	28974	63.240
	30050	76.168
	30408	60.144
IV	43100	42.000
V	44645	95.308
	47289	33.900
	48167	74.684
	51636	138.000
	Total	844.632

Source: JICA Study Team based on DPR

5.2.5 Pavement Design

The pavement design and construction of new pavement sections and overly for the existing pavement shall be carried out in accordance with IRC SP 84-2014 for dual two-lane carriageway or four lane carriageways. The pavement performance requirements for main carriageway, service roads, entry/exit ramps and acceleration/deceleration lanes are provided in Sub-clause 5.4.3 of IRC SP 84-2014.

(1) Flexible Pavement Design

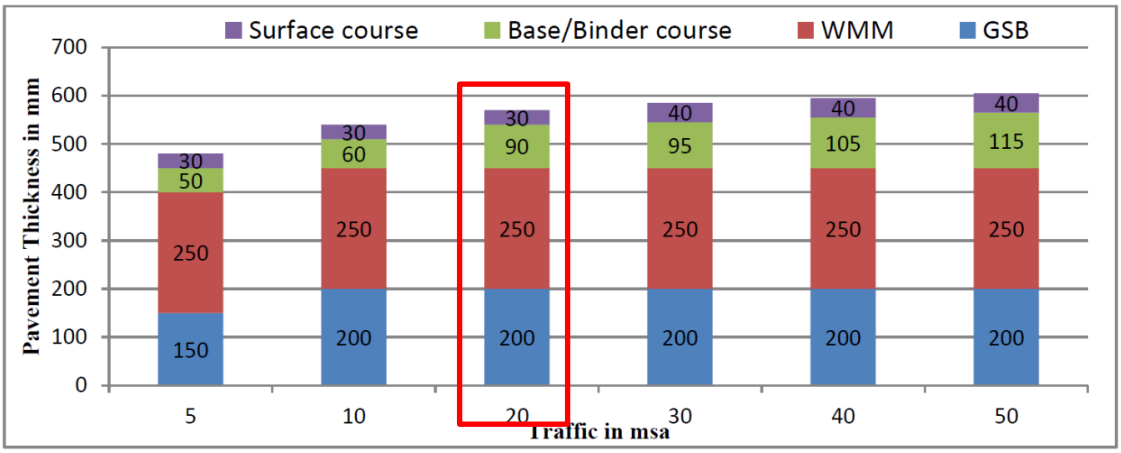
The DPR consultant adopted IRC 37-2012 for the design of flexible pavements in accordance with IRC SP 73-2015 for two-lane highways. However, the design standard of carriageway was updated to four lanes of IRC SP 84-2014; therefore, the pavement design is recommended to adopt IRC 37-2018 of the Guidelines for the Design of Flexible Pavements unless otherwise specified in Schedule 'B' of the Concessionaire Agreement.

For the design period, Sub-clause 5.4.1 in IRC SP 84-2014 stated that flexible pavement shall be designed for a minimum design period of 15 years or operation period, whichever is more. Similarly, Sub-clause 4.3.1 in IRC 37-2018, the design period of 15 years is recommended.

For the pavement structural design, Clause 12 in IRC 37-2018 presents six categories and shown in the catalogues. The predetermined layer combinations and the parameters conducted from the traffic survey are used for obtaining the pavement thickness from the pavement structural design catalogues.

Since the design traffic of 20msa and the design CBR of 8% are applied for the survey stretch, the pavement with bituminous surface course with granular base and sub-base has been considered as per predetermined design. The following pavement thickness are obtained from the catalogue and shown in the figure below. The exposed pavement layer is treated as sub-grade course after compaction. The thicknesses shall be provided on existing portion after removal of existing pavement layer up to a required depth based on the profile design.

Bituminous Concrete (BC) = 30 mm
Dense Bituminous Macadam (DBM) = 90 mm
Wet Mix Macadam (WMM) = 250 mm
Granular Sub-base (GSB) = 200 mm



Source: IRC 37-2018

Figure 5-17: Catalogue for Pavements with a Bituminous Surface Course with a Granular Base and Subbase – Effective CBR 8% (Plate-4)

For the comparison purposes, the below table presents the different thicknesses between IRC 37-2012 and IRC 37-2018 for the design traffic of 20msa and a design CBR (California Bearing Ratio) of 8%. It showed that the total thickness applied as per IRC 37-2018 was 5mm more economical than that of IRC 37-2012. In particular, the bituminous concrete thickness (BC) of IRC 37-2018 was thinner by 10 mm than that of IRC 37-2012. On the other hand, the Dense Bituminous Macadam (DBM) of IRC 37-2018 was thicker by 5 mm than that of IRC 37-2012. Therefore, in the view of economy, IRC 37-2018 for the flexible pavement design is recommended for the survey stretch.

Table 5-30: Comparison of Flexible Pavement Thickness between IRC 37-2012 and IRC 37-2018

	BC (mm)	DBM (mm)	WMM (mm)	GSB (mm)	Total thickness
IRC 37-2012 (Plate-6)	40	85	250	200	575
IRC 37-2018 (Plate-4)	30	90	250	200	570

Source: JICA Survey Team

(2) Rigid Pavement

The rigid pavement shall be designed as per IRC 58-2015 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways unless otherwise specified in Schedule 'B' of the Concessionaire Agreement.

Sub-clause 5.4.2 in IRC SP 84-2014 stated that rigid pavement shall be designed for a minimum design period of 30 years. The stage construction shall not be permitted. In addition, the Pavement Quality Concrete (PQC) shall rest over Dry Lean Concrete (DLC) sub-base of 150 mm thickness. Below DLC layer, a properly designed drainage layer Granular Sub Base (GSB) of 150 mm thickness shall be provided throughout the road width. It shall be designed to obtain a drainage coefficient of not less than 30 m per day.

Sub-clause 5.4.4 in IRC SP 84-2014 stipulated that the performance of the rigid pavement shall meet the requirements as specified in IRC SP 16 Guidelines for the Surface Evenness of Highway Pavements and IRC SP 83 Guidelines for Maintenance, Repair and Rehabilitation of Cement Concrete Pavements.

After construction of the new 6 lane bridge, the survey road may encounter traffic of higher axle configuration with higher loading in near future. From the calculations of thicknesses, it showed PQC was safe for 240mm. However, considering the future traffic pattern and load, PQC of 280 mm thickness has been recommended in place of 240 mm.

Table 5-31: Rigid Pavement Thickness

PQC (mm)	DLC (mm)	GSB (mm)
280	150	150

Source: JICA Survey Team based on DPR

(3) Sub-grade

Clause 5.6 in IRC SP 84-2014 provides that the Sub-grade, whether in cut or fill, shall meet the requirements stipulated in Clause 305 of MoRTH Specifications. The thickness of sub-grade shall not be less than 500 mm.

(4) Using IITPAVE

Sub-clause 3.2 in IRC37-2018 stated that the mechanistic-empirical design approach, which was used for the design of flexible pavements. The theory selected for the analysis of pavements is 'linear elastic layered theory' in which the pavement is modeled as a multi-layer system. The bottom most layer (foundation or subgrade) is considered to be semi-infinite, and all the upper layers are assumed to be infinite in the horizontal extent and finite in thickness. Elastic modulus, Poison's ratio and thickness of each layer are the pavement inputs required for calculation of stresses, strains and deflections produced by a load applied at the surface of the pavement.

In order to analyze the pavements of any combination of traffic and pavement layer composition, IITPAVE software shall be used for the computation of stresses and strains in flexible pavements. The traffic volume, number of layers, the layer thickness of individual layers and the layer properties are the user's specified inputs in the program, which gives strains at critical locations as output.

5.2.6 Drainage Design

The DFR created by the DPR consultant was reviewed.The cross-drainage canals were summarized in the Final Detailed Project Report Volume-IID Appendix to Design Report (Hydraulic Calculation of Culvert).The cross-drainage canals were summarized in the Final Detailed Project Report Volume-IID Appendix to Design Report (Hydraulic Calculation of Culvert).The box culvert calculation was calculated according to IRC:SP:13-2004 Guidelines for the Design of Small Bridges and Culverts of the Indian Road Association. The catchment area divides the total length of the road into seven zones,The amount of rainfall in that zone was calculated and the number and section of existing culverts and new culverts were determined.

Regarding the cross-sectional dimensions of the box culvert, it was confirmed by reviewing the calculation results, but the position of the new box culvert could not be confirmed in the report, so a hearing was conducted with the DPR consultant. I confirmed. As a result of the hearing, it was confirmed that it was installed considering the local situation and the new linear sag. Since we have not conducted a field survey, we believe that the accuracy is low, but it is generally appropriate.

(1) Cross Drains

There are 55 existing culverts (28 Hume pipe culverts, 25 slab culverts, 1 box culvert, and 1 fully choked culvert) on the project road. A total of 50 of the existing culverts are proposed to be reconstructed with box culverts; the remaining five existing culverts were omitted due to cutting and realignment of the project road. An additional 66 box bridges are proposed for the new alignment.

All existing culverts on the project road alignment have been reconstructed. The reason is considered to be reasonable as follows.

- The project road will be widened and lengthened.
- Since the box cross section is determined using the current rainfall intensity formula in the Assam area, the existing cross section will lack capacity.
- According to the hearing from DPR consulting, in the recent design, the cross drainage adopts the box culvert type considering the flood, and the existing pipe culvert needs to be changed to the box culvert.

The cross-sectional shape and arrangement of the box culvert are determined based on the calculation results and are considered to be appropriate. Due to the effects of corona, it is not possible to carry out a field survey, so it is necessary to confirm the local situation again before carrying out the site construction.

Table 5-32 summarizes cross drains for Assam.

Table 5-32: Cross Drains (Assam)

	NH127B Assam (Srirampur-Dhubri)
Proposed Culvert	116
Reconstruction	
Pipe Culvert	
Box Culvert	50
New Proposal	
Box Culvert	66
Existing Culverts Omitted	5

Source: JICA Study Team based on DPR

(a) Reconstruction Box Culverts (NH127B Assam)

Table 5-33 to Table 5-39 summarize proposed reconstruction box culverts and new box culverts in Assam along NH127B.

