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, Ministry of Road Transport and Highways (MoRTH) implemented a strategy called the "National Highway Development Project" in 2001 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 bring about hindrance to reliable logistics and cause delay in 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 indicative of 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 product 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 the market. In order to benefit from these resources and encouraging investment, improving road connectivity becomes essential.

In this Project "Improvement on Road connectivity in Northeast Region (NH208, NH 127B)" one of the target roads, National Highway 208 (NH208), crosses Tripura state and leads to Chittagong, the second largest city in Bangladesh as well as largest port city in Bangladesh. This road should become a pathway for improved international distribution network. Within the northeast area, India exports agricultural products such as bamboo trees and fruits, as well as mining resources such as marbles to Bangladesh. On the other hand, India imports construction materials such as processed stones, brick, tiles, and cements from Bangladesh. Currently, the connectivity between those two states is via Agartala to Acura custom clearance, however, 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 connects from Sabroom, has several related projects that can create synergy on connectivity and regional development with this Project, such as support on repairmen of bridges through "Cross-border Road Network Maintenance Project" or "Matarbari Port Development Maintenance Project" which is planned to maintain the national highway （connecting Chittagong and national highway 1, between Chakaria and Matarbari） that leads to Matarbari area where industrial clusters are promoted. The experience of the past 4 projects"Improvement of Road

[1] Motor Vehicles, Statistical Year Book India 2017

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 6 in order to establish and improve NH208 (state of Tripura). 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 (NH208)
(2) The purpose of project	To newly establish and improve roads in Northeast India, from Khowai to Sabroom in Tripura state 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 208: Improving and widening of 2 lane roads (including bridges, drainage channel bypass etc.) from Khowai to Sabroom in Tripura state. (approximately 163km) 2) Consultation service (design and construction management)
(4) Target Area	Tripura State
(5) 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.

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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^2, 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.

[2] 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.

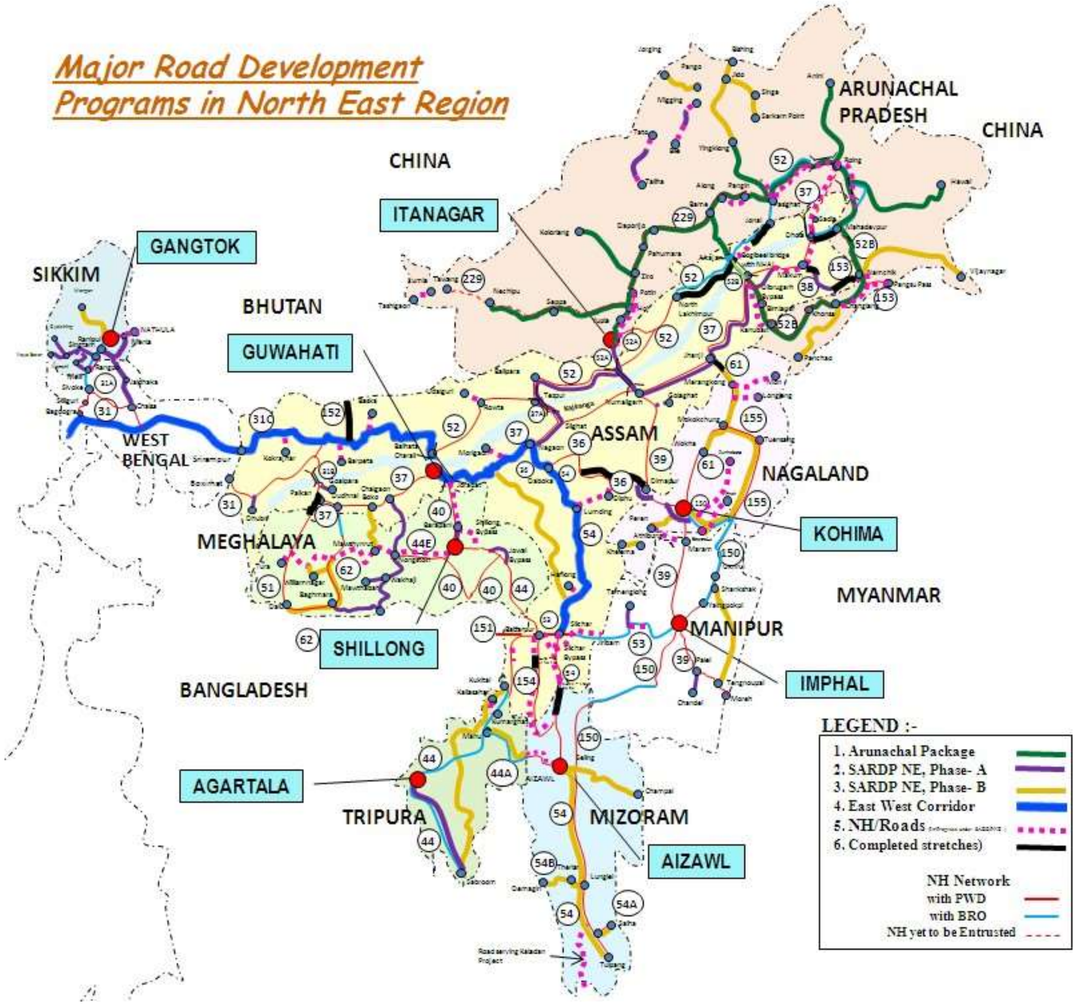
The SARDP-NE programme has been divided into 3 parts: Phase-A, Arunachal Pradesh Package of Roads and Highways (Arunachal Package), and Phase-B. The details of approvals are as follow:

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.

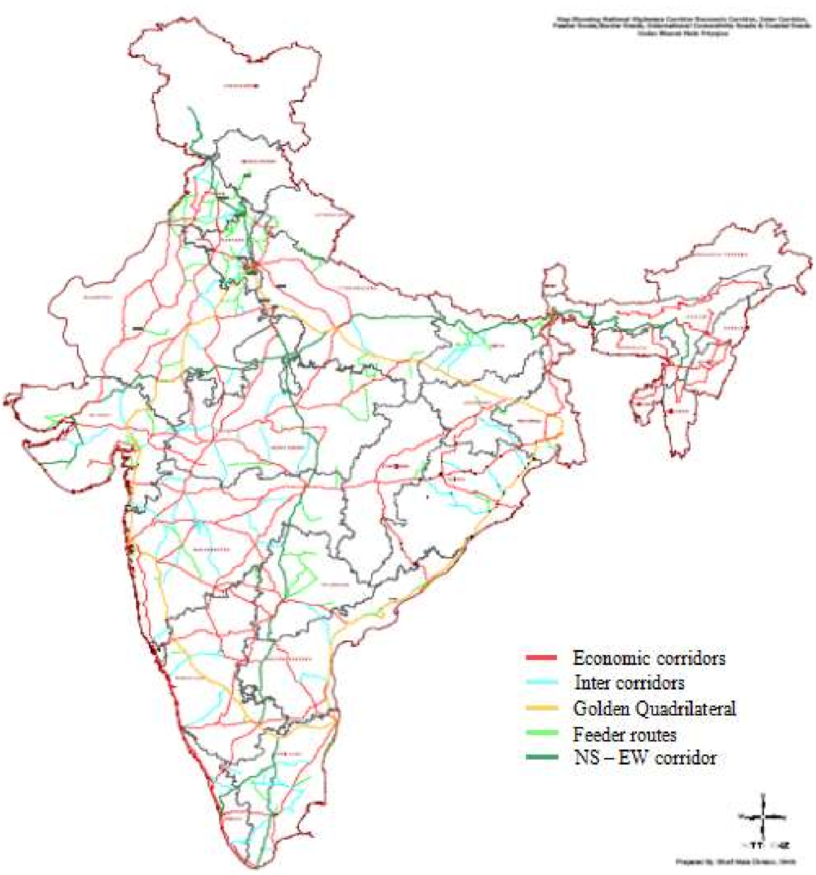
Under Bharatmala Pariyojana, the total road length of about 5,301km in North Eastern Region have been approved for improvement. Out of this, 3,246km road length has been approved for development of Economic Corridors in the North East[3]. The road network under Bharatmala Project is shown in Figure 2-3. 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

[3] 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

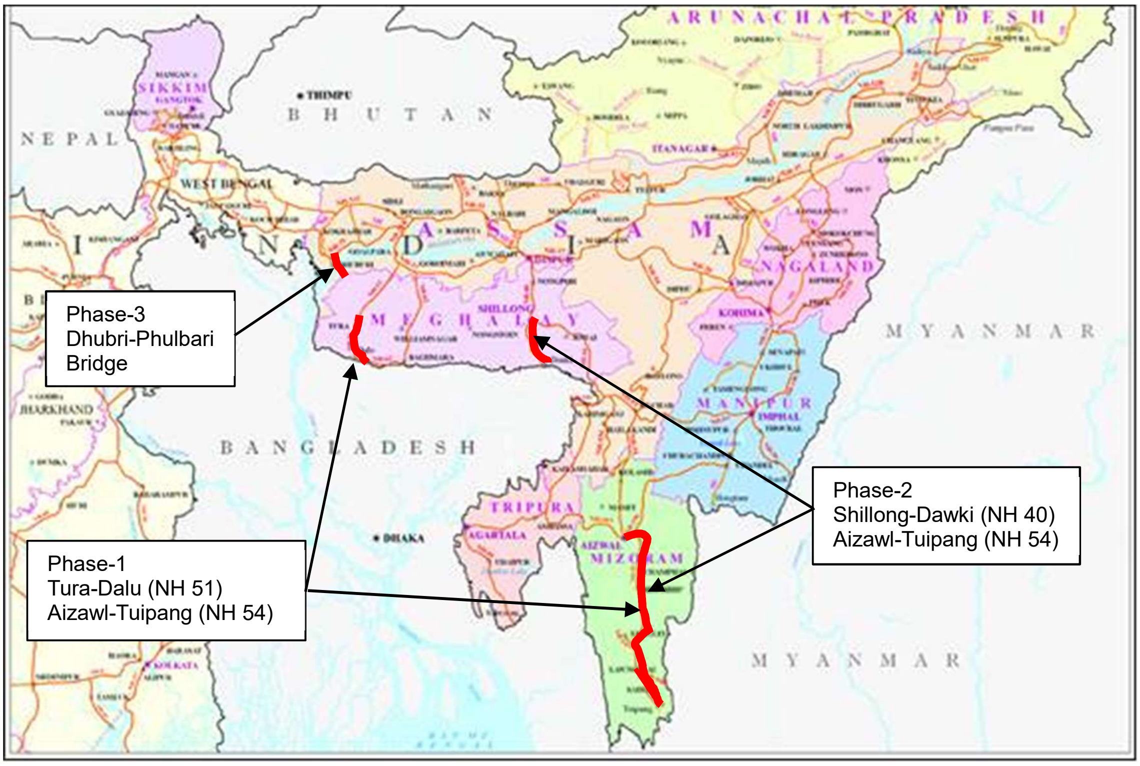
One of the achievements in Joint Statement on Japan and India Vision 2025 issued in 2015 was that ODA loans were provided for the improvement of road network connectivity in north-eastern states of India.

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 Survey 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.[4]

(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

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

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.

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

Table 2-9 shows the major on-going projects by the central ministries and departments in North Eastern Region.

Table 2-9: Summary of Major On-going Projects (Costing Rs. 100 Cr. And above)

SI. No.	Name of the Project	Length (km)	Total Project Cost	Scheduled Date of Completion	Physical Progress (%)
1	2 laning from Pasighat to Pangin section of NH-229 from km 41.3 to 58 (Existing Km 42 to km 59)	17.12	247.44	31.12.2019	89.20%
2	2 laning from Km 40 to Km 58 of Changlang/Tirap District boundary to Changlang of NH-52B	18.27	172.75	31.12.2019	81.89%
3	2 laning from Longding to Kanubari of NH-52B	47.21	522.87	31.12.2019	66.80%
4	2 laning with paved shoulders from Pasighat to Bomjur section from km 583.450 to 595.00	22.15	244.82	23.02.2020	38.62%
5	2 laning from ChanglangDist Boundary – Khonsa (42.844 km) section of NH-52B	42.844	438.32	16.05.2019	98%
6	2 laning of Singer river to Sizohnala	23.38	238.46	14.01.2019	91.34%
7	Construction of 2-lane road from existing km. 21.50 of Hunli-Anini road (Near Ithun Bridge) to Km. 37.500	16	322.15	20.12.2019	35.16%
8	Construction of 2-lane road from existing km. 37.500 of Hunli-Anini road (Near Ithun Bridge) to Km. 53.50	16	259.52	06.10.2019	68.94%
9	Construction of 2-lane Hunli-Anini road from km. 53.500 to km. 92.500	39	568.92	15.12.2019	29.40%
10	Construction of 2-lane of Hunli-Anini road from km. 92.50 to Km. 106.20	13.7	188.78	18.01.2020	19.56%
11	Construction of 2-lane of Hunli-Anini road from km. 106.20 to Km. 120.00	13.8	200.44	18.01.2020	40.48%
12	Construction of 2-lane road from km. 0.00 (Existing km. 16.00 of Roing -Hunli Road) to Km. 74.00 (Ithun Bridge near existing km. 21.50 of Anini Road)	74.86	1718.59	04.03.2021	16.54%
13	2 langing of Khupa - Hayuliang – Hawai Road on EPC basis from design Km. 0.000 (Khupa) to Km. 17.000 [Existing Km 95.800 of (Khupa – Hayuliang Road) to Km 8.970 (Hayuliang – Hawai Road)]	17	252.05	09.11.2020	21.18%
14	2 langing of Hayuliang – Hawai Road on EPC basis from design Km. 17.000 (Khupa) to Km. 34.000 [Existing Km 16.950 to Km 34.310 (Hayuliang – Hawai Road)]	17	252.79	09.11.2020	15.10%
15	2 langing of Hayuliang – Hawai Road on EPC basis from Design Km. 34.000 to Km. 51.825 [Existing Km 26.625 to Km 45.050 (Hayuliang – Hawai Road)]	17.825	263.31	09.11.2020	18.10%
16	2 langing of Hayuliang– Hawai bypass Road on EPC basis from design Km. 51.825 to Km. 63.131 Existing Km 45.050 of Hayuliang – Hawai road to Hawai Town	11.31	256.66	14.01.2021	11.51%
17	2-laning of existing Akajan-Likabali-Bame Road from design Km 12+000 to Km33+000 (existing km 12+000 to km 36+000) under SARDP-NE on EPC basis.	21	210.05	20.01.2019	65.67%
18	2-laning of existing Akajan-Likabali-Bame Road on EPC basis from design Km 33.000 to Km65.810 (Existing km 36.000 to km 71.000) under SARDP-NE on EPC basis.	32.81	263.4	11.09.2018	26.58%

Sl. No.	Name of the Project	Length (km)	Total Project Cost	Scheduled Date of Completion	Physical Progress (%)
19	Two-Lane with Hard Shoulders of Akajan-Likabali-Bame Road on EPC basis from Existing km 71.000 to km 99.000 (Design Length-26.118 Km)under SARDP-NE on EPC basis	26.118	374.73	20.03.2021	18.33%
20	Two-Laning of Joram – Koloriang Road (NH-713) from design Km. 20+000 to Km. 32+050 [Existing Km 20.000 to Km 35.150]	12.05	159.06	04.02.2020	0%
21	Two-Laning of Joram – Koloriang Road (NH-713) from design Km. 32+050 to Km. 44+000 [Existing Km 35.150 to Km 50.050]	11.95	160.15	04.02.2020	0%
22	Two-Laning of Joram – Koloriang Road (NH-713) from design Km. 44+000 to Km. 59+363 [Existing Km 50.000 to Km 70.000]	15.363	202.03	04.02.2021	0%
23	Two-Laning of Joram – Koloriang Road (NH-713) from design Km. 138+000 to Km. 154+036 [Existing Km 138.00 to Km 158.00]	16.04	215.46	19.02.2021	13.71%
24	Two-Laning of Joram – Koloriang Road (NH-713) on EPC basis from design Km. 70.00 to Km 88.00	18	262.43	04.02.2021	6.42%
25	Two-Laning of Joram – Koloriang Road (NH-713) on EPC basis from design Km. 88.00 to Km 103.00	15	209.52	04.02.2021	8.34%
26	Two-Laning of Joram – Koloriang Road (NH-713) on EPC basis from design Km. 103.00 to Km 118.00	15	187.76	04.02.2021	2.44%
27	Two-Laning of Joram – Koloriang Road (NH-713) on EPC basis from design Km. 118.00 to Km 132.00	14.99	175.89	19.02.2021	3.42%
28	Construction of 2-lane of Hunli-Anini road from km.120.00 to Km. 130.300	10.3	139.37	14.06.2021	0%
29	Two laning of Pasighat – Pangin Road (NH-229) for the stretch of Km 57.00 to Km 71.596 (Package-IV)	14.6	103.87	-	96.09%
30	Two laning of Road from Gobuk – SijhonNalla from Km 26.210 to 75.485	49.28	389.45	-	84.28
31	Nechipu to Hoj on DBFOT, Annuity under Arunachal Pradesh Package of SARDP-NE.	252.209	1979	-	96.69
32	4-lanning of NH-415 from design chainage 29/500 to 40/400 (Itanagar-Bandardewasection) on EPC Mode Package-A	10.9	243.89	-	50.62
33	Rehabilitation and Upgradation of Existing Road to 2-lane with Paved Shoulders Configuration in Jowai-Meghalaya/ Assam Border Section of NH-44	102.256	468.27	30.6.2019	97.87
34	2 laning of Tura – Dalu section of NH-51 from km 85 to km 95 and from km 105 to km 145	51.5	553.41	-	-
35	Balance work of 4 laning from WB Border (Srirampur) to Kochugaon section	30	129.189	4.4.2020	78.62
36	4 laning from Kaljhar to Patacharkuchi section	27.3	207.165	31.12.2019	91.91
37	4 laning from Khanapara (Guwahati) to Sonapur	19.1	166.72	30.6.2019	96.84
38	4 laning from end of Nagaon bypass to Rangagara (Km. 278.600 to Km. 297.000) of NH-37	18.4	291.62	18.11.2019	19.85
39	4 laning from Rangagara to KaliabhorTiniali from km 297.00 to km 315.315 of NH-37	18.315	289.99	20.4.2020	5.5

SI. No.	Name of the Project	Length (km)	Total Project Cost	Scheduled Date of Completion	Physical Progress (%)
40	4 laning from KaliaborTinali to Dolabari section from Km 0.0 to Km 17.3 of NH 37-A including construction of new Brahmaputra bridge	17.3	873.91	9.11.2020	54.47
41	4 - lane highway connecting km 17.3 of NH 37A and km 182 of NH 52 between Dolabari and Jamuguri	18.81	1050	1.3.2020	10.98
42	Four laning from Jamuguri to BiswanathChariali from km 182 to km 208 of NH-52	26	520.01	19.6.2019	18.25
43	Four laning from BiswanathChariali to Gohpur from km 208 to km 265.50 of NH-52	57.5	1307.5	-	39.61
44	Four laning from Gohpur to Holongi section from km 264.10 of NH 52 to km 20.37 of NH 52A	10.08	259.79	31.12.2019	29.08
45	Four Laning of Numaligarh to Jorhat section from Km. 402.500 to Km. 453.000 (Design Km 403.200 to Km 454.240) except Dergaon bypass (with Toll Plaza)	39.72	814.56	-	22.48
46	Four Laning of Jorhat to Jhanji section from Km. 453.00 to Km. 491.08	37.8	738.15	31.12.2020	1.87
47	Four Laning of JhanjhiJn to Demow section from Km. 491.050 to Km. 535.250(Design Km 490.800 to Km 534.800) (with Toll Plaza)	44.075	801.54	19.1.2021	3.01
48	4-laning of NH-37 Section between Demow to End of Moran Bypass (From Km. 534.800 to Km. 561.700)	26.9	385.57	-	19.01
49	Construction of Dibrugarh By Pass / realignment of NH-37 from Bogibeel Junction at km. 581.700 to km. 597.147	15.5	351.31	-	82.74
50	4 laning of Balachera-Harangjao section of NH-54 (ext.) from km 275.00 to km 244.00	25.25	818.4	24.6.2020	4.1
51	2 – laning of Aizawl – Tuipang section of NH-54 from km 8.0 to km 380.0 (8 packages)	372	6167.58	Contract concluded on Feb 2019	Just commenced
52	Widening to 2 lane, re-alignment and geometric improvement from Km 11/00 to Km 114/618 of NH-44A in Mizoram	104	992.67	-	81.75
53	Construction of a new 2-lane Highway to support Kaladan Multi-Modal Transit Transport Project in Phase-'A of SARDP-NE	99	1011.52	-	Package1 - 79.3, Package2 - 92.98 and Package3 - 77.61
54	Construction of 2-Lane with paved shoulder of flexible pavement from km 42.80 to km 60.30 on NH No.150 during 2016-17	17.5	205.95	-	44
55	Improvement/widening to two laning with paved shoulder of Udaipur-Sabroom section from km 55.00 to km 128.712 of NH-44 under SARDP(NE) Phase Á	73.712	607.44	21.9.2018	100%
56	Improvement/widening to two laning with paved shoulder of Agartala- Udaipur section from km 6.80 to km 55.00 of NH-44 under SARDP(NE) Phase Á'	48.36	462.79	-	70.69
57	2 laning of Chakabama-Zunheboto (C-Z) road from 0 km to 115.53 km (5 packages) under SARDP-NE Phase 'A'	115.53	1420.22	Dec,. 2021	Length (0-75 km) delay in land acquisition
58	2 laning of Pfutsero – Phek (PP) road from km 0 to km 62.56 (3 packages) under SARDP-NE Phase 'A'	62.56	772.67	Nov., 2021	Package1 – 3, Package2- 3 and Package3- 2.25

SI. No.	Name of the Project	Length (km)	Total Project Cost	Scheduled Date of Completion	Physical Progress (%)
59	2 laning of Merankong – Tamlu-Mon (MTM) road km 0 to km 86.84 (4 packages) under SARDP-NE Phase 'A'	86.84	1027.78	Dec., 2021	Package1 – 5, Package2- 0.2 and Package3- & 4 – Delay in Land Acquisition
60	Construction of Four/Six laning from Km 132.375 to Km 158.058 (Total New Alignment length of 20.683 Km) of Daboka-Dimapur Section (Dimapur Bypass) of NH-36 & 39	20.68	645.02	4.9.2020	27.68
61	Construction of Dimapur Bypass (Assam Portion) of 4/6 lane pavement on EPC basis from existing Km 159.400 of NH-36 to existing Km 102.500 of NH-39 and up-to end point of Assam portion [Design Km 118.050 to design Km 132.375] (length 14.325 Km)	14.33	500.09	19.3.2021	Delay in Land Acquisition
62	4- laning of Dimapur – Kohima (3 packages)	42.87	1066.55	Sept, 2019	Package1 –55, Package2- 71and Package3- 52
63	Construction of 2 lane road from Melli - Manpur- Namchi in South Sikkim	32	269.14	-	84
64	Construction of 2 lane road fromTarku - Damthang- Namchi in South Sikkim	32	203.26	-	80
65	Construction of 2 lane NayabazarLegship road in West Sikkim	24	240.58	-	83
66	Constuction/Upgradation of existing highway to 2 lane with paved shoulder from Km 00.00 to Km 16.167 NH -17A. (Ranipool-Pakyong) Airport Road	16.167	275.26	10.10.2021	0
67	Construction of Alternate Highway from Rhenock-Pakyong NH-717A	26.706	447.37	30.10.2021	22.77
68	Construction / Upgrade existing road to 2 lane with paved shoulder from Km 16.000 to 32.500 Tarku - Ravongla NH-510	16.5	290.04	30.10.2021	18.14
69	Construction of Rangpo-Viaduct at Rangpo town Km 51.100 to 53.800 NH-10	1.8	133.49	20.2.2020	16.79

Note: Status as on 31.08.2019
Source: Ministry of Development of North Eastern Region
https://mdoner.gov.in/dashboard/schemetables/major_project_morth.php

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 2-10.

Table 2-10: 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 2-11 and shown in Figure 2-5.

Table 2-11: 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.
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 Tripura.

2.3.2 Geographical Conditions of Tripura

(1) Physiography

Tripura is the smallest of the "Seven Sister" States with an area of 10,486 Sq. Km. making up 4.11% of the North-Eastern Region. Nonetheless, the Tripura State holds a lot of potential as it shares 856 km of its border with Bangladesh and is the state closest to Bangladesh's biggest port district of Chittagong.

South Tripura, which is to the very south of Tripura, has an area of 1,514.322 Sq. Km. while Khowai and Gomati districts in West Tripura cover an area of 1,377.28 Sq. Km. and 1,522.8 Sq. Km., respectively. Approx. 43% of the area is forest area in Khowai, 74% is forest area in Gowati, and 79% is forest area in South Tripura.

The three Survey Corridor districts are surrounded by Baramura, Debtamura, and Atharamura hill ranges. The Khowai River and Gomati River are the main water sources for Khowai and Gomati districts, respectively. In the South Tripura district, Muhuri and Feni rivers can be found which also flow down into Bangladesh.

(2) Climate

Much like Assam and Meghalaya, the Survey Corridor districts in Tripura are also impacted by the South-West monsoon season starting from May and continuing into September. The average annual rainfall is estimated to be around 2,000 mm. While it is very humid during the monsoon and summer, winter tends to be rather dry. The maximum temperature during summer/monsoon season is around 35° Celsius while it dips down to approx.7° Celsius during the winters.

2.3.3 Socio-Economic Conditions

(1) Demographics

Though Tripura covers the smallest area within North Eastern India, it ranks second in terms of population as about 8.16% of the total population of North East region live in Tripura. Out of the 3.67 million, approx. 74% live in rural areas while 26% live in urban areas. The most populated city within Tripura is Agartala which is located approx. 43 km. to the west of Teliamura.

As shown in Table 2-12, the Survey Corridor districts of South Tripura and Gomati share similar area and population density, while Khowai has a comparatively higher population density despite having smaller geographical coverage.

It is noteworthy that based on Census 2011, there was a considerable gender gap in literacy rate of 8.8%. However, based on the Literacy Assessment Survey 2016, literacy rate in Tripura has gone up to 97.22% in total with the gap in male and female literacy rates decreased to 0.8%.

Table 2-12: Demographics of Tripura (Census 2011)

Area	Population	Area (Sq. Km.)	Population Density	Literacy Rate (%)
Tripura[1]	Total: 3,673,917 *Male: 1,874,376* *Female: 1,799,541*	10,486	350 per Sq. Km.	Total: 87.22% *Male: 91.53%* *Female: 82.73%*
South Tripura District[2]	Total: 453,079 *Male: 234,118* *Female: 218,961*	1,514.3	299 per Sq. Km.	Total: 85.09% *Male: 93.39%* *Female: 79.54%*
Gomati District[3]	Total: 441,538 *Male: 225,428* *Female: 216,110*	1,522.8	286 per Sq. Km.	Total: 84.53% *Male: 89.94 %* *Female: 78.90%*
Khowai District[4]	Total: 327,564 *Male: 167,401* *Female: 160,163*	1,377.28	326 per Sq. Km.	Total: 87.78% *Male: 92.17%* *Female: 83.17%*

Source: [1]India Census 2011, [2]Official Website of South Tripura District, [3]Official Website of Gomati, [4]Official Website of Khowai

(2) Economy and Sectoral Distribution

The GSDP of Tripura estimated for 2017-18 was approx. Rs. 46,133 Crore[5], which is higher than that of Meghalaya. The per capita NSDP estimated for 2017-18 is approx. Rs. 116,058. CAGR of Tripura's GSDP between 2011-12 and 2017-18 stood at 15.72% and CAGR of per capita NSDP between 2011-12 and 2017-18 was estimated as 14.31%.

Despite the high per capita NSDP, Tripura suffers from high rate of poverty and inequality with 74% of the population living in rural areas and around 42% dependent on agrarian activities though only 27% of the land is cultivable**.** Table 2-13 shows the contribution of each sector and growth in the primary or agrarian sector can be seen.

Table 2-13: Sectoral Contribution to GSVA (%) of Tripura

Sector	2011-12	2017-18 (est.)
Primary/Agriculture (and allied activities)	33.48%	46.79%
Secondary/Industry	14.11%	13.49%
Tertiary/Services	52.40%	39.72%

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

Source: India Brand Equity Foundation

2.4 Industrial Development

2.4.1 Overview

Industrial development and investment initiatives and schemes within Northeast India, such as North Eastern Region Vision 2020 and Tripura Industrial Investment Promotion Incentives Scheme (2017), recognize and emphasize the importance of harnessing the potentials of agricultural and agriculture-allied activities within the North Eastern states of India. 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

2.4.2 Current Status of Existing Industries and Industrial Development in Tripura

Tripura, much like Assam and Meghalaya, is primarily known for its horticulture and agricultural produce. It is an agrarian state with the livelihood of much of its population dependent on agricultural and allied activities, though only 27% of its land is cultivable.

Within North East India, Tripura is particularly known for its surplus production of agro-foods such as rice, fruits, and vegetables. In terms of forestry, Tripura ranks as the second largest producer of natural rubber in India. It also has vast reserves of mineral resources with surplus natural gas supply which could potentially cater to the need of all sister states of North East India.

However, despite the state's potential, Tripura's geographical disposition has long impacted its industrial development and economic growth due to: (i) isolation from the rest of the North Eastern India and Mainland India, (ii) vast forest coverage and mountainous geography, (iii) poor transport infrastructure, and (iv) long international border shared with Bangladesh but with unregulated or inadequate trade border mechanism.

Nonetheless, in recent years, there has been increased investment for industrial development going into South Tripura and West Tripura, in particular, Sabroom (on the Survey Corridor) and Agartala, the capital of Tripura, which is approx. 43 km. away from Teliamura on the Survey Corridor NH208.

One of the most important recent developments in Tripura is the introduction of plans to set up Tripura's first Special Economic Zone (SEZ) in Sabroom, South Tripura. This initiative is led by Tripura Industrial Development Corporation (TIDC) under the Government of Tripura. It is expected that agro-food processing industries, bamboo and rubber industries, and textile industries will be established within this SEZ unit for promotion of export given Sabroom's proximity to Chittagong port in Bangladesh.

Moreover, under the Smart Cities Mission by the Government of India, Agartala was selected as one of the 100 cities in India where the urban renewal and retrofitting program would be implemented. Under this initiative the Agartala Smart City Special Purpose Vehicle (SPV) was created and the SPV has received funding from ADB to carry out Area Based Development

Project and PAN City Project which focus on urban development and recreation of commercial, trade, and logistics hubs and skill development centers, implementation of smart network and rapid transit system, etc.

Some industrial areas in close proximity to the Survey Corridor in West Tripura and South Tripura are:

> **Bodhjungnagar Industrial Area** – The area is located at Bodhjungnagar in West Tripura (40 km from Teliamura) and covers 535.73 acres. The complex covers growth centre, food park, rubber park, and export promotional industrial park.
>
> **R. K. Nagar Industrial Area** – This complex covers an area of 226.16 acres and is located adjacent to the Bodhjungnagar Industrial Area. It is run by TIDC. The complex comprise a textile park, an oil corporation, and also a bamboo park which was developed by TIDC.
>
> **Dhukli Industrial Area** – This complex is spread across 45.77 acres of land and is located at Dhukli which is around 60 km to the west of Teliamura along the Survey Corridor. TIDC has been undertaking a project for upgrading the infrastructure at Dhukli.
>
> **Industrial Estates under TIDC** – Out of the 5 industrial estates currently under TIDC, 3 are to the west of the Survey Corridor. These are A.D Nagar and Badharghat near Agartala and Dhajanagar in Udaipur.
>
> **Integrated Infrastructure Development Centres (IIDCS)** – Under the Cluster Development Programme (CDP) of MSMEs, there are 4 IIDCs being set up out of which two are in the South Tripura District in Belonia and Sabroom.

These industrial parks and development centers are not fully operational yet. However, once functional capacity is maximized, they can drive promotion of agriculture and horticulture (mainly paddy and fruit cultivation and bamboo and rubber plantation), sericulture, fisheries, handloom, and related manufacturing and services which are the predominant sectors of South Tripura and West Tripura.

2.4.3 Impact of Survey Corridor on Future Industrial Development

(1) Regional Impact

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

Isolation from the rest of India and lack of adequate intra-state connectivity generate several supply-side issues which include limited access marketing links, high costs associated with transportation of goods, inability to produce and deliver large orders in time, and operational inefficiency and raw produce wastages due to lack of access to processing units or required resources for production.

National Highway 8 (NH-8), locally known as “Assam Road”, is the main road connecting Tripura to the other North Eastern states, primarily Assam. Despite NH-8 being recognized as the sole lifeline for Tripura, the road itself is single-lane and in very poor condition. Just recently, there have been reports of disruption in connectivity due to poor road maintenance resulting in trucks getting trapped in giant potholes, hour-long traffic congestions, and even risk of collapse. [6] [7]

Limited road connectivity has not only led to unrealized industrial and economic potential but also wasted goods and resources. Despite Tripura's comparatively limited arable land, the state has seen considerable growth in yield of agricultural produce with surplus production of paddy (rice), fruits, and vegetables compared to other states within North Eastern India.[8] However, such surplus agro-food products are often wasted due to inaccessibility to processing units, manufacturing units, and/or markets. For instance, just last year, it was reported that the state government of Tripura spent over Rs. 600 crores on rice import though there was surplus of paddy (rice) locally.[9] The surplus paddy got wasted as a result of limited access to processing units and lack of post-harvest skills of farmers leading to low quality rice production.

Similarly, another study identifies the supply of fruits and vegetables far exceeds the produced amounts in Tripura, leaving behind marketable surplus which is currently being wasted.[10] Considering the reliance on agricultural or agriculture allied activities by majority of the population living in Tripura, value addition to surplus agro-food produce through better access to processing and manufacturing units would create employment opportunities and enhance industrial potential.

With the industrial parks and development centers being actively set up in Tripura, the missing link for acceleration of industrial development is regional and state level road connectivity to such facilities which the NH-208 under this Project will provide. Moreover, NH208 would provide an alternative route to the existing NH-8 and help promote efficient transportation of surplus agro-food products from Tripura to neighboring North Eastern states like Assam where demand of such goods are more than what can be supplied within the state.

(2) Impact on International Trade

Another significant way NH-208 would promote industrial development is by facilitating foreign trade with Bangladesh. Tripura is in a geographical advantageous position as it shares the longest border with Bangladesh (856 km in length) after West Bengal. It is worth noting that bilateral trade between North Eastern India and Bangladesh has long existed and Tripura has been recognized as a strategic gateway between Bangladesh and the North Eastern region. Furthermore, under the Look East Policy, Tripura is in a highly advantageous geographical disposition to act as the land bridge between Bangladesh and other ASEAN countries.

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6 http://tripurainfoways.com/news-details/TN/124788/assam-agartala-road-at-telimura-turns-risky-after-bricks-were-theft-from-the-national-highway-anytime-connectivity-may-collapse.html

7 https://www.barakbulletin.com/en_US/horrible-condition-of-assam-tripura-nh8-locals-share-grief-mla-blames-covid-for-delay-in-construction/

8 Roy, A. et al.. "Food Security in North-East Region of India – A State-wise Analysis." *Agricultural Economics Research Review*, vol. 28, 2015, pp. 259-266.

9 https://indianexpress.com/article/north-east-india/tripura/lack-of-milling-facility-forces-paddy-surplus-tripura-to-spend-crores-on-rice-imports-5773444/

10 Majumder, S.H. "Exploring Agri Business Potential in Tripura through Fruits and Vegetable Production." *Economic Affairs*, vol. 63, no.1, 2018, pp. 137-140.

The distance between the main cities in Tripura and Bangladesh are as summarized in Table 2-14.

Table 2-14: Distance (By Road) Between Tripura and Bangladesh

Tripura	Bangladesh	Distance (in Km)
Agartala	Dhaka	150 km
Kaliashar	Sylhet	90 km
Sabroom	Chittagong	75 km
Sonamura	Comilla	25 km

Source: Department of Industries and Commerce, Government of Tripura

Given that the distance between Tripura and major cities in North East India, let alone mainland India, is much more (e.g. Agartala to Guwahati, Assam is 587 km apart by road and Agartala to Kolkata is 1645 km apart by road), Tripura would benefit significantly from increased cross border trade with Bangladesh.

Currently, over 90% if the trade with Bangladesh takes place via land border. There are eight Land Custom Stations (LCSs) along the Tripura-Bangladesh border in close proximity to the main cities which are detailed in Chapter x (need to include reference to relevant heading). Nonetheless, based on recent trade statistics, there are more goods imported from Bangladesh than exported from Tripura through the active LCSs as evident from Table 2-15.

Table 2-15: Trade Volume at LCSs in Tripura (2018-2019)

LCS, City	Export Value (Rs. in Crore)	Import Value (Rs. in Crore)
Agartala LCS, Agartala	0.57	355.10
Muhurighat LCS, Belonia	-	45.42
Khowai LCS, Khowai	0.24	2.18
Srimantapur LCS, Sonamura	0.47	95.93
Manu LCS, Sabroom	10.05	14.58
Old Raghna Bazar LCS, Dharmanagar	3.33	9.21
Total	**14.66**	**522.42**

Source: TripuraInfo

There are multitude of factors causing the large trade deficit, with border point inefficiencies and inadequate transport infrastructure being some of the main factors. However, it is worth noting that in recent years such factors are being recognized and addressed and tremendous efforts are being put into strengthening regional connectivity with Bangladesh. In terms of efficiency at border points, the Agartala LCS has been upgraded to Integrated Checkpost (ICP) while the Srimantapur LCS has been updated to Integrated Development Complex (IDC) to ensure all-encompassing facilities and services are available at the LCSs to further promote bilateral trade.