Table 5-33: Proposed Reconstruction Box Culverts (Assam) (1)

No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
1	1.943	1+946	Slab	1×2.0m	1×2.0×2.0
2	2.997	2+992	Pipe	3×φ1.0m	1×3.0×3.0
3	3.384	3+378	Slab	1×3.0m	1×3.0×3.0
4	4.325	4+322	Slab	1×3.0m	1×3.0×3.0
5	4.328	5+760	Pipe	2×φ1.0m	1×2.0×3.0
6	5.768	6+059	Pipe	2×φ1.0m	1×2.0×2.0
7	6.080	6+221	Pipe	2×φ1.0m	1×2.0×3.0
8	6.231	6+723	Pipe	2×φ0.9m	1×2.0×3.0
9	7.860	7+850	Slab	1×1.7m	1×2.0×2.0
10	8.068	8+058	Pipe	2×φ1.0m	1×2.0×2.0
11	10.921	10+909	Pipe	1×φ1.1m	1×2.0×2.0
12	11.838	11+825	Pipe	2×φ0.9m	1×2.0×2.0
13	12.170	12+099	Slab	1×1.5m	1×2.0×2.0
14	12.248	12+177	Pipe	2×φ1.0m	1×2.0×3.0
15	12.745	12+675	Pipe	2×φ1.0m	1×2.0×2.0
16	12.922	12+851	Pipe	2×φ1.0m	1×2.0×2.0
17	13.825	13+800	Slab	1×1.3m	1×2.0×2.0
18	14.814	14+837	Slab	1×0.7m	1×2.0×3.0
19	16.288	16+310	Slab	1×2.3m	1×3.0×2.0
20	16.447	16+469	Slab	1×1.0m	1×2.0×2.0
21	17.816	17+538	Slab	1×2.1m	1×2.0×2.0
22	25.545	25+156	Pipe	1×φ0.6m	1×2.0×2.0
23	25.763	25+374	Slab	1×0.8m	1×2.0×2.0
24	26.538	26+147	Slab	1×0.9m	1×2.0×3.0
25	27.181	26+785	Slab	1×0.9m	1×2.0×2.0
26	27.895	27+494	Pipe	1×φ0.8m	1×2.0×3.0

Source: JICA Study Team based on DPR

Table 5-34: Proposed Box Culverts (Assam) (2)

No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
27	28.270	27+870	Slab	1×0.8m	1×2.0×3.0
28	32.181	31+339	Box	1×2.0×1.5m	1×3.0×3.0
29	32.743	31+902	Pipe	1×φ0.8m	1×2.0×3.0
30	33.849	33+013	Slab	1×0.9m	1×2.0×2.0
31	34.548	33+717	Slab	1×0.9m	1×2.0×3.0
32	34.643	33+809	Slab	1×1.0m	1×2.0×3.0
33	37.191	36+382	Pipe	1×φ0.9m	1×2.0×3.0
34	38.435	37+626	Pipe	1×φ0.9m	1×2.0×2.0
35	40.379	39+172	Slab	1×2.25m	1×2.0×2.0
36		39+500	Slab		1×2.0×3.0
37		39+505	Slab		1×2.0×3.0
38		39+500			1×2.0×3.0
39		39+800			1×3.0×4.0
40		39+795			1×3.0×4.0
41		39+800			1×3.0×4.0
42		40+310			1×2.0×3.0
43		40+250			1×2.0×3.0
44		40+193			1×2.0×3.0
45	41.792	41+083	Slab	1×1.5m	1×2.0×3.0
46	42.904	42+191	Pipe	1×φ0.9m	1×2.0×3.0
47	43.195	42+482	Pipe	2×φ0.8m	1×2.0×3.0
48	43.983	43+268	Slab	1×2.8m	1×3.0×3.0
49	44.502	43+788	Slab	1×1.5m	1×3.0×3.0
50	44.688	43+974	Slab	1×1.5m	1×2.0×2.0
51	44.936	44+222	Slab	1×3.0m	1×3.0×3.0
52	46.041	45+325	Slab	1×2.5m	1×3.0×3.0
53	46.081	45+370	Pipe	1×φ0.8m	1×2.0×3.0
54	47.666	46+856	Pipe	1×φ0.8m	1×2.0×2.0
55	49.473	50+485	Pipe	1×φ0.9m	1×2.0×3.0
56	51.329	50+611	Pipe	1×φ0.9m	1×2.0×2.0

Source: JICA Study Team based on DPR

Table 5-35: Proposed New Box Culverts (Assam) (1)

No.	Design Chainage (km)	Proposed Box Size (m x m)
1	0+350	1×2.0×2.0
2	2+300	1×2.0×3.0
3	2+550	1×2.0×3.0
4	2+800	1×2.0×2.0
5	3+530	1×2.0×3.0
6	3+835	1×2.0×3.0
7	4+475	1×2.0×2.0
8	4+800	1×2.0×2.0

Source: JICA Study Team based on DPR

Table 5-36: Proposed New Box Culverts (Assam) (2)

No.	Design Chainage (km)	Proposed Box Size (m x m)
9	4+950	1×2.0×2.0
10	5+400	1×2.0×2.0
11	6+450	1×2.0×2.0
12	6+940	1×2.0×2.0
13	7+600	1×2.0×2.0
14	8+450	1×2.0×2.0
15	8+700	1×2.0×2.0
16	8+950	1×2.0×2.0
17	9+229	1×2.0×2.0
18	9+850	1×2.0×2.0
19	10+250	1×2.0×2.0
20	10+500	1×2.0×2.0
21	11+220	1×2.0×2.0
22	11+550	1×2.0×2.0
23	12+450	1×2.0×2.0
24	13+390	1×2.0×2.0
25	14+300	1×2.0×2.0
26	14+650	1×2.0×2.0
27	15+483	1×2.0×2.0
28	15+980	1×2.0×2.0
29	17+020	1×2.0×2.0
30	17+573	1×2.0×2.0
31	18+050	1×2.0×2.0
32	18+250	1×2.0×3.0
33	18+650	1×2.0×3.0
34	19+000	1×2.0×3.0
35	19+300	1×2.0×2.0
36	19+650	1×2.0×2.0
37	20+000	1×2.0×3.0
38	20+450	1×2.0×3.0
39	20+750	1×2.0×3.0
40	20+882	1×2.0×2.0
41	21+425	1×2.0×3.0
42	21+675	1×2.0×3.0
43	22+250	1×2.0×3.0
44	22+575	1×2.0×3.0
45	22+900	1×2.0×3.0
46	23+220	1×2.0×2.0
47	23+500	1×2.0×2.0
48	23+800	1×2.0×2.0
49	24+100	1×2.0×2.0
50	24+450	1×2.0×2.0
51	24+900	1×2.0×2.0

Source: JICA Study Team based on DPR

Table 5-37: Proposed New Box Culverts (Assam) (3)

No.	Design Chainage (km)	Proposed Box Size (m x m)
52	25+600	1×2.0×2.0
53	25+930	1×2.0×2.0
54	26+500	1×2.0×3.0
55	28+170	1×2.0×2.0
56	28+525	1×2.0×3.0
57	29+500	1×2.0×2.0
58	29+750	1×2.0×2.0
59	30+800	1×2.0×2.0
60	30+925	1×2.0×2.0
61	31+625	1×2.0×2.0
62	32+150	1×2.0×3.0
63	32+450	1×2.0×2.0
64	32+870	1×2.0×2.0
65	33+450	1×2.0×2.0
66	34+500	1×2.0×2.0
67	36+150	1×2.0×2.0
68	36+750	1×2.0×2.0
69	37+150	1×2.0×2.0
70	38+000	1×2.0×2.0
71	38+350	1×2.0×2.0
72	38+550	1×2.0×3.0
73	38+850	1×2.0×3.0
74	41+400	1×2.0×2.0
75	41+800	1×2.0×3.0
76	42+605	1×2.0×3.0
77	42+810	1×2.0×2.0
78	43+650	1×2.0×2.0
79	45+094	1×2.0×2.0
80	45+825	1×2.0×2.0
81	46+200	1×2.0×2.0
82	46+490	1×2.0×3.0
83	47+500	1×2.0×3.0
84	47+750	1×2.0×2.0
85	47+950	1×2.0×2.0
86	48+390	1×2.0×2.0
87	49+250	1×2.0×2.0
88	49+630	1×2.0×2.0
89	50+100	1×2.0×2.0
90	50+900	1×2.0×2.0
91	52+030	1×2.0×2.0
92	52+600	1×2.0×2.0
93	52+930	1×2.0×2.0
94	53+500	1×2.0×2.0

Source: JICA Study Team based on DPR

Table 5-38: Proposed New Box Culverts (Assam) (4)

No.	Design Chainage (km)	Proposed Box Size (m x m)
95	53+736	1×2.0×2.0
96	53+976	1×2.0×2.0

Source: JICA Study Team based on DPR

(2) Drainage Works

According to DPR of DPR, the following types of road drainage will be installed.

The DPR consult has been requested to obtain a road drainage list by type, but it is not available at this time. After obtaining it, we will recheck it and propose an optimal road drainage system. The road drainage used on this line is shown below.

- Footpaths cum cover drains of 2.0 m width have been proposed in the built-up area, as follows:
- Cover drains of 1.0 m width have been proposed in road-over-bridge (ROB) approaches for service road(s);
- Brick masonry drains have been proposed on the hillside; and
- Catch water drains have been proposed on the hillside for proper drainage.

Table 5-39 provides details of the drainage works.

Table 5-39: Details of Drainage Works

No	Type of Drainage	Length (m)
1	2.0 m Width RCC Cover Drain	
2	1.0 m Width RCC Cover Drain for Service Road	
3	Brick Masonry Drain	
4	Catch Water Drain	

Abbreviation: RCC = reinforced cement concrete
Source: JICA Study Team based on DPR

The reports and drawings we have received so far do not contain details about road drainage. We are currently requesting information from a DPR consultant.

5.2.7 Intersection Design

The types of new intersections shall be based on requirements stipulated in IRC SP 41, IRC 5, IRC 92 and MoRTH Specifications. Intersections and junctions have been classified as either "major" or "minor" based on functional and locational importance. All major and minor junctions and intersections were analyzed with respect to vehicular movements and vehicular turning movements based on a traffic study to provide appropriate grade and grade-separated intersections for cross and turning traffic.

Sub-clause 3.2.2 in IRC SP 84-2014 provided that the intersections shall be designed having regard to flow, speed, composition, distribution and future growth of traffic. Design shall be specific to each site with due regard to physical conditions of the site available. At multi leg intersections, the points of conflict should be studied carefully and possibilities of realigning one or more of the intersecting legs and combining some movements to reduce the conflicting movements shall be examined. The channelizing islands shall start from the edge of the paved shoulder as per MoRTH Specifications.

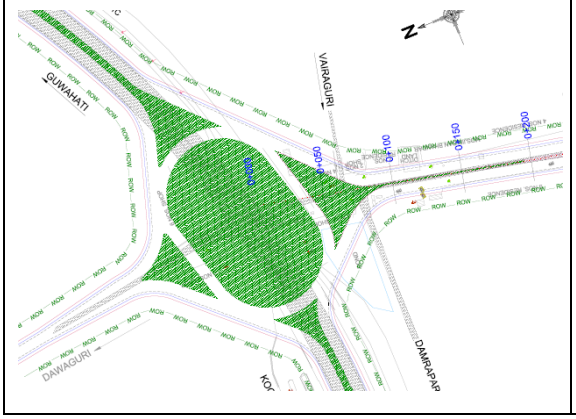
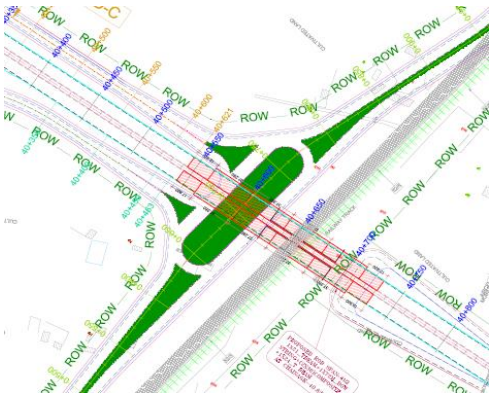
The DPR consultant proposed improvement of major junctions with channelized at-grade junctions. Traffic islands and rotaries were provided wherever necessary to channelize the flow of traffic and minimize collision points to increase road safety. Two major junctions were proposed along the project road. One of the major junctions, located at 0.000 km, is currently a four-legged type and configured for the intersection with NH31C and a village road; the DPR proposes a rotary (roundabout) at the chainage point. The other of the major junctions is located at the 42.25 km point at the intersection with NH31; the DPR proposes a three-legged type intersection near the ROB at this junction. However, Sub-clause 3.2.1 of IRC SP 84-2014 for At-Grade Intersections stipulates that rotaries are not to be provided along such highways.

Table 5-40 summarizes the major intersections along the project road, while Figure 5-18 maps the major intersections.

Table 5-40: Major Intersections along Project Road

No	Package	Existing Chainage (km)	Proposed chainage (km)	Type	Location	Improvement Proposal
1	Package-1	0	0	4-legged	Intersection with NH-31C & Village Road	At-grade 4-legged Junction with turning radius, traffic islands
2	Package-4	42.25	40.6	3-legged	Intersection with NH-31	ROB at CH. 40.600km

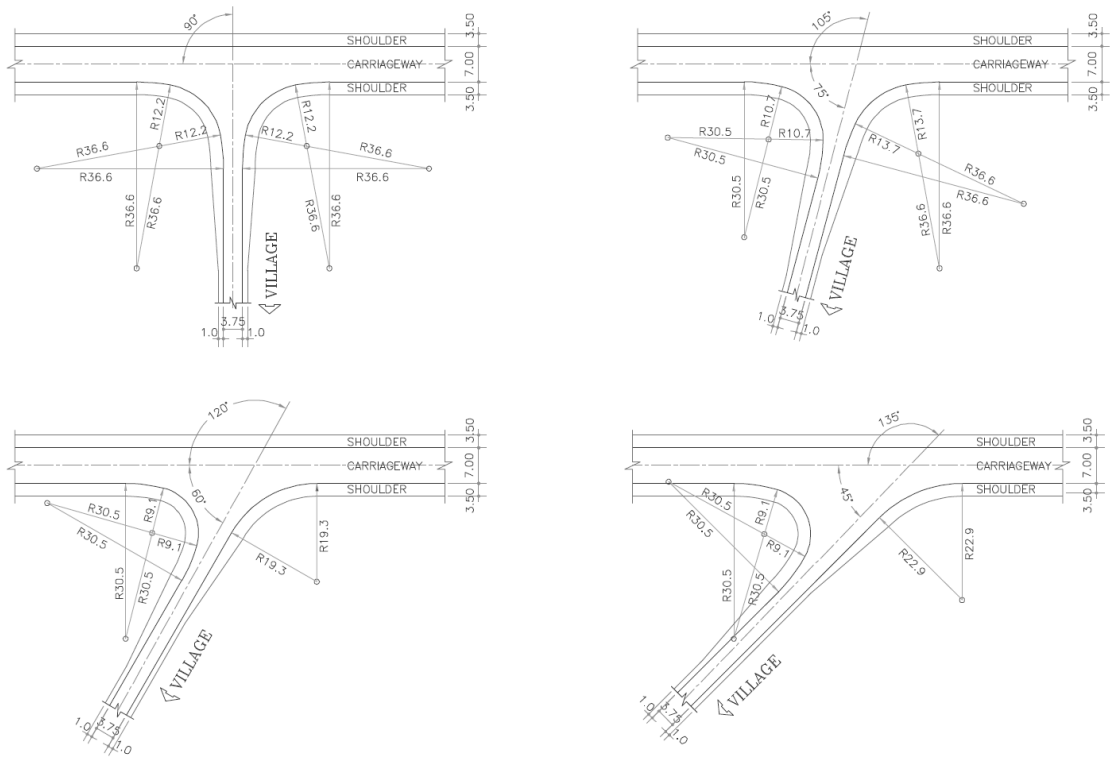
Source: JICA Survey Team based on DPR

No.1 (Package-1), CH 0+000	No.2 (Package-4), CH 40+600
	

Source: JICA Survey Team based on DPR

Figure 5-18: Location of Major Intersections

The DPR consultant proposed a total of 158 minor intersections shown in the below figure along the project road.



Source: JICA Survey Team based on DPR

Figure 5-19: Typical Minor Intersections

Sub-clause 4.8.2 in IRC SP 41-1994 states that Speed change lanes are more important in rural. In urban areas such lanes are rarely required but provision of short lanes to assist merging and diverging maneuvers are provided in conjunction with channelizing islands. In addition, acceleration lane should be designed so that vehicles turning left from the minor road may join the traffic flow on the major road at approximately the same speed as that of the nearside lane traffic in the major road.

5.2.8 Road Appurtenances Plan

Currently, traffic signs are missing at many locations on the survey stretch. No warning signs are installed before the approach of the junction and approach of curves. Directional signs are installed at few locations. In order to improve the safety conditions, DPR consultants proposed the road safety items including delineators as per IRC guidelines. The guideline for design of road appurtenances is shown in the table below.

Table 5-41: IRC Guidelines for Design of Road Appurtenances

IRC Code	Title
IRC 8-1980	Type Designs for Highway Kilometre Stones
IRC 21-2000	Standard Specifications and Code of Practice for Road Bridges
IRC 25-1967	Type Designs for Boundary Stones
IRC 26-1967	Type Design for 200-Meter Stones
IRC 35-1997	Code of Practice for Road Markings
IRC 66-1976	Recommended Practice for Sight Distance on Rural Highways
IRC 67-2012	Code of Practice for Road Signs
IRC 79-1981	Recommended Practice for Road Delineators
IRC 103-1988	Guidelines for Pedestrian Facilities

Source: JICA Survey Team

(1) Metal Beam Crash Barriers (MBCB)

Metal Beam Crash Barriers are proposed on both edges of road embankments where the height is more than 3.00 m on both sides of main carriageway. The metal beam crash barrier shall consist of W-Beam fixed on posts (15 MB150) placed at 5.0 m apart c/c with spacers (also 15 MB-150). Reflectors shall be fixed on the Metal Beams @ 3m c/c for proper delineation of barrier line.

(2) Guard Posts

Standard Guard Posts made of M20 grade concrete fixed with M-20 grade concrete foundation proposed to be provided on inner and outer edges of road with sharp curves, road on hill side at 1.50 m intervals and 2.00 m from the edge of carriageway with reflectors fixed on it.

(3) 200 m Kilometer and 5th km stones

These stones shall be fixed as per guidelines of IRC 8 and IRC 26 with lettering and numbering as per code provisions. There shall be fixed on LHS for each directions of travel.

(4) Delineators

- Delineators are provided for visual assistance to drivers to follow and negotiate the alignment of road ahead and provide warning about hazards particularly at night. Various types in use are:
- Clustered Red Reflectors on triangular nodes as object markers are provided at the edge of median and directional islands.
- Circular red reflector on face / top of islands and medians.
- Circular white Reflectors on Guard Posts.

(5) Boundary Stones

Road boundary stones shall be fixed on both sides of the road to demarcate the boundary of new ROW. There shall be fixed with proper founding concrete and dowel bars to guard against tempering.

(6) Traffic Signals

All at grade junctions in built up areas shall be provided with traffic signals. There shall be provided as per safety manual.

(7) Lighting System

All road stretch passing through built up are shall be provided with lighting system erected on poles with ade3quate height and 30 m c/c, such that it shall provide uniform illumination of 40 lux minimum at all places.