Similarly, on the Bangladesh side, several investments are underway to boost bilateral trade with India, such as the Baroiarhat-Heyako-Ramgarh Road Development Project which was approved in August 2020. Ramgarh in Bangladesh connects directly to NH-208 at Sabroom, Tripura via the River Feni Bridge which was expected to be completed in March 2020.

With such trade facilitation investments underway, Tripura holds undeniable potential to increase exports and enhance trade volume with Bangladesh. Given the lack of interstate and inter-regional connectivity (outlined in the previous sections) causing inefficiencies with regards to goods transportation and surplus resource wastages, expansion of exportable goods can be achieved through the new Survey Corridor NH-208, ultimately leading to effective industrial development.

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 (i) in Tripura State that is the subject of this feasibility study. Of all of these highways, cross-border logistics is most relevant regarding this road because of the potential importance of the connection between India and Bangladesh through the Sabroom (India)-Ramgarh (Bangladesh) border crossing. Since this corridor has not been open for cross-border movements to/from Bangladesh due to a lack of trade and transport facilitation arrangements, 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.

2.5.2 Analysis of the Current Situation (Issues/Barriers) and Recent Developments

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

(i) There are **transport infrastructure barriers** (i.e., a need for a crossing over the Feni River and improved road access to Chattogram port), although these are being addressed. A new, 150 m-long extradosed[12] road **bridge** is being constructed **over the Feni River at Sabroom** in southern Tripura, India (and Ramgarh, Bangladesh, in Khagrachhari in the Chittagong Hill Tracts), connecting the two countries, at a cost of USD 13 million equivalent, with completion in 2020 or early 2021. In addition, on the Bangladeshi side, **four-laning of a 38 km approach road** is ongoing **between Ramgarh-Baroiarhat**, which will link with the Dhaka-Chattogram Highway.[13]

(ii) **Inadequate border facilities** are another issue/barrier. At Sabroom there is currently only a land customs station (LCS), which offers rudimentary immigration and customs facilities.[14] To address this constraint, an **integrated check post** (ICP), sanctioned in March 2020, will be constructed by the Land Ports Authority of India (LPAI), Ministry of Home Affairs (MHA), **at Sabroom**, at a cost of INR 365 crore (USD 48 million equivalent). It will be a full-fledged logistics hub (similar to the one opened at Akhaura in November 2013), offering a one-stop solution, with warehouses, container transshipment facilities, parking, and airport-like immigration facilities. There are plans to address a similar constraint on the Bangladesh side by developing a **land port at Ramgarh**, with support from the World Bank's Bangladesh Regional Connectivity

[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] An extradosed bridge uses a structure that is a cross between a girder bridge and a cable-stayed bridge.
[13] Developments related to cross-border transport between Tripura and Bangladesh by other modes include: (i) extension of the broad-gauge National Frontier Railway Line to Sabroom, via Dharmanagar-Agartala-Sabroom, in October 2019 (the Governments of India and Bangladesh have agreed to extend this line to Chattogram Port, but there is no specific timetable for this work); and (ii) inclusion of the Sonamura-Daudkandi route along Tripura's Gomti [or Gumi or Gomati] River (a tributary of the Ganges River) in the Indo-Bangladesh Protocol on Inland Water Transit and Trade, in May 2020.
[14] Joyeeta Bhattacharjee, "Integrated Check-Posts on the India-Bangladesh Border: A Field Survey and Brief Analysis", *ORF Special Report No. 96*, Observer Research Foundation, August 2019, p. 8 ["not a single LCS between India and Bangladesh offers services that are comparable to the international standard"] [downloadable from https://www.orfonline.org/research/integrated-check-posts-on-the-india-bangladesh-border-a-field-survey-and-brief-analysis-54559/]. Additional LCS along the Tripura-Bangladesh border include Muhurighat, Belonia, Khowai, Srimantapur, Sonamura, Manu, Old Raghna Bazar, and Dharmanaga.

Project 1, although there have been land acquisition issues; in any case, the inefficiencies of a traditional two-stop border post would remain.[15]

(iii) **Restrictions on cross-border transport** remain (**e.g., transshipment is required** at the border between India and Bangladesh),[16] although there are signed and planned international agreements to address these 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 transport of goods between Chattogram (Chittagong)[17] Port (and Mongla Port) and India**. Chattogram Port is about 72 km from Sabroom. Later developments have included (a) 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; (b) commencement of transshipment after trial runs in January 2020; and (c) 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.[18] However, agreement still needs to be

[15] In addition, Tripura State planned to develop two Integrated Development Complexes (IDCs, including customs, immigration, banking with currency exchange, warehousing, and public utility services) at Manughat in Unakoti and Muhurighat, about 70-80 km east of Khowai, the northern point of the subject road section in Tripura. Although funds were sanctioned (approved) by the Ministry of Commerce, India, work was stopped in the first quarter of 2019 when Border Guards Bangladesh did not grant permission for the project. Debra Deb, "Tripura: Work Halted for Setting up Integrated Development Complex Despite Funds", *Indian Express*, 1 March 2019.

[16] Other nonphysical barriers to transport between India and Bangladesh include a lack of standardization of documents and implementation of modern customs procedures. Exporters are required to prepare separate documents on each side of the border resulting in errors in transposition. Additional barriers problems include a lack of through bills of lading, the nonavailability of electronic data interchange systems, and different weekend holidays between the two countries. SAARC Secretariat, *Report of the SAARC Multimodal Transport Study (SRMTS)*, Version 2.0, September 2019, p. 41.

[17] 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.

[18] See, e.g., (i) "Transshipment Deal; Chattogram Port to Provide Priority Services for India", *Business Standard*, 10 January 2020 [downloadable from https://tbsnews.net/economy/trade/transshipment-deal-chattogram-port-provide-priority-services-india]; and (ii) Rejaul Karim Byron and Porimol Palma, "India's Transit Thru Bangladesh: Reaping Benefit Is a Challenge", *The Daily Star*, 29 November 2019 [routes via Agaratala (Tripura), Dawki (Meghalaya), Sutarkandi (Assam), and Srimantpur (Tripura), in both directions, were agreed] [downloadable from https://www.thedailystar.net/frontpage/india-bangladesh-trasit-route-challenge-reap-benefit-1833220]. Expected cargo to North East India includes construction material, iron and steel, fertilizer, consumer goods, petroleum products, and cement; expected cargo from the North East to various parts of India through Chattogram Port include grains, fruits, organic products, tea, fish, and jute. Ministry of Shipping, India, "Shri Masukh Mandavia Says Conclusion of SOP [standard operating procedure(s)] with Bangladesh for Chattogram and Mongla Ports a Win-Win Situation for Both Countries", 7 October 2019. The Indian Council for Agricultural Research (ICAR) in association with the Tripura state government has been working with farmers to grow such crops and develop animal husbandry and fishing through Chattogram Port. R.N. Bhaskar, "Agartala on Its Way to Becoming a Major Hub for Trade and Commerce", *Money Control*, 19 February 2019.

reached on the administrative fees charged by Bangladesh under this arrangement,[19] and in the longer term Chattogram Port will require significant efficiency and capacity improvements if it is to serve this increased traffic.[20]

(b) The **Bangladesh-Bhutan-India-Nepal (BBIN) and Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC)**[21] **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.[22]

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[19] Neither transit charges nor customs duties are applicable to goods in transit, as per the General Agreement on Tariffs and Trade (GATT). However, "administrative operational fees and other charges prescribed by the inter-government committee for transit of goods" may be charged. The Ministry of Shipping, Bangladesh, proposed charges of BDT 192,25 per ton of goods using its ports, BDT 34 per ton for ship landing charges, and the Ministry of Road Transport and Bridges, Bangladesh, has proposed a charge of BDT 2.10 per ton-km for use of roads within Bangladesh. In December 2019, the Ministry of Shipping, India, stated that: "On the quantum of administrative fees to be charged by Bangladesh for movement of India's transit cargo from the NER (North East Region) through Chattogram and Mongla Ports, Bangladesh agreed to review its proposal as the proposed high charges would be unfruitful for the industry to adopt the shorter route." "No Fees Finalized as Ports Readied for Indian Cargo Transshipment, *Hellenic Shipping News*, 16 January 2020 [downloadable from https://www.hellenicshippingnews.com/no-fees-finalized-as-ports-readied-for-indian-cargo-transshipment/]; see also (i) Shakhawat Hossain, "India to Use Bangladesh Seaports without Transit, Customs Fees", *New Age*, 9 December 2019; and (ii) Rejaul Karim Byron and Porimol Palma, "India's Transit Thru Bangladesh: Reaping Benefit is a Challenge", *The Daily Star*, 29 November 2019.

[20] A World Bank study measuring the competitiveness of South Asian ports found that containers spent an average of 17 days in Chattogram Port in 2012, compared to 3-4 days at comparable ports and less than one day at the most efficient container terminals. https://www.worldbank.org/en/news/feature/2019/06/26/can-south-asia-unstrangle-the-chicken-neck ["Can South Asia Unstrangle the Chicken's Neck"].

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

[22] 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

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) In December 2019 Bangladesh withdrew **import restrictions** on nine items[23] from Tripura State, although restrictions on tea and other exports remain.

(v) A number of these issues 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 fourth quarter of 2020. The plan includes a number of relevant projects, both ongoing and planned, such as (a) the construction of the bridge over the Feni River at Sabroom (2017-2020); (b) improvement of NH 208 between Teliamura and Harina (158 km) in Tripura (2021-2022); (c) development of the Ramgarh (Bangladesh) land port at a greenfield site, under the Bangladesh Regional Connectivity Project 1 (2017-2021); (d) development of the Chattogram port access road (2021-2023); (e) development of a bay multipurpose terminal on the west coast of Chattogram, 6 km from Chattogram port (2019-2021); (f) (further) development of automated clearance systems and development of advanced logistics (2018-2028); and (f) training in trade facilitation and border management (2018-2028).

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)

limitation that favors larger operators). Bipul Chatterjee and Arnab Ganguly, "Time to Implement the BBIN Motor Vehicles Agreement", *The Economic Times*, 12 February 2020.

[23] The nine items on which the restriction was removed as of 1 December 2019 were cashew nuts, paper, sugar, generators, broken glass, chocolate, baby wipes, confectionary products, and bitumen.

2.5.3 Recommended Next Steps

Recommended next steps include the following:

(i) **The Sabroom ICP should be completed**, and as proposed by the World Bank,[24] **a "co-location border post"** (which would be the first of its kind in South Asia) **may be considered** between Sabroom and Ramgarh (Bangladesh), similar to one-stop border posts (OSBPs) supported by JICA in Africa.[25] In the meantime, LPAI and the Bangladesh Land Port Authority can pursue traditional two-stop border posts by developing new ICPs / land ports along this strategic Northeast-Southwest corridor.

(ii) The **agreement to allow the transport of goods between Chattogram (Chittagong) Port and India should be implemented**, to include the Sabroom/Ramgarh-Chattogram route, with reasonable administrative charges and ideally dedicated space for cargo handling provided for India in Chattogram Port, in 2020.

(iii) The **BBIN MVA** should be implemented by Bangladesh and India (as well as Nepal), by 2021;[26] this would address most of the nonphysical barriers to transport between/among the countries. 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,[27] to increase bilateral trade along land routes in North East India. At a minimum, Bangladesh should permit the import of additional items from Tripura (e.g., tea from Tripura's 54 large tea gardens).

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

[24] World Bank, Project Appraisal Report on a Proposed Credit on a Proposed Credit in the Amount of SDR 110.8 Million (US$ 150.0 Million Equivalent) to the People's Republic of Bangladesh for a Bangladesh Regional Connectivity Project 1, 13 March 2017, pp. 6, 17, and 28 ["If Bangladesh and India succeed in implementing a co-location border post management model, this would be a ground-breaking step forward for regional collaboration efforts"].

[25] Japan International Cooperation Agency, *One-Stop Border Post Sourcebook, 2nd Edition*, May 2016 [prepared by PADECO].

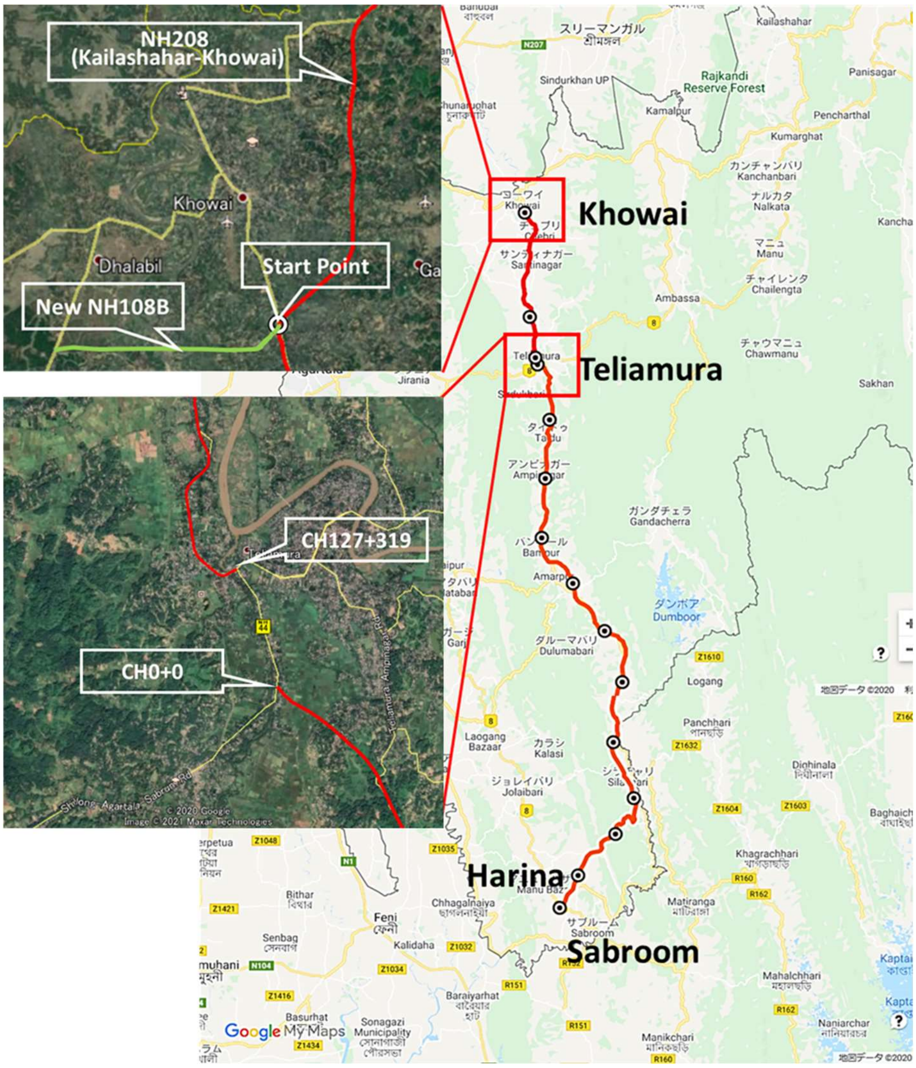
[26] In October 2019, H.E. Sheik Hasina, Prime Minister, Bangladesh, called for early operationalization of the BBIN MVA, even without Bhutan's participation. "Bangladesh PM calls for Operationalizing BBIN Motor Vehicle Agreement with India and Nepal", *DD News*, 27 October 2019. While a meeting held on 8 February 2020 negotiated an MOU for implementation, and follow-on action was called for by May 2020 [https://www.outlookindia.com/newsscroll/bbin-nations-deliberate-on-mou-for-implementation-of-motor-vehicle-agreement/1729563], there does not seem to have been additional action as of January 2021.

[27] 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.

Chapter 3. Present Conditions of NH208 Tripura (Khowai - Sabroom)

3.1 Description and Present Conditions of NH208 Tripura

(1) Description of NH208 Tripura



Source: JICA Survey Team

Figure 3-1: Locations of NH208 Tripura

The Survey Road starts at the future connecting point between the Khowai bypass and the NH108B in Khowai Districts of Tripura and ends at Harina near Sabroom. The Project alignment is separated at Teliamura with two separate sections with different chainages namely CH101+200 through CH127+319 and CH00+000 through CH108+670.

The first section of the Survey Road starts passing through village /localities namely Khowai, Mahadevtila, Saratala, Chebri, Gourangatila, Baganbazar, Dwarikapur, Kalyanpur, Totabari, Komolnagar, Mohorchora and Trishabari before connecting to NH-44 (current NH-8) at Teliamura.

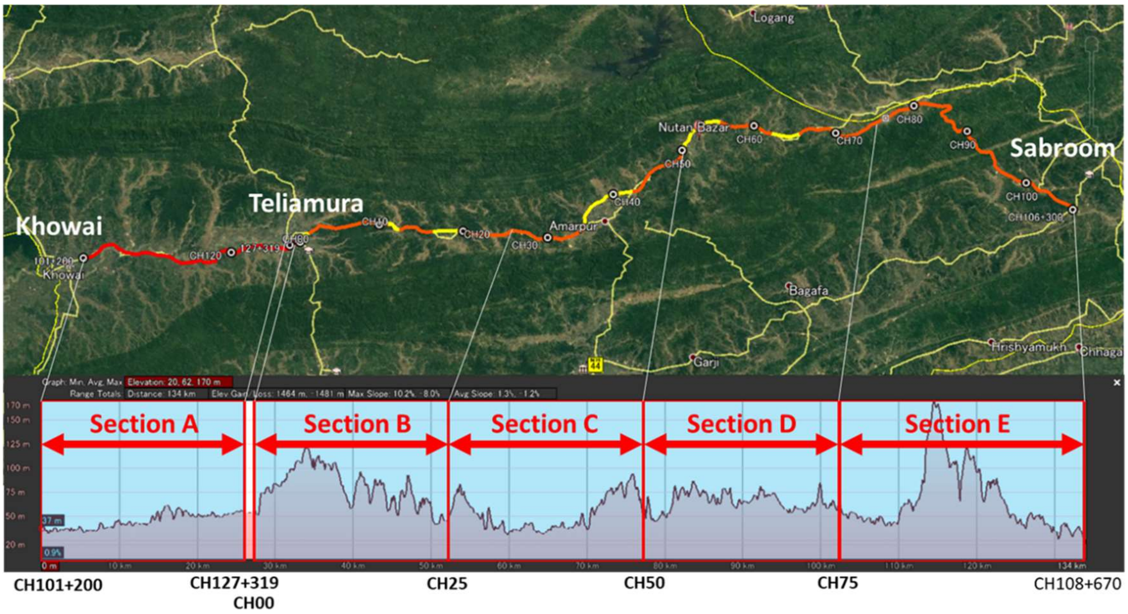
Then the second section restarts from Ompi chowmuhani (T-Junction with NH-08 at Teliamura) passes through Twidu, Sonacherra, Amarpur, Nutan Bazar, Karbook, Ailmara, Khedacherri, Ropaichari and ends at Harina (T-Junction with NH-08). Sabroom is 8.1 km away from Harina junction. To avoid congestion in Teliamura, a bypass of 1.3 km is proposed that starts at NH-08 (1.24 km from Khowai chowmuhani, towards Agartala) and merges at the existing CH2+580 of the Teliamura – Sabroom section. The Survey Road runs parallel to the international border (India – Bangladesh) for some portion of its length.

The existing road is mostly single lane with poor riding quality. The total length is 26.119 km between Khowai and Teliamura and 108.670 km between Teliamura and Sabroom.

(2) Present Condition of NH208 Tripura

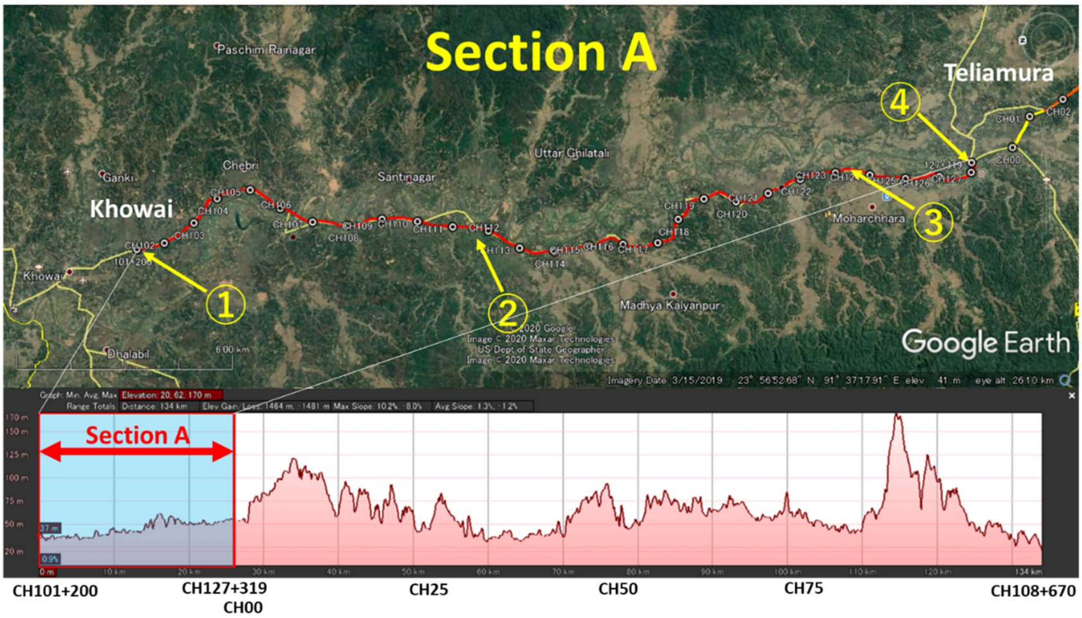
The existing road alignment is very poor and shall be improved to comply with IRC design standards. The improvement work of two-lane with paved shoulder shall be within the existing right of way as much as possible avoiding land acquisition, except for locations having inadequate width and where provisions of short alignment corrections and, improvement of intersections are considered necessary and practicable. Seven bypasses are proposed of total length 22.600km length, namely Teliamura, Twidu, Ompi Nagar, Amarpur, Nutan Bazar, Jatan Bari, and Karbook.

The present condition of the survey road is indicated in figures from Figure 3-2 through Figure 3-7.



Source: JICA Survey Team

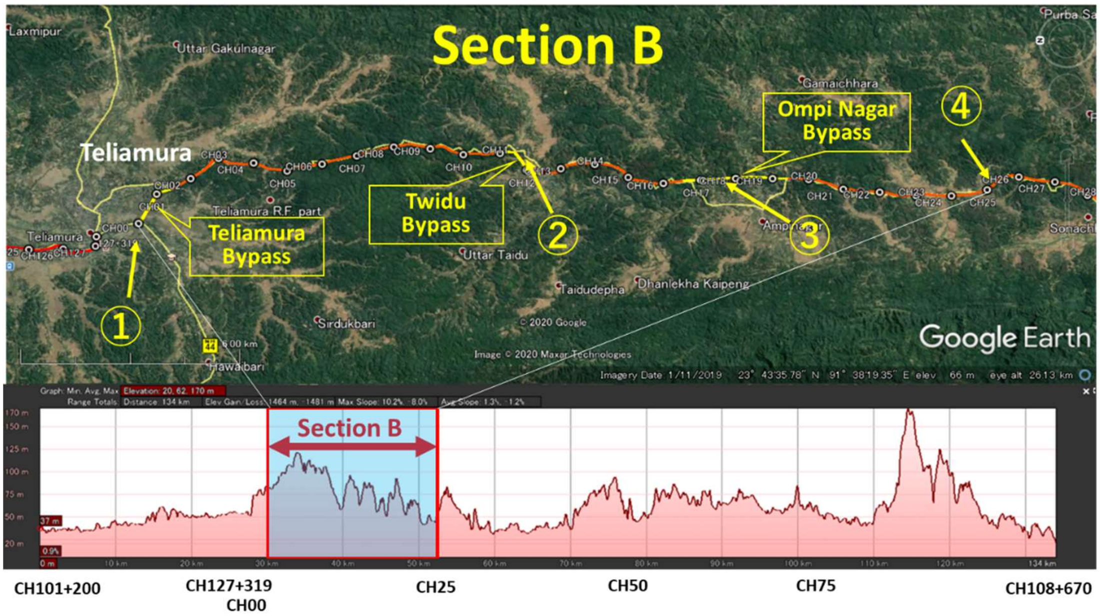
Figure 3-2: Locations of Site Photos (CH101+200 - CH108+670)



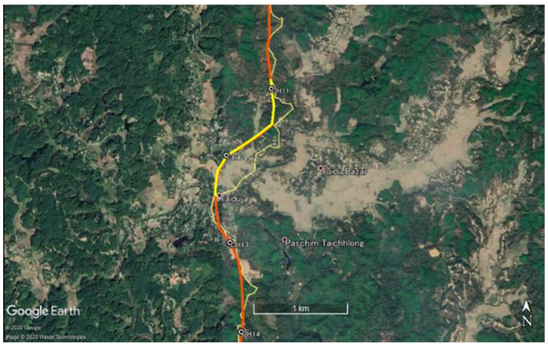
 ① CH101+200 Start Point	 ② CH111+600 Road and riverbank
 ③ CH124+300 A railway crossing	 ④ CH127+300 Teliamura intersection

Source: JICA Survey Team

Figure 3-3: Locations of Site Photos in Section A (CH101+200 – CH127+319)



① CH00 Start Point



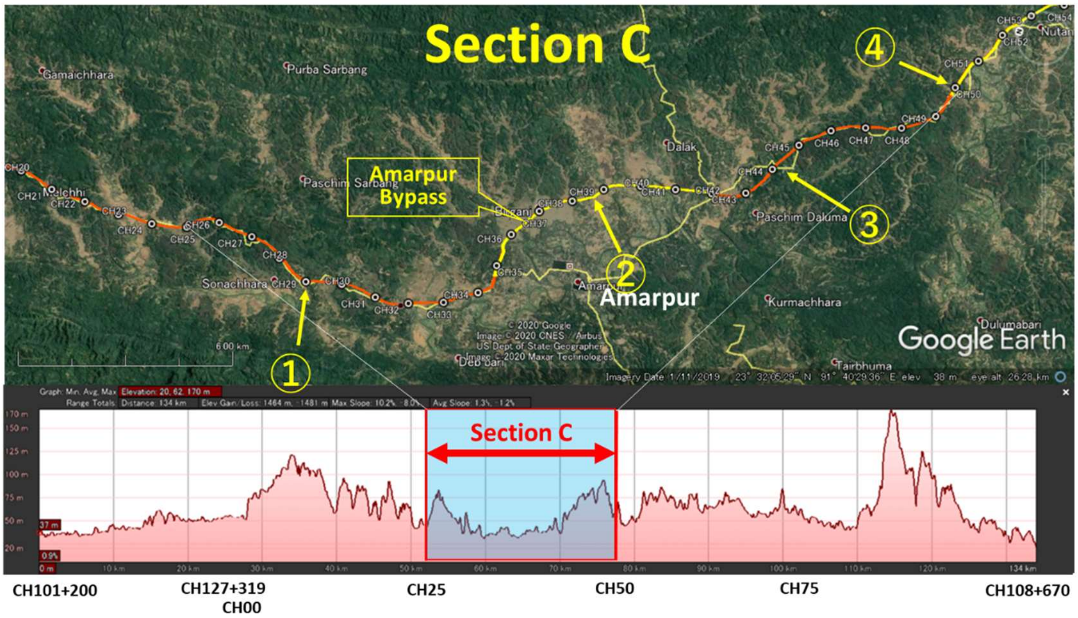
② CH11 Twidu Bypass

③ CH18 Ompi Nagar Bypass

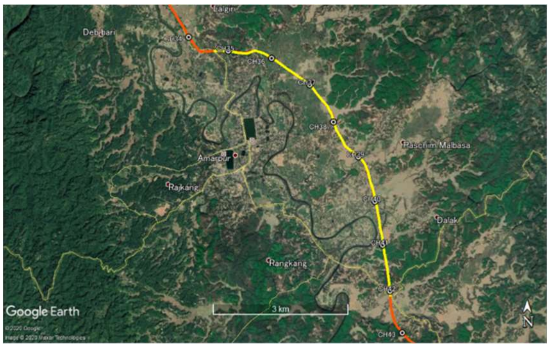
④ CH25 Point

Source: JICA Survey Team

Figure 3-4: Locations of Site Photos in Section B (CH00+000 – CH25+000)



① CH29 Sonachhara



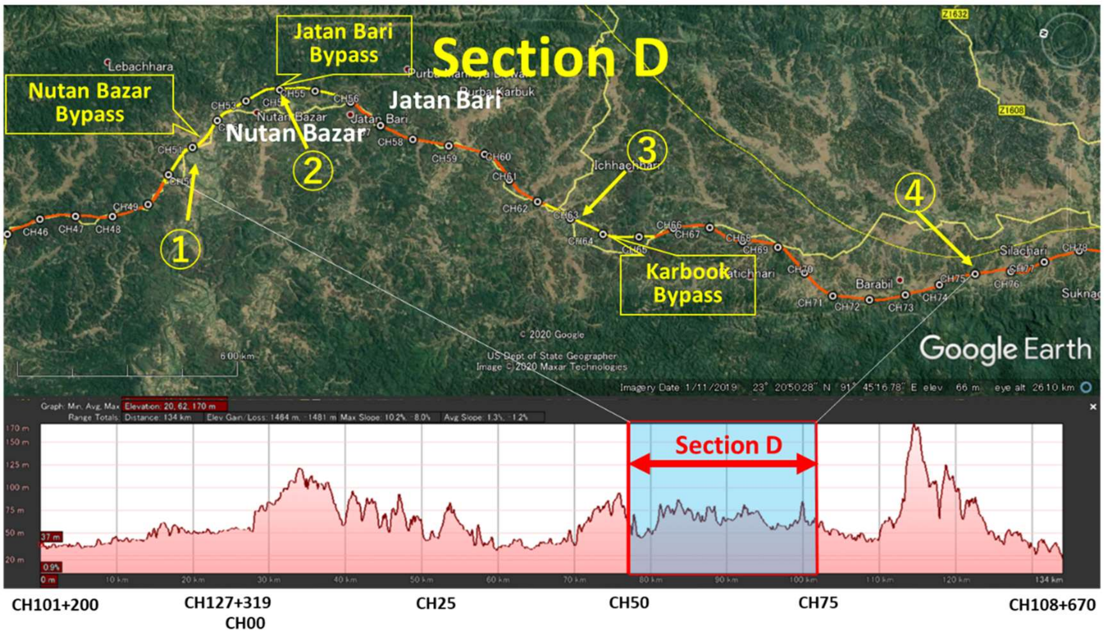
② CH40 Amarpur Bypass

③ CH45 A Paschim Dalma

④ CH50 Point

Source: JICA Survey Team

Figure 3-5: Locations of Site Photos in Section C (CH25+000 – CH50+000)



① CH50 Nutan Bazar Bypass

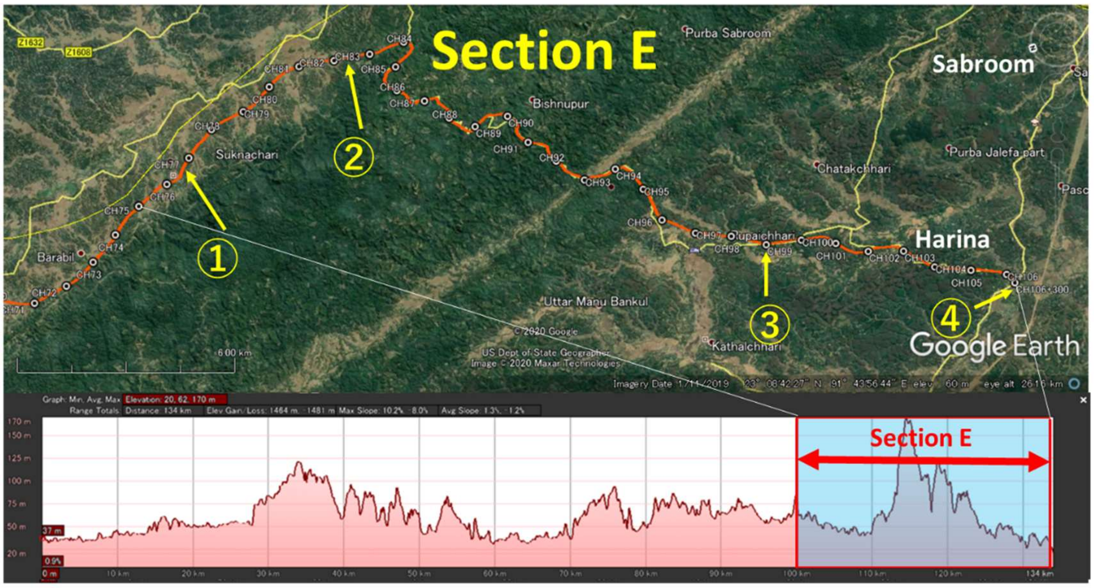
② CH55 Jatan Bari Bypass

③ CH64 Karbook Bypass

④ CH75 Point

Source: JICA Survey Team

Figure 3-6: Locations of Site Photos in Section D (CH50+000 – CH75+000)



 ① CH76 Silachari	 ② CH83 Ghorakappa
 ③ CH99 Rupaichhari	 ④ CH106+300 End Point on NH8

Source: JICA Survey Team

Figure 3-7: Locations of Site Photos in Section E (CH75+000 – CH108+670)

3.2 Major Issues of NH208 Tripura

3.2.1 Terrain Along Highway Alignment

IRCSP73-2018[28], Clause 2.9.1 states that the geometric design shall conform to IRC73[29] 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."

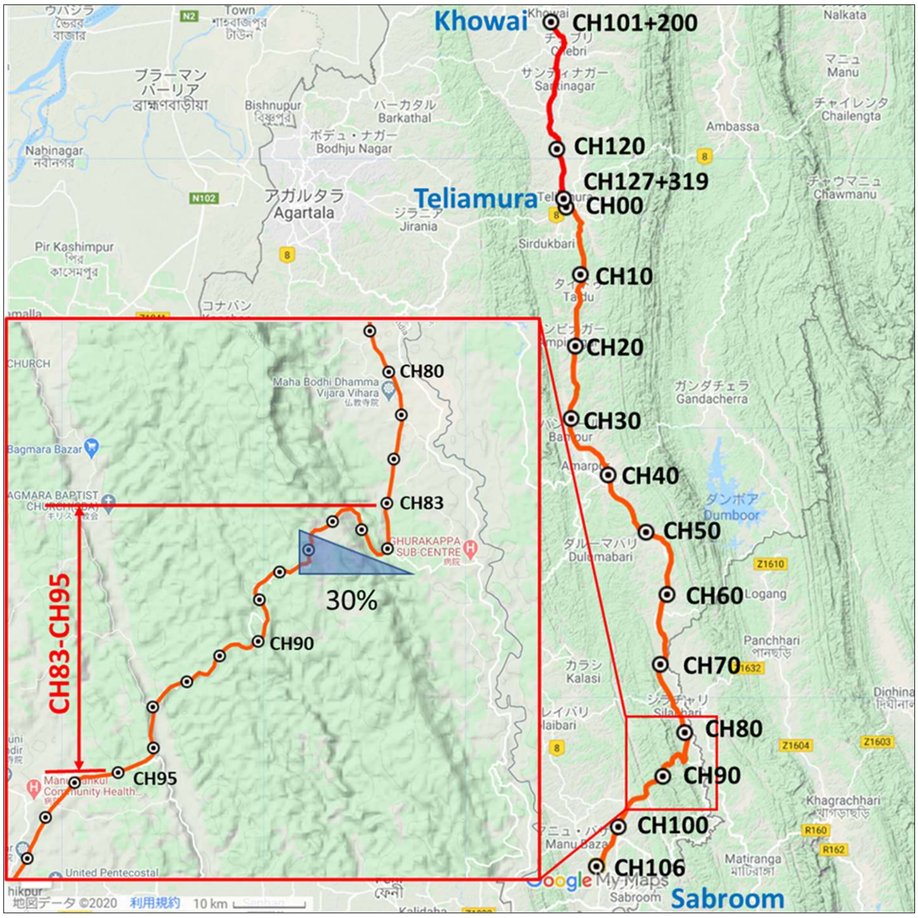
Table 3-1: Terrain Classification as per IRC73-1980

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

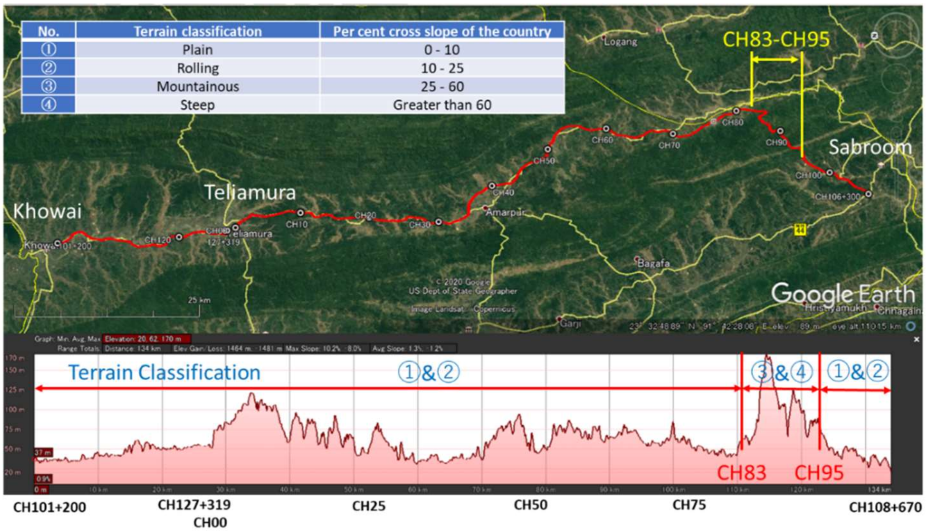
As indicated in the figure below (the enlarged area), the steepest section of the cross slope of the country across the Survey Road is 30% and the section between CH83 –CH95 should be classified as Mountainous. The sections of different terrains for the Survey Road should be demarcated as presented in the figure below.

[28] IRCSP73-2018 Manual of Specifications and Standards for Two Laning of Highways with Paved Shoulder (Second Revision)
[29] IRC73-1980 Geometric Design Standards for Rural (nonurban) Highways



Source: JICA Survey Team

Figure 3-8: Terrain Classification of NH208 Tripura



Source: JICA Survey Team

Figure 3-9: Design Terrain Classification of NH208 Tripura

3.2.2 Existing ROW and Work on Existing Road

(1) Existing ROW

DPR states that there is no marking of existing ROW on the ground along the Survey Road, and the details of existing ROW are not available with PWD. However, as per visual inspection and inquiry through local people, it is found that the available land is only 6-15m. The proposed ROW has been considered 30-45m for the entire road stretch and details are presented in DPR.

(2) Work on Existing Road

As per MORTH-2013 Specifications for Road and Bridge Works 5th Revision[30], Clause 305.4.3, 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.

3.2.3 Difficult Conditions for Widening

The road construction and social activities are an 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 which includes: 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 3-10, 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.

[30] MORTH-2013 Specifications for Road and Bridge Works 5th Revision

Source: IRCSP55-2014

Figure 3-10: Types of Warning Devices in IRCSP55

3.2.4 Pavement Conditions

The DPR Consultant conducted the pavement condition survey on every 500m of the pavement edge either on the right- or left- hand side. In the survey, the thicknesses of bitumen layer and brick soiling were measured, and the average thicknesses of bitumen layer and brick soiling were 40mm and 215mm, respectively. Furthermore, the conditions of pavement surfaces including shoulders were evaluated as as along with the riding quality. The survey results are outlined in the Appendix.

The existing carriageway consists of the bitumen layer and brick soling of sub-base. The width of bitumen layer is 3.5m - 7.5m, though at a few stretches consist of the width of 12.1m and 9.0m. The earthen shoulders of 1.0m - 1.5m on both sides are provided. The existing condition of the pavement has been poor with the existing cracking, raveling, potholes, rutting and patching. During the pavement condition survey, cracking and raveling were detected at each chainage, and the surface areas were affected by 30-60% and 30-40%, respectively. Potholes were also observed, and these defected and distressed conditions make riding quality poor.

Note: Pictures will be replaced when JICA Survey Team receive pictures of current condition.
Source: DPR

Figure 3-11 Existing Pavement Conditions

3.2.5 Slope Protection

(1) Present Conditions and Major Issues

The slope inventory survey was not carried out, and the conditions of cut slopes on the existing road were not examined because JICA Survey Team could not visit India due to the COVID-19 pandemic. However, the project road is planned in the southern extension of NH208 (Kailashahar–Teliamura), which was reported last year as “Final Report on Basic Information and Data Collection Study on Connectivity Improvement in North Eastern Region of India” and the topographic and geological features of NH208 (Teliamura–Sabroom) is the same as those of NH208 (Kailashahar–Teliamura). Also, as for slope protection measures, the major issues are the same as those of NH208 (Kailashahar–Teliamura).

As mentioned in “Chapter 5.1.3 geological survey”, the stratigraphy of the Project Poad is composed of the Alluvium, Dupitila Group, Tipam Group, and Surma Group. The issues of these stratigraphy are as follows:

- Dupitila Group

The Dupitila Group is distributed in the valley bottom plain intermittently, and the upper parts of their surfaces show almost the same altitude. This feature is similar to the surface of eroded fluvial terrace.

The Dupitila Group consists of unconsolidated sand, silt, and gravel. Even an exposed vertical cut slope looks to be stable. However, the slope surface is eroded by surface water flow.

- Tipam Group

  The topography of the Tipam Group consists of a gently undulating plain, which is called “Rolling”.

  The Tipam Group consists of weakly consolidated sandstone and siltstone. The cut slopes along the existing road are stable even with gradient of 0.5H : 1V. However, there are many slopes where the topsoil has collapsed at the top of the slope and on the shoulder. Cut slopes of sandstone are eroded by surface water flow, and eroded sand is deposited at the toe of the relevant cut slope. The countermeasures against topsoil collapse and surface erosion are necessary for the slope protection of the Project Poad.

- Surma Group

  The Surma Group is distributed in the hilly and mountainous terrains. The Group mainly consists of alternation of siltstone and shale and is as hard as soft rock. The feature of this layer looks like a massive rock because the bedding planes with several centimeter intervals are hard to separate, and few joints are developed. The bedding planes are sometimes inclined with 30° to 60°.

  While the layer of the Surma Group itself is impermeable, the topsoil on the top of the cut slope is an unconsolidated and high permeable layer. Therefore, the topsoil is easy to fall down during heavy rain due to rising up of ground water level in the topsoil. A lot of topsoil collapses are observed in the hilly and mountainous terrain where the Surma Group is distributed.

  Although the Surma Group seems to be stable, the weathered layers are collapsed together with topsoil on the cut slopes where there is a dip slope structure. The cut slopes with dip slope structure have long-term stability problem.

(2) Recommended Solutions

“IRC:SP:48-1998 Hill Road Manual” proposes the gradients of cut slopes for rock types. The cut slope gradients of the Project Poad should be proposed based on rock types of this Manual.

The cut slopes composed of the Dupitila Group and Tipam Group are stable, and hydroseeding is applicable for slope protection measures. However, the cut slopes composed of the Surma Group with dip slope structure have a problem with long-term stability. It is necessary to detect whether cut slopes have dip slope structure or not. In the case of high cut slopes with dip slope structure, it is necessary to consider application of internal slope reinforcing methods for slope protection.

In the hilly terrains where the Surma Group is distributed, landslide study is necessary. The slope inventory survey on site is impossible due to the COVID-19 pandemic so that JICA Survey Team applied an analysis method using highest precision satellite data (DEM: purchased) with high resolution of 0.5 m. Whether landslides exist or not is estimated by the study of landslide topography on the satellite data. If there are some areas where landslides are suspected, the contour maps and cross sections will be prepared from satellite data and landslide prevention measures will be proposed.

3.2.6 Bridges

Due to road realignment, all the 32 existing bridges on the current road are out of the planned alignment and will be retained. On the other hand, the new 46 bridges are planned along with the new road alignment.

It is suggested that the bore holes shall be shown in LOCATION PLAN because their locations cannot be identified on the General Arrangement Drawings. The DPR Consultant agreed and updated on GADs.

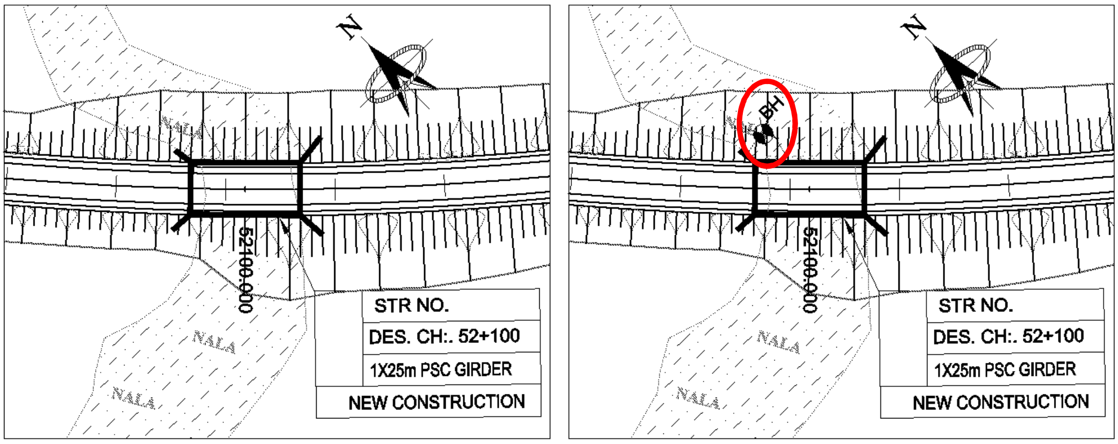


Figure 3-12 Indication of Boring Location

It is anticipated that scouring may occur at CH19+770, CH69+895, CH 85+270, CH 85+445 because the bottom of pile cap is higher than the maximum scour level.

Because only "POT/PTFE BEARING" is indicated but its dimensions and requirements (capacity for force and deformation) are not indicated on the drawings, it is suggested to indicate bearing information. The DPR Consultant agreed and added bearing drawings with specific information.

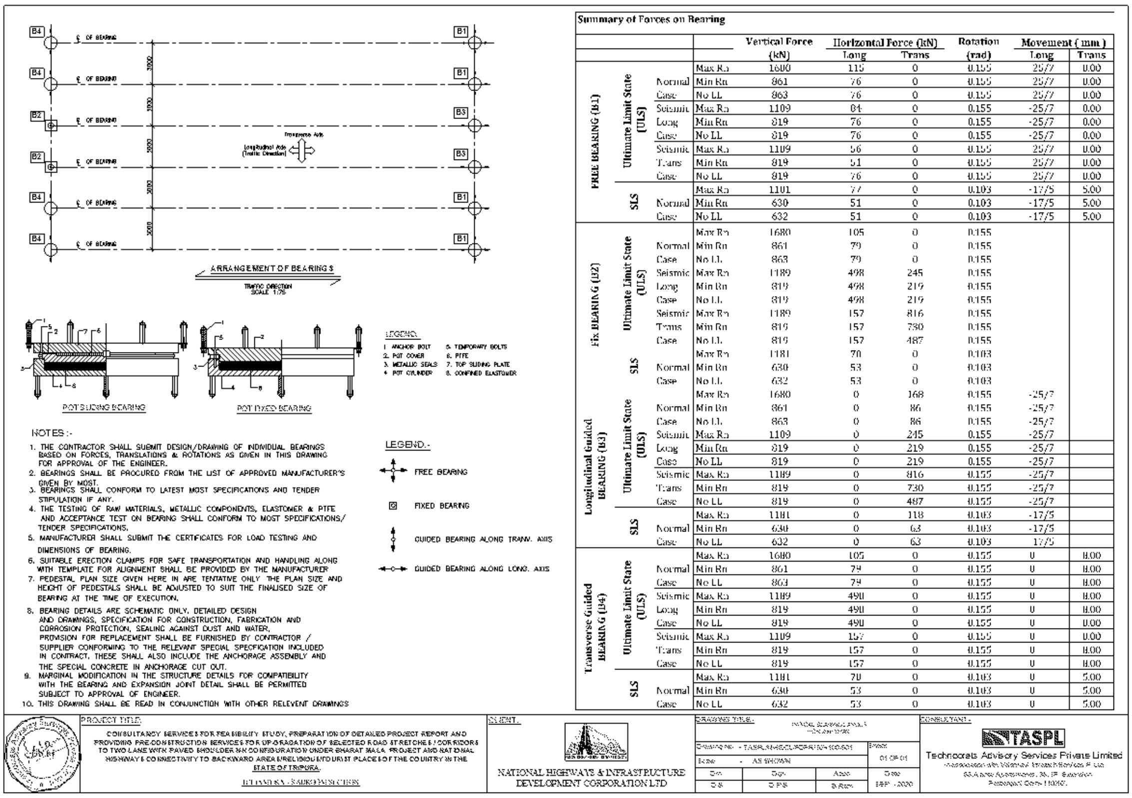


Figure 3-13 Bearing Drawings

It is suggested that anchor bolts connecting the approach slab and the abutment are missing. The DPR Consultant replied to update them.

Because pile length seems to be measured from the bottom of the pile cap and founding level, it would be necessary for the pile tip to dig/plug into the founding level (bearing stratum/layer) as deep as pile diameter (1D = 1.2m). The DPR Consultant replied to update them.

3.2.7 Drainages

Due to the ongoing pandemic, it is not possible to go to the site and survey. Therefore, JICA Survey Team referred to the DPR and drawings prepared by the DPR Consultant to identify and confirm the problems related to drainage on the survey road. According to the DPR prepared by the DPR consultant, the capacity calculation sheet that determined the cross section of the box culvert was not carried out at all points, but only at the representative points. Therefore, JICA Survey Team conducted a hearing to the DPR Consultant to confirm the reason why the calculation was not performed for other cross sections.

As a result of the hearing, the DPR Consultant conducted an analysis of areas with well-defined watersheds. Regarding other locations, JICA Survey Team received the response from the DPR Consultant that culvers of appropriate standard sizes will be installed on the suitable locations. Therefore, JICA Survey Team considers the results conducted by the DPR Consultant are appropriate for the locations other than the locations where the cross section was being examined.

For the future construction, it will be necessary to reconfirm the local situation and install a box culvert with an appropriate cross section for the uncalculated box culvert.
The major issues at this point are shown below:

(1) Major issues of DPR

A) Type of Culvert

NH208 has been renovated or redesigned for all cross drainage channels as the road width increases as the road improves. The existing crossing channel culverts used slab culverts, pipe culverts, and box culverts, but due to the improvement of this road, they were all changed to box culverts. Considering workability, it is necessary to consider the adoption of precast pipe culverts and box culverts. In the design of the DPR, due to this road improvement, many box culvert shapes have been adopted. Currently, there is no basis for determining the size because the flow rate calculation sheet is not available yet. JICA Survey Team requested the DPR Consultant to obtain flow rate calculation sheet. If it's available, JICA Survey Team will review the results. If it is not available, JICA Survey Team will conduct a hearing to local consultants to confirm the rationale.

B) Box culvert cross-section dimensions

According to the DPR, many box culverts will be rebuilt and newly installed due to the road improvement, and box culverts with appropriate flow capacity will be installed. The flow calculation of the box culvert is only for the representative location, and there is no basis for determining the size of the box culvert in other locations. JICA Survey Team confirmed that the box culvert capacity statement at the representative location was valid, but capacity statements for other locations were not available. Therefore, JICA Survey Team interviewed the DPR consultant about the matter. As a result of the hearing, the DPR consultant replied that other parts would be installed with the capacity of the existing crossing channel or more (standard size).

C) Installation location of new waterway

The NH208 Tripura Line is a route that passes through flat areas and mountainous areas. The mountain route is planned to be constructed with a new route instead of the existing road alignment. Therefore, many box culverts will be newly installed. The rationale for the location was not clarified in the final DPR. Therefore, regarding the location of the new box culvert, JICA Survey Team will conduct a hearing with a DPR consultant and confirm the grounds.

(2) Recommended solutions

A) Type of Culvert

Normally, the selection of culvert format is decided by comprehensively considering the characteristics of the normal area (construction efficiency, economic efficiency, ease of acquisition). In the DPR, the crossing channel format is the box culvert format. When JICA Survey Team interviewed the DPR Consultant, the reply was that this area uses a box culvert that has a larger cross section and has a flow capacity than a pipe culvert because it is an area with a lot of rainfall. It is difficult to obtain precast products, and it is difficult to adopt pipe culverts. Therefore, the validity of adopting the box culvert type is high. At the time of construction, it is better to check the local situation and consider the adoption of the culvert type that is most suitable for the site.

B) Box culvert cross-section dimensions

JICA Survey Team obtained typical box culvert capacity statements from the DPR Consultant. However, the capacity statements were not available for other box culverts. JICA Survey Team conducted interviews to the DPR Consultant and confirmed the concept of design. As a result of the review and hearing, it was confirmed that the capacity statement of the box culvert at the representative location is appropriate. Regarding other places, JICA Survey Team received the response from the DPR Consultant that standard size culverts with the same cross section as the existing ones will be installed. When the road construction starts, it is necessary to check the local situation and adopt the optimum culvert format.

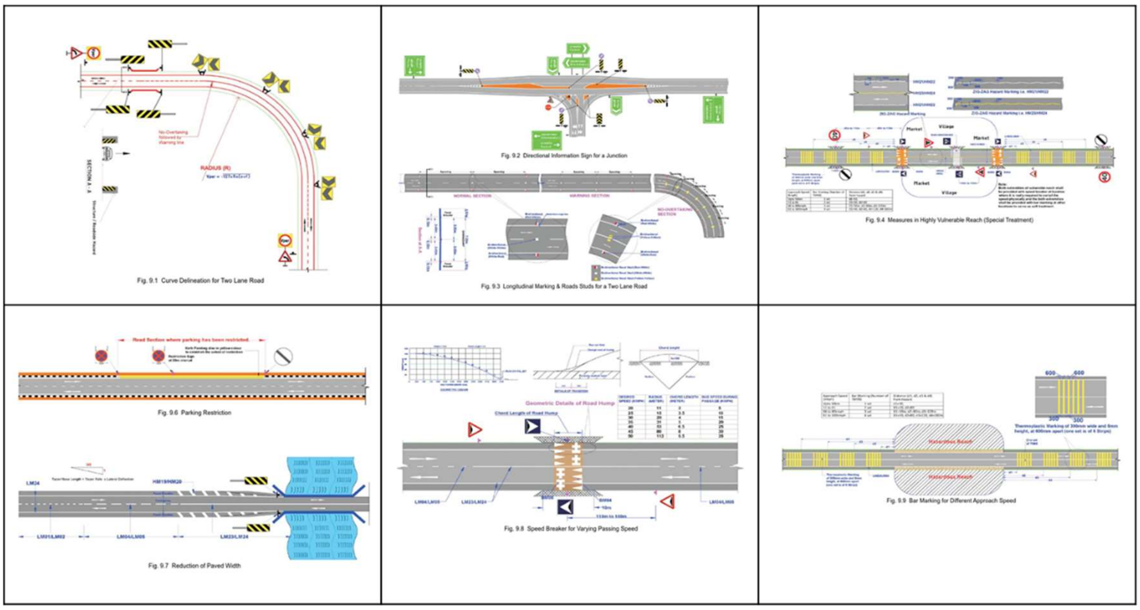
C) Installation location of new waterway

Since a field survey was not possible, a hearing was conducted by the DPR Consultant to confirm the validity of the location of the crossing channel. According to the report, regarding the new location, JICA Survey Team received responses from the DPR Consultant that culverts will be installed every 200 m and the locations were confirmed from the drawings. At the time of construction, it is necessary to check the culvert location in the site.

3.2.8 Safety Issues

(1) Road Safety Measures for Mountainous Roads with Poor Visibility

The Particular Specification for this survey work states that "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

(2) Management of Safety for Construction Work

India has a well-organized guidance for the management of safety for construction work. There is an Act, 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. The table below shows the comparison between the Japanese Guidance and the Indian Regulations. Although the concept of PDCA for safety management has not been introduced into the Indian regulations, most items are identical with those of the Japanese Guidance and therefore the management of safety for construction work is sufficiently regulated.

Table 3-2: Comparison between Japanese Guidance and Indian Regulations

	Indian Regulations		
The Guidance for the Management of Safety for Construction Works on Japanese ODA Projects	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

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. The DPR for NH208 Teliamura-Sabroom, Tripura was by Technocrats Advisory Private Limited, which covers the section of Teliamura-Sabroom though the Survey Corridor currently studied covers the section Khowai-Sabroom. The DPR for NH208 by CETEST Engineering Consultants which covers the stretch of Kaliashar-Teliamura is also taken into consideration. Therefore, the data for the Teliamura-Khowai section has been taken from the DPR for NH208 Kaliashar-Teliamura.

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 NH208 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 NH208 (Tripura)

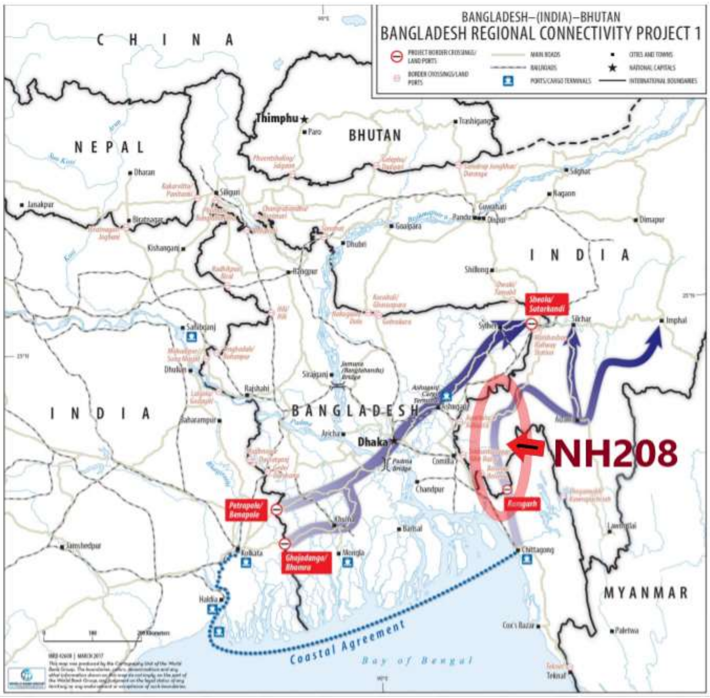
Table 4-1: Survey Road Network and Sections

State	Survey Road Network		Target Length (km)
Tripura	Teliamura-Sabroom	The target road extends from Khowai in West	Approx. 163

		Tripura to Sabroom in South Tripura.	

Source: JICA Survey Team

After the improvement of NH208, it is anticipated by the JICA Survey Team that the Survey Corridor will receive not only diverted traffic from existing, alternative routes but also new cross-border traffic. This new traffic is expected as a result of establishment of Tripura's first Special Economic Zone in Sabroom (announced in 2019) and also because the Survey Corridor is considered as one of the planned freight transportation routes under the World Bank's *Bangladesh Regional Connectivity Project 1* (expected completion in 2023) that connects Sabroom with Chittagong Port as shown in Figure 4-2.



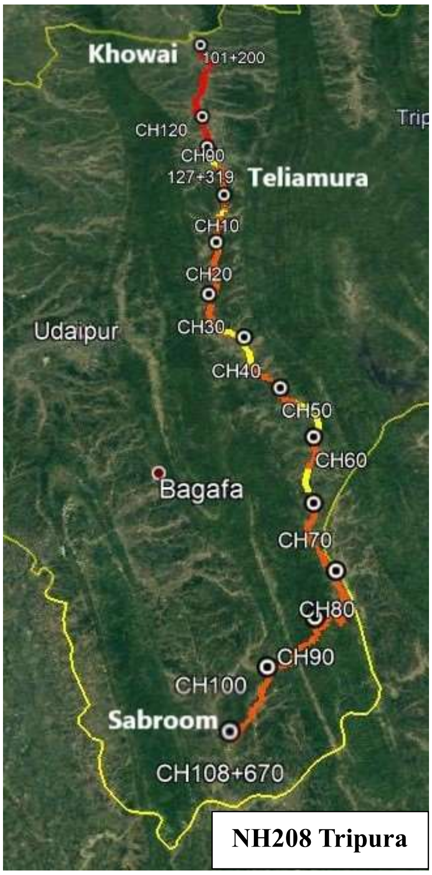
Source: Project Appraisal Document for World Bank's Bangladesh Regional Connectivity Project 1

Figure 4-2: Trade Routes under World Bank's Bangladesh Regional Connectivity Project 1

4.3 Traffic Survey

For the Survey Corridors, 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 projection of future traffic. The types of surveys conducted along the chainage shown in Figure 4-3 were:

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



Source: JICA Survey Team

Figure 4-3: Chainage along the Survey Corridors

Reconnaissance survey was undertaken to identify homogenous sections along the Survey Corridors 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 Tripura.

Table 4-2: Traffic Surveys at NH208, Tripura

Type of Survey	Location	Survey Dates	Survey Duration
Classified Traffic Volume Count Survey	Ch. 117+500 (Trishabari) * [*For reference only*]	2015 (*date not available*)	24 Hours x 7 days
	Km 42.300 Km 88.000 Km 132.800	14/02/2017 (Tue) to 20/02/2017 (Mon)	
Origin-Destination (O-D) Survey	Not Conducted		
Turning Movement Survey	Ch. 85+500 3-legged junction at Khowai*	2015	12 Hours x 1 day
	Km 0.00 at Teliamura	16/02/2017 (Thu)	8 Hours x 1 day
	Km 88.000 at Amarpur	17/02/2017 (Fri)	
	Km 132.800 at Ailmara	18/02/2017 (Sat)	
	Km 42.300 at Harina	18/02/2017 (Sat)	
Axle Load Survey	Not Conducted		

Source: DPR by Technocrats Advisory Services and *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.
- 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		Assam: 8.00 (Bullock Cart), 4.00 (Horse); Meghalaya: 6.00 Tripura: 4.00
Others (only for NH208 Tripura)		3.00

Source: DPR

4.4 Traffic Survey Results

4.4.1 Classified Traffic Count Survey Analysis

(1) Observed Traffic Volume

Table 4-4 summarizes ADT along NH208 Khowai-Sabroom, Tripura. The traffic count data has been taken from the respective DPRs but aggregate calculations have been newly generated.

Table 4-4: Average Daily Traffic (NH208, Tripura)

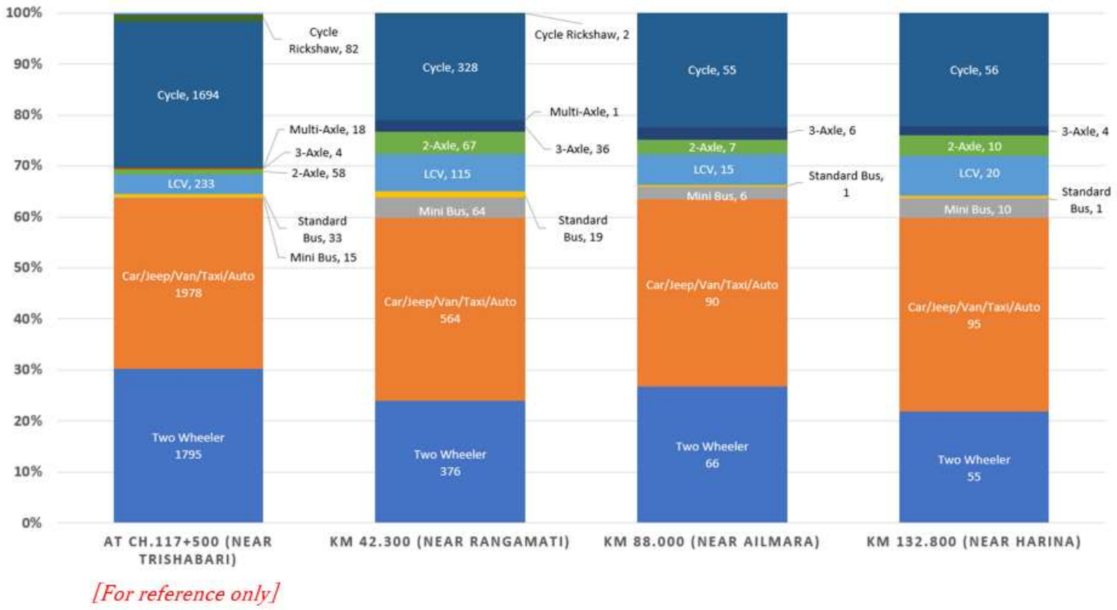
Vehicle Type	At Ch.117+500 (near Trishabari) [For reference only]	Km 42.300 (near Rangamati)	Km 88.000 (near Ailmara)	Km 132.800 (near Harina)
Two Wheeler	1795	376	66	55
Car/Jeep/Van/Taxi/Auto	1978	564	90	95
Mini Bus	15	64	6	10
Standard Bus	33	19	1	1
LCV	233	115	15	20
2-Axle	58	67	7	10
3-Axle	4	36	6	4
Multi-Axle	18	1	0	0
Tractor With Trailer	0	0	0	0
Tractor Without Trailer	0	0	0	0
Cycle	1694	328	55	56
Cycle Rickshaw	82	2	0	0
Hand Cart	16	0	0	0
Bullock Cart	0	0	0	0
Horse Cart	0	0	0	0
Others	0	7	0	0
Total Motorized Vehicles (No.)	**4134**	**1242**	**191**	**195**
Total Non Motorized Vehicles (No.)	**1792**	**337**	**55**	**56**
Total Commercial Vehicle per day (No.)	**361**	**302**	**35**	**45**
Total Motorized Vehicles (PCU)	**3614**	**1391**	**197**	**213**
Total Non Motorized Vehicles (PCU)	**1059**	**189**	**28**	**28**
Total PCU per day	**4673**	**1580**	**224**	**241**

Source: DPR by Technocrats Advisory Services and CETEST Engineering Consultants (calculations by the JICA Survey Team)

The area where the Survey Corridor intersects with the road going towards Udaipur has a traffic count of 1,580 PCU per day. The Southernmost sections on NH208 has traffic of less than 250 PCU per day. As a reference for the target section, the maximum traffic count of 4,673 PCU is counted in near Teliamura (not in the target section) where the Survey Corridor intersects with NH08 which goes to Agartala, the capital of Tripura.

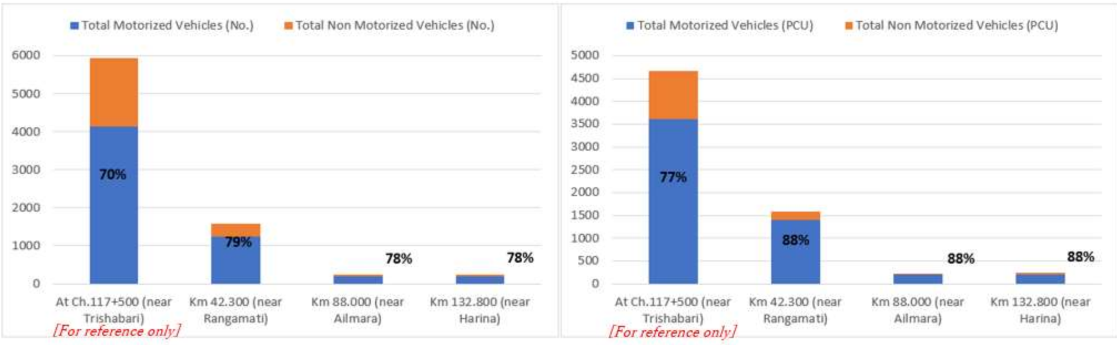
(2) Characteristic of the Traffic

From Figure 4-4**,** it can be deduced that approx. 80% or more traffic along NH208 Khowai-Sabroom is made up of small and private vehicles (i.e. Two Wheeler and Car/Jeep/Van/Taxi /Auto). At Ch.117+500 (intersection near Teliamura) small and private vehicles make up more than 90% of the total traffic. Moreover, as shown in Figure 4-5, small and private motorized vehicles make up majority of the traffic within the Survey Corridor Area in Tripura pointing to dominance of short-distance travel.



Source: JICA Survey Team

Figure 4-4: Vehicle Types on NH208 Tripura



Source: JICA Survey Team

Figure 4-5: Motorized Vehicles vs. Non-Motorized Vehicles on NH208 Tripura

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 NH208 (Tripura) 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. For NH208, 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 Hour for NH208 is 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 NH208 Tripura

Count Location (NH208, Tripura)	Peak hour	Peak Traffic Volume (PCU)*	PHF (%)
Ch. 117+500 km (near Trishabari,Teliamura)	10:00 am ~ 11:00am	445	9.53%

Source: Estimated by the JICA Survey Team

(3) Average Seasonal Variation Factor (ASVF)

ASVF for NH208 was taken as 1.00 due to unavailability of data according to the DPR Consultant (Technocrats Advisory Services).[31]

4.4.3 Annual Average Daily Traffic (AADT)

AADT for NH208 Tripura are shown in Table 4-6.

Table 4-6: AADT on Homogeneous Sections of NH208 Tripura

Vehicle Type	Km 42.300 (near Rangamati)	Km 88.000 (near Ailmara)	Km 132.800 (near Harina)	At Ch.117+500 (near Trishabari) [For reference only]
Two Wheeler	376	66	55	2131
Car/Jeep/Van/Taxi/Auto	564	90	95	2225
Mini Bus	64	6	10	18
Standard Bus	19	1	1	40
LCV	115	15	20	277
2-Axle Truck	67	7	10	69
3-Axle Truck	36	6	4	5
Multi-Axle	1	0	0	22
Tractor With Trailer	0	0	0	1
Tractor Without Trailer	0	0	0	0
Cycle	328	55	56	2012
Cycle Rickshaw	2	0	0	97
Hand Cart	0	0	0	19
Bullock Cart	0	0	0	0
Horse Cart	0	0	0	0
Others	7	0	0	0
Total Motorized Vehicles (No.)	**1242**	**191**	**195**	**4788**
Total Non Motorized Vehicles (No.)	**337**	**55**	**56**	**2128**
Total Commercial Vehicle per day (No.)	**302**	**35**	**45**	**432**
Total PCU per day	**1580**	**224**	**241**	**5436**

Source: DPR by Technocrats Advisory Services and CETEST Engineering Consultants (calculations by the JICA Survey Team)

[31] Based on the reference DPR for NH208 Kaliashar-Teliamura by CETEST Engineering Consultants, the ASVF taken are **1.00** for petrol and **1.06** for Diesel.

4.5 Traffic Projection Methodology

4.5.1 Existing Traffic Data

Existing traffic data available for NH208 Khowai-Sabroom is as follows:

- NH208 Khowai-Teliamura from 2015 by CETEST Engineering Consultants
- NH208 Teliamura-Sabroom from February 2017 by the Technocrats Advisory Services

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 Consultants.

4.5.2 Homogeneous Sections

Four homogenous sections were identified for NH208 Khowai-Sabroom:

- Homogeneous Section I: Km. 85+500 to Km 118+000
- Homogeneous Section II: Km. 0.00 to Km 45.00 (Teliamura-Amarpur section)
- Homogeneous Section III: Km. 45.00 to Km 88.00 (Amarpur-Ailmara section)
- Homogeneous Section IV: Km. 88.00 to Km 133.00 (Ailmara-Harina section)

Homogeneous Section I is taken from the DPR by CETEST Engineering Consultants while Homogeneous Sections II-IV 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

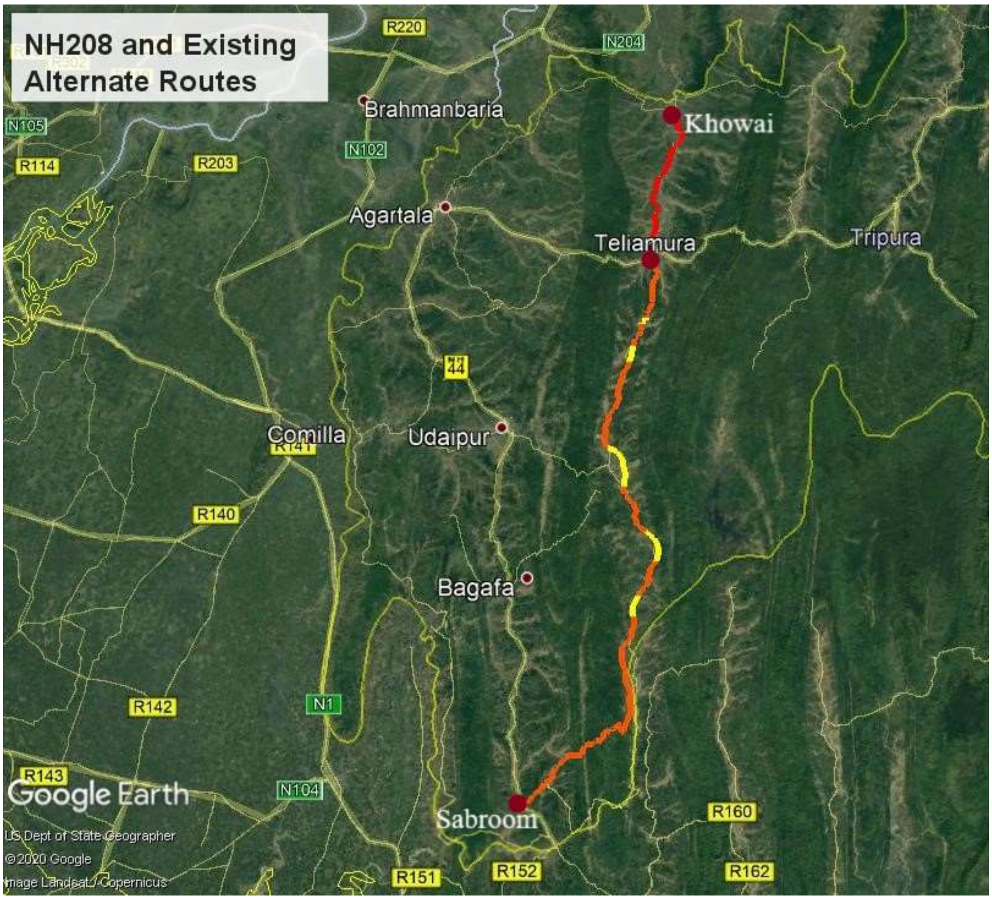
O-D Survey was not carried out by the DPR Consultant Technocrats Advisory Services for the NH208 Teliamura-Sabroom section as there is limited commercial traffic as well as lack of any major traffic along the corridor. However, an induced traffic of 15% was assumed for this road section after its completion.