(8) Landscaping and Arboriculture

The environmental along proposed corridor shall be enhanced using various techniques of soft landscapes, principally though plantation of various types of shade and ornamental trees along with shrubs. Landscaping strategy has been developed to enhance the visual quality of the survey stretch. Tree plantations have manifold benefits. They may help in reducing the air pollution levels, especially Suspended Particulate Matter (SPM) in the surrounding area. A marginal decrease of 3 to 4 dB (A) in noise levels may also be expected due to the plantation used for landscaping.

Tree plantation is proposed along survey stretch at 10-15 m c/c on both side parallel to the road. Set back distance of trees in different situation shall be as per IRC SP 21 and IRC 66. The nearest edge of tree trunk shall be at 2.00 m minimum from road edge or carb edge.

The scheme of landscaping shall be part of overall Environmental Mitigation Plan (EMP). The planting shall be such that it does not obstruct the visibility of traffic from any side and shall be pleasing in appearance.

5.2.9 Preliminary Study of Bypass Route

The project route consists of sparsely built-up and open portions. IRCSP84-2014, Clause 2.1 states "Where there is constraint of ROW width, the Authority may specify construction of a bypass. In view of minimizing social impacts and land acquisition, four bypasses have been proposed. Various alternative alignments were considered for the finalization of various bypasses and the most suitable option were finalised based on less damaging to existing built-up structures, deviation from settlement areas, and the most economical project cost among the others.

Table 5-42: Bypass Locations and Length

No	Bypass Location	Length (m)
1	CH 20+300 – CH 23+050	2,750
2	CH 28+500 – CH 30+400	1,900
3	CH 39+150 – CH 41+200	2,050
4	CH 47+700 – CH 49+540	1,840
	Total	8,540

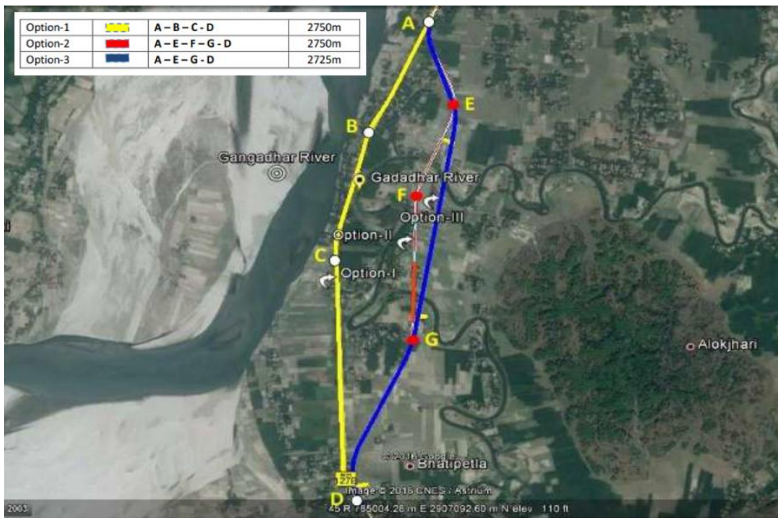
Source: JICA Survey Team base on DPR

(1) Criteria for Comparing Alternative Alignment Options for Bypasses

The following criteria are used for selecting the preferred alignment.

- Design Speed: The proposed alignment should maintain design speed between 80-100 kmph.
- Riding Comfort: The proposed alignment is such that passengers of the vehicle feel comfort while traveling through the proposed Road.
- Land Acquisition: Minimum land to be acquired. Try to acquire Govt. land as much as possible and minimum acquisition of existing structures.
- Social Impact & Severance: The proposed alignment has minimized effect upon the existing structures and R&R impact of that locality.
- Cost Effectiveness: The Project cost consisting of Civil construction Cost, LA & R&R, Utility Shifting cost of the proposed alignment has been kept minimal.
- Safety: The proposed alignment has been prepared in such a way that it requires minimum safety hazards along its entire length.

(2) Bypass No. 1 (CH 20+300 - CH 23+050)



Source: JICA Survey Team base on DPR

Figure 5-20: Alternative Alignment Options for Bypass No. 1

Table 5-43: Comparison of Alternative Alignment options for Bypass No. 1

S. No	Design, Safety &other Parameter	Alignment Option - I (Follows the Existing alignment)	Alignment Option - II (Red alignment)	Alignment Option- III (Blue alignment)
1	Design Speed	100 Kmph	100 Kmph	100 Kmph
2	Total Length	Total length 2.750 km	New alignment length 2.750 km,	New alignment length 2.725 km,
3	Land Acquisition	4.13 Hectare	16.50 Hectare	16.35 Hectare
4	Description of alignment	This Alignment Passes in between Gangadhar River & Gadadhar River with in Builtup Area of Madhya Petla Village.	Greenfield Alignment having right angle crossing over Gadadhar River.	A greenfield alignment having Skew crossing over Gadadhar River.
5	Social Impact and R&R	Nearly 45 Nos. structures and one Big Temple are affected	Nearly 4 nos. structures are affected	No conflict with settlement or structures
6	Structures and Protective Works	Both side service/slip road, approx 800m Retaining/curtain wall/ grouted rip-rap, to protect embankment in contact with water and approx. 10 nos. balancing box culverts are required.	2 nos. minor Bridge (approx length 48m) required over Gadadhar River and approx. 8 nos. balancing box culverts are required.	1 nos. major Bridge required over Gadadhar River due to skew crossing (approx length 96m) and 1 no minor bridge required (approx length 48m) and approx. 8 nos. balancing box culverts are required.
7	Civil Cost	15.99 Crore (5.92 Cr. Per KM)	24.04 Crore (8.66 Cr. Per KM)	30.24 Crore (10.67 Cr. Per KM)
8	R&R & LA Cost	LA Cost = 3.06 Crore R&R Cost = 4.65 Crore	LA Cost = 8.15 Crore R&R Cost = 0.42 Crore	LA Cost = 8.08 Crore R&R Cost = Nil
9	Total Cost including R&R and LA	23.70 Crore	32.60 Crore	38.32 Crore
10	Utility Shifting Cost	Maximum	Minimum	Minimum

Source: JICA Survey Team base on DPR

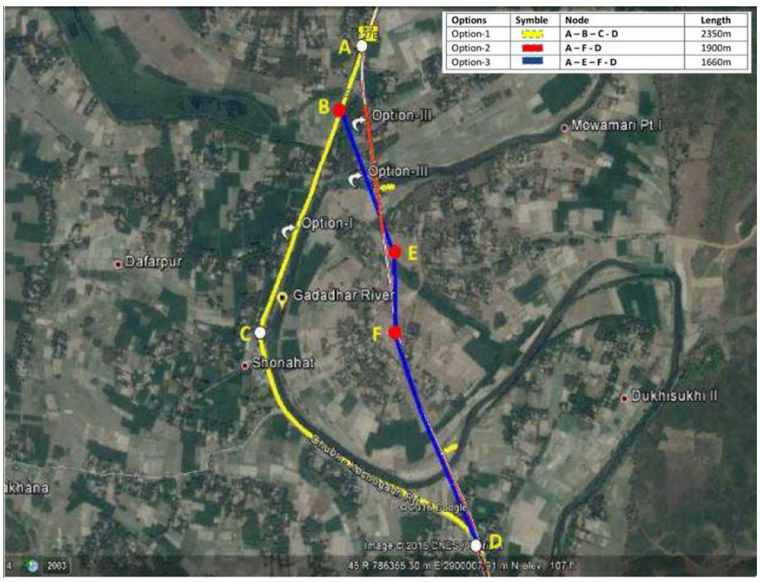
Alignment Option - II is most preferable because of securing a distance from Gangadhar River and avoiding built-up location of Madhya petal village with less R&R cost, and overall evaluation including the total cost. Merits and Demerits of each options are summarized in the table below.

Table 5-44: Merits and Demerits of Each Options for Bypass No. 1

	Alignment Option - I (Follows the Existing alignment)	Alignment Option - II (Red alignment)	Alignment Option- III (Blue alignment)
Merits	➢ Totally following the existing alignment ➢ Land acquisition cost is less than option II & III	➢ Totally Greenfield alignment ➢ R& R cost is less than option I ➢ Right angle crossing over Gadadhar River	➢ Totally Greenfield alignment ➢ R& R cost is Nil
Demerits	➢ This Alignment Passes in between Gangadhar River & Gadadhar River with in Builtup Area of Madhya Petla Village. ➢ Approximately 45 nos. of houses are affected at Madhya Petla village. So, LA and R&R cost is high. ➢ Utility Shifting Cost maximum	➢ Civil cost is high because 2 nos. minor bridge is required over Gadadhar River. ➢ LA Cost High ➢ Utility Shifting Cost minimum	➢ Civil cost is high because 1 nos. major Bridge required over Gadadhar River due to skew crossing (approx length 96m) and 1 no minor bridge required (approx length 48m) ➢ LA Cost high compare to Option I ➢ Utility Shifting Cost minimum

Source: JICA Survey Team base on DPR

(3) Bypass No. 2 (CH 28+500 - CH 30+400)