For NH208 Khowai-Teliamura section the DPR Consultant CETEST Engineering Consultants assume that traffic can be expected to be diverted from NH08 (old NH44) to avoid going through the existing hilly terrain routes (shown in Figure 4-6). The percentage and number of vehicles expected to be diverted from NH08 to NH208 is shown in Table 4-7**.**

Table 4-7: Diverted Traffic on NH208 Tripura

Vehicle Type	Probable diverted traffic NH-08 -> NH208 (%)	Probable diverted traffic NH-08 -> NH208 (No.)
Car/Jeep/Van/Taxi/Auto	0%	0
Bus	86%	6
2-Axle Truck	82%	106
3-Axle Truck	88%	50
Multi-Axle	83%	83
LCV	69%	11

Source: CETEST Engineering Consultants



Source: JICA Survey Team

Figure 4-6: NH208 and Existing Alternate Routes

A growth rate of 5% for all vehicles were taken for all motorized vehicles for NH208 Teliamura-Sabroom section while 5% was taken for all motorized and non-motorized vehicles for NH208 Khowai-Teliamura section.

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 respective DPR Consultant are shown below in Table 4-8.

Table 4-8: Traffic Projections by DPR Consultant for NH208 Tripura

Year	NH208 Tripura (DPR by Technocrats Advisory Services and CETEST Engineering Consultants)							
	At Ch.117+500 (near Trishabari)		Km 42.300 (near Rangamati)		Km 88.000 (near Ailmara)		Km 132.800 (near Harina)	
	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2017*	8272	8313	1579	1583	246	224	251	241
Road Opening 2020*	9576	9624	2124	2162	328	299	340	334
2025	12221	12283	2709	2750	414	368	433	423
2030	15598	15676	3453	3500	521	451	550	532
2035	19908	20007	4404	4457	659	559	697	666
2040	25408	25535	5613	5673	835	696	892	854

** 2015 is base year for Ch.117+500 (near Trishabari) as per projections by CETEST Engineering Consultants and 2015 figures are inclusive of diverted traffic.*

Note: Figures in red are estimated by the JICA Survey Team as projection for the section was only up to 2033.
Source: DPR by Technocrats Advisory Services and 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 for NH208 Tripura is taken as 2017. For NH208 Khowai-Teliamura section for which the base year in DPR was 2015, estimated 2017 figures have been considered (exclusive of any traffic diversion).

In general, a traffic growth rate of 5% for all sections of NH208 has been taken for traffic projections given that it was assessed as reasonable in the JICA NH208 DPR Review Report from February 2020.

Moreover, 2025 is taken as the estimate year of road opening of NH208, therefore, traffic for this year has been increased to include diverted traffic from alternative routes. Diverted traffic for NH208 Khowai-Teliamura section has been increased based on the percentages provided by the DPR Consultant as shown in Table 4-7. For the remaining NH208 Teliamura-Sabroom section, traffic is estimated to increase by 15% after road opening.

4.7.2 Revised Traffic Growth Rates

Traffic growth rates used by the JICA Survey Team for revised traffic projections has been kept the same as per the DPR at 5% across all motorized and non-motorized vehicles.

4.7.3 Revised Traffic Projections

Table 4-9 shows the traffic projections estimated by the JICA Survey Team for NH208 Tripura. The projection takes 2017 as base figures and is estimated until 2045.

As mention, diverted traffic from existing routes passing through hilly terrain (shown in Figure 4-6) is expected to get diverted to the improved NH208 after its expected opening in 2025.

Therefore, traffic for 2025 has been increased by 15% for NH208 Teliamura-Sabroom and by the respective diversion percentages for NH Khowai-Teliamura.

Based on the traffic forecast, the road section NH208 Khowai-Sabroom is expected to receive a comparatively higher level of traffic. However, based on the estimated traffic, the highway could maintain a LOS "B" until 2045 (based on design service volume of 30000 PCU/day for 2-lane).

Table 4-9: Revised Traffic Forecasts for NH208 Tripura

Year	NH208 Tripura							
	At Ch.117+500 (near Trishabari)		Km 42.300 (near Rangamati)		Km 88.000 (near Ailmara)		Km 132.800 (near Harina)	
	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2017	7615	5963	1579	1587	246	224	251	241
2020	8815	6903	1828	1837	285	259	291	278
Road Opening 2025	11507	9686	2683	2696	418	381	426	409
2030	14686	12362	3424	3441	533	486	544	522
2035	18743	15777	4370	4392	681	620	695	666
2040	23922	20136	5577	5606	869	791	887	850
2045	30531	25700	7118	7154	1109	1010	1132	1084

Source: JICA Survey Team

4.8 Further Revision of Traffic Projection

4.8.1 Justification for Further Revision

Traffic growth rate of 5% for NH208 has been assessed as reasonable in the JICA NH208 DPR Review Report from February 2020. However, the traffic diversion ratio for the projection could be revised if a broader scope is considered. According to the World Bank *Bangladesh Regional Connectivity Project 1* (expected completion in 2023), NH208 is considered as one of the planned freight transportation routes (as shown in Figure 4-2). The connection of Sabroom with Chittagong Port, makes the route the shortest link of India NE region to the sea port, which will play an extremely important role in the regional and international logistics network and have a huge impact on the future traffic.

Moreover, there are other socio-economic factors that could bring additional traffic to NH208. The Special Economic Zone in Sabroom, the Smart City planned for Agartala, as well as the development of India-Bangladesh Trade Agreement and the associated tax preference policy are anticipated to significantly increase trade and traffic between India and Bangladesh and Myanmar, and boost economy and generate new traffic which could be incorporated in the traffic projection.

Theoretically, there are three types of traffic growth:

Normal traffic. Normal traffic growth is based on historical trends of vehicle growth rates in relation to economic growth rates, and on the economic growth outlook for future years.

Diverted traffic. Diverted traffic has been estimated for all project roads based on an analysis of existing travel demand on competing corridor sections. The diverted volume is estimated based on the regional and national multi-model transport network configuration, current traffic volume and socio-economic situation, as well as the potential changes brought by new hard/soft infrastructure to the network.

Generated traffic. The magnitude of generated traffic depends on the estimated level of benefits accrued to the project by the improvement of road infrastructure. It considers the broader impact of transport infrastructure on the economy development and the extra created traffic flow.

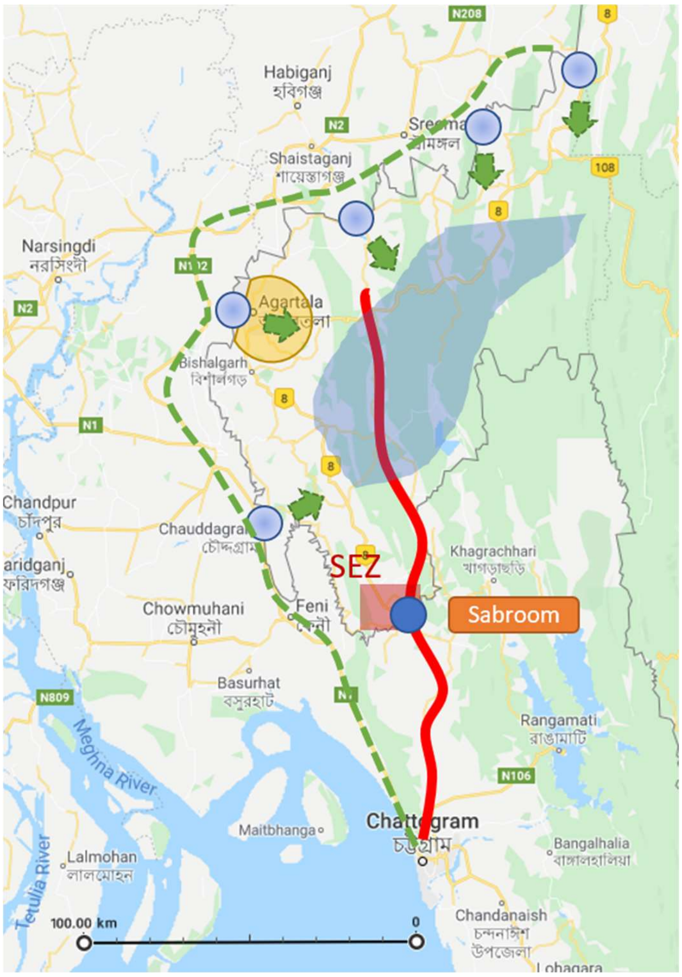
DPR has considered the normal traffic growth based on traffic survey data and socio-economic data. Using the elasticity approach, DPR proposed the 5% annual traffic growth rate for the entire route. In addition to that, JICA revision considered the traffic diversion from alternative National Highway routes (mainly NH 8) in a limited scope and estimated a 15% diversion at the time of road opening. However, the broader scope traffic diversion and the generated traffic are missing in the previous analysis.

Therefore, this traffic revision will focus on the diverted traffic from a broader scope and the generated traffic brought by the trade policy. In the following part of this section, firstly the respective impact of these factors on the traffic projection are analyzed. Then, the traffic growth rate in terms of vehicle types, route sections, and year ranges are summarized, based on which, the traffic projection is revised as the conclusion of the traffic analysis.

4.8.2 Diverted Traffic – Tripura State Level

The following map (Figure 4-7) shows the strategic role of NH208 for Tripura State when it is connected with Chittagong Port after opening.

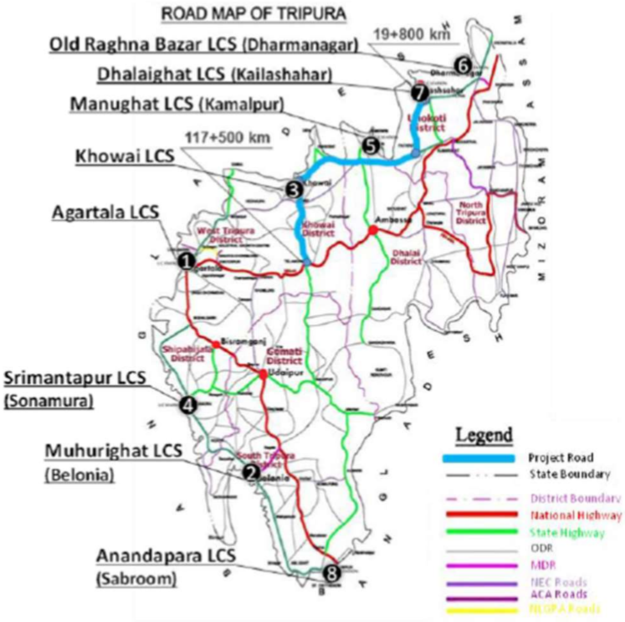
The red route above Sabroom is the NH208, while the section below is the freight transportation route that connects to Chittagong Port. The green dotted route is the current freight transportation route for commodities from Chittagong to Tripura State. The main existing Land Customs Stations (LCSs) are marked by the light blue circle, and the dark blue circle is the planned Sabroom LCS.



Source: JICA Survey Team

Figure 4-7: Strategic Role of NH208 for Tripura State

The introduction of Tripura's trade across the Bangladesh Border is necessary to understand the strategic role of NH208. There are eight Land Custom Stations (LCSs) as shown below in Figure 4-8, namely:1) Agartala LCS, 2) Muhurighat LCS (Belonia), 3) Khowai LCS, 4) Srimantapur LCS (Sonamura), 5) Manughat LCS (Kamalpur), 6) Old Raghna Bazar LCS (Dharmanagar), 7) Dhalaighat LCS (Kailashahar), 8) Anandapara LCS (Sabroom). Out of these, Dhalaighat LCS (Kailashahar) and Anandapara LCS (Sabroom) have no trade at present.



Source: JICA Survey Team

Figure 4-8: LCSs in Tripura

In term of the trade values, since the year 2006 -2007 when the border trade was launched in six LCSs, the trading value between Tripura and Bangladesh have increased from Rs. 49.56 Crores to Rs. 537.08 Crores in 12 years by the 2018-2019.[32] Import values account for more than 90% of the trading values, and the main commodity imported are Variety fish/Hilsa/Dry fish, and Food items/Drinks, as shown in Table 4-10.

Table 4-10: Composition of Commodity-wise Imports (2018-19)

Rs. In Crores

SI No.	Imports Commodity	Total Value
1.	Cement	68.13
2.	Variety fish/Hilsa/Dry fish	128.27
3.	Broken or Crushed stones	9.4
4.	Food items/Drinks	92.43
5.	Plastic Goods	30.05
6.	Other commodities	194.14
	Total	522.42

Source: JICA Survey Team

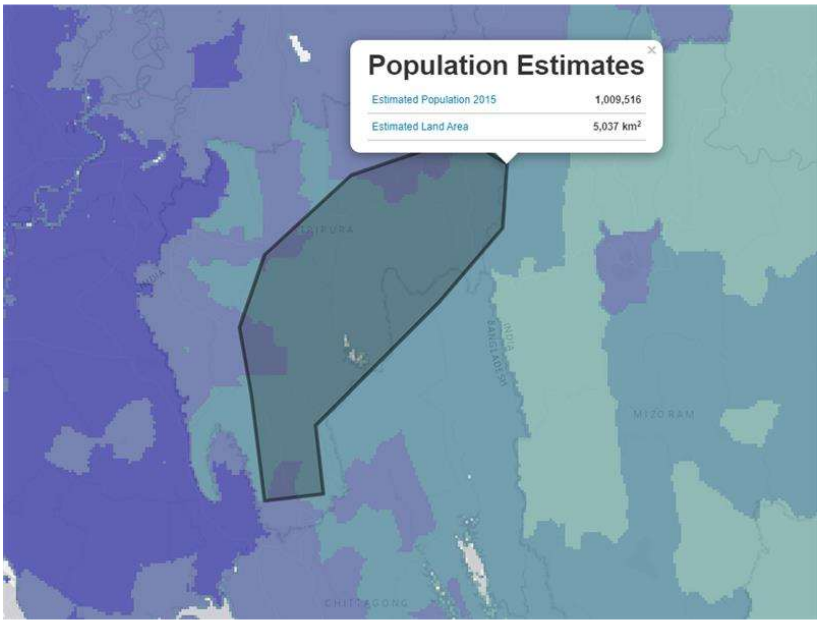
The rapid development of trade across the Bangladesh Border demonstrates the increase of demand from Tripura State, especially on the imported commodities from the sea side. Therefore, the role of the connection with Chittagong Port is essential for the State. NH208 will be the shortest route for the inner part of the State, and Sabroom LCS is expected to be the most important gateway in the future among the current LCSs in Tripura, considering its proximity to the port.

Part of the trade volume of Tripura will be diverted to Sabroom LCS after its opening. To estimate the diversion from existing LCSs to Sabroom LCS, the total trade volume of all LCSs and the portion of Sabroom LCS is needed. Each LCS has its own service area, or hinterland. For regions

[32] JICA, Basic Information and Data Collection Study on Connectivity Improvement in North Eastern Region of India, Volume II, February, 2020

near the exiting LCSs, such as Agartala City, the existing LCSs still remain as the good choice when the Sabroom LCS is in place, and the green dotted route will be the route for freight transportation for such regions as it is now. However, for the potential hinterland of Sabroom which is basically the inner part of the State as shown in blue color in Figure 4-7, NH208 would be the route for freight transportation from Chittagong Port. It is assumed that the demand of imported commodities is proportional to the population size. Therefore, by aggregating the population of the hinterland area of Sabroom LCS and comparing it with the total State population, the diverted portion for Sabroom LCS can be obtained.

According to the State Statistics Department, the population of Tripura State is 3.7 million in 2015 and is estimated to be 4 million in 2020. The population of the hinterland area is estimated based on an open source data on the spatial distribution of population that developed by Columbia University.[33] Based on this online tool, the population of the Sabroom Hinterland is around 1.0 million, roughly 25% of the total population of the State. Therefore, a 25% of the total trade volume and freight transportation of all existing LCSs would be diverted to Sabroom LCS after the opening.



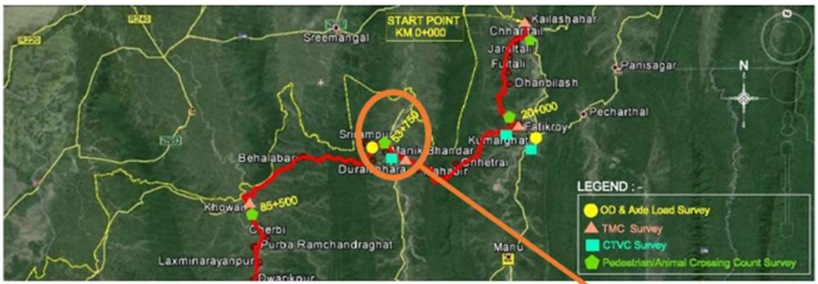
Source: JICA Survey Team

Figure 4-9: Population Estimation for Sabroom LCS Hinterland

It is worth noting that while the freight travelling north to the inner part of the hinterland, the freight will be discharged along the way, and the freight being transported further is assumed to be proportional with the hinterland area left - more accurately, the population of the remaining hinterland area. There are four survey sections for NH208 route: Km 132.800 (near Harina), Km 88.000 (near Ailmara), Km 42.300 (near Rangamati), and Ch.117+500 (near Trishabari), from south to north. Using the same method of population estimation and relating that to the diverted freight volume, there will be additional 25% of total freight transportation of all existing LCSs to the section of Km 132.800 (near Harina and Sabroom), 15% to the section of Km 88.000 (near Ailmara), and 5% to the section of Km 42.300 (near Rangamati). There will be no diverted traffic for Ch.117+500 (near Trishabari) as it is out of the Sabroom LCS hinterland and will be using the exiting LCS for freight transportation.

[33] Lind for the open source data on the spatial distribution of population: https://sedac.ciesin.columbia.edu/mapping/popest/gpw-v4/

In terms of the total traffic volume at LCSs, the data is not available for all LCSs. Fortunately, the traffic survey data for the road section near Manughat LCS (Kamalpur, see the location in Figure 4-10) is available from JICA Study Team's Kailashahar-Teliamura Section Report. The traffic survey is conducted in 2015, and the result is listed below.



Vehicle Type	19+800 Km	Kumarghat on NH-44	54+000 Km	117+500 Km
Two-Wheeler	741	863	750	1,898
Car/Jeep/Van/Taxi/Auto	1,089	1,361	794	1,856
Minibus	3	9	21	14
Standard Bus	0	31	3	31
LCV	62	168	122	216
2-Axle Truck	58	270	23	53
3-Axle Truck	1	115	0	4
Multi-Axle	1	257	0	17
Tractor with Trailer	0	0	1	0
Tractor Without Trailer	0	2	0	0
Cycle	1,357	359	1,005	1,694
Cycle Rickshaw	38	12	7	82
Hand Cart	14	11	3	16
Bullock Cart	2	0	0	0
Horse Cart	0	0	0	0
Total Motorized Vehicles (Number)	1,955	3,076	1,714	4,089
Total Non-Motorized Vehicles (Number)	628	382	1,015	1,792
Total Motorized Vehicles (PCU)	1,854	4,945	1,563	3,717
Total Non-Motorized Vehicles (PCU)	437	250	556	1,120
Total Commercial Vehicle per day	126	850	170	335
Total PCU per day	2,291	5,195	2,119	4,837

Source: JICA Survey Team based on DPR

Figure 4-10: Location and Traffic Survey Result of Manughat LCS

The focus of the traffic diversion is put on freight transportation related vehicle type, which are LCV, 2-Axle Truck, 3-Axle Truck, and Multi-Axle Truck as orange framed in the table. Manughat LCS operated 11.64 Rs. in terms of trade volume. To handle this trade volume, 122 LCVs and 23 2-Axle Trucks are necessary[34]. Of the same year (Year 2015), the total trade volume of Tripura State was 383.7 Rs. (see Table 4-11). Therefore, the total freight vehicle needed for transporting all trade volume is estimated to be 4067 LCVs and 767 2-Axle Trucks.

[34] Manughat LCS is a small LCS, and there is no record for 3- and Multi- Axle Truck in the traffic survey. It would be ideal to have Agartala LCS's traffic survey data as it is the largest LCS.

Table 4-11: Trade Volume of LCSs in Tripura (2014-19)

(unit: Rs. in cr.)

Sl. NO.	Year	Total				
		2014-15	2015-16	2016-17	2017-18	2018-19
1.	Agartala LCS	266.1	282.4	190.3	235.5	355.7
2.	Muhurighat LCS	34.83	38.62	43.55	40.06	45.42
3.	Khowai LCS	2.26	1.32	0.84	2.58	2.42
4.	Srimantapur LCS	43.97	48.44	58.82	93.30	96.4
5.	Manughat LCS	10.84	11.64	10.77	15.66	24.63
6.	Old Raghna Bazar LCS	0.63	1.26	0.50	3.66	12.54
Total		358.7	383.7	304.8	390.8	537.1

Source: JICA Survey Team based on DPR

Once the equation between quantity of freight vehicles and trade volume is established, 25% diversion can be translated into the absolute quantity of diverted freight traffic that can be added to the Sabroom traffic projection.

As discussed earlier in 4.3, the traffic survey for NH208 section is conducted in 2017. In 2017, the total trade volume is 390.8 Rs. (see Table 4-11), which is equivalent to a freight traffic of 4142 LCVs and 781 2-Axle Trucks. 25% of that is diverted to Sabroom LCS, which is the section of Km 132.800 (near Harina), so the diverted traffic volume is 1035 LCVs and 195 2-Axle Trucks.

Compared to the diverted traffic volume to the 2017 traffic survey result (Table 4-6), the increase is significant. Under such a hypothetical traffic diversion in 2017, the traffic of LCVs increases from 20 to 1035 and 2-Axle Truck increased from 10 to 195, corresponding to a traffic growth of 5175% and 1950%, respectively. With all else being equal, this traffic increase rate should be the same till the year 2025 when the LCS is open.

Following the same method, the diverted traffic is calculated for other sections, and the result is summarized in Table 4-12.

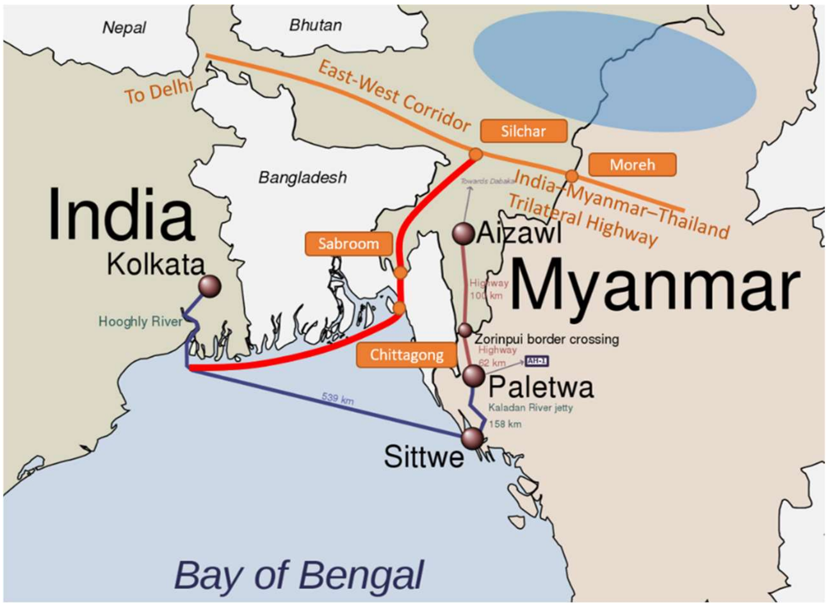
Table 4-12: Summary of Traffic Diversion and Growth Rate

Section 1	Ch.117+500 (near Trishabari)			
	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck
2017 freight traffic added (**0%** diversion)	0	0	0	0
2017 traffic survey	305	76	6	24
traffic growth rate for 2025 opening	0%	0%	0%	0%
Section 2	Km 42.300 (near Rangamati)			
	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck
2017 freight traffic added (**5%** diversion)	207	39	0	0
2017 traffic survey	115	67	36	1
traffic growth rate for 2025 opening	180%	58%	0%	0%
Section 3	Km 88.000 (near Ailmara)			
	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck
2017 freight traffic added (**15%** diversion)	621	117	0	0
2017 traffic survey	15	7	6	0
traffic growth rate for 2025 opening	4140%	1671%	0%	0%
Section 4	Km 132.800 (near Harina)			
	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck
2017 freight traffic added (**25%** diversion)	1035	195	0	0
2017 traffic survey	20	10	4	0
traffic growth rate for 2025 opening	5175%	1950%	0%	0%

Source: JICA Survey Team

4.8.3 Diverted Traffic – Regional and Global Level

To estimate the diverted traffic on a broader scope, it is important to understand the role of NH208 at the regional and global level. The India NE region is connected by land with the rest of India through West Bengal and is critically located for the integration with its neighbors in South and South East Asia. The regional connectivity projects, including the National Highway Development Project, Bharatmala Project, North-East Road Network Connectivity Project, among others, are discussed in Chapter 2. Once in place, NH208 will be integrated into the regional connectivity network. It does not only provide an alternate outlet to the landlocked NE region which is heavily dependent on the narrow ‘Chicken’s Neck’ at Siliguri but also enhances cross border trade between India and Myanmar.



Source: JICA Survey Team

Figure 4-11: NE Regional Connectivity Network

As shown in Figure 4-11, NH208 (the red route) joins the East-West Economic Corridor (the orange route) at Silchar. The corridor runs through the NE region, connecting the mainland of India to the west, and extending to the east where it merges with the India-Myanmar-Thailand Trilateral Highway at Moreh City, the largest Indo-Myanmar LCS for now.

In 2008, the Govt. of India and the Govt. of Myanmar reached an Agreement to facilitate the cross border trade between the two countries, and to develop the transport route to the India NE region through Myanmar, after the initial effort made by India failed in persuading Bangladesh to offer transport and transit rights to the NE region, including the access to Chittagong Port. Under the Agreement, the Kaladan Multimodal Transport Project, a multimodal transit route (Figure 4-11), was implemented.

Table 4-13: Components of Kaladan Multimodal Transit Transport Project

Stretch	Mode	Distance
Kolkata to Sittwe port in Myanmar	Shipping	539 km
Sittwe to Paletwa (River Kaladan)	IWT	158 km
Paletwa to Indo-Myanmar Border(in Myanmar	Road	110 km
Border to NH.54 (Lawngtlai) (in India)	Road	100 km

Source: Ministry of Development of North Eastern Region

The Kaladan Multi-Modal Transport Project is designed to link Kolkata and Sittwe in Myanmar by sea (539 km) – link Sittwe to Paletwa jetty by Kaladan river (158 km) – road link Palewa to Indo-Myanmar border (110 km) – road link Indo-Myanmar border to Lawangtlai in Mizoram (100 km) – continuing further to Dabaka in Assam (850 km long NH-54) and rest of India's road network[35] (Table 4-13). Once completed, this project will reduce the travel distance from Kolkata to Sittwee by approximately 1328 km and will reduce the need to transport goods through the narrow Chicken's Neck for the NE region.

[35] Data Collection Survey on National Logistics in the Republic of the Union of Myanmar, JICA, 2018

However, with the construction of NH208, especially the establishment of linkage with Chittagong Port, it is obvious that the alternative red route in Figure 4-11, which is also a multi-modal transit route including a waterway component from Kolkata to Chittagong and a land way component (mainly the NH208), has an advantage over the Kaladan route in terms of distance traveled.[36] For the same Origin-Destination of Kolkata and Silchar, the distance can be 200 km shorter. Therefore, it is safe to assume a notable traffic diversion from the Kaladan route to the red route, or NH208.

Taking a broader view, the hinterland of the envisaged route is even larger. The landlocked inner NE region and the vast north part of Myanmar (colored in bule in Figure 4-11) can be the benefited area of the route, as it is the shortest link to the seaport for this region. The main commodities transported for this region are construction materials such as coal, stone, sands, aggregate, cement, etc., as well as the daily necessities of fresh and dry fish, PVC items, cotton, oil, and so on. These commodities heavily rely on the supply from the mainland and the sea area. Therefore, the freight transportation demand will be high if the route is open.[37]

Box 4-1 Importance of Seaport Linkage to Landlocked Area: Case of Nepal

Nepal is a landlocked country in South Asia. Over the past decade and a half in particular, Nepal has invested in the main corridor linking it to the Kolkata port complex in India. In the late 1990s, with support from the World Bank, major border crossing points with connection to Kolkata was constructed as the largest trans-loading mode for Nepal's international trade.

The connection now (as of 2014) handles more than 60% of Nepal's containerized third-country trade traffic. This case shows the importance of seaport linkage to landlocked area. NH208 will play a vital role for the landlocked inner NE region and the vast north part of Myanmar.

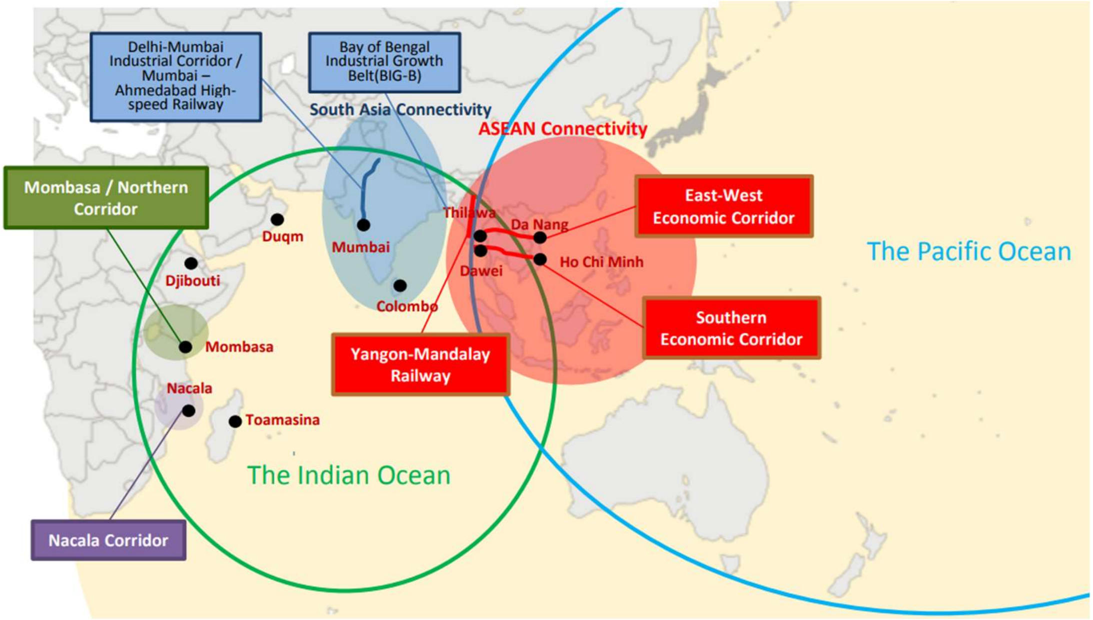
Source: Improving Trade and Transport for Landlocked Developing Countries, World Bank, 2014 (https://www.tralac.org/images/docs/6592/improving-trade-and-transport-for-ldcs report.pdf)

At the global level, NH208 and the connection with Chittagong Port is a key mode for international logistics network. The NE region and the surrounding regions are the "hinge" of the Indian Ocean and the Pacific Ocean, as described by the Japanese Initiatives of Free and Open Indo-Pacific (FOIP).[38]

36 The advantage also includes the road condition. It is reported that the road link from Palewa to Indo-Myanmar border is with issues of floods, landslides, road blockages, and local unrest. These issues affected the freight transportation. The planed NH208 will be a better choice in terms of improved road condition. (source: JICA Myanmar Report, 2018)

37 Another justification for the traffic demand is the low trade volume between Indo-Myanmar. Most cross-border trade in India's NE region is conducted through the Moreh LCS. Yet, trade at this LCS has represented less than 1% of India's total trade with Myanmar in the last decade. This is in contrast with border trading activities on the China–Myanmar and Thailand–Myanmar borders. According to Myanmar's Department of Border Trade, border trade with the China surpassed $7.8 billion in the four years to FY2011, while border trade with India reached only about $66 million. Border trade with Thailand surpassed $1.5 billion during the same period and border trade with Bangladesh was more than $117 million. There is the huge potential of trade development between Indo-Myanmar, and as a result the freight transportation would increase a lot.

38 Ministry of Foreign Affairs of Japan, https://www.mofa.go.jp/files/000430632.pdf.



Source: Ministry of Foreign Affairs of Japan

Figure 4-12: NE Regine as the Hinge for Free and Open Indo-Pacific (FOIP)

FOIP is proposed by Prime Minister Shinzo Abe at the Tokyo International Conference on African Development VI (TICAD VI) held in Kenya in 2016. By positioning fast-growing Asia and high-potential Africa as important regions, the strategy aims for economic growth of the entire region connected by the Indian Ocean and the Pacific Ocean. FOIP promotes free trade and infrastructure investment, including the East -West Economic Corridor in South East Asia, Mombasa Corridor in Africa, and the Bay of BENGAL Industrial Growth Belt (BIG-B) in South Asia, as shown in Figure 4-12. Therefore, NH208 enhances the connectivity between Asia and Africa under FOIP.

The NE region is located between China and India, the 2nd and 6th largest economy in the world. In 2015, China proposed including the Bangladesh, China, India and Myanmar Economic Corridor (BCIM) as part of its vision for the One Belt One Road Initiative (OBOR). The OBOR was supported by India from the start. The BCIM Corridor covers 1.65 million square kilometers, encompassing an estimated 440 million people in China's southwest provinces, Bangladesh, Myanmar, and the NE region of India through the combination of road, rail, water and air linkages in the region. The BCIM envisages greater market access for goods and services, elimination of trade barriers and better trade facilitation, and investment in infrastructure development.[39]

The trade volume between China and India is substantial and will increase with the rapid economic growth of the two countries. In general, the trade route can be classified into the sea route and sea-land route, as illustrated by blue and green dotted line in Figure 4-13, respectively. For the sea route, commodities from India first go the southeast direction for the Strait of Malacca, then travel north to Hong Kong, and finally reaches China's southwest provinces, such as Kunming and Chongqing. For the sea-land route, the first step is to cross the sea for the Dawei Port of Myanmar where commodities lands on Indochina Peninsula, and then shifted north by land transportation through the hilly area to China.

[39] Source: https://en.wikipedia.org/wiki/BCIM_Economic_Corridor

Source: JICA Survey Team

Figure 4-13: China-India Trade Route

With the opening of NH208, a much shorter sea-land route for Indo-China trade can be expected. NH208 connects the Chittagong Port with the BCIM Corridor. Commodities from India can be transported to Chittagong Port first (the red route), go through NH208 and take the advantage of the BCIM Corridor to China. The distance saved will be substantial compared to the blue and green route. Therefore, the traffic diversion from global logistics network can be expected in the future.

At the current state, it is difficult to estimate the potential traffic diversion after the road opening. All the broader scope connectivity projects, including the Kaladan Multi-Modal Transport Project at the regional level and the BCIM Corridor or OBOR at the global level, are in progress. The lack of actual traffic data, and the complexity of logistics network at the broader scope make the estimation impossible though a significant traffic diversion can be justified.

In this report, it is conservatively estimated that the traffic diversion will create a 10% annual increase of the freight traffic on all sections of NH208 route when opened. Considering the broad scope and large volume of international trade, the diversion may take years before stabilization. Therefore, a five-year period (2026-2030) is set for this 10% annual increase.

4.8.4 Generated Traffic – Indo-Bangladesh Trade Agreement

Up to now, the traffic projection has considered the traffic diversion from the improvement of hard transport infrastructure projects. However, from the transport economics perspective, the rational travel choice is made based on the generalized cost, which consists of the road toll, time cost, and other costs such as service fee at Customs. This section will focus on the "soft infrastructure" of Indo-Bangladesh Trade Agreement, to investigate how the traffic projection is affected by the associated cross-border time reduce and procedure fee reduce under the Trade Agreement.

As introduced in Chapter 2, the restrictions on Indo-Bangladesh cross border trade remains though effort are being made. In October 2018, the Ministry of Shipping, Road Transport and Highways, India, and the Ministry of Shipping, Bangladesh signed an Agreement to allow the transport of goods between Chittagong Port and India. Following that, some negotiations were held in 2019 and early 2020, but the Agreement is still not fully reached. Interested reader could go to Chapter 2 for details. In general, the main points covered by Indo-Bangladesh Trade Agreement are:

- Standardization of customs operation procedures and fees, removal of restrictions for a free trade environment.
- Designated trade route and goods loading space, including the infrastructure development of NH208 route, the Feni River Bridge, the Ramgarh-Chittagong route in Bangladesh territory, and Sabroom LCS and SEZ (SEZ will be discussed in next section).
- Motor Vehicles Agreements (MVAs) for free vehicle entry (such as Bangladesh-Bhutan-India-Myanmar Motor Vehicles Agreement in 2015) without the requirement for transshipment of goods from one country's truck to another at the border.

These points are extremely important and are in line with the World Bank’s Guideline on the development of well-functioning domestic and international logistics (see Box 4-2). If fully achieved, the Trade Agreement will smoothen border procedures, lower the cross-border cost, and save trade time significantly.

Box 4-2 World Bank's Logistics Performance Index (LPI)

Logistics is understood as a network of services that support the physical movement of goods, trade across borders, and commerce within borders. It comprises an array of activities beyond transportation, including warehousing, brokerage, express delivery, terminal operations, and related data and information management.

The World Bank's Logistics Performance Index (LPI) is a unique benchmarking tool for the logistics performance evaluation. It analyzes countries through six indicators:

1. The efficiency of customs and border management clearance.
2. The quality of trade- and transport-related infrastructure.
3. The ease of arranging competitively priced international shipments.
4. The competence and quality of logistics services.
5. The ability to track and trace consignments.
6. The frequency with which shipments delivery on time.

The LPI covers more than 160 countries, and the score for 2018 Logistics Performance Index is as follow.

India has a score of 3.22 in the 5.00 point scale, ranking the 42th and Bangladesh has a score of 2.60, ranking the 100th. Both need improvement. The six indicators are indicative and are emphasized in the Indo-Bangladesh Trade Agreement.

Source: Connecting to Compete 2018 Trade Logistics in the Global Economy, World Bank, 2018. (https://openknowledge.worldbank.org/bitstream/handle/10986/29971/LPI2018.pdf)

The following table (Table 4-14) shows the cross-border time of India NE region in 2013, in comparison with Country's average of India, Bangladesh, and OECD countries as a whole.

Table 4-14: Cross-border Time Comparison

Indicator	NE	India	Bangladesh	OECD
Documents to export (number)	8	9	6	4
Time to export (days)	22	16	25	10
Cost to export (US$ per container)	713	1,120	1,025	1,028
Documents to import (number)	9	11	8	5
Time to import (days)	28	20	34	10
Cost to import (US$ per container)	794	1,200	1,430	1,080

Source: Developing Cross-Border Production Networks between North Eastern Region of India, Bangladesh and Myanmar: A Preliminary Assessment, Research and Information System for Developing Countries, 2014

As of 2013, it took India 16 days to export a container load of goods and Bangladesh about 25 days, compare to that of the India NE region's 22 days. For time to import, India took 20 days and Bangladesh took 34 days, compare to that of the India NE region's 28 days. In contrast, OECD countries only needed 10 days for both export and import. For the time needed for export and import documents, the Indo-Bangladesh Trade also took a long time, more than 2 times of that needed for OECD countries. In addition, in terms of the costs to export and import goods, the export cost was relatively expensive in India as compared to Bangladesh, whereas Bangladesh had relatively higher import costs than India.

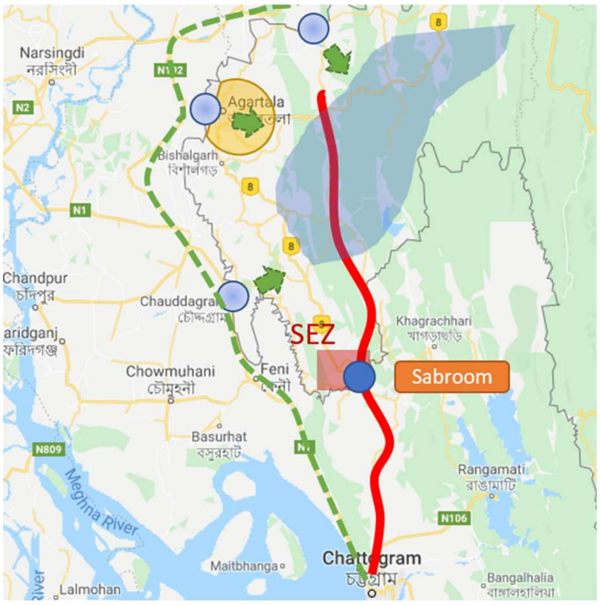
There is a huge space for the improvement of cross-border time. However, the question is how much traffic would be generated with the improvement of cross-border time. In one study on Rusumo OSBP by JICA Study Team[40], it concludes that when the customs clearing time reduced to one-third, the amount of freight traffic doubled. The traffic increase may attribute to other factors such as improvement of road conditions and general economy development. Therefore, for the case of Indo-Bangladesh Trade, it is considered that the shortening of the cross-border time of one-third would newly generate a half of the freight traffic.

Since the Indo-Bangladesh Trade Agreement negotiations are still underway, it is expected that incremental progress could be made annually. By the year of NH208 road opening in 2025, a remarkable Indo-Bangladesh Trade Agreement could be in place to make the best use of the new trade route from Chittagong Port to Sabroom and NH208. Therefore, from the year 2021 to 2025, an annual 8% growth of freight traffic is assumed on all sections of NH208. Under such assumption, the freight traffic volume increases to about 1.5 times ($1.08^5 = 1.47$) in a 5-year period. The assumption can be justified if a one-third cross-border time reduce can be achieved, which is reasonable considering the current long cross-border time and the positive negotiations underway.

4.8.5 Generated Traffic – Sabroom SEZ

To further improve the capacity of Sabroom LCS for the projected trade development, and to stimulate the economy of South Tripura region, Tripura Industrial Development Corporation (TIDC) under the Government of Tripura has introduced the planning of Tripura's first Special Economic Zone (SEZ) in Sabroom. The location of Sabroom SEZ is marked in Figure 4-14.

[40] JICA: Facilitation of border procedures in Africa: When transport and logistics between countries change, so do people's lives (https://www.jica.go.jp/english/news/field/2017/180124_01.html)



Source: JICA Survey Team

Figure 4-14: Location of Sabroom SEZ

SEZ can be regarded as the advanced form of LCS. An LCS provides services for the handling and temporary storage of containers, general and/or bulk cargoes that enters or leaves the station, and inspection and customs clearance of freight moving in international trade. On top of LCS, SEZs are more capable in the reconciliation of transport infrastructure and supply chain management, shifting distribution function from seaport terminals, and adding value to market players.

The Sabroom SEZ is expected to accommodate Agro-food processing industries, bamboo and rubber industries, and textile industries. The functional capacity of SEZ can drive promotion of agriculture and horticulture, sericulture, fisheries, handloom, and related manufacturing and services which are the predominant sectors of South Tripura.

After the SEZ is set up, it will enjoy the following preferential tax treatment[41]:

- 100 percent income tax exemption will be provided for the first 5 years.
- 50 percent exemption will be provided for the next 5 years.

According to a research conducted by ADB in 2017, a similar tax incentive program was implemented for some districts in India during the period 1994-2000 (see Box 4-3). The program's 5-year tax exemption led to a significant increase in firm entry and employment, and a general 30% of economic growth was achieved.

The same economic growth during the 5-year preferential tax treatment period can be expected for the Sabroom SEZ. Suppose the SEZ functions after the NH208 route opening in 2025, then a total 30% growth can be translated into an annual growth of 5% ($1.05^5 = 1.28$) for the next 5-year period (2026-2030). Assuming that the general traffic growth is the same as the general economic growth rate, the traffic growth rate will be 5% for all vehicle types for the year 2026-2030, as the generated traffic from the development of Sabroom SEZ.

[41] TRIPURA GETS ITS FIRST SEZ (http://www.maritimegateway.com/tripura-gets-first-sez/)

Box 4-3 Tax Incentive Program in India (1994-2000)

The Government of India initiated a tax incentive program in 1994 to promote economy in districts designated as backward. A composite index was developed based on eight financial, infrastructural, and industrial indicators to approximate a district's degree of development. For the targeted 14 States, about 120 districts were selected for the program, as listed below.

State Name	Backward Group 1	Backward Group 2	Backward Group 3	Backward Total	Nonbackward Group 4	Nonbackward Group 5	Nonbackward Group 6	Nonbackward Total
Andhra Pradesh	–	–	2	2	–	9	12	21
Bihar	19	10	4	33	3	1	5	9
Gujarat	–	2	1	3	–	1	15	16
Haryana	–	–	–	–	–	1	15	16
Karnataka	–	–	1	1	3	4	12	19
Kerala	2	–	–	2	1	2	9	12
Madhya Pradesh	3	7	8	18	10	5	12	27
Maharashtra	1	–	1	2	7	6	15	28
Orissa	2	2	2	6	3	1	3	7
Punjab	–	–	–	–	–	–	12	12
Rajasthan	2	6	4	12	4	3	8	15
Tamil Nadu	–	–	–	–	2	3	16	21
Uttar Pradesh	6	16	13	35	5	5	18	28
West Bengal	6	2	1	9	1	–	5	6
Total	41	44	38	123	39	41	157	237

The program offered new industrial undertakings in the backward districts a tax holiday in which firms are granted tax deductions of 100% of profits and gains for the first 5 assessment years.

Based on the regression analysis, the program's 5-year tax exemption led to a significant increase in economy. Specifically,

- Backward districts have experienced 32% growth in firm entry.
- Employment of the backward districts by 15% in general.
- In addition, the employment in the qualified sectors went up by 30%.

Source: Place-Based Preferential Tax Policy and Its Spatial Effects: Evidence from India's Program on Industrially Backward Districts, ADB, 2017. (https://www.adb.org/sites/default/files/publication/379681/ewp-524.pdf)

It is worth noting that under the Smart Cities Mission by the Government of India, Agartala of Tripura was selected as one of the 100 cities in India where the urban renewal and retrofitting program would be implemented (see Figure 4-14 for the location of Agartala Smart City). The Agartala Smart City focuses on urban development and recreation of commercial, trade, and logistics hubs and skill development centers, implementation of smart network and rapid transit system, etc.

In terms of impact of Agartala Smart City on traffic projection, the following considerations are taken. First, the smart city is planned for the Agartala, a city not directly linked with the NH208 route. The traffic on NH208 route may increase as the Smart City promotes the economy for the whole region but may also decrease as more traffic is attracted to Agartala. Second, some smart city practices have witnessed the decrease of traffic volume after the introduction of smart urban traffic. Therefore, the impact of Smart City on traffic is not clear at current stage and thus not considered in this projection

4.8.6 Final Traffic Projection

Based on DPR's traffic projection and JICA's revision, this sub-section considered the traffic diversion and generation on a broader scope. The traffic growth rate, in terms of vehicle types, NH208 sections, and year ranges are summarized in Table 4-15.

Based on the traffic growth rate, the traffic projection for each route section is revised, and the result is listed in Table 4-16, Table 4-17, Table 4-18, and Table 4-19.

Finally, a summary of the final traffic projection is provided in Table 4-20.

Table 4-15: Summary of Traffic Growth Rate

Category	Period	At Ch.117+500 (near Trishabari)					Km 42.300 (near Rangamati)					Km 88.000 (near Ailmara)					Km 132.800 (near Harina)				
		LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles
Diverted Traffic – Tripura State Level	2025 (opening diversion)	0%	0%	0%	0%	0%	180%	58%	0%	0%	0%	4140%	1671%	0%	0%	0%	5175%	1950%	0%	0%	0%
Diverted Traffic – Regional and Global Level	2026-2030	10%	10%	10%	10%	0%	10%	10%	10%	10%	0%	10%	10%	10%	10%	0%	10%	10%	10%	10%	0%
Generated Traffic – Trade Agreement	2021-2025	8%	8%	8%	8%	0%	8%	8%	8%	8%	0%	8%	8%	8%	8%	0%	8%	8%	8%	8%	0%
Generated Traffic – Sabroom SEZ	2026-2030	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
DPR Base Growth Rate	2017 (base year)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2018	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2019	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2020	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2021-2025	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2025 (opening diversion)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	2026-2030	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2031-2035	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2036-2040	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2041-2045	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
JICA Traffic Revision	2025 (opening diversion)	69%	82%	88%	83%	0%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Total Traffic Growth Rate	2017 (base year)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2018	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2019	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2020 (now)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2021-2025	13%	13%	13%	13%	5%	13%	13%	13%	13%	5%	13%	13%	13%	13%	5%	13%	13%	13%	13%	5%
	2025 (opening diversion)	69%	82%	88%	83%	0%	195%	73%	15%	15%	15%	4155%	1686%	15%	15%	15%	5190%	1965%	15%	15%	15%
	2026-2030	20%	20%	20%	20%	10%	20%	20%	20%	20%	10%	20%	20%	20%	20%	10%	20%	20%	20%	20%	10%
	2031-2035	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2036-2040	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	2041-2045	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Category	Period	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck	Other vehicles
		At Ch.117+500 (near Trishabari)					Km 42.300 (near Rangamati)					Km 88.000 (near Ailmara)					Km 132.800 (near Harina)				

Source: JICA Survey Team

Table 4-16: Traffic Projection for Section 1 of NH208

At Ch.117+500 (near Trishabari)

Years	Two Wheeler	Car/Jeep/Van/Taxi/Auto	Mini Bus	Standard Bus	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle	Tractor With Trailer	Tractor Without Trailer	Cycle	Cycle Rickshaw	Hand Cart	Bullock Cart	Horse Cart	Others	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2015	2131	2225	18	40	277	69	5	22	1	0	2012	97	10	0	0	0	**6907**	**5409**
2016	2238	2336	19	42	291	72	5	23	1	0	2113	102	11	0	0	0	**7252**	**5679**
2017	2349	2453	20	44	305	76	6	24	1	0	2218	107	11	0	0	0	**7615**	**5963**
2018	2467	2576	21	46	321	80	6	25	1	0	2329	112	12	0	0	0	**7996**	**6261**
2019	2590	2705	22	49	337	84	6	27	1	0	2446	118	12	0	0	0	**8396**	**6574**
2020	2720	2840	23	51	354	88	6	28	1	0	2568	124	13	0	0	0	**8815**	**6903**
2021	2856	2982	24	54	399	100	7	32	1	0	2696	130	13	0	0	0	**9294**	**7323**
2022	2999	3131	25	56	451	112	8	36	1	0	2831	136	14	0	0	0	**9802**	**7774**
2023	3148	3287	27	59	510	127	9	41	1	0	2973	143	15	0	0	0	**10341**	**8259**
2024	3306	3452	28	62	576	144	10	46	2	0	3121	150	16	0	0	0	**10913**	**8780**
Expected Road Openining 2025	3471	3624	29	65	651	162	12	52	2	0	3277	158	16	0	0	0	11520	9342
Diverted Traffic (No.)	0	0	0	6	11	106	50	83	0	0	0	0	0	0	0	0	256	876
Diverted Traffic (%)	*0%*	*0%*	*0%*	*86%*	*69%*	*82%*	*88%*	*83%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*		
2025 (Total with diverted traffic)	**3471**	**3624**	**29**	**71**	**662**	**268**	**62**	**135**	**2**	**0**	**3277**	**158**	**16**	**0**	**0**	**0**	**11776**	**10218**
2026	3818	3987	32	78	795	322	74	162	2	0	3605	174	18	0	0	0	**13067**	**11499**
2027	4200	4385	35	86	954	386	89	194	2	0	3966	191	20	0	0	0	**14509**	**12960**
2028	4620	4824	39	95	1145	464	107	233	2	0	4362	210	22	0	0	0	**16122**	**14628**
2029	5082	5306	43	104	1373	556	128	279	2	0	4798	231	24	0	0	0	**17929**	**16539**
2030	5590	5837	47	115	1648	667	154	335	3	0	5278	254	26	0	0	0	**19955**	**18730**
2031	5870	6129	50	120	1731	701	161	352	3	0	5542	267	28	0	0	0	**20953**	**19666**
2032	6163	6435	52	126	1817	736	169	370	3	0	5819	281	29	0	0	0	**22001**	**20649**
2033	6472	6757	55	133	1908	773	178	388	3	0	6110	295	30	0	0	0	**23101**	**21682**
2034	6795	7095	57	139	2003	811	187	408	3	0	6416	309	32	0	0	0	**24256**	**22766**
2035	7135	7450	60	146	2104	852	196	428	3	0	6736	325	33	0	0	0	**25468**	**23904**
2036	7492	7822	63	154	2209	895	206	449	4	0	7073	341	35	0	0	0	**26742**	**25100**
2037	7866	8213	66	161	2319	939	216	472	4	0	7427	358	37	0	0	0	**28079**	**26355**
2038	8260	8624	70	169	2435	986	227	495	4	0	7798	376	39	0	0	0	**29483**	**27672**
2039	8672	9055	73	178	2557	1036	238	520	4	0	8188	395	41	0	0	0	**30957**	**29056**
2040	9106	9508	77	187	2685	1087	250	546	4	0	8598	414	43	0	0	0	**32505**	**30509**
2041	9561	9983	81	196	2819	1142	263	573	4	0	9027	435	45	0	0	0	**34130**	**32034**
2042	10039	10482	85	206	2960	1199	276	602	5	0	9479	457	47	0	0	0	**35837**	**33636**
2043	10541	11006	89	216	3108	1259	290	632	5	0	9953	480	49	0	0	0	**37629**	**35318**
2044	11069	11557	93	227	3263	1322	304	664	5	0	10450	504	52	0	0	0	**39510**	**37083**
2045	11622	12135	98	238	3426	1388	319	697	5	0	10973	529	55	0	0	0	**41485**	**38938**

Source: JICA Survey Team

Table 4-17: Traffic Projection for Section 2 of NH208

Km 42.300 (near Rangamati)																		
Years	Two Wheeler	Car/Jeep/Van/Taxi/Auto	Mini Bus	Standard Bus	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle	Tractor With Trailer	Tractor Without Trailer	Cycle	Cycle Rickshaw	Hand Cart	Bullock Cart	Horse Cart	Others	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2017	376	564	64	19	115	67	36	1	0	0	328	2	0	0	0	7	1579	1587
2018	395	592	67	20	121	70	38	1	0	0	344	2	0	0	0	7	1658	1666
2019	415	622	71	21	127	74	40	1	0	0	362	2	0	0	0	8	1741	1750
2020	435	653	74	22	133	78	42	1	0	0	380	2	0	0	0	8	1828	1837
2021	457	686	78	23	150	88	47	1	0	0	399	2	0	0	0	9	1940	1974
2022	480	720	82	24	170	99	53	1	0	0	419	3	0	0	0	9	2059	2124
2023	504	756	86	25	192	112	60	2	0	0	440	3	0	0	0	9	2188	2287
2024	529	794	90	27	217	126	68	2	0	0	462	3	0	0	0	10	2327	2467
Expected Road Opening 2025	556	833	95	28	245	143	77	2	0	0	485	3	0	0	0	10	2476	2663
Diverted Traffic (No.)	83	125	14	4	478	105	12	0	0	0	73	0	0	0	0	2	896	1311
Diverted Traffic (%)	*15%*	*15%*	*15%*	*15%*	*195%*	*73%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*		
2025 (Total with diverted traffic)	**639**	**958**	**109**	**32**	**724**	**248**	**88**	**2**	**0**	**0**	**557**	**3**	**0**	**0**	**0**	**12**	**3373**	**3975**
2026	703	1054	120	36	868	297	106	3	0	0	613	4	0	0	0	13	3816	4582
2027	773	1160	132	39	1042	356	127	4	0	0	674	4	0	0	0	14	4325	5293
2028	850	1275	145	43	1250	428	153	4	0	0	742	5	0	0	0	16	4910	6125
2029	935	1403	159	47	1500	513	183	5	0	0	816	5	0	0	0	17	5585	7101
2030	1029	1543	175	52	1800	616	220	6	0	0	898	5	0	0	0	19	6364	8248
2031	1080	1620	184	55	1890	647	231	6	0	0	942	6	0	0	0	20	6682	8660
2032	1134	1702	193	57	1985	679	242	7	0	0	990	6	0	0	0	21	7016	9093
2033	1191	1787	203	60	2084	713	254	7	0	0	1039	6	0	0	0	22	7367	9548
2034	1251	1876	213	63	2188	749	267	7	0	0	1091	7	0	0	0	23	7735	10025
2035	1313	1970	224	66	2298	786	280	8	0	0	1146	7	0	0	0	24	8122	10526
2036	1379	2068	235	70	2413	825	294	8	0	0	1203	7	0	0	0	26	8528	11053
2037	1448	2172	246	73	2533	867	309	9	0	0	1263	8	0	0	0	27	8954	11605
2038	1520	2280	259	77	2660	910	325	9	0	0	1326	8	0	0	0	28	9402	12186
2039	1596	2394	272	81	2793	955	341	9	0	0	1392	8	0	0	0	30	9872	12795
2040	1676	2514	285	85	2933	1003	358	10	0	0	1462	9	0	0	0	31	10366	13435
2041	1760	2640	300	89	3079	1053	376	10	0	0	1535	9	0	0	0	33	10884	14107
2042	1848	2772	315	93	3233	1106	395	11	0	0	1612	10	0	0	0	34	11428	14812
2043	1940	2910	330	98	3395	1161	414	12	0	0	1692	10	0	0	0	36	12000	15552
2044	2037	3056	347	103	3565	1219	435	12	0	0	1777	11	0	0	0	38	12600	16330
2045	2139	3208	364	108	3743	1280	457	13	0	0	1866	11	0	0	0	40	13230	17147

Source: JICA Survey Team

Table 4-18: Traffic Projection for Section 3 of NH208

Km 88.000 (near Ailmara)																		
Years	Two Wheeler	Car/Jeep/Van/Taxi/Auto	Mini Bus	Standard Bus	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle	Tractor With Trailer	Tractor Without Trailer	Cycle	Cycle Rickshaw	Hand Cart	Bullock Cart	Horse Cart	Others	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2017	66	90	6	1	15	7	6	0	0	0	55	0	0	0	0	0	**246**	**224**
2018	69	95	6	1	16	7	6	0	0	0	58	0	0	0	0	0	**258**	**235**
2019	73	99	7	1	17	8	7	0	0	0	61	0	0	0	0	0	**271**	**247**
2020	76	104	7	1	17	8	7	0	0	0	64	0	0	0	0	0	**285**	**259**
2021	80	109	7	1	20	9	8	0	0	0	67	0	0	0	0	0	**302**	**278**
2022	84	115	8	1	22	10	9	0	0	0	70	0	0	0	0	0	**320**	**298**
2023	88	121	8	1	25	12	10	0	0	0	74	0	0	0	0	0	**339**	**320**
2024	93	127	8	1	28	13	11	0	0	0	77	0	0	0	0	0	**360**	**345**
Expected Road Openining 2025	98	133	9	1	32	15	13	0	0	0	81	0	0	0	0	0	382	371
Diverted Traffic (No.)	15	20	1	0	1329	252	2	0	0	0	12	0	0	0	0	0	1631	2791
Diverted Traffic (%)	*15%*	*15%*	*15%*	*15%*	*4155%*	*1686%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*		
2025 (Total with diverted traffic)	**112**	**153**	**10**	**2**	**1361**	**267**	**15**	**0**	**0**	**0**	**93**	**0**	**0**	**0**	**0**	**0**	**2013**	**3162**
2026	123	168	11	2	1634	320	18	0	0	0	103	0	0	0	0	0	**2379**	**3767**
2027	136	185	12	2	1960	384	21	0	0	0	113	0	0	0	0	0	**2814**	**4490**
2028	149	204	14	2	2352	461	25	0	0	0	124	0	0	0	0	0	**3332**	**5355**
2029	164	224	15	2	2823	553	31	0	0	0	137	0	0	0	0	0	**3949**	**6389**
2030	181	246	16	3	3387	664	37	0	0	0	151	0	0	0	0	0	**4684**	**7627**
2031	190	259	17	3	3557	697	38	0	0	0	158	0	0	0	0	0	**4918**	**8008**
2032	199	272	18	3	3735	732	40	0	0	0	166	0	0	0	0	0	**5164**	**8408**
2033	209	285	19	3	3921	768	42	0	0	0	174	0	0	0	0	0	**5422**	**8829**
2034	220	299	20	3	4117	807	45	0	0	0	183	0	0	0	0	0	**5694**	**9270**
2035	230	314	21	3	4323	847	47	0	0	0	192	0	0	0	0	0	**5978**	**9734**
2036	242	330	22	4	4539	889	49	0	0	0	202	0	0	0	0	0	**6277**	**10220**
2037	254	347	23	4	4766	934	52	0	0	0	212	0	0	0	0	0	**6591**	**10731**
2038	267	364	24	4	5005	981	54	0	0	0	222	0	0	0	0	0	**6921**	**11268**
2039	280	382	25	4	5255	1030	57	0	0	0	233	0	0	0	0	0	**7267**	**11831**
2040	294	401	27	4	5518	1081	60	0	0	0	245	0	0	0	0	0	**7630**	**12423**
2041	309	421	28	5	5793	1135	63	0	0	0	257	0	0	0	0	0	**8011**	**13044**
2042	324	442	29	5	6083	1192	66	0	0	0	270	0	0	0	0	0	**8412**	**13696**
2043	341	464	31	5	6387	1251	69	0	0	0	284	0	0	0	0	0	**8833**	**14381**
2044	358	488	33	5	6707	1314	73	0	0	0	298	0	0	0	0	0	**9274**	**15100**
2045	375	512	34	6	7042	1380	76	0	0	0	313	0	0	0	0	0	**9738**	**15855**

Source: JICA Survey Team

Table 4-19: Traffic Projection for Section 4 of NH208

Km 132.800 (near Harina)																		
Years	Two Wheeler	Car/Jeep/Van/Taxi/Auto	Mini Bus	Standard Bus	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle	Tractor With Trailer	Tractor Without Trailer	Cycle	Cycle Rickshaw	Hand Cart	Bullock Cart	Horse Cart	Others	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2017	55	95	10	1	20	10	4	0	0	0	56	0	0	0	0	0	251	241
2018	58	100	11	1	21	11	4	0	0	0	59	0	0	0	0	0	264	253
2019	61	105	11	1	22	11	4	0	0	0	62	0	0	0	0	0	277	265
2020	64	110	12	1	23	12	5	0	0	0	65	0	0	0	0	0	291	278
2021	67	115	12	1	26	13	5	0	0	0	68	0	0	0	0	0	308	299
2022	70	121	13	1	30	15	6	0	0	0	71	0	0	0	0	0	327	321
2023	74	127	13	1	33	17	7	0	0	0	75	0	0	0	0	0	348	346
2024	77	134	14	1	38	19	8	0	0	0	79	0	0	0	0	0	370	373
Expected Road Openining 2025	81	140	15	1	43	21	9	0	0	0	83	0	0	0	0	0	393	403
Diverted Traffic (No.)	12	21	2	0	2214	419	1	0	0	0	12	0	0	0	0	0	2682	4619
Diverted Traffic (%)	*15%*	*15%*	*15%*	*15%*	*5190%*	*1965%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*		
2025 (Total with diverted traffic)	**93**	**161**	**17**	**2**	**2257**	**440**	**10**	**0**	**0**	**0**	**95**	**0**	**0**	**0**	**0**	**0**	**3075**	**5022**
2026	103	178	19	2	2708	529	12	0	0	0	105	0	0	0	0	0	3654	5998
2027	113	195	21	2	3249	634	14	0	0	0	115	0	0	0	0	0	4344	7166
2028	124	215	23	2	3899	761	17	0	0	0	127	0	0	0	0	0	5168	8564
2029	137	236	25	2	4679	913	20	0	0	0	139	0	0	0	0	0	6153	10239
2030	151	260	27	3	5615	1096	24	0	0	0	153	0	0	0	0	0	7329	12245
2031	158	273	29	3	5896	1151	26	0	0	0	161	0	0	0	0	0	7696	12857
2032	166	287	30	3	6191	1208	27	0	0	0	169	0	0	0	0	0	8080	13500
2033	174	301	32	3	6500	1269	28	0	0	0	177	0	0	0	0	0	8484	14175
2034	183	316	33	3	6825	1332	30	0	0	0	186	0	0	0	0	0	8909	14883
2035	192	332	35	3	7166	1399	31	0	0	0	196	0	0	0	0	0	9354	15628
2036	202	348	37	4	7525	1469	33	0	0	0	205	0	0	0	0	0	9822	16409
2037	212	366	39	4	7901	1542	34	0	0	0	216	0	0	0	0	0	10313	17229
2038	222	384	40	4	8296	1619	36	0	0	0	226	0	0	0	0	0	10829	18091
2039	233	403	42	4	8711	1700	38	0	0	0	238	0	0	0	0	0	11370	18996
2040	245	423	45	4	9146	1785	40	0	0	0	250	0	0	0	0	0	11938	19945
2041	257	445	47	5	9604	1874	42	0	0	0	262	0	0	0	0	0	12535	20943
2042	270	467	49	5	10084	1968	44	0	0	0	275	0	0	0	0	0	13162	21990
2043	284	490	52	5	10588	2067	46	0	0	0	289	0	0	0	0	0	13820	23089
2044	298	515	54	5	11117	2170	48	0	0	0	303	0	0	0	0	0	14511	24244
2045	313	540	57	6	11673	2278	51	0	0	0	319	0	0	0	0	0	15237	25456

Source: JICA Survey Team

Table 4-20: Summary of Final Traffic Projection

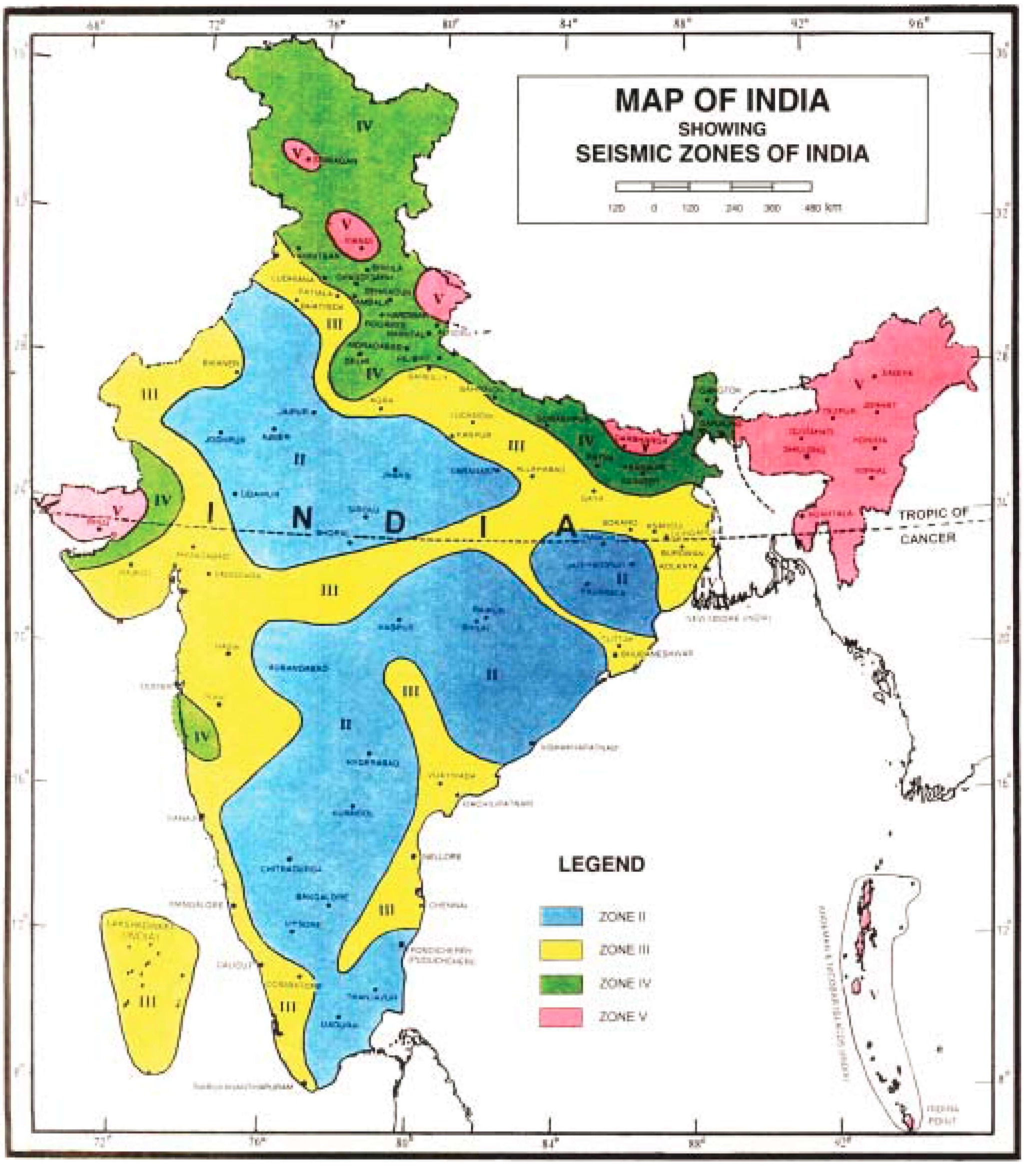
Year	NH 208							
	At Ch.117+500 (near Trishabari)		Km 42.300 (near Rangamati)		Km 88.000 (near Ailmara)		Km 132.800 (near Harina)	
	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)	Total Traffic (No.)	Total Traffic (PCU)
Base Year 2017	7615	5963	1579	1587	246	224	251	241
2018	7996	6261	1658	1666	258	235	264	253
2019	8396	6574	1741	1750	271	247	277	265
2020	8815	6903	1828	1837	285	259	291	278
2021	9294	7323	1940	1974	302	278	308	299
2022	9802	7774	2059	2124	320	298	327	321
2023	10341	8259	2188	2287	339	320	348	346
2024	10913	8780	2327	2467	360	345	370	373
Road Opening 2025	11776	10218	3373	3975	2013	3162	3075	5022
2026	13067	11499	3816	4582	2379	3767	3654	5998
2027	14509	12960	4325	5293	2814	4490	4344	7166
2028	16122	14628	4910	6125	3332	5355	5168	8564
2029	17929	16539	5585	7101	3949	6389	6153	10239
2030	19955	18730	6364	8248	4684	7627	7329	12245
2031	20953	19666	6682	8660	4918	8008	7696	12857
2032	22001	20649	7016	9093	5164	8408	8080	13500
2033	23101	21682	7367	9548	5422	8829	8484	14175
2034	24256	22766	7735	10025	5694	9270	8909	14883
2035	25468	23904	8122	10526	5978	9734	9354	15628
2036	26742	25100	8528	11053	6277	10220	9822	16409
2037	28079	26355	8954	11605	6591	10731	10313	17229
2038	29483	27672	9402	12186	6921	11268	10829	18091
2039	30957	29056	9872	12795	7267	11831	11370	18996
2040	32505	30509	10366	13435	7630	12423	11938	19945
2041	34130	32034	10884	14107	8011	13044	12535	20943
2042	35837	33636	11428	14812	8412	13696	13162	21990
2043	37629	35318	12000	15552	8833	14381	13820	23089
2044	39510	37083	12600	16330	9274	15100	14511	24244
2045	41485	38938	13230	17147	9738	15855	15237	25456

Source: JICA Survey Team

Chapter 5. Preliminary Design of NH208 (Teliamura-Sabroom)

5.1 Natural Condition Surveys

Natural condition surveys are bases of engineering design and 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 NH208 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

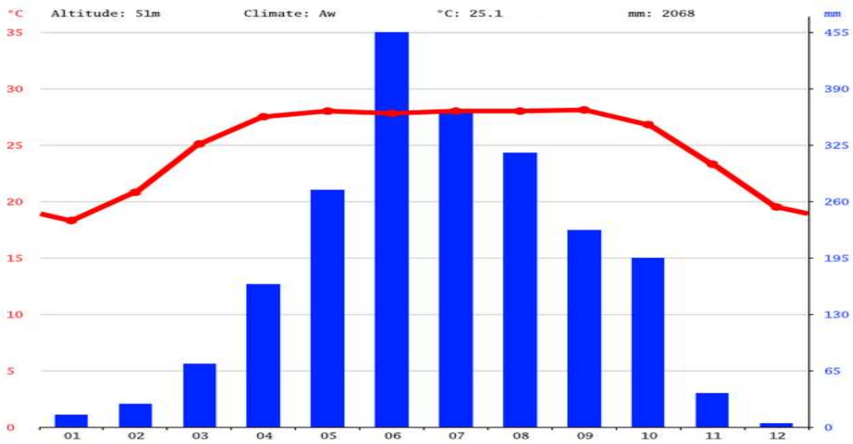
5.1.1 Meteorological and Hydrological Surveys

(1) General

The study area has a warm and humid tropical climate with five distinct seasons, i.e., spring, summer, monsoon, autumn, and winter. The area is categorized as "Aw" (i,e., tropical, dry winter) in the Köppen-Geiger climate classification[42], and has suffered flooding or landslide caused by cyclones from April to June or monsoons from June to September. The heavy rainfall is brought by the south-western monsoon winds which are blocked by the hill ranges of the area and result in rain on the windward side of the hills.

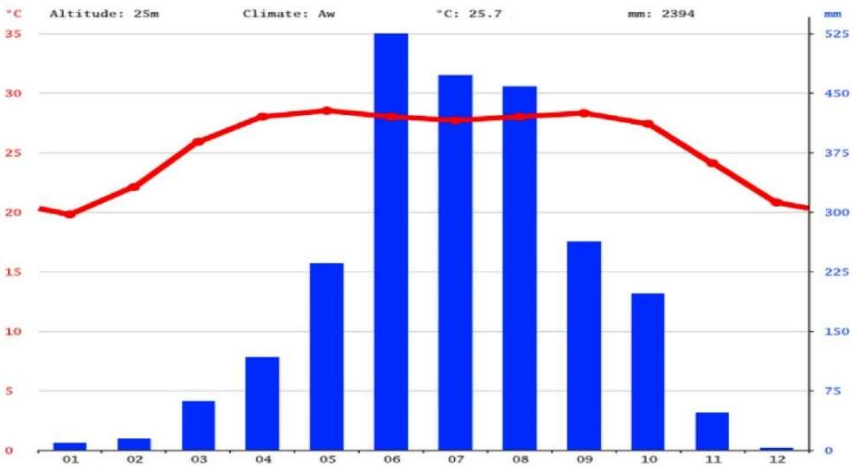
(2) Meteorological Condition

The monsoon season is from June to September. Annual average precipitations is 2,068mm at Teliamura and 2,394 mm at Sabroom. The annual average annual temperatures is 25.1°C at Teliamura and 25.7°C at Sabroom, basically the same. Figure 5-2 and Figure 5-3 presents average monthly precipitation and temperatures at Teliamura and Sabroom, respectively.