Source: JICA Survey Team base on DPR

Figure 5-21: Alternative Alignment Options for Bypass No. 2

Table 5-45: Comparison of Alternative Alignment options for Bypass No. 2

S. No.	Design, Safety &other Parameter	Alignment Option - I (Follows the Existing alignment)	Alignment Option - II (Red alignment)	Alignment Option- III (Blue alignment)
1	**Design Speed**	65 Kmph	100 Kmph	80 Kmph
2	**Total Length**	Total length 2.350 km	New alignment length 1.900 km,	New alignment length 1.660 km,
3	**Land Acquisition**	3.50 Hectare	Private Land=5.0 Ha; Govt Land = 6.40 Ha	Private Land=5.96 Ha; Govt Land = 4.0 Ha
4	**Description of alignment**	This Alignment passes along the Gadadhar River and Builtup Area of Sonahat Village.	Greenfield Alignment passes through maximum Govt. Lands.	Greenfield Alignment passes through minimum Govt. Lands.
5	**Social Impact and R&R**	Nearly 90 Nos. structures and one Big Mosque are affected	Nearly 5 nos. structures are affected	Nearly 10 nos. structures are affected
6	**Structures and Protective Works**	Both side service/slip road required in built up area, approx 1450m Retaining/curtain wall/ grouted rip-rap, to protect embankment in contact with water and approx. 8 nos. balancing box culverts are required.	2 nos. minor Bridge (approx length 48m) required over Gadadhar River and approx. 6 nos. balancing box culverts are required.	2 nos. minor Bridge (approx length 48m) required over Gadadhar River and approx. 6 nos. balancing box culverts are required.
7	**Civil Cost**	20.09 Crore (8.55 Cr. Per KM)	20.66 Crore (10.87 Cr. Per KM)	20.10 Crore (12.11 Cr. Per KM)
8	**R&R & LA Cost**	LA Cost = 2.61 Crore R&R Cost = 9.30 Crore	LA Cost = 2.47 Crore R&R Cost = 0.52 Crore	LA Cost = 2.94 Crore R&R Cost = 1.03 Crore
9	**Total Cost including R&R and LA**	32.00 Crore	23.65 Crore	24.08 Crore
10	**Utility Shifting Cost**	Maximum	Minimum	Minimum

Source: JICA Survey Team base on DPR

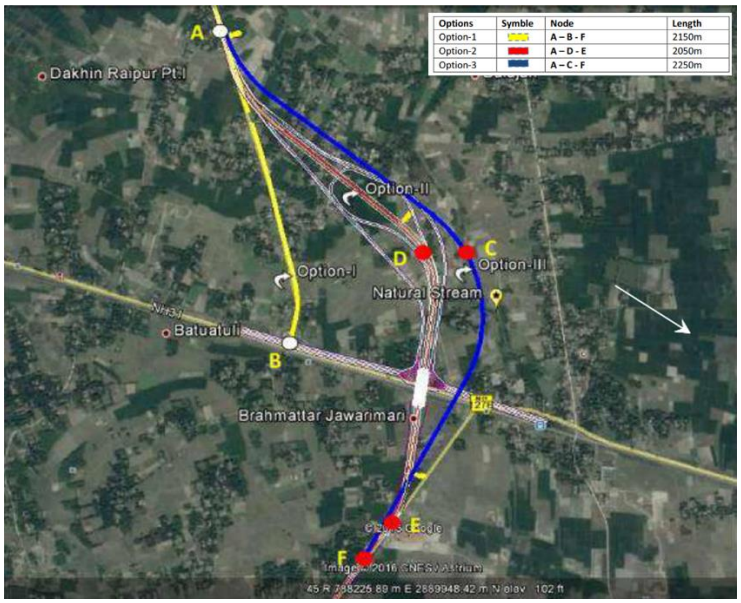
Alignment Option - II is most preferable because of utilizing maximum Government land and the least total project cost.

Table 5-46: Merits and Demerits of Each Options for Bypass No. 2

	Alignment Option - I (Follows the Existing alignment)	Alignment Option - II (Red alignment)	Alignment Option- III (Blue alignment)
Merits	➢ Totally following the existing alignment ➢ Land acquisition cost is less than option II & III	➢ Totally Greenfield alignment ➢ R& R cost is less than option I & III ➢ Maximum Government land is utilized.	➢ Totally Greenfield alignment ➢ R&R cost is less than Option I
Demerits	➢ This Alignment passes along with Gadadhar River so protection cost is so high ➢ Approximately 90 nos. of houses are affected at Sonahat village. So, LA and R&R cost is also high. ➢ Poor Geometry. Design Speed has not reached as per standard.	➢ Civil cost is high because 2 nos. minor bridge is required over Gadadhar River.	➢ Civil cost is high because 2 nos. minor bridge is required over Gadadhar River. ➢ R& R cost is more than Option II

Source: JICA Survey Team base on DPR

(4) Bypass No. 3 (CH39+150 - CH 41+200)



Source: JICA Survey Team base on DPR

Figure 5-22: Alternative Alignment Options for Bypass No. 3

Table 5-47: Comparison of Alternative Alignment options for Bypass No.3

S. No.	Design, Safety &other Parameter	Alignment Option - I (Follows the Existing alignment)	Alignment Option - II (Red alignment)	Alignment Option- III (Blue alignment)
1	**Design Speed**	100 Kmph	100 Kmph	100 Kmph
2	**Total Length**	Total length 2.150 km	New alignment length 2.050 km,	New alignment length 2.250 km,
3	**Land Acquisition**	3.23 Hectare	12.30 Hectare	13.50 Hectare
4	**Description of alignment**	This Alignment passes through Builtup Area of Saheb Ganj Village.	This Alignment passes through completely Greenfield land and some structures are to be effected.	This Alignment passes through completely Greenfield land & one settlement area are effected
5	**Social Impact and R&R**	Nearly 60 Nos. structures and one Big Mosque are affected	Nearly 6 nos. structures are affected	Nearly 25 nos. structures are affected
6	**Structures and Protective Works**	Both side service/slip road required in built up area and 1 no. grade separator required between NH-127B and NH-31.	1 no. grade separator required between NH-127B and NH-31.	1 no. grade separator required between NH-127B and NH-31.
7	**Civil Construction Cost (Without Grade Separator)**	10.43 Crore (4.85 Cr. Per KM)	8.53 Crore (4.16 Cr. Per KM)	9.33 Crore (4.15 Cr. Per KM)
8	**R&R & LA Cost**	LA Cost = 2.39 Crore R&R Cost = 6.20 Crore	LA Cost = 6.08 Crore R&R Cost = 0.52 Crore	LA Cost = 6.70 Crore R&R Cost = 2.58 Crore
9	**Total Cost including R&R and LA**	19.02 Crore	15.12 Crore	18.58 Crore
10	**Utility Shifting Cost**	Maximum	Minimum	Minimum

Source: JICA Survey Team base on DPR

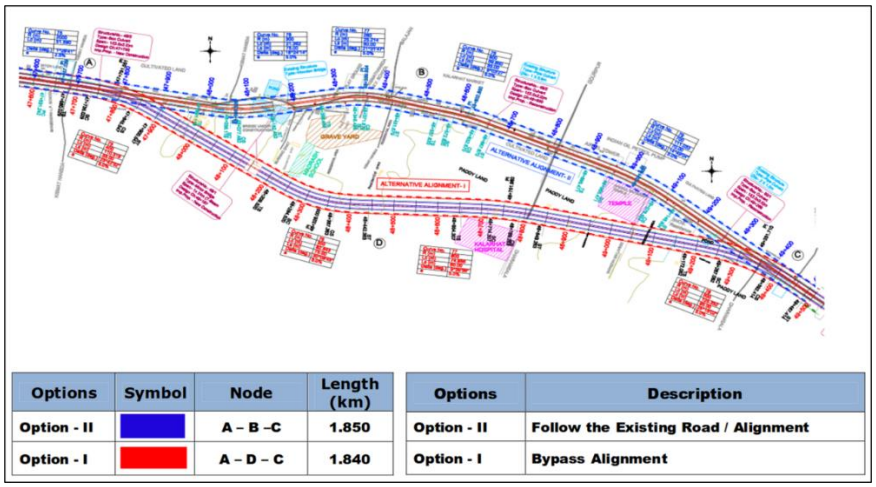
Alignment option - II is most preferable because of the shortest bypass length and the least project cost.

Table 5-48: Merits and Demerits of Each Options for Bypass No. 3

	Alignment Option - I (Follows the Existing alignment)	Alignment Option - II (Red alignment)	Alignment Option- III (Blue alignment)
Merits	➢ Totally following the existing alignment ➢ Land acquisition cost is less than option II & III	➢ This Alignment passes through completely Greenfield land and some structures are to be effected. ➢ Total Cost is less than option I & III ➢ Short length than option III	➢ Totally Greenfield alignment
Demerits	➢ Approximately 60 nos. of houses are affected at Saheb Ganj village. So, LA and R&R cost is also high.	➢ Nothing.	➢ Total Cost is higher than option I & II

Source: JICA Survey Team base on DPR

(5) Bypass No. 4 (Ch 47+700 - CH 49+540)



Options	Symbol	Node	Length (km)
Option - II		A – B –C	1.850
Option - I		A – D – C	1.840

Options	Description
Option - II	Follow the Existing Road / Alignment
Option - I	Bypass Alignment

Source: JICA Survey Team base on DPR

Figure 5-23: Alternative Alignment Options for Bypass No. 4

Table 5-49: Comparison of Alternative Alignment options for Bypass No.4

Particulars	Option – II (Blue Alignment)	Option – I (Red Alignment)
Description	Follow the Existing Alignment	Bypass
Length	1.850km	1.840km
New/Existing Alignment Length	New Alignment- Nil Existing Alignment-1.600km	New Alignment-1.590km Existing Alignment- Nil
Structure	Minor Bridges- 1 Nos. Box Culvert -4 Nos R.C. Covered drain – 2.7 km	Minor Bridges- 1 Nos. Box Culvert - 4 Nos Earthen Drain – 3.5 km
Design Speed	65 kmph to 80 kmph	80 kmph to 100 kmph
Land Acquisition	3.7 Hec	8.30 Hec.
Social Impact and R&R	About 56 nos. commercial structures and one no. Mosque to be effected.	6 Nos. only hutment
Civil Cost	22 Cr.	18 Cr.

Source: JICA Survey Team base on DPR

Alignment Option - I is most preferable because of less R&R cost, avoiding religious structures and easier traffic management during construction.