Source: Climate-Data org

Figure 5-2: Average Monthly Precipitation and Temperature at Teliamura



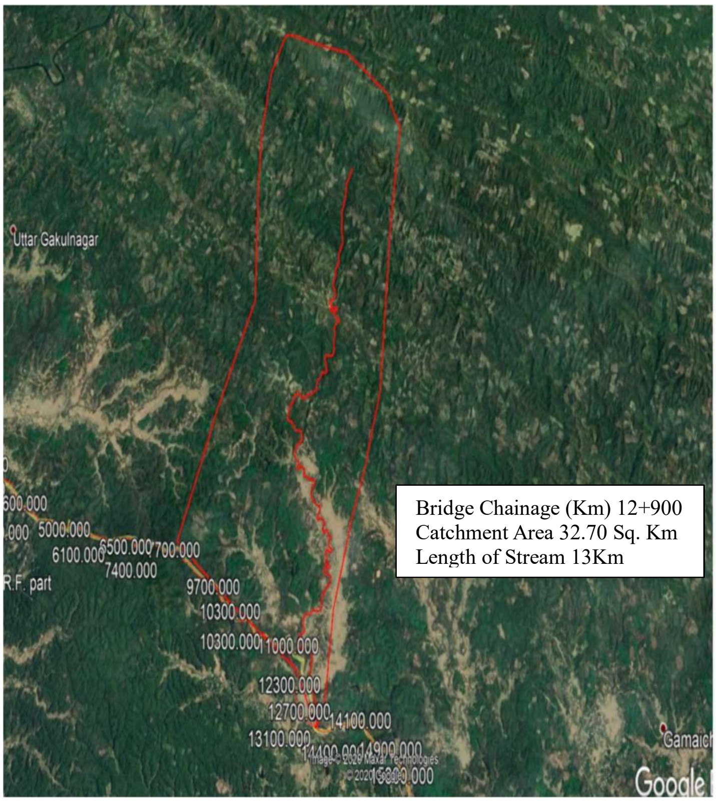
Source: Climate-Data org

Figure 5-3: Average Monthly Precipitation and Temperature at Sabroom

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

(3) Hydrological Survey

Pursuant to IRC SP-13-2004 and IRC SP-42-2014, a hydrological survey was conducted to obtain hydraulic design data for bridges and drainage facilities during floods. The flooding parameters were studied with topographic maps. The necessary parameters for each drainage facility are (i) the catchment area, (ii) tributary length, and (iii) differences in elevation along the road. Calculation of the flood discharge volume, is described in Section 5.3.6 Drainage Design. Figure 5-4 presents an example of catchment area, of which full data is provided in Appendix C-1.



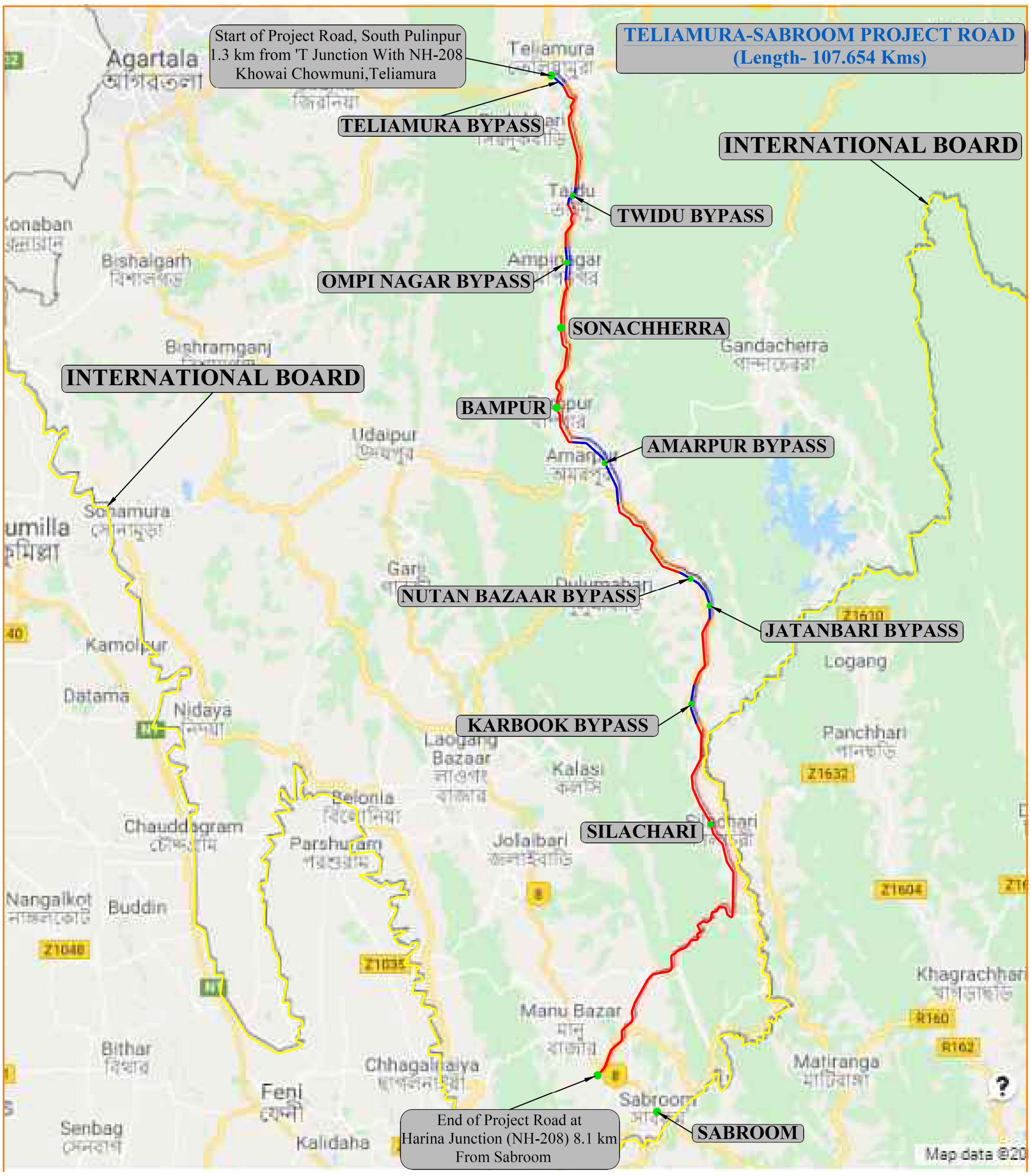
Source: DPR by TASPL Engineering Consultants

Figure 5-4: An Example of Catchment Area

5.1.2 Topographic Survey

(1) General

The project road starts from Ompi chowmuhani (T-Junction with NH-08 at Teliamura) and passes through Twidu, Sonacherra, Amarpur, Nutan Bazar, Karbook, Ailmara, Khedacherri, Ropaichari and ends at Harina (T-Junction with NH-08, 8.1 km away from Sabroom), traversing plain, rolling, and mountainous terrain The Survey area lies in Khowai, Gomati and South Tripura districts. The project road runs parallel to international border between India and Bangladesh in some sections. The existing length of the project road is 132.882 km and the design length is 108.191 km after geometrical improvement. Figure 5-5 presents location map of NH208.



Source: DPR by TASPL Engineering Consultants

Figure 5-5: Location Map of NH208

(2) Review of the DPR Survey

The JICA Survey 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. Through the survey, longitudinal sections along the road alignment at 25 m intervals and cross-sections at 50 m intervals were obtained. The plan covers all permanent features near the alignment, the existing roads, foot tracks, cart tracks, wells, shops, houses /buildings, temples, community structures, retaining structures, cross drainage structures, utility services, etc. The survey was conducted using total stations and Global Positioning System (GPS). Control points and benchmarks were fixed and tied to GTS (Great Trigonometrical Survey) benchmark established by Survey of India to verify the accuracy of the survey. Results of the road geometric design based on the survey are presented as Table 5-1 Horizontal Alignment Report and Table 5-2 Vertical Alignment Report. The full reports are provided in Appendix A-1 and A-2.

Table 5-1: Horizontal Alignment Report

Curve No.	HORIZONTAL CURVE								Terrain	Horizontal Intersection Point (HIP)			Transition Length (m)	Speed	Reason for Deviation
	Start Chainage (Km)	End Chainage (Km)	Start Easting	Start Northing	End Easting	End Northing	Radius	Direction		Chainage (Km)	Easting	Northing		(Kmph)	
1	0+128.086	0+205.912	360606.921	2635884.157	360666.919	2635834.782	400	Left	Plain	0+167.122	360634.511	2635856.542	55	80	
2	0+433.205	0+682.957	360863.118	2635720.073	361062.594	2635570.539	1200	Right	Plain	0+558.534	360970.665	2635655.723	40	100	
3	1+131.439	1+283.253	361385.329	2635259.175	361472.516	2635135.387	600	Right	Plain	1+207.754	361436.795	2635202.826	80	100	
4	1+737.048	1+928.826	361659.469	2634721.928	361750.682	2634553.378	1500	Left	Plain	1+833.068	361699.681	2634634.733	35	100	
5	2+476.917	2+574.951	362049.567	2634094.047	362117.327	2634023.416	500	Left	Plain	2+526.092	362079.974	2634055.399	95	100	
6	2+824.288	3+054.713	362318.852	2633876.737	362337.504	2633669.145	150	Right	Plain	2+969.182	362428.44	2633781.95	30	50	Due to School/College
7	3+162.272	3+395.525	362263.96	2633590.713	362183.401	2633376.393	350	Left	Plain	3+283.416	362186.59	2633497.495	60	80	
8	4+011.147	4+104.363	362212.832	2632761.77	362184.821	2632673.427	250	Right	Plain	4+058.302	362207.158	2632714.957	90	80	
9	4+294.157	4+350.609	362075.231	2632518.808	362054.306	2632466.506	250	Left	Plain	4+322.504	362061.803	2632493.843	90	80	
10	4+657.901	4+781.670	362022.808	2632161.099	362026.169	2632037.499	800	Left	Plain	4+719.909	362019.698	2632099.169	60	100	
11	4+872.000	4+906.430	362036.222	2631947.817	362026.545	2631915.089	75	Right	Hill	4+889.524	362035.207	2631930.322	30	40	
12	4+970.383	5+062.749	361987.683	2631864.443	361996.224	2631778.227	75	Left	Hill	5+023.449	361961.453	2631818.313	30	40	
13	5+108.072	5+188.064	362030.633	2631748.83	362070.694	2631681.166	125	Right	Hill	5+149.491	362061.874	2631721.635	15	40	
14	5+608.954	5+641.001	362136.775	2631265.53	362148.085	2631235.61	150	Left	Hill	5+625.039	362140.826	2631249.964	30	50	
15	5+799.979	5+864.850	362231.92	2631100.59	362247.969	2631038.256	150	Right	Hill	5+832.929	362246.791	2631071.186	30	50	
16	6+156.127	6+305.712	362230.267	2630747.545	362248.473	2630599.949	400	Left	Hill	6+231.804	362225.408	2630672.025	20	50	
17	6+571.660	6+628.751	362329.317	2630346.589	362339.592	2630290.518	300	Right	Hill	6+600.292	362337.13	2630319.044	20	65	
18	6+759.957	6+769.582	362348.025	2630159.637	362350.583	2630150.364	80	Left	Hill	6+764.776	362349.025	2630154.924	25	40	
19	7+194.796	7+252.657	362546.676	2629773.194	362544.846	2629716.615	80	Right	Hill	7+225.057	362556.462	2629744.558	25	40	
20	7+359.932	7+460.994	362491.036	2629623.917	362513.28	2629532.098	80	Left	Hill	7+418.462	362468.569	2629569.87	25	40	
21	7+581.661	7+711.885	362615.181	2629467.6	362674.727	2629356.362	150	Right	Hill	7+651.196	362670.737	2629425.783	30	50	
22	8+232.089	8+296.623	362654.878	2628836.623	362685.919	2628782.032	80	Left	Hill	8+266.228	362658.75	2628802.705	25	40	
23	8+393.893	8+491.034	362770.209	2628733.664	362798.334	2628646.822	80	Right	Hill	8+449.465	362814.434	2628700.012	25	40	

Source: DPR by TASPL Engineering Consultants

Table 5-2: Vertical Alignment Report

PVI	PVI		Curve Length (m)	Gradient (%)		Chainage (m)		Level (m)		Type Of Curve	K Value
No	Design Chainage (km)	Level (m)		IN	OUT	Start of Curve (km)	End of Curve (km)	Start of Curve (m)	End of Curve (m)		
1	0+500.529	50.583	200	0.367	2.406	0+400.529	0+600.529	50.216	52.989	Sag	98.105
2	1+591.364	76.825	475	2.406	-1.943	1+353.864	1+828.864	71.111	72.209	Hog	109.226
3	2+154.383	65.884	250	-1.943	1.097	2+029.383	2+279.383	68.313	67.256	Sag	82.229
4	4+540.483	92.063	500	1.097	-0.635	4+290.483	4+790.483	89.32	90.475	Hog	288.657
5	5+812.726	83.984	300	-0.635	2.846	5+662.726	5+962.726	84.937	88.252	Sag	86.192
6	6+771.396	111.264	500	2.846	-4.351	6+521.396	7+021.396	104.15	100.387	Hog	69.479
7	7+565.569	76.711	250	-4.351	3.842	7+440.569	7+690.569	82.149	81.513	Sag	30.513
8	8+323.279	105.824	250	3.842	-0.357	8+198.279	8+448.279	101.021	105.378	Hog	59.536
9	9+490.000	101.661	300	-0.357	-0.702	9+340.000	9+640.000	102.196	100.608	Hog	869.1
10	10+742.699	92.867	400	-0.702	-1.864	10+542.699	10+942.699	94.271	89.139	Hog	344.231
11	11+420.000	80.242	300	-1.864	-3.76	11+270.000	11+570.000	83.038	74.602	Hog	158.216
12	12+060.000	56.177	300	-3.76	0.351	11+910.000	12+210.000	61.817	56.703	Sag	72.977
13	13+010.208	59.51	400	0.351	3.95	12+810.208	13+210.208	58.808	67.409	Sag	111.139
14	13+885.008	94.063	400	3.95	-1.22	13+685.008	14+085.008	86.163	91.622	Hog	77.365
15	14+928.187	81.331	400	-1.22	-4.754	14+728.187	15+128.187	83.772	71.823	Hog	113.205
16	15+444.836	56.77	300	-4.754	2.266	15+294.836	15+594.836	63.901	60.168	Sag	42.738
17	16+090.240	71.392	200	2.266	0.935	15+990.240	16+190.240	69.126	72.327	Hog	150.281
18	16+900.000	78.961	650	0.935	-3.343	16+575.000	17+225.000	75.923	68.097	Hog	151.959
19	17+678.041	52.953	150	-3.343	-0.334	17+603.041	17+753.041	55.46	52.703	Sag	49.848
20	19+060.331	48.342	200	-0.334	2.826	18+960.331	19+160.331	48.676	51.168	Sag	63.299
21	19+554.839	62.317	350	2.826	0.337	19+379.839	19+729.839	57.371	62.906	Hog	140.59
22	20+407.818	65.19	400	0.337	-1.548	20+207.818	20+607.818	64.516	62.095	Hog	212.249
23	21+120.000	54.168	100	-1.548	-0.425	21+070.000	21+170.000	54.942	53.956	Sag	89.061
24	21+549.132	52.345	100	-0.425	1.461	21+499.132	21+599.132	52.557	53.076	Sag	53.014
25	21+989.505	58.781	300	1.461	-0.42	21+839.505	22+139.505	56.589	58.151	Hog	159.423
26	22+792.276	55.407	400	-0.42	-1.615	22+592.276	22+992.276	56.248	52.176	Hog	334.728
27	23+473.700	44.4	250	-1.615	0.406	23+348.700	23+598.700	46.419	44.907	Sag	123.692
28	24+410.000	48.2	500	0.406	-0.296	24+160.000	24+660.000	47.185	47.461	Hog	712.81
29	25+500.000	44.978	150	-0.296	1.856	25+425.000	25+575.000	45.2	46.37	Sag	69.703
30	26+175.392	57.516	425	1.856	-1.014	25+962.892	26+387.892	53.571	55.36	Hog	148.042
31	26+640.000	52.803	150	-1.014	1.248	26+565.000	26+715.000	53.564	53.739	Sag	66.305
32	27+349.922	61.662	500	1.248	-1.172	27+099.922	27+599.922	58.542	58.733	Hog	206.643
33	28+560.000	47.483	250	-1.172	0.372	28+435.000	28+685.000	48.948	47.948	Sag	161.977
34	29+180.000	49.787	400	0.372	-0.799	28+980.000	29+380.000	49.044	48.19	Hog	341.79
35	30+718.569	37.499	400	-0.799	0.382	30+518.569	30+918.569	39.097	38.263	Sag	338.702
36	31+430.000	40.217	400	0.382	-0.341	31+230.000	31+630.000	39.453	39.535	Hog	553.127
37	33+149.469	34.353	200	-0.341	0.326	33+049.469	33+249.469	34.694	34.679	Sag	299.606
38	35+363.602	41.581	300	0.326	-0.393	35+213.602	35+513.602	41.092	40.992	Hog	417.009
39	37+622.352	32.706	250	-0.393	0.396	37+497.352	37+747.352	33.197	33.201	Sag	316.808
40	39+985.117	42.067	250	0.396	-0.326	39+860.117	40+110.117	41.572	41.66	Hog	346.222
41	40+760.837	39.539	200	-0.326	0.315	40+660.837	40+860.837	39.865	39.854	Sag	312.205

PVI	PVI		Curve Length (m)	Gradient (%)		Chainage (m)		Level (m)		Type Of Curve	K Value
No	Design Chainage (km)	Level (m)		IN	OUT	Start of Curve (km)	End of Curve (km)	Start of Curve (m)	End of Curve (m)		
42	41+547.574	42.015	300	0.315	-0.78	41+397.574	41+697.574	41.543	40.845	Hog	274.044
43	42+409.750	35.29	250	-0.78	0.656	42+284.750	42+534.750	36.265	36.11	Sag	174.048
44	43+634.986	43.33	200	0.656	2.151	43+534.986	43+734.986	42.674	45.48	Sag	133.79
45	44+196.733	55.412	400	2.151	1.067	43+996.733	44+396.733	51.11	57.546	Hog	369.016
46	46+579.926	80.839	500	1.067	0.354	46+329.926	46+829.926	78.171	81.725	Hog	701.667
47	47+572.875	84.357	300	0.354	-1.235	47+422.875	47+722.875	83.826	82.504	Hog	188.736
48	48+257.432	75.901	200	-1.235	1.559	48+157.432	48+357.432	77.137	77.461	Sag	71.573
49	49+193.757	90.5	750	1.559	-3.967	48+818.757	49+568.757	84.653	75.623	Hog	135.711
50	50+005.489	58.296	150	-3.967	-1.419	49+930.489	50+080.489	61.271	57.232	Sag	58.854
51	50+706.928	48.345	200	-1.419	0.338	50+606.928	50+806.928	49.764	48.683	Sag	113.87
52	51+435.805	50.807	300	0.338	-0.655	51+285.805	51+585.805	50.3	49.824	Hog	302.061
53	52+386.875	44.573	200	-0.655	0.302	52+286.875	52+486.875	45.228	44.875	Sag	208.827
54	54+103.370	49.762	200	0.302	1.704	54+003.370	54+203.370	49.46	51.466	Sag	142.646
55	54+817.785	61.938	300	1.704	0.319	54+667.785	54+967.785	59.381	62.417	Hog	216.598
56	56+213.632	66.395	125	0.319	2.063	56+151.132	56+276.132	66.195	67.684	Sag	71.694
57	57+024.511	83.122	600	2.063	-1.904	56+724.511	57+324.511	76.934	77.41	Hog	151.254
58	57+620.000	71.784	200.071	-1.904	1.285	57+519.964	57+720.036	73.689	73.07	Sag	62.735
59	58+345.527	81.105	600	1.285	-3.172	58+045.527	58+645.527	77.251	71.59	Hog	134.64
60	58+950.000	61.933	150	-3.172	0.499	58+875.000	59+025.000	64.312	62.307	Sag	40.868
61	59+520.736	64.779	300	0.499	-0.382	59+370.736	59+670.736	64.031	64.205	Hog	340.471
62	60+233.864	62.051	150	-0.382	1.405	60+158.864	60+308.864	62.338	63.105	Sag	83.897
63	60+943.801	72.029	400	1.405	-1.099	60+743.801	61+143.801	69.218	69.831	Hog	159.71
64	62+316.358	56.943	300	-1.099	0.343	62+166.358	62+466.358	58.592	57.458	Sag	208.04
65	64+364.868	63.968	300	0.343	-0.473	64+214.868	64+514.868	63.454	63.259	Hog	367.703
66	65+106.405	60.461	200	-0.473	0.7	65+006.405	65+206.405	60.934	61.161	Sag	170.547
67	67+164.559	74.863	500	0.7	-1.133	66+914.559	67+414.559	73.114	72.03	Hog	272.794
68	68+644.764	58.09	300	-1.133	-0.333	68+494.764	68+794.764	59.79	57.591	Sag	374.822
69	70+809.836	50.886	250	-0.333	0.466	70+684.836	70+934.836	51.302	51.469	Sag	312.837
70	73+337.657	62.675	400	0.466	-0.486	73+137.657	73+537.657	61.743	61.703	Hog	419.812

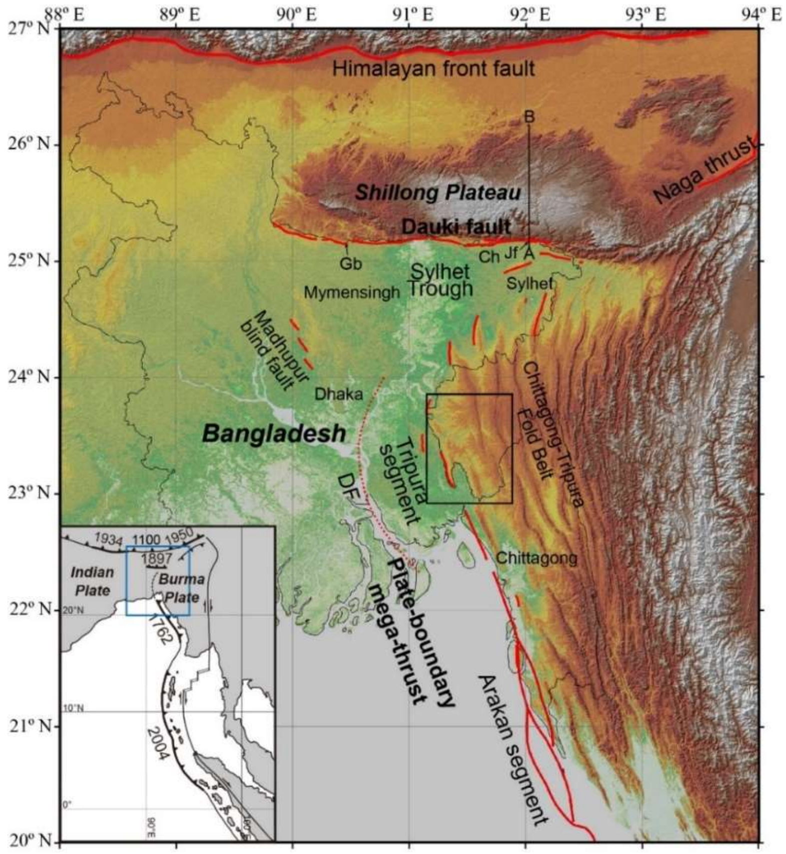
Source: DPR by TASPL Engineering Consultants

5.1.3 Geological Survey

(1) Tectonics of the Tripura Hills

As shown in Figure 5-6, the Tripura Hill, where the Project Road passes through, is geologically called "Chittagong-Tripura Fold Belt (CTFB)". It is the geomorphic characteristics of the CTFB that north-south elongated hills (mountains) and valley bottom plains appear repeatedly. The geological structures agree with geomorphology of the CTFB. Hills and valley bottom plains show anticlinal and synclinal structures, respectively. The altitude of hills is higher in the east side and the stratigraphy is older in the east side than those in the west side.

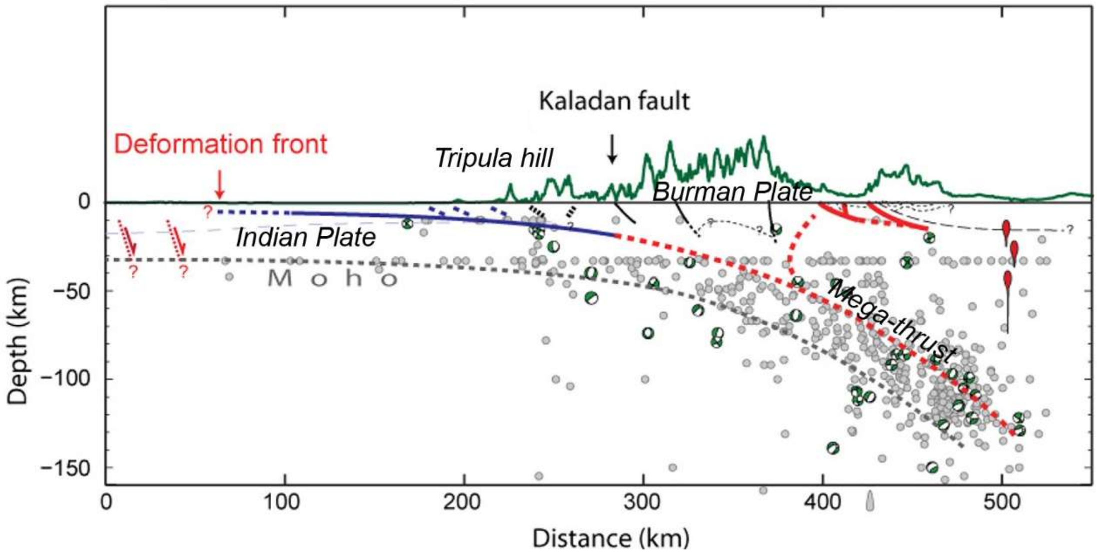
The cross section which traverses the CTFB with E-W direction is shown in Figure 5-7. The Tripura Hill is located just above the mega-thrust that demarcates the boundary between the Indian and Burman plates. The CTFB represents a differential topography which has been formed on the Burma plate. The Burman plate is compressed with E-W direction, and as a result, the CTFB has been created. The mega-thrust migrates to the western foreland from the eastern hinterland. It is thought that the present megathrust is located on the western margin of the Tripura Hill or in the plain of Bangladesh (DF shown in Figure 5-6).



Source: Morino, M., A. S. M. M. Kamal, S. H. Akhter, Md. Z. Rahman, R. Md. Ekram Ali, A. Talukder, Md. M. H. Khan, J. Matsuo, and F. Kaneko, 2014, A paleo-seismological study of the Dauki fault at Jaflong, Sylhet, Bangladesh: historical seismic events and an attempted rupture segmentation model. *Journal of Asia Earth Sciences*, **91**, 218-226.

Note: A rectangle represents the location of geological map shown in Figure 5-7. DF: Deformation Front.

Figure 5-6: A Shaded-Relief Map and Active Fault Map in North-East India and Bangladesh



Source: Yu, W. and K. Sieh, 2013, Active tectonic features that pose a seismic threat to Bangladesh. CDMP report.

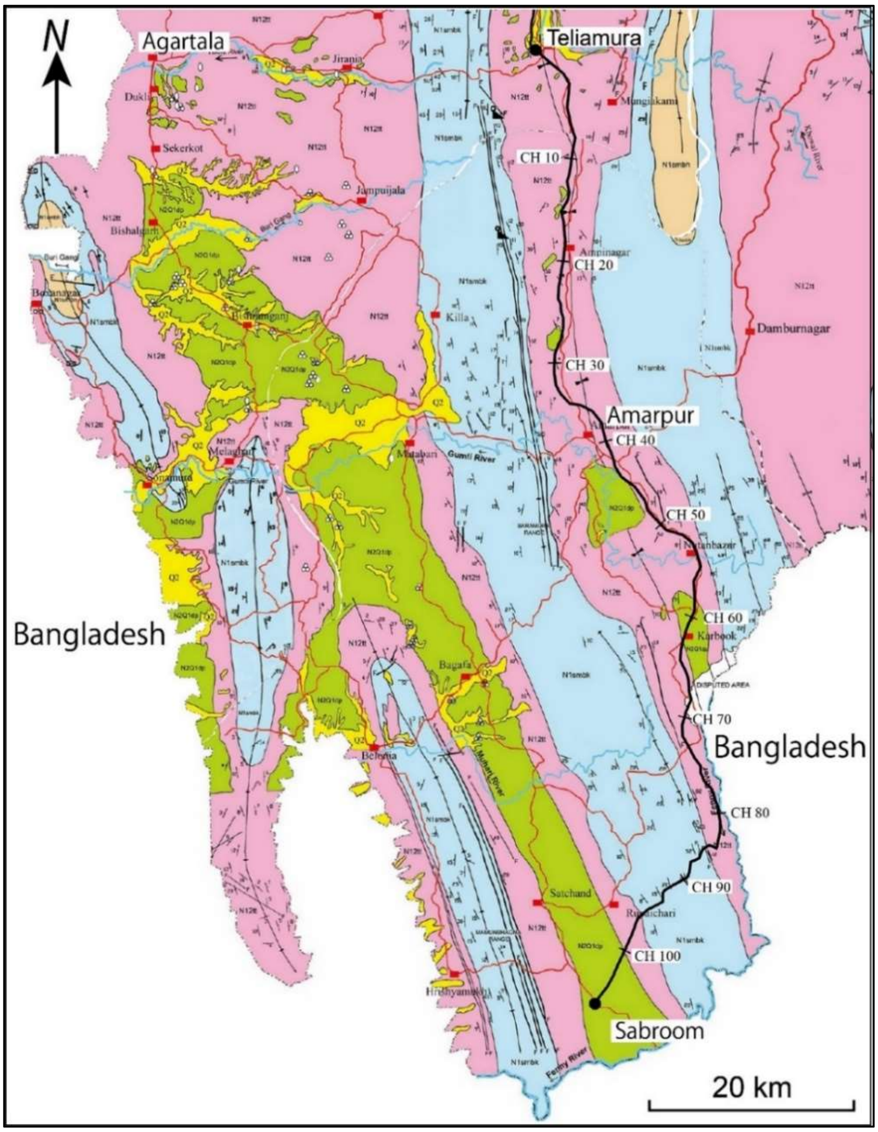
Note: The mega-thrust demarcating the boundary between the Indian and Burman plates is inclined to the east with a low angle. The red broken fault line shows fault slips during inter-seismic periods. The solid blue fault line shows locked fault portion, and slips during large earthquakes. The Tripura Hills are located just above the mega-thrust.

Figure 5-7: Cross section of the CTFB with E-W direction

The mega-thrust on the western margin of the Tripura Hill corresponds to a northern extension of the mega-thrust that caused the 2004 Sumatra earthquake (M 9.1) and tsunami. The mega-thrust from Sumatra to Andaman Islands has ruptured during the 2004 earthquake. The mega-thrust from Myanmar to Chittagong has ruptured during the 1762 Arakan earthquake (M 8.5). Dhaka has been damaged by tsunami caused by this earthquake (refer inset of Figure 5-6). Concerning the mega-thrust on the western margin of the Tripura Hill, the time of the latest seismic event and the recurrence interval are not well-known.

(2) Stratigraphy of the Tripura Hills

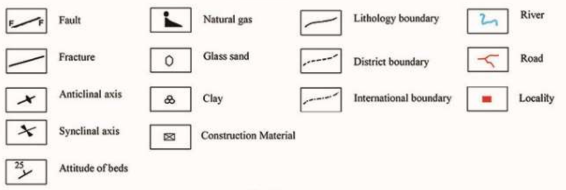
The geological map along NH 208 is shown in Figure 5-8. The stratigraphy of the Tripura Hills is composed of the Miocene Surma Group, the Mio-Pliocene Tipam Group, the Plio-Pleistocene Dupitila Group, and Alluvium as shown in Figure 5-8 and Table 5-3.



LEGEND : I. GEOLOGY & MINERALS

Symbol	Lithology	Formation	Group	Age
Q2	Undifferentiated sand, silt & clay.		Newer Alluvium (Undifferentiated)	Holocene
N2Q1dp	Poorly consolidated sandstone with clay & shale bands and pockets of silica sand.	Dupitila Formation	Dupitila Group	Plio-Pleistocene
N12tt	Sandstone, siltstone, shale alternations with pockets of clay & fine sand.	Tipam Sandstone Formation	Tipam Group	Mio-Pliocene
N1smbk	Shale, siltstone, sandstone with intra-formational conglomerate.	Bokabil Formation	Surma Group	Miocene
N1smbh	Sandstone with shale partings, limestone bands & sand lenses.	Bhuban Formation		

SYMBOLS



Source: Gupta, 2011, District Resource Maps of West Tripura, Dhalai, and South Tripura.
Note: A black solid line shows the project road of NH 208.

Figure 5-8: Geological map along NH 208

Table 5-3: Stratigraphy of the Tripura Hill

<table>
<tr><th colspan="2">Age</th><th colspan="2">Group/Formation</th><th>Lithology</th><th>Degree of consolidation</th></tr>
<tr><td rowspan="3">Quaternary</td><td>Holocene</td><td colspan="2" rowspan="2">Alluvium</td><td rowspan="2">Sand, Silt, Clay</td><td rowspan="2">Unconsolidated</td></tr>
<tr><td rowspan="2">Pleistocene</td></tr>
<tr><td colspan="2" rowspan="2">Dupitila Group</td><td rowspan="2">Sand, Silt, Clay, Gravel</td><td rowspan="2">Unconsolidated</td></tr>
<tr><td rowspan="5">Tertiary</td><td rowspan="2">Pliocene</td></tr>
<tr><td colspan="2" rowspan="2">Tipam Group</td><td rowspan="2">Sandstone, Siltstone</td><td rowspan="2">Weakly consolidated</td></tr>
<tr><td rowspan="3">Miocene</td></tr>
<tr><td rowspan="2">Surma Group</td><td>Bokabil Formation</td><td>Shale, Siltstone, Sandstone</td><td rowspan="2">Soft rocks</td></tr>
<tr><td>Bhuban Formation</td><td>Alternation of Siltstone and Shale</td></tr>
</table>

Source: JICA Survey Team

The Surma Group is the marine sedimentary rocks in the Miocene age, and subdivided into the Bhuban and the Bokabil Formation. The Bhuban Formation consists of alternation of siltstone and shale with several centimeter intervals. The bedding plane of the Bhuban Formation is hard to separate despite its layered structure. The Bokabil Formation consists of a similar stratigraphy to the Bhuban Formation, and interbeds sandstone frequently. The degree of consolidation of these formations are regarded as soft rocks.

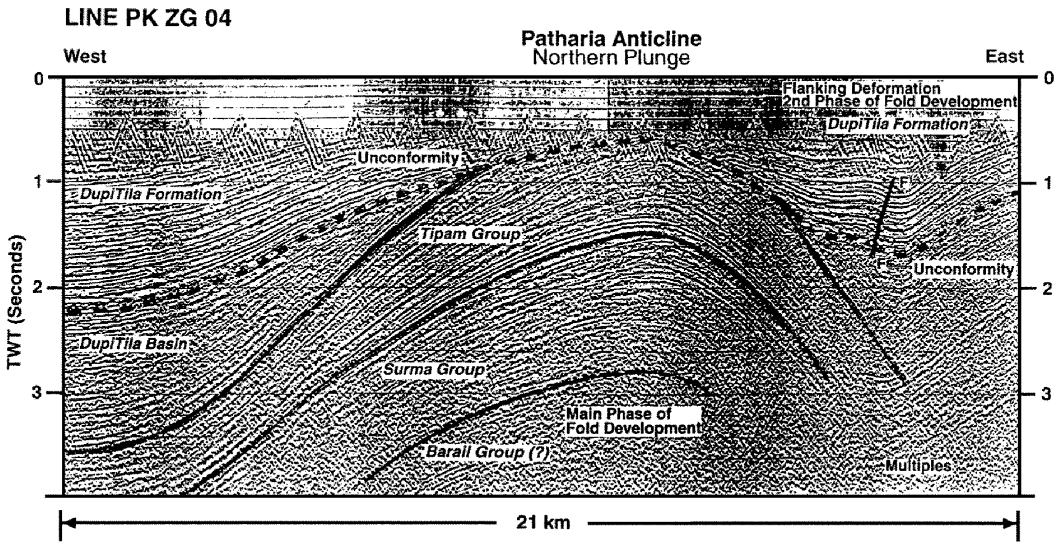
The Tipam Group, which consists of sandstone and siltstone with cross lamina, is marine and delta deposits in Miocene to Pliocene age. The layers are weakly consolidated.

The Dupitila Group, which consists of sand, silt, and clay interbedding gravel with cross lamina, is fluvial deposits in Pliocene to Pleistocene age. The layers are unconsolidated.

The alluvium, which consists of sand, silt, and clay, is valley bottom plain deposits between hills.

(3) Geological Structure

These stratigraphy exhibits the geological structure called “Growth strata”. As shown in Figure 5-9, younger layers were deposited together with the growth of the folding of older layers, so younger layers overlying older layers are folded as well. The inclination of the bedding plane of older layers is steeper than that of younger layers. The boundary of them shows angular unconformity. The angular unconformity between the Dupitila and Tipam Group is clearly recognized in the seismic reflection profile shown in Figure 5-9, which was performed in the plain of Bangladesh.