Table 5-50: Merits and Demerits of Each Options for Bypass No. 4

	Alignment Option – II (Follow the Existing Alignment)	Alignment Option – I (By pass)
Merits	➢ Land acquisition is minimum	➢ Length is minimum compare to Option II ➢ Entire green field alignment. Therefore Construction process is quick & easier than option II. ➢ Utility shifting cost is not required. ➢ Less R&R activities as only 6nos. of hutment structure is affected.
Demerits	➢ During construction Traffic management is Difficult. ➢ Future widening is difficult ➢ R & R effect is maximum. ➢ Religious structure to be affected. ➢ Utility shifting cost is maximum	➢ Land acquisition is maximum

Source: JICA Survey Team base on DPR

5.2.10 Preliminary Study of Spoil bank

As shown in Table 6-1 : Major Quantities, only 39,000m3 of excavated material is generated for disposal in total against 190,000m3 of total excavation volume due to 1490,000m3 of re-use. The total disposal volume is further spread into 5 packages. As 80% of excavated material is designed to be reused, substantial Spoil Bank is not required, and Spoil Banks are not studied in DPR. Because of the above reason JST consider that Spoil Bank can easily arranged by the Contractors somewhere nearby the Site.

5.3 Consideration of Climate Change Adaption

To be filled later

Chapter 6. Preliminary Project Cost Estimate

6.1 Outline of the Project

6.1.1 Description of Civil Construction Works

The road project is to construct & upgrade the newly declared NH-127B (Assam section) starting from Srirampur to the proposed bridge over river Brahmaputra to provide 4 lanes flexible pavement and rigid pavement (partially), generally on/along the existing road alignment. The total design length is 54.154km which is planned to be divided into 5 construction packages. The construction includes earthworks, roadworks, drainage, bridges, culverts, retaining walls, slope protection, Bus Bay, Truck Lay Bye, road appurtenances and other miscellaneous works that can make the highway be properly function. The major quantity of the works is summarized in Table 6-1 below.

Table 6-1: Major Quantities

Activities		Unit	P1	P2	P3	P4	P5	Assam Total	
Design Length		km	10.900	16.750	8.850	6.800	10.854	54.154	km
Design Lane		no.	4	4	4	4	4	4	no.
Excavation for road	for re-use	m3	18,500	68,200	14,300	3,600	44,600	149,200	m3
	for disposal	m3	7,900	29,200	0	1,600	0	38,700	m3
Embankment fill	from excavation	m3	18,500	68,200	14,300	3,600	44,600	149,200	m3
	from borrow pit	m3	75,800	167,600	435,600	89,700	711,500	1,480,200	m3
Subgrade	with shoulder	m3	159,400	226,500	126,600	114,900	16,500	643,900	m3
Flex paving		m2	190,800	264,000	153,900	117,300	193,900	919,900	m2
Concrete Pavement		m2	0	10,400	0	9,100	0	19,500	m2
Bridges	Major	no.	0	0	0	0	1	1	no.
	Minor	no.	1	3	3	1	3	11	no.
	ROB	no.	1	0	1	1	0	3	no.
Culverts	Reconstruction	no.	10	16	7	7	9	49	no.
	New proposal	no.	12	20	7	18	12	69	no.
Retaining Wall	h=3.5~6.0m	m	0	1,300	600	900	1,500	4,300	m
Toe Wall		m	300	400	500	0	100	1,300	m
Stone Pitching		m	0	400	200	0	2,600	3,200	m
Longitudinal Drains		m	3,600	8,500	3,400	1,700	2,000	19,200	m
Bus-Bay	both side	no.	1	3	1	3	1	9	no.
Truck Lay Bye	both side	no.	0	1	0	0	0	1	no.
Intersection	Major	no.	1	0	0	1	0	2	no.
	Minor	no.	38	49	27	19	25	158	no.
Service Road		m	2,720	0	2,850	1,100	5,100	11,770	m
Flyover								Nil	
Underpasses	VUP & LVUP	no.	0	0	0	1	2	3	no.
Toll Plaza		no.	0	0	0	0	1	1	no.
turfing		m2	121,100	167,500	94,700	60,700	97,400	541,400	m2
Hydroseeding		m2	0	0	0	0	71,800	71,800	m2

Source: DPR, summarized by JICA Survey Team

6.2 Construction Plan

6.2.1 Major Construction Materials

Procurement condition of major construction materials are summarised as Table 6-2. JST conclude that there is no problem with procurement of major construction materials for permanent works.

Table 6-2: Resource of Major Construction Materials

Material	*Location of resource*	*Approx. lead to the Project Center Grid*	*Probable purpose of use*	*Note*
Re-bar	Dhubri, 1km from end point	28km	Structural work, retaining wall, drain	As rates of all the item are given at site in SOR, lead for the package length has been considered in the rate analysis.
Coarse Aggregate	Harafuta, 6km from Sriampur	33km	Road & Structural work	
Fine Aggregate	Korahat,26km from Dhubri	53km	Road & Structural work	
Bitumen	Guwahati 270km from Sriampur	297km	Road work and wearing course	
Cement	Dhubri, 1km from end point	28km	Structural work, retaining wall, drain	

Source: DPR, Summarized by JICA Study Team

6.2.2 Construction Technique

To the extent of the DPR, JST conclude that all the permanent works do not require any unique/special construction technique that the local contractors have not experienced and/or would have difficulty carrying out. However, JST consider that the following activities require attention specifically.

1) During rainy season for about 5 months (May to September) construction progress will drop presumably by 50% overall and foundation/pier works for bridge construction in river is unlikely to be possible. These factors have already been reflected in the construction schedule. Please see Figure 6-1.
2) It is specified to use prestress concrete beams for the construction of major bridge. From the viewpoint of the existing road condition, it will not be realistic to transport such long size/heavy weight beams for long distance. Therefore, establishment of precast yards near the bridge construction site will be essential so that the existing traffic flow will not be disturbed.
3) Construction of foundation and substructure of major bridges are planned to be carried out during dry season. As the river stream becomes very narrow and shallow at the time, the works can be carried out on the riverbed directly therefore, large scale temporary work such as access bridges and/or earth band in the river will not be required.
4) Construction of Railway Over Bridge – Temporary arrangement or methodology of launching bridge girders over railway track require approval of Railway Authority before start works (by the Contractor). Night work (during no train operation time) will be required for launching bridge girders and protection works to girders to prevent construction material from falling.
5) Temporary road diversion is required to maintain public traffic flow during road construction.

   Temporary road diversion can be carried out using road widening area alongside the existing road. The temporary road will also be used as the access road for construction. The

road diversion will be carried out step by step in order that the existing traffic flow will not be interrupted.

In case of NHB127 (Assam), as the designed highway has four lanes and existing road has two lanes, widening area is much wider than existing road, therefore, road diversion is much easier than the case that designed highway has two lanes only. Problem will be minimal at the location where the designed road is totally separated from the existing road.

6.2.3 Construction Safety

Prior to the commencement of the construction, EPC Contractor is required to submit the proposed methodology to be adopted for executing the Works which includes Safety Plan giving details of measures for ensuring safety complying with the Applicable Laws and Good Industry Practice. The Safety Plan is required to be prepared with reference to 'The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects (September 2014)' published by JICA. It is essential that the above ODA Safety Guidance is included in the Bidding Documents as reference document.

JST consider that in addition to the description of safety plan in general specific safety plan in detail including hazards assessment should be provided for the following works.

1) Railway Over Bridge (Railway proximity Construction)
2) Major Bridge (work at height)
3) Traffic Management including temporary traffic diversion (public safety)
4) Slope work (work at height)

The Authority's Engineer review the Safety Plan to ensure that the Plans complies with the Applicable Laws and Good Industrial Practice, and also the ODA Safety Guidance is taken consideration and give consent to the Safety Plan upon confirmation of those requirement.

The EPC Contractor is obliged to implement the Works in accordance with the approved methodology and Safety Plan. The Authority's Engineer and his/her staff will visit the sites for the observation of the safety condition during construction to ensure that the Contractor is implementing the works on the line of the Safety Plan. The Authority's Engineer will take prompt action to the Contractor to rectify the situation when any deviation from the plan and/or dangerous situation is found.

The Authority's Engineer will in collaboration with the Contractor establish Project Emergency Communication Network among the Employer, the Engineer's Supervision Team, the Contractor and any other Safety related agencies like as fire station, police station, hospital and so on in order to take prompt action against any emergency occurrences.

JST consider that the above 1) Railway Over Bridge is the highest risk work in the Project as it is Railway proximity with work at height. The Authority's supervision team is required following specific action to the Contractor as mitigation counter measure to the risk.

1) Ensure that the construction methodology has been prepared and agreed with the Railway Authority before commencement of site work.
2) Ensure that safety staff who is well experienced with Railway proximity construction work has been employed

3) Ensure that communication system between the contractor and Railway Authority firmly established so that the train operation information can be confirmed with 24 hrs basis and the contractor can take immediate counter action against deficiency on safety that may be pointed out by the Railway Authority.
4) Ensure by periodical site inspection that the safety facilities especially for prevention of materials falling are properly provided and functioning.

6.2.4 Earth Work Quantity Balance-Cutting & Filling

Cut and fill balance within the project area may have significant impact on not only cost and construction period but also the required numbers of construction plant that will affect public traffic and planning of temporary access road.

As described in Table 6-1, about 190,000 m3 soil is excavated and 150,000m3 is re-used. Only 40,000m3 is subject to disposal. 1,480,000m3 of embankment fill is required from borrow pits, however, as the volume is well shared by 5 packages. It is confirmed by DPR Consultant that sufficient good quality borrowable earth is available in the close vicinity of the site in general. There is no significant affect to the construction schedule. JST consider that the design is well prepared with the point of view of earth work balance.

6.2.5 Construction Schedule

NHIDCL expects 2 years (24 months) as construction period for each package (completed parallelly) with 5 years of maintenance period including defect liability period. As construction schedule is not provided in the DPR, JST prepared a preliminary construction schedule to study the feasibility of 24 months of construction period. The schedule is prepared based on 5 Packages with the following considerations (Table 6-3).

Table 6-3: Basic Consideration for Planning the Construction Schedule

Works	Duration/ Consideration
Topographical survey	3months
Detail design	6months
Earth Work (Critical pass)	800m3/day/team. Supposed transportation distance =3km, round trip=6km, one hr./trip including loading and unloading. 8hrs./one hour/ trip=8times/day 18t lorry (7.5m3) 15nos@7.5m3@8times/day=900m3/day, Apply 800m3 considering loss time. 400m3 during rainy season (operation rate 50%) Employ two nos. of 1.5m3 class excavator(70m3/hr) is enough for excavation and loading.
Subgrade	500m3/day/team, 250m3 during rainy season (output is totally depending on the number of compaction rollers, appropriate no of roller to be arranged)
Protective work (Retaining Wall)	Early stage of earth work (appropriate number of teams to be arranged not to disturb the earth work progress
Drainage work	Follow the progress of earth work (appropriate number of teams to be arranged no to disturb the progress of earth work
Box culvert	Follow the progress of earth work (appropriate number of teams to be arranged not to disturb earth work
Paving	2,000m2/day/team (1,000m2 during rainy season) not critical) can be commence earlier date than in construction schedule.
Major bridge	
a) Temporary works	3months, no work during rainy season
b) Foundation, Pier	6months, no work during rainy season Foundation (2nos same time): 2nos/7days@20 =70days, say 2.5month Pier (4nos same time): re-bar (10days) + formwork(10days) + concrete(days)=21days@5=105days, say 3.5month Total. 2.5month+3.5 month= 6.0month no work during rainy season
c) Superstructure	6months exclude precast production. Precast beams can be produced during the period of above a) and b). Installation of Precast beam 3days/span+ formwork 10 days/span + re-bar& concrete 10days/span=23days @6 span=138days=4.6month, add miscellaneous works 1.4 month= 6month, duration can be reduced by construction from both side (as contingency plan)
Minor bridge	1no/5months/team, 0.5no/5months/team during rainy season
Road apparatus	After paving (not critical)
Road Facility (Bus bay/ Track Lay Bye)	Follow earth work (not critical)
Slope protection (Turfing/Hydroseeding)	Follow earth work (not critical)

Source: JICA Survey Team

Design Length:	54.154km
Construction period:	2 years
Maintenance period:	5 years
Nos. of Construction Package	5 Packages

Works Activities	*Unit*	*Qty.*	*Work Teams*	*Year 1*												*Year 2*												*5 Years maintenance period*
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
				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 - 84
1. Detailed design	Ls	1	1x5																									
2. Survey & Soil Investigation	Ls	1	1x5																									
3. Mobilization and prelimoinary works	Ls	1	1x5																									
4. Earth Works			2x5																									
a) Road excavation	m3	180,000																										
b) Embankment fill	m3	1,600,000																										
5. Protection Works	Ls	1	2x5																									
6. Drainage Works	Ls	1	2x5																									
7. Pavement Works	m2	940,000	1x5																									
8. Road apparatus works	Ls	1	1x5																									
9. Associated structures	Ls	1	1x5																									
10. Minor Bridges	Nos	11	2x5																									
11. Major Bridges	Nos	1	1																									
a) Temporary Works																												
b) Bridge Substructure																												
c) Superstructure																												
12. Deffect liability period																												

Rainy season. *(subject to the actual commencement date)*

Source: JICA Survey Team

Figure 6-1: Construction Schedule

As show on the schedule (Figure 6-1), JST consider that construction period for 24 months of NH127B (Assam) is feasible.

6.3 Preliminary Project Cost Estimate

6.3.1 Condition of Cost Estimates and Reference Documents

Project estimate has been prepared as per PWD National Highway- Schedule of Rates (SOR) (2013-14) with the escalation based on the latest (May 2020) WPI. As 12% of GST took effect on July 2017, SOR (2013-14) does not cover GST. Therefore, GST is added on Total Civil Cost separately.

Quantities are measured from the DPR drawings section by section and type by type. Priced B.O.Q is made accordingly. The cost summary has been prepared in line of the Office Memorandum on 9th March 2019 (No. Secy/RTH/Circular/005) issued by Ministry of Road Transport & Highway for Calculation of Cost-estimates and provision for Contingencies/Centages.

6.3.2 Preliminary Item

Preliminary items are not separately provided in BOQ such as Contractor's indirect cost & profit however, as stated in the Preface of Schedule of Rates 10 % for contractor's overheads and 10% profit (added overhead also) total 21% is included in each rate which covers the following costs.

(1) Site accommodation, setting up plant, access road, water supply, electricity, and general site arrangements.

(2) Site office infrastructure

(3) Expenditure on:

a) Corporate office of the Contractor.
b) Site supervision by the contractor.
c) Preparation of 'as built' drawings.

(4) Mobilization/demobilization of resources.

(5) Labour camps with minimum amenities, required as per labour laws.

(6) Light vehicles for site supervision including administrative and managerial requirements.

(7) Minor Tool & Plants (T&P) including needle vibrators required for concrete work.

(8) Survey instrument and the task of setting out of works including verification of line and dimensions.

(9) Watch and ward.

(10) Arrangement for traffic and traffic management during construction.

(11) Expenditure on safeguarding environment during construction.

(12) Sundries

(13) Financing expenditure of the contractor.

(14) Work insurance/compensation.

(15) Sales/Turnover tax assuming

6.3.3 Temporary Works

Cost for temporary works relating to work directly are included in each rate. For example, temporary shoring and bracing are included in the rate of excavation.

The JICA Survey team concluded that no cost adjustment is required for preliminaries and they are not separately provided in BOQ.

6.3.4 Total Project Cost

Priced B.O.Q is made for the 5 packages separately and tallied up. After confirmation with the DPR Consultant total project cost is as presented in Table 6-4 below. JST conclude that no cost adjustment is required for the cost indicated in Table 6-4A and in 6-4B (in Japanese Yen) .

Table 6-4A: Project Cost Summary

		Lakh						Million INR
		P-1	P-2	P-3	P-4	P-5	Total	
	Chainage (km) Start:	*0.000*	*10.900*	*27.650*	*36.500*	*43.300*	*0.000*	
	End:	*10.900*	*27.650*	*36.500*	*43.300*	*54.154*	*54.154*	
	Design Length (km)	*10.900*	*16.750*	*8.850*	*6.800*	*10.854*	*54.154*	
1	Site Clearance	109.8	155.3	85.6	78.4	134.1	563.2	56.3
2	Earth works	1,410.4	2,250.0	2,104.2	1,064.2	1,225.2	8,054.1	805.4
3	Sub-base, Base	2,577.4	3,516.2	1,950.1	1,416.7	2,539.3	11,999.7	1,200.0
4	Bituminous surface	2,345.3	3,140.0	2,022.8	1,541.4	2,549.2	11,598.7	1,159.9
5	rigid Pavement	-	1,521.4	-	-	-	1,521.4	152.1
6	Traffic signs, Road Marking and others	339.3	499.8	234.0	323.2	510.7	1,907.0	190.7
7	Drain & Protection						0.0	0.0
a)	Drain	684.1	1,968.9	701.9	359.7	390.9	4,105.4	410.5
b)	RE wall (Reinforced Earth Wall)	2,039.3	-	2,351.6	5,002.2	1,166.9	10,560.0	1,056.0
c)	Retaining Wall		737.5	344.8	412.6	664.8	2,159.7	216.0
d)	Toe Wall	37.1	46.8	58.6	-	13.7	156.2	15.6
e)	Stone Pitching	-	1,527.9	29.8	-	353.3	1,911.1	191.1
8	project Facilities						0.0	0.0
a)	Bus bay with passenger shelter	70.2	212.4	71.7	216.3	72.5	643.0	64.3
b)	Trucklay Bye	-	83.3	-	-	-	83.3	8.3
9	Service Road	551.2	-	728.4	279.6	1,270.4	2,829.7	283.0
10	Junction	638.9	344.2	209.9	950.4	218.4	2,361.7	236.2
11	Grade Separator	-	-	-	1,097.5	-	1,097.5	109.8
12	Major Bridges	-	-	-	-	867.8	867.8	86.8
13	Minor Bridges	156.4	1,592.9	2,198.4	199.7	1,334.8	5,482.3	548.2
14	Rail over Bridge	5,631.8	-	2,927.6	4,139.1	-	12,698.4	1,269.8
15	VUP (Vehicular Underpass)	-	-	-	317.8	1,210.3	1,528.1	152.8
16	Culvert	1,232.3	2,080.1	849.3	1,221.0	1,139.6	6,522.4	652.2
17	Repairing & Rehabilitation of Bridges	0.6	4.8	4.5	-	15.7	25.6	2.6
(A)	Total Cost of Civil works	17,823.9	19,681.4	16,873.2	18,619.8	15,677.7	88,676.0	8,867.6

Source: DPR, Summarized by JICA Survey Team

Table 6-5B: Project Cost Summary （in Japanese Yen）

Unit: Million JPY

		P-1	P-2	P-3	P-4	P-5	Total
	Chainage (km) Start:	*0.000*	*10.900*	*27.650*	*36.500*	*43.300*	*0.000*
	End:	*10.900*	*27.650*	*36.500*	*43.300*	*54.154*	*54.154*
	Design Length (km)	*10.900*	*16.750*	*8.850*	*6.800*	*10.854*	*54.154*
1	Site Clearance	15.8	22.4	12.3	11.3	19.3	81.1
2	Earth works	203.1	324.0	303.0	153.2	176.4	1,159.8
3	Sub-base, Base	371.1	506.3	280.8	204.0	365.7	1,728.0
4	Bituminous surface	337.7	452.2	291.3	222.0	367.1	1,670.2
5	rigid Pavement		219.1				219.1
6	Traffic signs, Road Marking and others	48.9	72.0	33.7	46.5	73.5	274.6
7	Drain & Protection	0.0	0.0	0.0	0.0	0.0	0.0
a)	Drain	98.5	283.5	101.1	51.8	56.3	591.2
b)	RE wall (Reinforced Earth Wall)	293.7		338.6	720.3	168.0	1,520.6
c)	Retaining Wall	0.0	106.2	49.6	59.4	95.7	311.0
d)	Toe Wall	5.3	6.7	8.4		2.0	22.5
e)	Stone Pitching		220.0	4.3		50.9	275.2
8	project Facilities	0.0	0.0	0.0	0.0	0.0	0.0
a)	Bus bay with passenger shelter	10.1	30.6	10.3	31.1	10.4	92.6
b)	Trucklay Bye		12.0				12.0
9	Service Road	79.4		104.9	40.3	182.9	407.5
10	Junction	92.0	49.6	30.2	136.9	31.4	340.1
11	Grade Separator				158.0		158.0
12	Major Bridges					125.0	125.0
13	Minor Bridges	22.5	229.4	316.6	28.8	192.2	789.4
14	Rail over Bridge	811.0		421.6	596.0		1,828.6
15	VUP (Vehicular Underpass)				45.8	174.3	220.0
16	Culvert	177.5	299.5	122.3	175.8	164.1	939.2
17	Repairing & Rehabilitation of Bridges	0.1	0.7	0.6		2.3	3.7
(A)	Total Cost of Civil works	2,566.6	2,834.1	2,429.7	2,681.2	2,257.6	12,769.3

Source: DPR, Summarized by JICA Survey Team (INR=1.44JPY)

6.4 Department Costs

The following Cost are considered as the Department Cost and are excluded from the JICA assistance therefore, cost for these activities are not included in the Project Cost summary.