Source: Sikder, A. M. and M. M. Alam, 2003, 2-D modelling of the anticlinal structures and structural development of the eastern fold belt of the Bengal Basin, Bangladesh. Sedimentary Geology, **155**, 209-226.

Figure 5-9: Example of "Growth Strata" After the Seismic Reflection Survey

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

Detailed road inventory surveys have been carried out at the project area to collect details of road and pavement features along the existing road sections. The inventory data includes:

i) Terrain (flat, rolling, mountainous) as per IRC SP 19 2001 guidelines;
ii) Land-use (agricultural, commercial, forest, residential etc.);
iii) Carriageway width, surfacing type;
iv) Shoulder surfacing type and width;
v) Sub-grade / local soil type (textural classification);
vi) Horizontal curve; vertical curve;
vii) Road intersection type and details, at every occurrence;
viii) Retaining structures and details, at every occurrence;
ix) Location of water bodies (lakes and ponds);
x) Height of embankment or depth of cut;
xi) Land width i.e. ROW;
xii) Culverts, bridges and other structures (type, size, span arrangement and location);
xiii) Roadside arboriculture;
xiv) Existing utility services on either side within ROW;
xv) General drainage conditions;
xvi) Design speed of existing road;
xvii) Inventory of all road side facilities for the public including educational, health, communication facilities and road user-based facilities such as tea shops, vehicle service shops etc.

Based on the above inventory of the existing road structures and conditions, it is identified:

- Which existing structures are to be abandoned, upgraded, or retained, in accordance with the latest design standards and loading requirements of the traffic;
- where new structures are to be required.

In addition to the road inventory, various inventories, details and soil data are presented as below:

i) Road Inventory
Extracted road inventory data is presented in Table 5-4, while the full data is provided in Appendix B-1 Road Inventory.

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

iii) Culvert Inventory
Extracted culvert inventory and condition data is presented in Table 5-6, while the full data is provided in Appendix B-3 Culvert Inventory.

iv) Bridge Inventory
Bridge inventory is presented in Table 5-7.

v) Soil Investigation Report for Bridge Foundation
Extracted boring log is presented in Table 5-8, while the full soil investigation report for bridge foundation is provided in Appendix G-1.

vi) Junction Inventory
Extracted junction inventory is presented in Table 5-9, while the full junction inventory is provided in Appendix B-4.

vii) Temple Details
Temple details are presented in Table 5-10.

viii) School Details
School details are presented in Table 5-11.

ix) Pond Details
Pond details are presented in Table 5-12.

Table 5-4: Extracted Road Inventory

From (km)	To (km)	Terrain (Plain/Rolling/Hilly)	Land Use (Built - Up/Agrt./Forest/ Indust./ Barren)	Name of Village/Town/City	CARRIAGEWAY			SHOULDER			LHS	RHS	Embank-ment Height (m)	Submer-gence (cm)	Details of Cross Roads			Remarks
					Type* (BT/CC/GR/ ER)	Width (m)	Condi-tion** (G/F/P/VP)	Type* (BT/CC/ GR/ ER)	Width (m)	Condi-tion** (G/F/P/VP)	Hill/ Valley	Hill/ Valley			Location (km)	To Village	Carriageway width (m)	
0+000	0+500	Plain	Built-up	Teliamura	BT	6.0	P	ER	1.5	P			RL		0+100, RHS BT	To Village	3.0	
0+500	1+000	Plain	Built-up	Teliamura	BT	5.5	P	ER	1.5	P			RL		0+200, LHS BT	To Dist. Forest Office	3.0	
1+000	1+500	Plain	Built-up	Teliamura	BT	5.5	P	ER	1.5	P			RL		1+050,LHS BT	To Kakracherra village	3.0	
1+500	2+000	Plain	Built-up/Forest	Teliamura	BT	5.5	P	ER	1.5	P			RL		2+000,LHS BT	To Village	3.0	
2+000	2+500	Plain	Partially Built-up	Gamaibari	BT	5.5	P	ER	1.5	P			RL					
2+500	3+000	Plain	Forest	-	BT	5.5	P	ER	1.5	P			RL					
3+000	3+500	Rolling	Forest	-	BT	5.5	P	ER	1.5	P			RL					
3+500	4+000	Rolling	Forest	Kharimangal	BT	5.5	P	ER	1.5	P			RL		4+300,LHS BT	To Manik Bazar	3.5	
4+000	4+500	Rolling	Forest	Kharimangal	BT	5.5	P	ER	1.5	P			RL					
4+500	5+000	Rolling	Forest	-	BT	5.5	P	ER	1.5	P			RL					
5+000	5+500	Rolling	Built-up/Forest	Govind sadar	BT	5.5	P	ER	1.5	P			RL		5+700,RHS BT	To BS Para Village	2.0	
5+500	6+000	Rolling	Forest	-	BT	3.5	P	ER	1.5	P			RL		6+400,RHS ER	To Village	3.0	
6+000	6+500	Rolling	Forest	-	BT	3.5	P	ER	1.5	P			RL					
6+500	7+000	Rolling	Forest	-	BT	3.5	P	ER	1.5	P			RL					
7+000	7+500	Hilly	Forest	-	BT	3.5	P	ER	1.5	P			RL					
7+500	8+000	Hilly	Forest	-	BT	3.5	P	ER	1.5	P			RL					
8+000	8+500	Hilly	Forest	-	BT	3.5	P	ER	1.5	P			RL					
8+500	9+000	Hilly	Forest	-	BT	4.5	P	ER	1.5	P			RL		9+550,LHS BT	To Bahadur Sadarpara	3.0	
9+000	9+500	Hilly	Forest	-	BT	4.5	P	ER	1.5	P			RL					
9+500	10+000	Hilly	Forest	-	BT	4.5	P	ER	1.5	P			RL					
10+000	10+500	Hilly	Forest	-	BT	3.5	P	BR	1.0	P			RL					
10+500	11+000	Hilly	Forest	-	BT	3.5	P	BR	1.0	P			RL					
11+000	11+500	Hilly	Forest	-	BT	3.5	P	BR	1.0	P			RL					
11+500	12+000	Hilly	Forest	-	BT	3.5	P	BR	1.0	P			RL					

Source: DPR by TASPL Engineering Consultants

Table 5-5: Extracted Pavement Condition

Chainage		Pavement Composition			Shoulder		Riding Quality		Pavement Condition					Pavement Edge Drop (mm)	Embankment Condition (Good/Fair/ Poor)	Road Side Drain (Non-Existing/ Partially Functional/ Functional)	Remarks
From (Km)	To (Km)	Composition	Type	Thickness (mm)	Compo-sition	Condition (Fair/Poor/ Falled) Every 500 m	Speed (Km/hr)	Quality (Good/Fair/ Poor/Very Poor)	Cracking (%)	Ravelling (%)	Potholing (%100m)	Rut (None/ Moderate/ Severe)	Patching (%100m)				
0+000	0+200	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
0+200	0+400	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
0+400	0+600	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
0+600	0+800	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
0+800	1+000	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
1+000	1+200	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
1+200	1+400	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
1+400	1+600	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-15	15-20	0-5	-	-	
1+600	1+800	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	-	-	
1+800	2+000	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	-	-	
2+000	2+200	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	-	-	
2+200	2+400	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	-	-	
2+400	2+600	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
2+600	2+800	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
2+800	3+000	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
3+000	3+200	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
3+200	3+400	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
3+400	3+600	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	-	-	
3+600	3+800	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
3+800	4+000	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
4+000	4+200	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
4+200	4+400	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
4+400	4+600	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	
4+600	4+800	-	BT	-	ER	POOR	20-25	POOR	30-60 %	30-40 %	10-20'	0-10	15-20	0-5	POOR	-	

Source: DPR by TASPL Engineering Consultant

Table 5-6: Extracted Culvert Inventory

Sl. No.	Existing Chainage (Km)	Type of Structure (Pipe/Slab /Box /Arch)	Formation Level	Span Arrangement			Carriageway Width (m)	Width of Paved Shoulder (m)	Total Width of Culverts (m)		Skew	Details of Protection works						Condition of various features of Culvert						Vent Height		Slab Thickness	Presence of Scour	Adequacy of waterway	Direction of Flow	Remarks
				No	Vent Width (m) (Clear)	C/C of Exp. Joint.			Inner	Outer		Type	Condition	Head Wall (LXB)	Wing Walls (LXBXH)	Return Wall Length (LXB)	Parapet/ Handrail (LXBXH)	Sub-structure	Slab /Pipe /Box /Arch	Head Walls	Wing Walls	Return Wall	Parapet/ Handrail	U/S	D/S					
1	0+400	SLAB		1	1.1	2.2	5.8			10.9		RCC	P					P	F					0.6	0.7	0.25	Y	Y	LR	
2	0+450	SLAB		1	1.1	2.2	5.8			10.9		RCC	P					P	F					0.6	0.7	0.25	Y	Y	LR	
3	0+500	SLAB		1	1.0	1.6	5.7			8.5		RCC	P					P	F					0.4	0.45	0.20	Y	Y	LR	
4	0+800	SLAB		1	0.9	1.5	6.7			8.5		RCC	P					P	F					0.5	0.4	0.20	Y	Y	LR	
5	0+900	SLAB		1	0.9	1.4	5.0		7.30	8.0		RCC	P					P	F				P	0.8	0.7	0.25	Y	Y	LR	
6	1+100	SLAB		1	1.2	1.7	4.9		7.0	8.2		RCC	P				3.3X0.45X0.2	P	F				P	1.1	1.0	0.20	Y	Y	LR	
7	1+250	SLAB		1	2.0	3.0	6.4			9.1		RCC	P					P	F					0.5	0.7	0.25	Y	Y	LR	
8	1+400	SLAB		1	2.0	2.0	5.8		7.3	8.0		RCC	P				3.4X0.4X0.2	P	F				P							
9	1+700	SLAB		1	3.5	4.8	7.1		8.4	9.2		RCC	P		3.3X0.4X2		5.4X0.3X1	P	F		P		P	3.5	3.3	0.30	Y	Y	LR	
10	1+950	SLAB		1	1.5	2.9	5.5		7.0	7.55		RCC	P		2.3X0.4X1.0		2.9X0.3X0.1	P	F		P			0.75	0.7	0.25	Y	N		
11	2+000	SLAB		1	1.5	2.9	5.5		7.0	7.55		RCC	P		2.3X0.4X1.1		2.9X0.3X0.2	P	F		P			0.75	0.7	0.25	Y	N		
12	3+500	SLAB		1	0.9	1.3	5.2			7.7		RCC	P					P	F					0.5	0.3	0.20	Y	N		
13	7+450	SLAB		1	1.5	2.8	4.2			8.0		RCC	P		5X0.4X1.2			P	F		P			1.4	1.8	0.30	Y	N		
14	7+750	SLAB		1	1.5	2.8	4.2			8.0		RCC	P		5X0.4X1.3			P	F		P			1.4	1.8	0.30	Y	N		
15	9+250	SLAB		1	1.4	2.4	4.1			7.9		RCC	P					P	F					1.6	1.4	0.20	Y	N		
16	9+550	SLAB		1	1.4	2.4	4.1			7.9		RCC	P					P	F					1.6	1.4	0.20	Y	N		
17	9+600	SLAB		1	1.4	2.5	4.0		7.5	8.2		RCC	P		2.4X0.4X0.25			P	F		P			1.5	1.2	0.20	Y	N		
18	9+750	PIPE		1	1.0		4.3		11.3	11.8					3.2X0.25X0.35			P	F		P									
19	10+000	PIPE		1	1.0		4.0											P	F											
20	10+100	PIPE		1	1.0		4.0											P	F											
21	10+500	SLAB		1	1.0	2.4	5.1			12.8		RCC	P					P	F					1.2	1.5	0.30	Y	N		
22	12+600	PIPE		1	1.0		4.1		9.3	9.9							2.9X0.35X0.5	P	F				P							
23	13+150	PIPE		1	1.0		4.1		9.3	9.9							2.9X0.35X0.6	P	F				P							
24	14+490	SLAB		1	1.3	1.8	3.7			7.6		RCC	P					P	F							-0.80	Y			
25	14+750	SLAB		1	1.3	1.8	3.7			7.6		RCC	P					P	F							0.20	Y			
26	15+100	SLAB		1	0.7	2.0	4.2			7.0		RCC	P					P	F					0.6	0.9	0.20	Y	N		
27	18+650	PIPE		4	1.0		4.0			10.5																				

Source: DPR by TASPL Engineering Consultant

Table 5-7: Bridge Inventory

Sl.No.	Location (Km.)	Name of River Bridge	Year of Constr-uction	No. of Spans	Span Arrangement (Expansion Joint to Expansion Joint) (m)	Clear Spans	Length of Bridge face to Face of Abutments (m)	High level or Sub-missible	Clear road way width between Kerbs (m)	Total Outer width of bridge (m)	Width of Footpath (m)	Super Structure						Details of Wearing coat		Sub Structure						Pier Foundation		Abutment Foundation		Protection Work		Skew Angle (Degree)	Vertical Clearance (Below bottom of deck Slab) (m)	Road Formation Level (m)	Direction of Flow	Present Condition of Bridge					Clear Water Way (m)	Design of Loading	High Flood level (HFL)	Lowest Water Level (LWL)	Design Discharge (cum)	Maximum Design Velocity (m/sec)	Remarks
																				Thickness on Pier (m)			Height of pier & Abutment (m)	Materials Used																							
												Gradient	Type	Type of Bearing	Thickness of Slab / Girder (m)	Material of Slab	Handrail Parapet Thickness & Height (m)	Type	Thickness (m)	Type	Top	Bottom		Abutment	Pier	Type	Material	Type	Material	Bed	Approach					Abut-ments	Piers	Slab	Bearings	Parapet							
1	15+650			2	25+ 23.7	20.5+ 19.0	45.3		7.5	12.1	1.7		RCC		0.25/ 0.3	RCC	0.3/1.0			RCC			5.0 (A)	RCC	RCC	WELL	RCC	OPEN	RCC				11.4		RL	F	F	F		P							
2	23+000		OLD STEEL TRUSS BRIDGE																																												
3	26+600		OLD WOODEN BRIDGE				35.1																																								
4	29+650		OLD WOODEN BRIDGE				41.0	New Bridge Constucted																																							
5	30+400			1	-	11.4	11.4		7.4	8.1	-	-	-	-	0.4	RCC	11.4X1.3X0.3	-	-	-	-	-	-	-	-	-	-						4.0		RL	P	P	P		P							
6	31+050		OLD STEEL TRUSS BRIDGE				29.0																																								
7	38+050		OLD STEEL TRUSS BRIDGE				31.0																																								
8	39+850			1	-	9.6	-	-	7.5	8.1	-	-	-	-	-	RCC	11X0.25X0.9	-	-	-	-	-	-	-	-	-	-						5.5							P							
9	41+550			1	-	11.8	-	-	7.4	8.1	-	-	-	-	-	RCC	0.95/0.25	-	-	-	-	-	-	-	-	-	-						5.0														
10	44+300		OLD STEEL TRUSS BRIDGE																																												
11	47+700			1	-	10	10	-	6.3	7.4	-	-	RCC	-	0.3	-	0.35	-	-	-	-	-	4.5	RCC	RCC	-	-	OPEN	RCC				4.9		RL	P		P		P							
12	48+850			2	-	5.9+ 5.9	-	-	5.1	5.8	-	-	RCC	-	0.25	RCC	0.3/0.9			RCC	0.6	0.6	5.0/5.0			-	RCC	OPEN	RCC				4.9		RL	F	F	F		P							
13	49+450			4	26.3+25.5+24.7+ 25.4	23.5+23 .2+24+2 4.2	94.9		7.5	8.5			RCC		0.25/1.7	RCC	0.2/0.7			WELL	1	1.4	4.9/3.2	RCC	RCC	WELL	RCC	WELL	RCC				10.1														
14	51+520			OLD STEEL TRUSS BRIDGE			37.8																																								
15	60+725			1	12	9.7	9.7		6.4	7			RCC		0.3/0.5	RCC	0.25/0.8						2.0	RCC				OPEN	RCC				2.5		RL	F		F		F							
16	62+250			OLD STEEL TRUSS BRIDGE			12.5	New Bridge under construction																																							
17	64+000			3	26.3+24.3+24.3	22.4+22 .9+24	71.3		7.5	8.5			RCC		0.2/2.2	RCC	0.2/0.75				1	2	6.4/ 5.5(A)	RCC	RCC	WELL	RCC	OPEN	RCC				10.7		RL	F	F	F		F							
18	71+120			2		2.8+2.8	-		5.3	6.5			RCC		-	RCC	0.2/0.75				0.5	0.5	1.7		RCC		RCC	OPEN	RCC						RL	F	F	F		F							
19	71+800			1	20.5	19.5	20.5		5.9	6.3			RCC		0.5	RCC	1											OPEN	RCC				6.5		LR	F		F		F							
20	74+050			1	30.5	29	29		5.5	6.4			RCC		0.3/1.8	RCC	0.2/0.9						1.5					OPEN	RCC				5.8		LR	F		F									
21	77+680			3	-	3.0+3.0 +3.0	-		5.0	6			RCC		0.3	RCC	0.2/0.85												RCC				2.5		LR	F		F		F							
22	82+300			3	-	3.0+3.0 +3.0	-		5.0	6.0			RCC		0.3	RCC	0.2/0.85												RCC						RL	F		F		F							
23	83+150			3	-	4.0+4.0 +4.0	-		5.0	6.0							0.2/0.9				0.4	0.4							RCC				2.5		LR	F		F		F							
24	84+350		OLD STEEL TRUSS BRIDGE																																												
25	87+370			1	-	9			5.2	6.0			RCC				0.2/0.85					-	-						RCC				2.5		RL	F		F		P							
26	91+500		OLD STEEL TRUSS BRIDGE				22.2																																								
27	95+150			1	34.5	31	31		7.5	9.0			RCC		0.25/1.8		0.25/1						2.7	RCC	-	-	-	OPEN	RCC				7.0		RL	F		F		F							
28	96+520			2	-	5.8+5.8	-		7.4	8.0			RCC		0.35		0.25/0.9				0.4	0.4		-	-	-	-		RCC				4.0		RL	F		F		F							
29	113+350			3	-	6.9+6.9 +7.1	-		7.5	8.4			RCC		0.3	RCC	0.35/0.95				0.5	0.5		-	-	-	-			Y	Y		4.0		LR		F	F		F							
30	120+860			3	-	4+4+4	-		7.2	8.0			RCC		0.3	RCC	0.25/0.85				0.4	0.4		-	-	-	-						3.6		RL		F	F		F							
31	124+050			1	-	24			7.5	8.4			RCC		0.3	RCC	0.35/0.95				-	-		RCC											-		-	F									
32	129+000			3		6.0			7.5	8.4			RCC		0.3	RCC	0.35/0.95				-	-		RCC			RCC						4.0		LR	F		F		F							

Source: DPR by TASPL Engineering Consultants

Table 5-8: Boring Log Extracted from Soil Investigation Report for Bridge Foundation

Sheet No.10 Job No.NEST/2020/Z-853

ISO 9001 : 2015 Certified

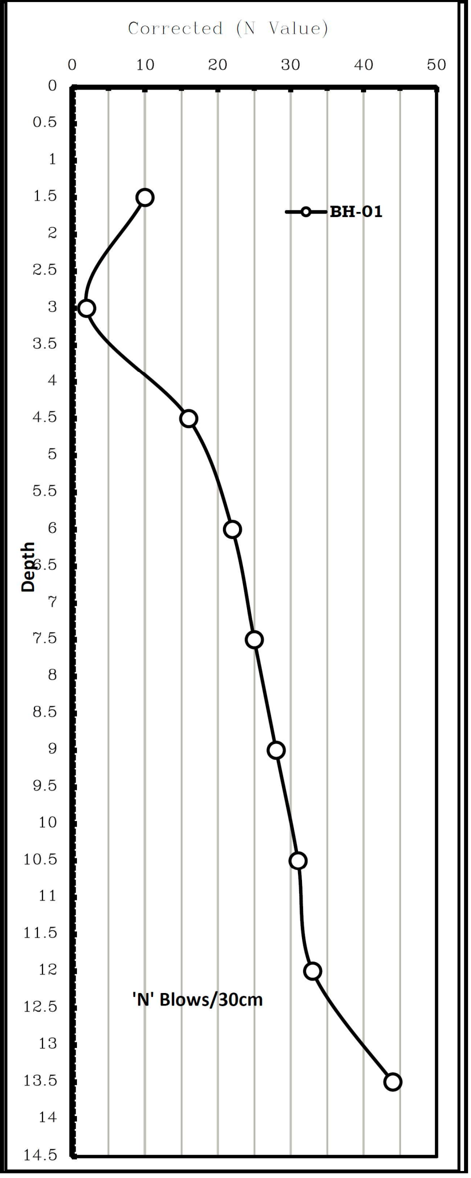
6. FIELD BORELOG SHEET

Sampling Type:- Standard split spoon sampler for disturbed samples and UDS samples by Shelby tubes for SPT.

Design km	12+900	**Sample BH No:-**01	**Depth of Water Table:-** 1.00
Boring Type	Auger/Wash	**Boring Diammeter:-**150mm	

Depth from EGL in m	Symbol	Visual Classification (IS: 1498-1970)	S.P.T. (N.Value) 0 to 15 cm	15 to 30 cm	30 to 45 cm	SPT Value (N)	ID No.
0.5			–	–	–	–	DS01
1.0		W.T. ▽ 1.00 m	–	–	–	–	DS02
1.5		Brownish Loose Clayey Silty Sand	2	3	5	8	SPT01
3.00		2.90 m	1	1	2	3	SPT02
4.50		Greyish Soft Silty Clay 4.00 m	3	6	10	16	SPT03
6.00			7	14	17	31	SPT04
7.50			11	17	22	39	SPT05
9.00			12	20	29	49	SPT06
10.50			14	26	33	59	SPT07
12.00			17	29	38	67	SPT08
13.50			24	41	60	101	SPT09
15.00		Greyish Medium to Dense Silty Sand					
16.50							
18.00							
19.50			Same Strata				
21.00							
22.50							
24.00							
25.50							
26.00		26.00 m					

Penetration Resistance Chart



Source: DPR by TASPL Engineering Consultants

Table 5-9: Extracted Junction Inventory

Sl. No.	Existing Chainage (Km)	Design Chainage (Km)	Type of Junction	Arm	Side	Village	Remarks
1	0+000	0+000	+	4	BHS	Rhs-To Agartala Lhs-To Ambassa	Improvement
2	0+135	-	T	3	LHS	Teliamura	Retained Due to Realignment/Bypass
3	0+190	-	T	3	RHS	Teliamura Town	Retained Due to Realignment/Bypass
4	0+300	-	+	4	BHS	Gango Tila, Jay Nagar	Retained Due to Realignment/Bypass
5	0+425	-	Y	3	RHS	Vivekanand Road	Retained Due to Realignment/Bypass
6	0+450	-	T	3	LHS	Vivekanand Road	Retained Due to Realignment/Bypass
7	0+590	-	T	3	RHS	Kali Tila	Retained Due to Realignment/Bypass
8	0+800	-	Y	3	LHS	Blok Chaumuhani	Retained Due to Realignment/Bypass
9	0+940	-	T	3	RHS	Kali Tila	Retained Due to Realignment/Bypass
10	1+080	-	Y	3	LHS	Forest Dip	Retained Due to Realignment/Bypass
11	1+200	-	Y	3	LHS	Gamay Bari	Retained Due to Realignment/Bypass
12	1+400	-	T	3	RHS	Gamay Bari	Retained Due to Realignment/Bypass
13	1+710	-	T	3	RHS	Gamay Bari	Retained Due to Realignment/Bypass
14	1+850	-	T	3	LHS	Bander Chaumuhani	Retained Due to Realignment/Bypass
15	1+920	-	T	3	LHS	Gamay Bari	Retained Due to Realignment/Bypass
16	2+020	-	T	3	LHS	Tripura State Electricity Corporation Ltd	Retained Due to Realignment/Bypass
17	2+300	-	Y	3	LHS	Gamay Bari	Retained Due to Realignment/Bypass
18	-	0+580	+	4	BHS		Improvement
19	-	0+760	Y	4	BHS		Improvement
20	-	0+870	+	4	BHS		Improvement
21	2+575	1+300	T	3	LHS		Improvement
22	2+875	1+580	T	3	LHS		Improvement
23	2+950	1+640	T	3	RHS	Kabong Bari Road	Improvement
24	3+250	1+970	Y	3	LHS		Improvement
25	4+100	2+710	T	3	LHS	Daya Ram Para (R.D	Improvement
26	4+250	2+860	Y	3	LHS	Bhavmar Chora	Improvement
27	4+330	2+990	+	4	BHS	Lhs-Bhavmar Chora	Improvement
28	4+750	3+390	T	3	LHS	Molsam Basti Road	Improvement
29	5+220	3+840	+	4	BHS		Improvement
30	5+250	3+860	T	3	LHS		Improvement
31	5+670	4+300	T	3	RHS	Patila Basti	Improvement

Source: DPR by TASPL Engineering Consultants

Table 5-10: Temple Details

Sl. No.	Design Chainage (km)	Existing Chainage (km)	Side	Type	Remarks
1	2+720	4+100	LHS	Temple	
2	28+530	34+950	LHS	Temple	
3	52+980	-	RHS	Temple	
4	54+760	-	LHS	Temple	
5	71+800	-	RHS	Temple	
6	74+120	-	LHS	Temple	
7	76+280	90+050	LHS	Temple	
8	78+900	93+470	LHS	Temple	
9	81+010	-	RHS	Temple	
10	98+320	-	LHS	Temple	
11	99+230		RHS	Temple	
12	101+980	-	LHS	Temple	
13	103+220	-	RHS	Temple	
14	106+920	-	RHS	Temple	
15	107+580	131+830	RHS	Temple	
16	108+430	132+700	BHS	Temple	

Source: DPR by TASPL Engineering Consultants

Table 5-11: School Details

Sl. No.	Design Chainage (km)	Existing Chainage (km)	Side	Type	Remarks
1	3+200	4+550	RHS	School	
2	23+370	28+850	RHS	School	
3	25+400	31+000	LHS	School	
5	73+020	-	LHS	School	
6	76+290	90+050	LHS	School	
7	83+700	-	LHS	School	
9	89+700	110+450	LHS	School	
10	104+500		RHS	School	
11	106+500	-	RHS	School	

Source: DPR by TASPL Engineering Consultants

Table 5-12: Pond Details

Sl.No.	Design Chainage (Km)	Side	Length (m)	Remarks
1	0+050	LHS	10	
2	0+200	LHS	15	
3	0+670	LHS	20	
		RHS	20	
4	0+760	LHS	20	
		LHS	20	
5	12+000	RHS	20	
6	12+350	LHS	20	
7	12+470	LHS	15	
		RHS	15	
8	12+750	LHS	20	
9	15+370	LHS	15	
10	15+470	LHS	15	
		RHS	15	
11	17+600	LHS	60	
		RHS	60	
12	18+700	LHS	30	
		RHS	30	
13	18+800	LHS	15	
		RHS	15	
14	19+000	LHS	60	
		RHS	60	
15	21+260	LHS	15	
		RHS	15	
16	21+970	LHS	10	
		RHS	10	

Source: DPR by TASPL Engineering Consultants

5.1.5 Satellite Image Interpretation (Slope Inventory Survey)

In the original plan we were scheduled to visit India and carry out the slope inventory survey on field. However, we could not visit India due to COVID-19 epidemic. Therefore, the study of landslide topography was performed based on the interpretation of satellite data instead of the field survey.

(1) Selection of Target Areas for the Satellite Image Interpretation

Along NH 208 (Teliamura–Sabroom), mainly the Tipam Group is distributed between CH 0 and CH 84+650, the Surma Group is distributed between CH 84+650 and CH 97+100, and the Tipam and Dupitila Group are distributed between CH 97+100 and CH 108+179 (the end of the project road).

According to the final report of NH208 (Kailashahar–Teliamura), which was reported last year, the cut slopes composed of the Tipam and Dupitila Group are stable with the gradient of 0.5H : 1V, while topsoil collapses are often recognized. However, the Surma Group, which is distributed on the hilly and mountainous terrains, is soft rocks composed of alternation of siltstone and shale. The cut slopes with dip slope structure have long-term stability problem. In addition, landslide topographies could be found around the Project Road. Therefore, the hilly terrain, where the Surma Group is distributed, was selected as target area of the satellite data interpretation.

(2) Satellite Data and Images

We purchased the following satellite data and images from Remote Sensing Technology Centre of Japan (RESTEC).

1) Highest precision DTM in 0.5 m resolution
2) Highest quality ortho-rectified image

Digital Terrain Model (DTM), a kind of Digital Elevation Model (DEM), represents the bare ground surface without any objects including vegetation and buildings.

Aerial photographs and satellite photographs are originally taken with distorted configurations by central projection. They are geometrically corrected by ortho-graphic projection, and called ortho-rectified images.

Above data and images are produced with the combination of Jaxa–ALOS and DigitalGlobe WorldView of the United States.

The satellite data and images in the hilly terrain between CH 82+000 and CH 100+000 are purchased.

(3) Method for Analysis

Satellite images for which interpretation of landslide topographies were made, were carried out with the following procedures.

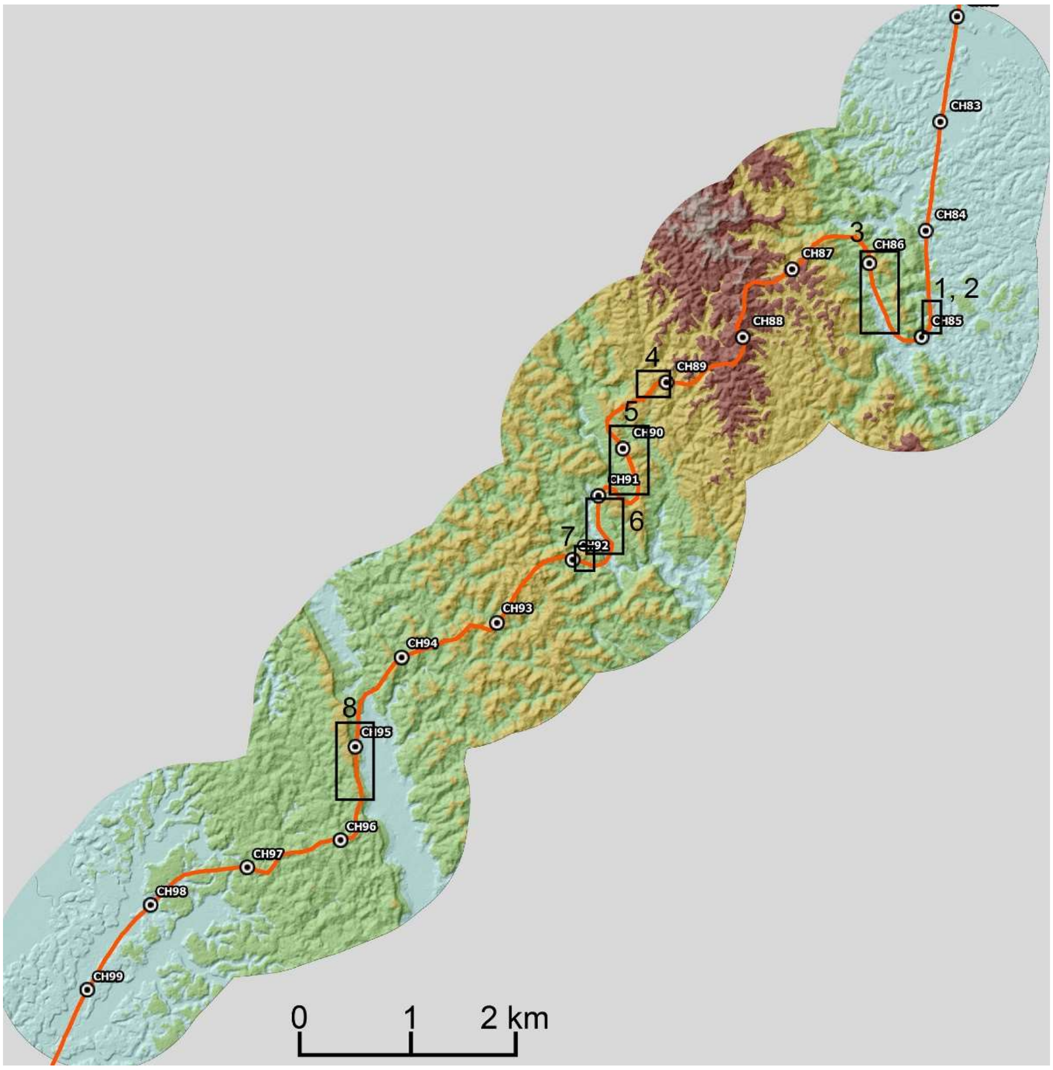
1) make a shaded-relief image possible to express 3D for bird's-eye view similar to aerial photograph,
2) shift the point of view, and then make up the next shaded-relief image under the condition that two images overlap 60%,
3) paste an ortho image on the shaded-relief images, and
4) observe landslide topographies by the pair of images for stereo-view.

(4) Results of Interpretation

20 pairs of satellite images possible to express in 3D were developed between CH 82+000 and CH 100+000, and landslide topographies were observed. As a result, detailed studies were performed in the target areas of 1 to 8.

The locations of target areas 1 to 8 are shown in Figure 5-10. The background shaded-relief map was made up from satellite data (DTM). On the shaded-relief map, the altitude of the hill is highest between CH 87+000 and 88+000. Because the topographic features coincide with the geological structure on the Tripura Hills, as hills and valley bottom plains show anticline and syncline, respectively, the anticlinal axis with NNW–SSE direction is inferred to pass around this section. Therefore, the layers incline towards the east in the eastern area of the anticline, and the layers incline towards the west in the western area of the anticline.

The topography, geology, and issues for slope protection are summarized in Table 5-13 and Table 5-14. Landslides A and B are inferred in the target areas 5 and 6, respectively.



Source: JICA Survey Team

Figure 5-10: Target Areas for Slope Protection

Table 5-13: Topography and Geology, and Issues of Target Areas (1)

Target Area (Landslide)	Chainage		Length (m)	Topography and Geology	Strati-graphy	Issues
	From	To				
1	84650	84800	150	The project road is located at the eastern wing of the anticline with NNW-SSE direction. The bedding planes incline to the east. The hill side cut slope shows dip slope structure. The layers could be strongly weathered because Target area 1 is located near unconformity between Surma G. and Tipam G.	Surma Group	The cut slope shows dip slope structure, though the height of cut slope is not so high.
2	84850	84950	100	ditto	Surma Group	Ditto
3	85300	86100	800	The project road is planned to pass on the east side slope of the valley. The bedding shows opposite dip slope structure, so natural slopes are relatively steep. In the west side slope of the valley, the bedding shows dip slope structure, so natural slopes are gentle and several landslides are recognized.	Surma Group	Hill side slopes are steep because of opposite dip slope structure. The cut slopes are higher than 40 m in height.
4	89000	89300	300	Several landslides are reconized around the project road.	Surma Group	There are less problems because landslides are distributed away from the project road.
5 (A)	89800	90500	700	The west side slope of the NNW-SSE trending long ridge represents abnormal topography that there are no ridges and streams. The east side slope of the ridge represents normal topography where branched ridges and streams are developed. Shallow lanslides or large collapses of A-1 to A-5 are inferred on west side slope where bedding shows dip slope structure and landslide massess slide on the bedding plane. Gully erosions are recognized on the landslide mass surfaces.	Surma Group	The project road is planned to cross landslides or go through beside landslides. Landslides are likely to become instable by the road construction.

Source: JICA Survey Team

Table 5-14: Topography and Geology, and Issues of Target Areas (2)

Target Area (Landslide)	Chainage		Length (m)	Topography and Geology	Strati-graphy	Issues
	From	To				
6 (B)	91100	91600	500	The west side slope of the NNW-SSE trending long ridge represents abnormal topography that there are no ridges and streams. The east side slope of the ridge represents normal topography where branched ridges and streams are developed. Shallow lanslides or large collapses of B-1 to B-5 are inferred on west side slope where bedding shows dip slope structure and landslide massess slide on the bedding plane.	Surma Group	The project road is planned to cross landslides or go through beside landslides. Landslides are likely to become instable by the road construction.
7 (C)	91600	91700	100	The collapse is recognized at the top of stream.	Collapsed materials	Debris flow could occur by collapsed materials and reach the road.
8	94600	95500	900	The cutting on the steep cliffs is planned. The bedding of the cliff show opposite dip slope structure. The talus is deposited at the foot of the cliff.	Surma Group	The high cut slope is designed, though the cliff shows opposite dip slope structure.