Table 6-6A: Department Cost

		Lakh						Million INR
	Package	P-1	P-2	P-3	P-4	P-5	Total	
	Design Length (km)	*10.900*	*16.750*	*8.850*	*6.800*	*10.854*	*54.154*	
1)	Land Acquisition cost	2,569.3	3,832.9	3,014.4	6,204.2	8,077.6	23,698.3	2,369.8
2)	Properties relocation cost	1,837.6	2,823.9	1,492.0	1,146.4	1,829.9	9,129.8	913.0
3)	Utility Shifting cost	234.8	40.2	21.3	16.3	26.1	338.7	33.9
4)	Envirenmental Cost	35.4	54.4	28.8	22.1	35.3	176.0	17.6
	Department Cost Total	4,677.1	6,751.4	4,556.4	7,389.0	9,968.9	33,342.8	3,334.3

Source: DPR, Summarized by JICA Survey Team

Table 6-7B: Department Cost (in Japanese Yen)

Unit: Million JPY

	Package	P-1	P-2	P-3	P-4	P-5	Total
	Design Length (km)	*10.900*	*16.750*	*8.850*	*6.800*	*10.854*	*54.154*
1)	Land Acquisition cost	370.0	551.9	434.1	893.4	1,163.2	3,412.6
2)	Properties relocation cost	264.6	406.6	214.8	165.1	263.5	1,314.7
3)	Utility Shifting cost	33.8	5.8	3.1	2.3	3.8	48.8
4)	Envirenmental Cost	5.1	7.8	4.1	3.2	5.1	25.3
	Department Cost Total	673.5	972.2	656.1	1,064.0	1,435.5	4,801.4

Source: DPR, Summarized by JICA Survey Team (INR=1.44JPY)

6.5 Study on Adequacy of the Estimates

For the consideration of adequacy of cost estimates, JST prepared the following table comparing the unit rate per km of this project with previous Study for NH208 (Kamplar - Kowai) 2019.

Table 6-8A: Unit Cost/km Comparison with Other Project

		(A) NH127B Assam Portion				(B) For comparison-NH208 (Kowi-Kmalpur)			(A)-(B) Dif.
Design length (km)		**54.154**				**80.200**			
Bill No.	*Description of Works*	*Crore*	*Include 6% GST*	*%*	*Crore /km*	*Crore*	*%*	*Crore /km*	*Crore/km*
1	Site clearance	*5.6*	5.9	0.6%	0.11	3.7	0.5%	0.05	0.06
2	Earthwork	*80.5*	85.3	9.1%	1.58	127.6	16.7%	1.59	(0.01)
3	Sub-Base, Base Course	*120.0*	127.2	13.5%	2.35	69.9	9.1%	0.87	1.48
4	Bituminous Courses	*116.0*	123.0	13.1%	2.27	163.6	21.4%	2.04	0.23
5	Rigid pavement	*15.2*	16.1	1.7%	0.30	0.0	0.0%	0	0.30
6	Major Bridges	*8.7*	9.2	1.0%	0.17	52.1	6.8%	0.65	(0.48)
7	Minor Bridges	*55.1*	58.4	6.2%	1.08	82.6	10.8%	1.03	0.05
8	ROB (Rail Over Bridge)	*127.0*	134.6	14.3%	2.49	0.0	0.0%	0	2.49
9	Culverts	*80.5*	85.3	9.1%	1.58	91.3	11.9%	1.14	0.44
10	Drainage and Protection Works	*188.9*	200.2	21.3%	3.70	154.4	20.2%	1.93	1.77
11	Traffic signs, Road markings .	*19.1*	20.2	2.2%	0.37	3.1	0.4%	0.04	0.33
12	Bus Bays & Track Lay Bye	*7.3*	7.7	0.8%	0.14	8.7	1.1%	0.11	0.03
13	Major & Minor Junctions	*23.6*	25.0	2.7%	0.46	incl.			0.46
14	Service Road	*28.3*	30.0	3.2%	0.55	0.0	0.0%	0	0.55
15	Miscelaneous	*11.0*	11.7	1.2%	0.22	incl.			
	Escalation for (2017-2019)		incl			7.9	1.0%	0.10	(0.10)
(A)	**Civil Work Total Cost**	*886.8*	**940.0**	100.0%	17.36	**764.9**	100.0%	9.54	7.82

Source: DPR & JICA Study Team

Table 6-9B: Unit Cost/km Comparison with Other Project（in Japanese Yen）

(Unit: 100Million JPY)		(A) NH127B Assam Portion				(B) For comparison-NH208 (Kowi-Kmalpur)			(A)-(B) Dif.
	Design length (km)	**54.154**				**80.200**			
Bill No.	*Description of Works*	*JPY*	*Include 6% GST*	*%*	*JPY /km*	*JPY*	*%*	*B.JPY /km*	*JPY /km*
1	Site clearance	*0.8*	0.9	0.6%	0.02	0.5	0.5%	0.05	(0.03)
2	Earthwork	*11.6*	12.3	9.1%	0.23	18.4	16.7%	1.59	(1.36)
3	Sub-Base, Base Course	*17.3*	18.3	13.5%	0.34	10.1	9.1%	0.87	(0.53)
4	Bituminous Courses	*16.7*	17.7	13.1%	0.33	23.6	21.4%	2.04	(1.71)
5	Rigid pavement	*2.2*	2.3	1.7%	0.04	0.0	0.0%	0.00	0.04
6	Major Bridges	*1.3*	1.3	1.0%	0.02	7.5	6.8%	0.65	(0.63)
7	Minor Bridges	*7.9*	8.4	6.2%	0.16	11.9	10.8%	1.03	(0.87)
8	ROB (Rail Over Bridge)	*18.3*	19.4	14.3%	0.36	0.0	0.0%	0.00	0.36
9	Culverts	*11.6*	12.3	9.1%	0.23	13.1	11.9%	1.14	(0.91)
10	Drainage and Protection Works	*27.2*	28.8	21.3%	0.53	22.2	20.2%	1.93	(1.40)
11	Traffic signs, Road markings .	*2.8*	2.9	2.2%	0.05	0.4	0.4%	0.04	0.01
12	Bus Bays & Track Lay Bye	*1.1*	1.1	0.8%	0.02	1.3	1.1%	0.11	(0.09)
13	Major & Minor Junctions	*3.4*	3.6	2.7%	0.07	incl.			0.07
14	Service Road	*4.1*	4.3	3.2%	0.08	0.0	0.0%	0.00	0.08
15	Miscelaneous	*1.6*	1.7	1.2%	0.03	incl.			
	Escalation for (2017-2019)		incl			1.1	1.0%	0.01	(0.01)
	Civil Work Total Cost	*127.7*	**135.4**	100.0%	2.50	**110.1**	100.0%	1.37	1.13

Source: DPR & JICA Study Team (INR=1.44JPY)

The unit rate of civil work of Assam is about 8 Crore/km higher than the compared project. The major cause of the rate difference comes from difference of lane numbers. i.e. 2 lanes for compared project and 4 lanes for Assam. In addition, there are several work activities in Assam that are not existed in compared project.

Table 6-10A: Analysis of Unit Cost/km difference with Other Project

Activities	Rate Difference (Crore/km)*	Note
Cost increase due to difference of lane numbers (2 lanes vs 4 lanes)	3.31	Site clearance, Sub-base, Bitumen Course, Culvert, Road appurtenances, Drainage
Rigid Pavement	0.30	Works do not included in the Compared Project
Rail over Bridge (ROB)	2.44	
Service Road	0.55	
Miscellaneous	0.22	
Escalation for 2017-2019	0.10	Assam Rate already includes Escalation
Total	6.92	

Source：DPR & JICA Study

Table 6-11B: Analysis of Unit Cost/km difference with Other Project (in JPY)

Activities	Rate Difference (100Million Yen /km)*	Note
Cost increase due to difference of lane numbers (2 lanes vs 4 lanes)	0.48	Site clearance, Sub-base, Bitumen Course, Culvert, Road appurtenances, Drainage
Rigid Pavement	0.04	Works do not included in the Compared Project
Rail over Bridge (ROB)	0.35	
Service Road	0.08	
Miscellaneous	0.03	
Escalation for 2017-2019	0.01	Assam Rate already includes Escalation
Total	1.00	

Source：DPR & JICA Study (INR=1.44JPY)

Table 6-10A summarises the cause of Unit Rates difference. The Table well explains that the overall unit rate difference with the compared project is 7.82 Crore/km and 6.92 Crore/km (about 90% of rate difference) of that is accountable. The adjusted difference is 0.9 Crore/km and it is only 5% of the Assam Rate of 17.36 Crore/km. In consideration with the above study, JICA Study Team conclude that the Cost Estimates for Assam is adequate.