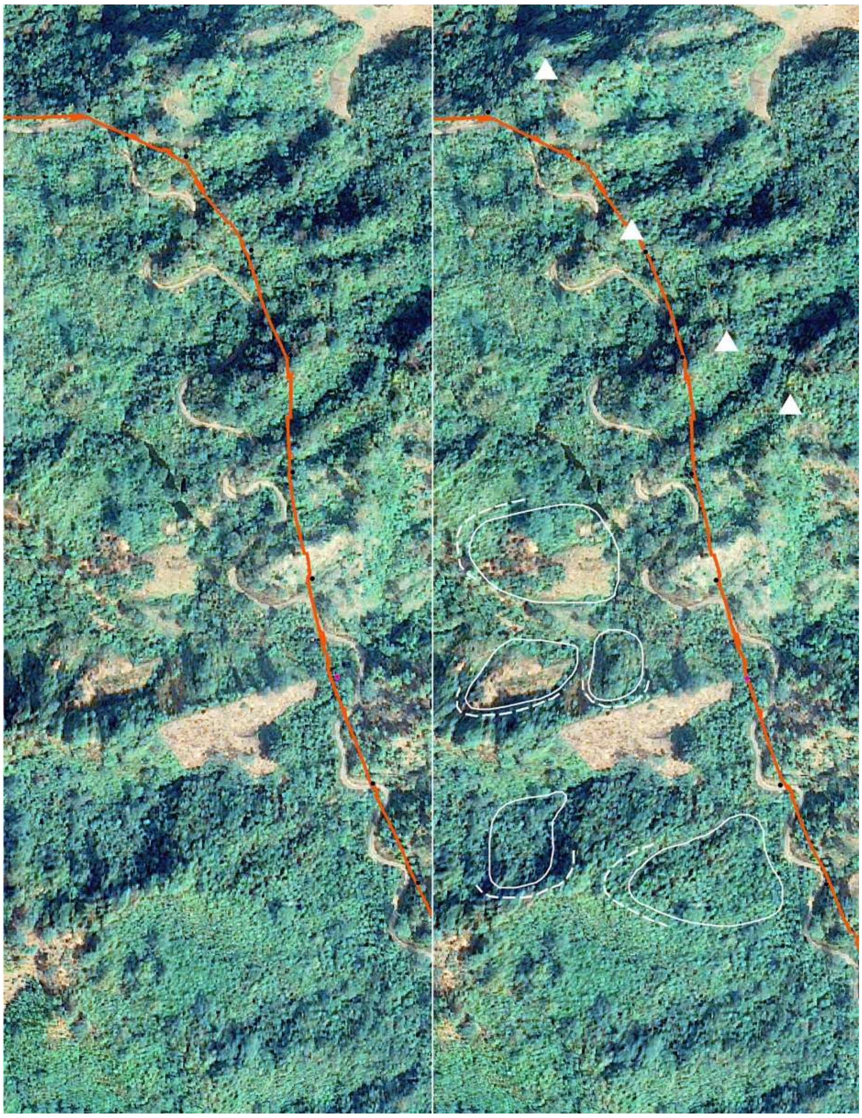
Source: JICA Survey Team

Target Area 1 and 2 (CH 84+650~CH 84+950)

The Project Road is located at the eastern wing of the anticline, so the hill side cut slopes show dip slope structure. However, there are less problems because cut slopes are not so high and any landslide topographies are not recognized.

Target Area 3 (CH 85+300~CH 86+100)

The Project Road passes through the eastern slope of the valley which extends with NNW–SSE direction parallel to the anticlinal axis. The Surma Group shows opposite dip slope structure on the eastern slope. Here, the natural slopes are relatively steep, and the cut slope higher than 40 m is planned. On the western slopes, the Surma Group shows dip slope structure. The slopes with dip slope structure tend to be gentle, so 5 landslide topographies are recognized (Figure 5-11).



Source: JICA Survey Team

Note: White solid ellipses and broken lines represent landslides and main scarps, respectively. The white triangle mark represents a summit. The red solid line represents the Project Road. The top of the images shows north.

Figure 5-11: Stereo-Pair Images of Target Area 3

Target Area 4 (CH 89+000~CH 89+300)

The west-facing slopes show dip slope structure because this area is located at the western wing of the anticline. Several landslides are inferred around the project road. However, there are less problems because landslides are away from the project road (Figure 5-12).

Source: JICA Survey Team

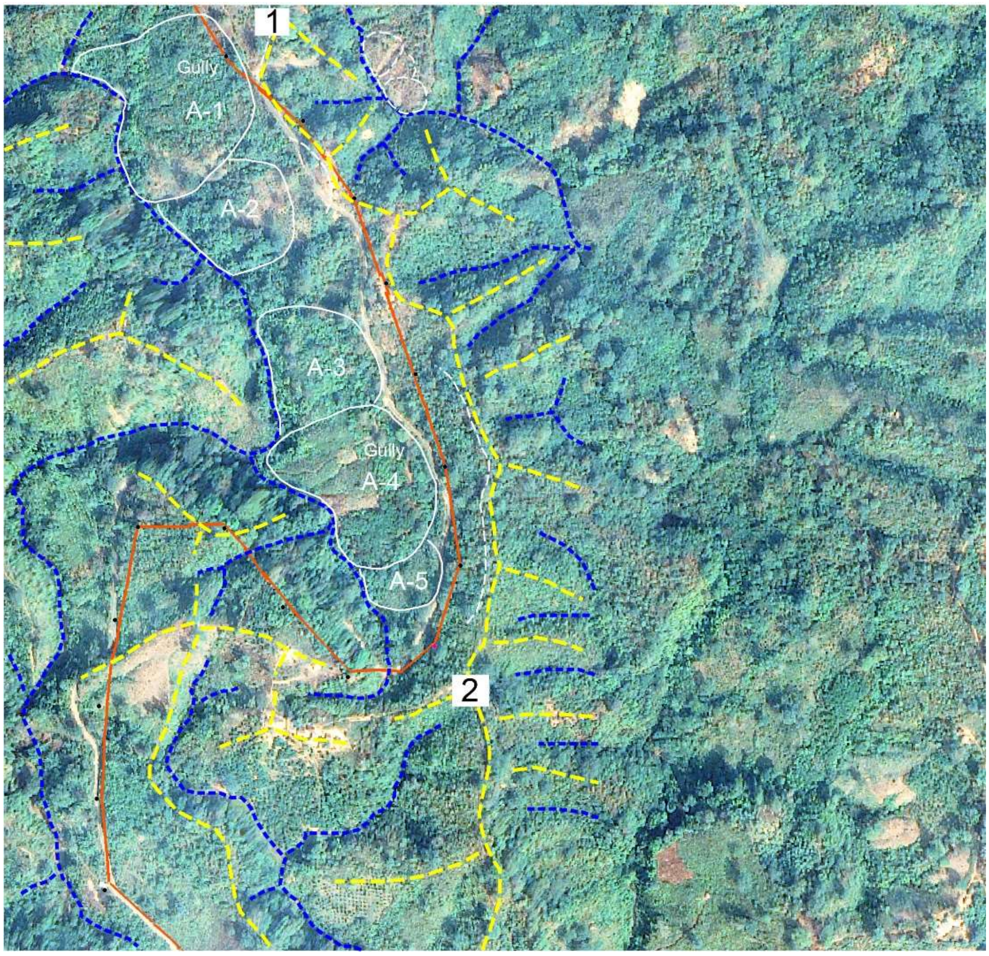
Note: White solid ellipses and broken lines represent landslides and main scarps, respectively. The red solid line represents the Project Road. The top of the image shows north.

Figure 5-12: Stereo-Pair Images of Target Area 4

<u>Target Area 5 (CH 89+800~CH 90+500)</u>

As shown in Figure 5-13, the western slope of ridge 1 to 2 shows an abnormal topography that there are no ridges and streams. The eastern slope shows a normal topography that branched ridges and streams develop. The western slope shows a geologically dip slope structure, and it is inferred that layers slid on the bedding plane and shallow landslides A-1 to A-5 have been formed. The slope just below the ridge is relatively steep, and its lower slope is gentle. The relatively steep slope and gentle slope are inferred to be a main scarp and a landslide mass, respectively. Gully erosions are observed on the landslide surfaces (Figure 5-14, Figure 5-15).

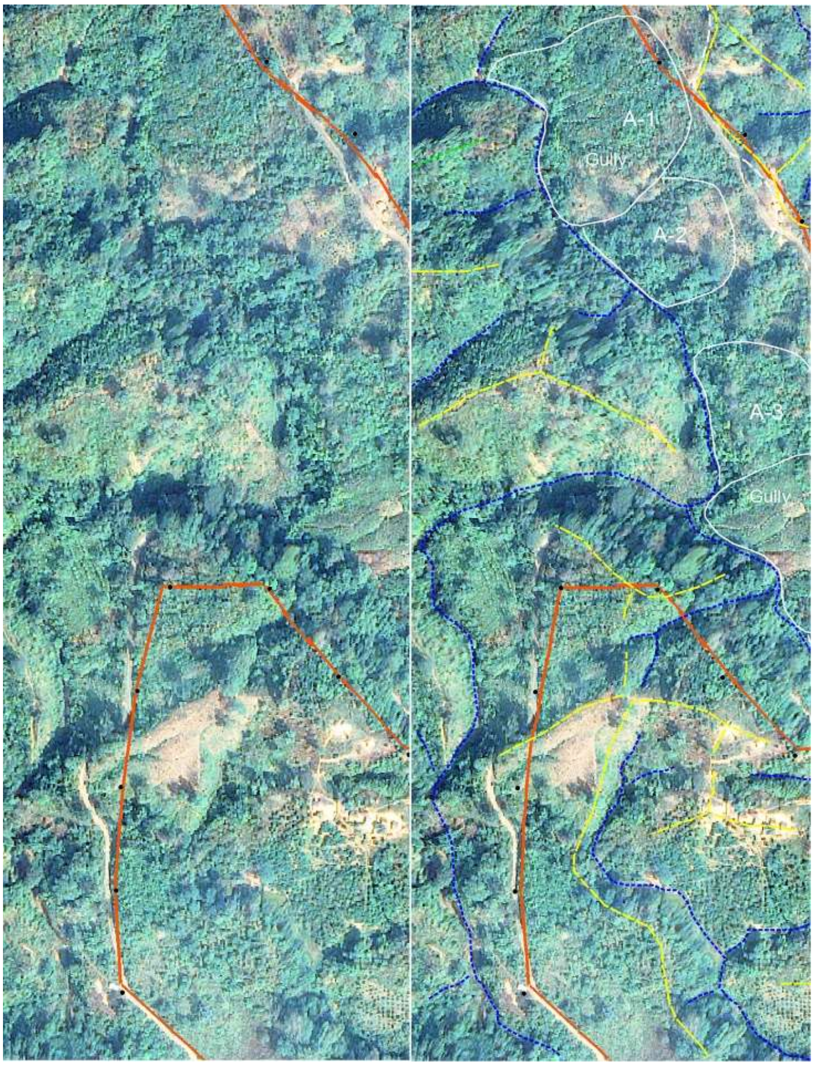
The contour map and cross sections, which were made from satellite data, are shown in Figure 5-16 and Figure 5-17, respectively. Cross section A-4 exhibits a most typical landslide topography. The inclination of a main scarp is parallel to the bedding planes. It is inferred that the upper part of the slope has slid on the bedding plane, and the landslide has been formed. The abnormal slope with no ridges and streams is indicative of such landslide mechanism. In cross sections of A-1, A-4, and A-5, embankments are planned on the upperpart of landslides.



Source: JICA Survey Team

Note: White solid ellipses and broken lines represent landslide and main scarp, respectively.
Yellow broken lines and blue broken line represent ridges and streams, respectively.
The red line represents the Project Road. The top of the image shows north.

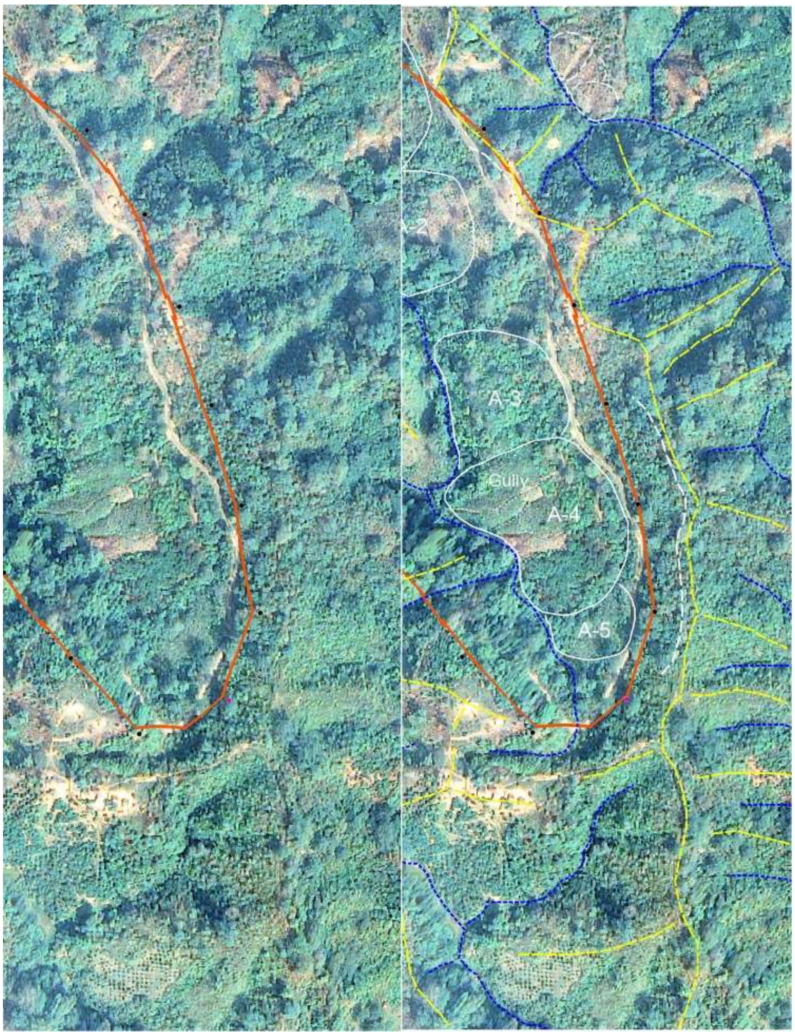
Figure 5-13: Satellite Image of Target Area 5



Source: JICA Survey Team

Note: White solid ellipses and broken lines represent landslide and main scarp, respectively. Yellow broken lines and blue broken line represent ridges and streams, respectively. The red line represents the Project Road. The top of the image shows north.

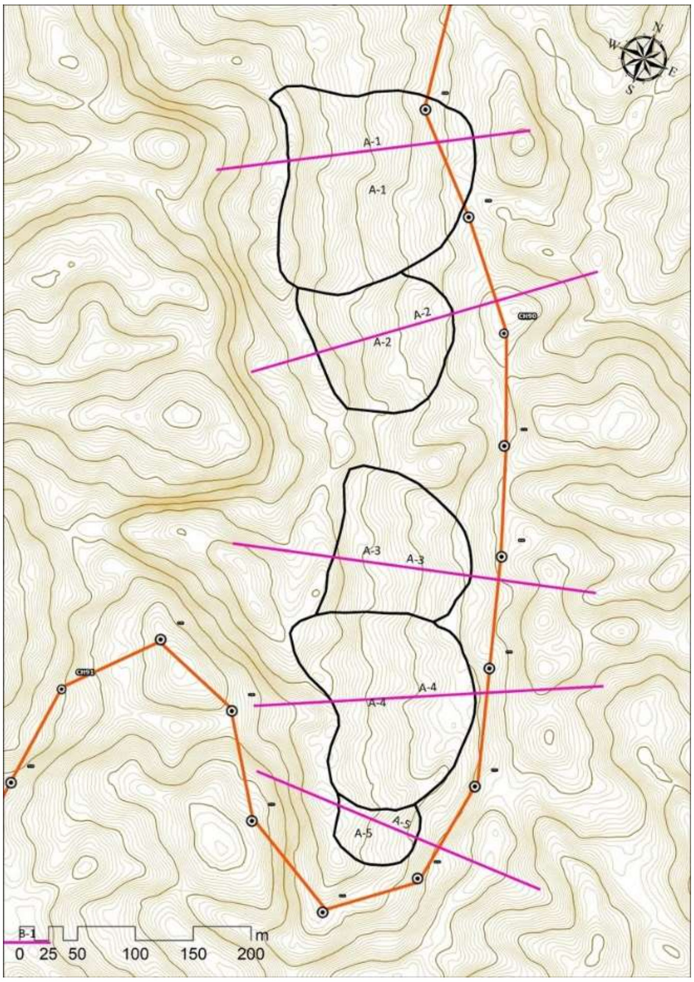
Figure 5-14: Stereo-Pair Images of Target Area 5 (1)



Source: JICA Survey Team

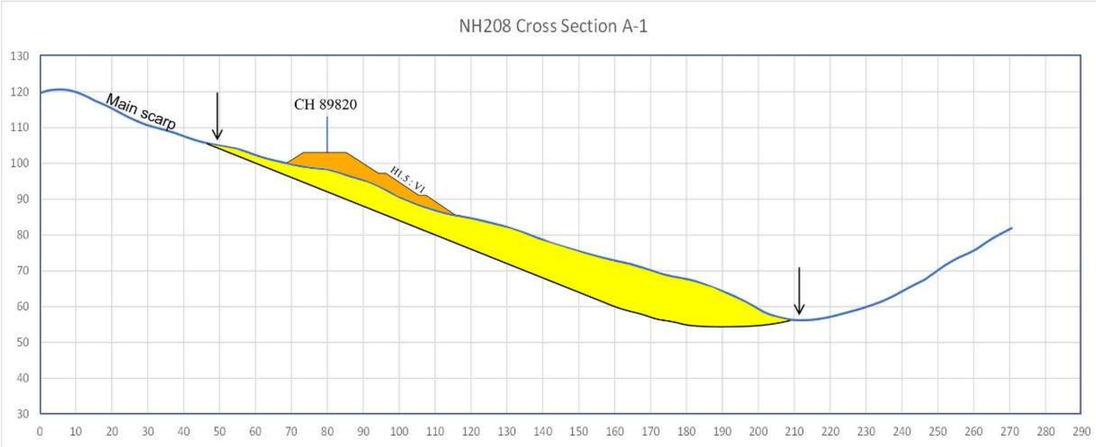
Note: White solid ellipses and broken lines represent landslide and main scarp, respectively.
Yellow broken lines and blue broken line represent ridges and streams, respectively.
The red line represents the Project Road. The top of the image shows north.

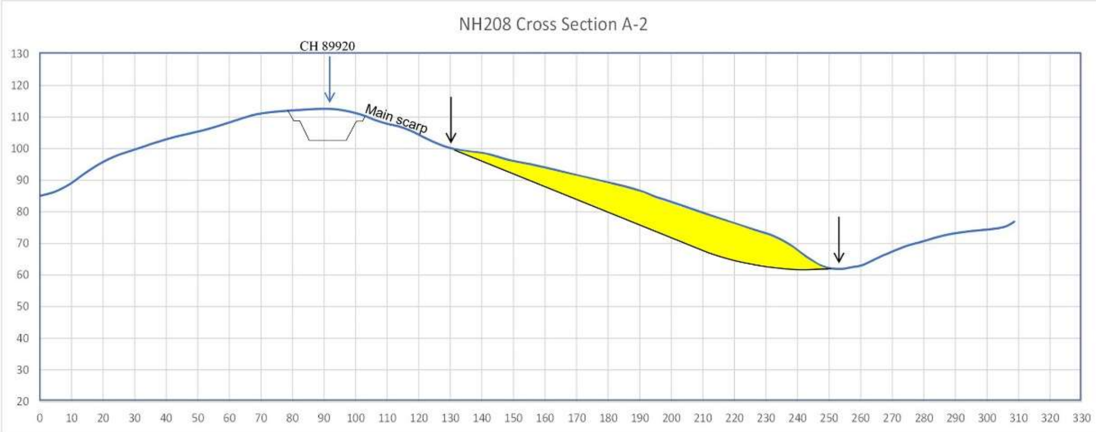
Figure 5-15: Stereo-Pair Images of Target Area 5 (2)

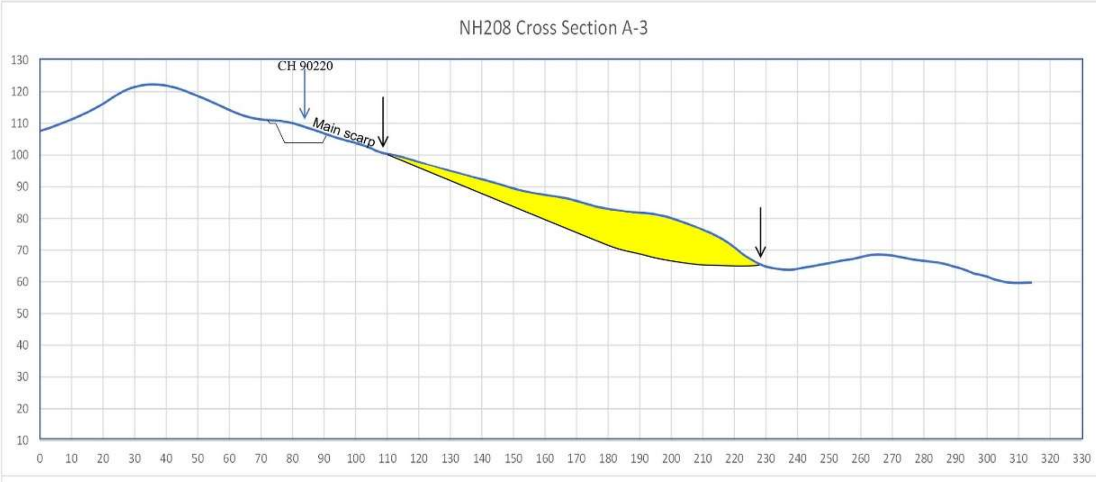


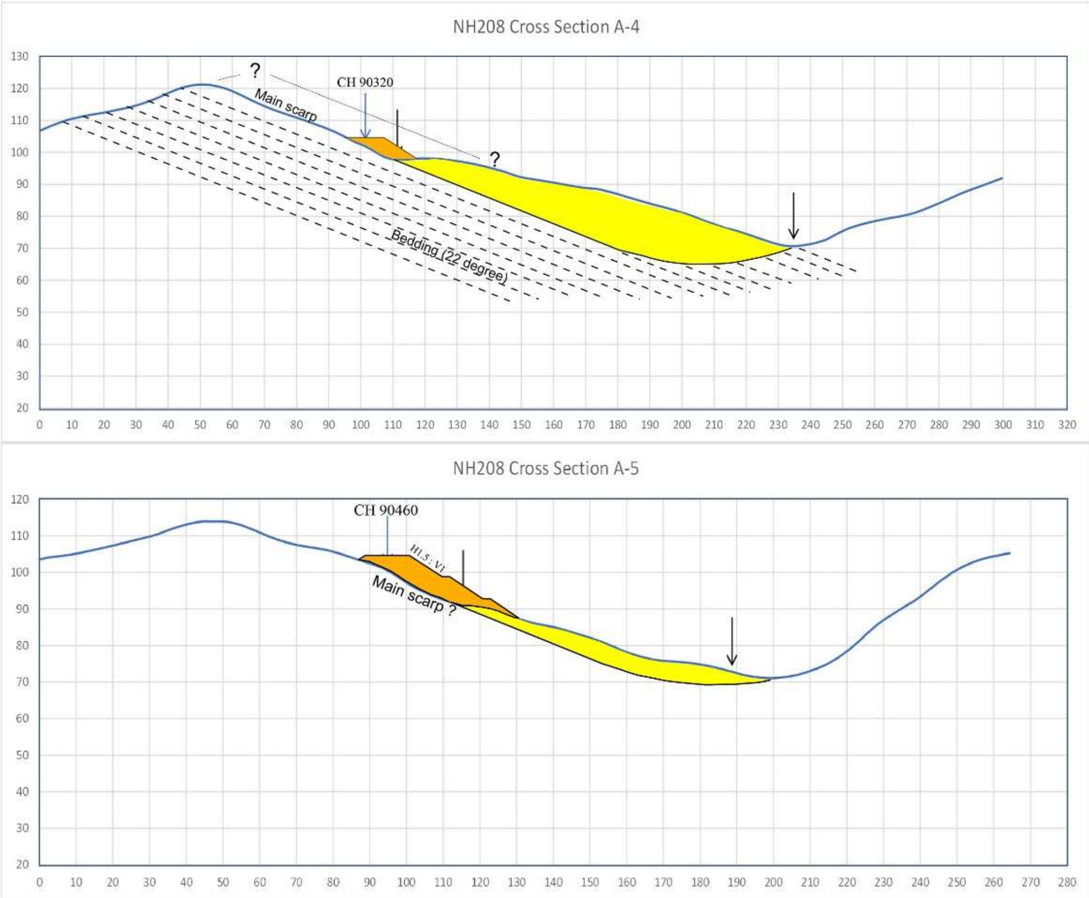
Source: JICA Survey Team

Figure 5-16: Contour Map of Target Area 5


NH208 Cross Section A-1
Main scarp
CH 89820


NH208 Cross Section A-2
CH 89920
Main scarp


NH208 Cross Section A-3
CH 90220
Main scarp



Source: JICA Survey Team

Note: Yellow represents landslide mass. Black broken lines represent bedding planes. Brown represents embankment of the Project Road.

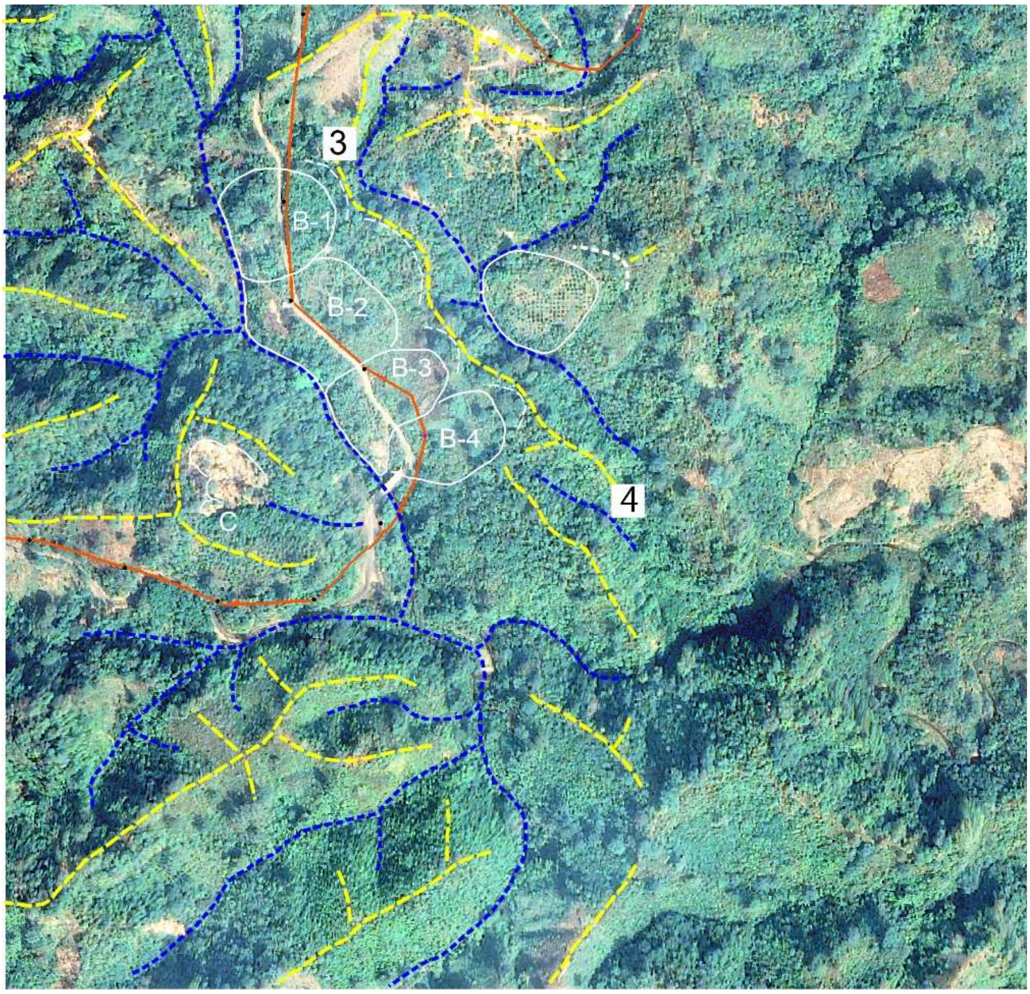
Figure 5-17: Cross Sections of Landslide A

Target Area 6 (CH 91+100~CH 91+600)

The topographic and geological features of target area 6 are the same as those of target area 5. The landslides B–1 to B–4 are inferred on the southwestern slope of ridge 3 to 4. The satellite image of target area 6 is shown in Figure 5-18, and the stereo–pair satellite images are shown in Figure 5-19 and Figure 5-20.

The cross sections are shown in Figure 5-21. The cross section B–3 shows the most typical landslide topography. The slope from the top to the upper part is relatively steep and is considered to be a main scarp. The lower part of the slope is gentle and is considered to be a slid down landslide mass.

The embankments of the Project Road are planned on the landslides B–1, B–2, and B–4. The cutting is planned on the landslide B–3.



Source: JICA Survey Team

Note: White solid ellipses and broken lines represent landslide and main scarp, respectively.
Yellow broken lines and blue broken line represent ridges and streams, respectively.
The red line represents the Project Road. The top of the image shows north.

Figure 5-18: Satellite Image of Target Area 6

Source: JICA Survey Team

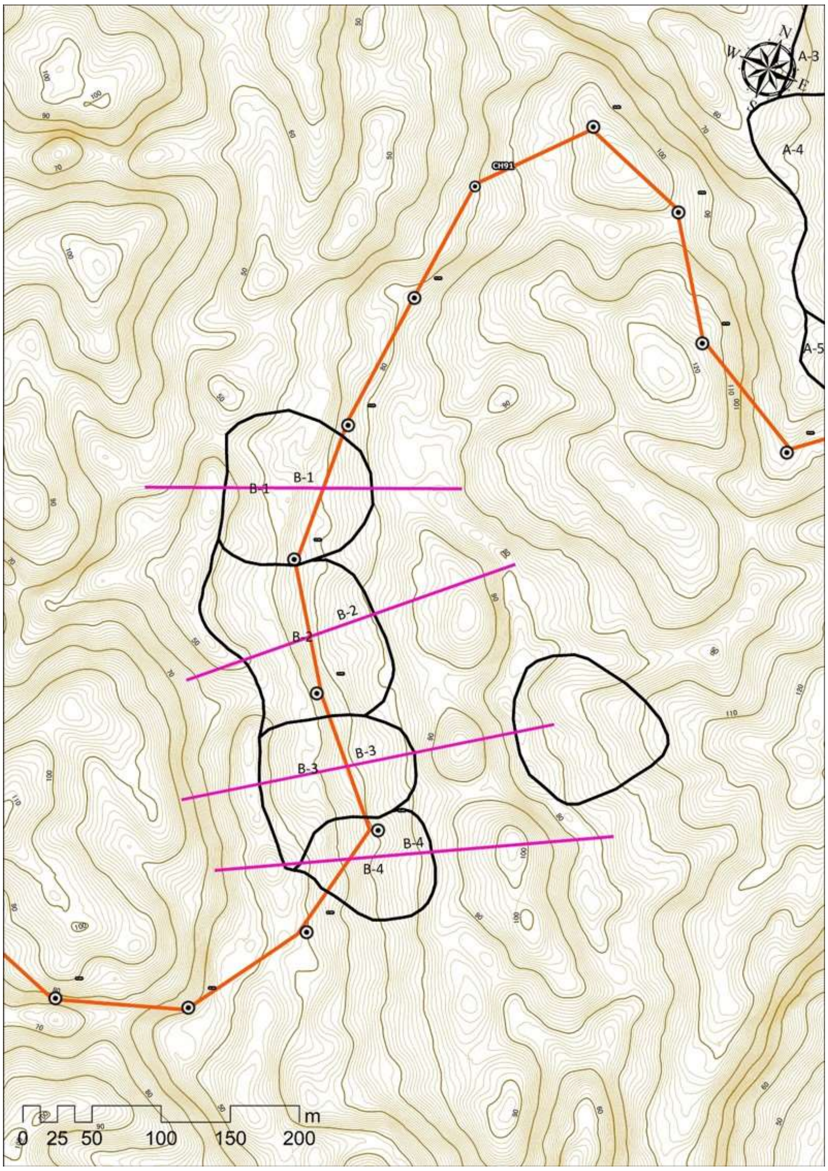
Note: White solid ellipses and broken lines represent landslide and main scarp, respectively.
Yellow broken lines and blue broken line represent ridges and streams, respectively.
The red line represents the Project Road. The top of the image shows north.

Figure 5-19: Stereo-Pair Images of Target Area 6 (1)

Source: JICA Survey Team

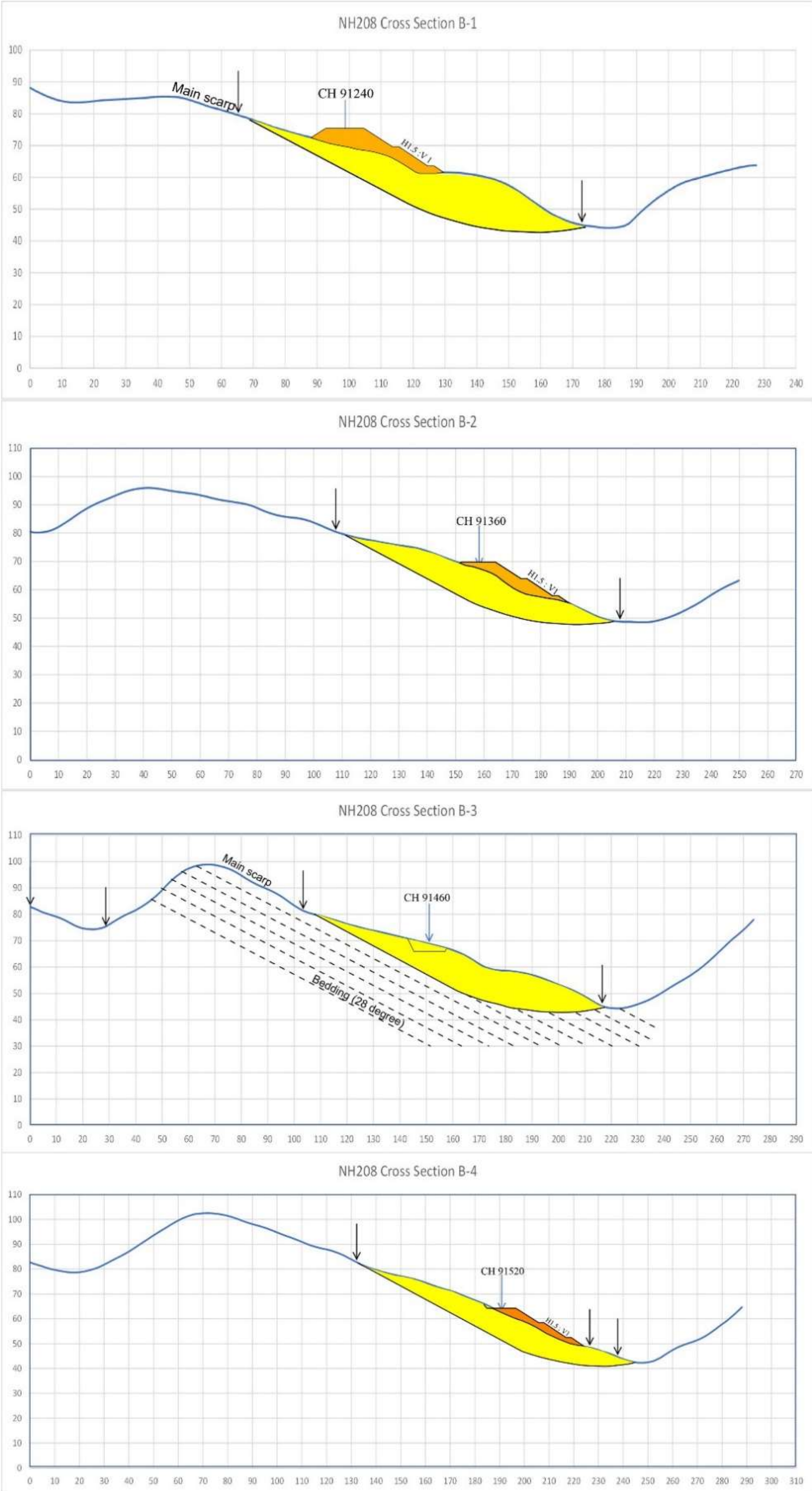
Note: White solid ellipses and broken lines represent landslide and main scarp, respectively. Yellow broken lines and blue broken line represent ridges and streams, respectively. The red line represents the Project Road. The top of the image shows north.

Figure 5-20: Stereo-Pair Images of Target Area 6 (2)



Source: JICA Survey Team

Figure 5-21: Contour Map of Target Area 6



Source: JICA Survey Team
Note: Yellow represents landslide mass. Black broken lines represent bedding planes.
Brown represents embankment of the project road.

Figure 5-22: Cross Sections of Landslide B

<u>Target Area 7 (CH 91+600~CH 91+700)</u>

The head of the stream is collapsed on the opposite side slope of landslide B–3 and B–4 ("C" in Figure 5-18). The collapsed earth and soil could reach the Project Road if the collapsed part (earth and soil) changes to debris flow during the heavy rain, though the quantity and condition of the part are unknown from the satellite image.

<u>Target Area 8 (CH 94+600~CH 95+500)</u>

Cutting works are planned on the steep cliff. Though cut slopes are high, there are less problems of cut slope stability because the layers of cut slope show opposite dip slope structure.

Source: JICA Survey Team
Note: The yellow broken line and red solid line represent ridge and the Project Road, respectively. Triangles represent talus.

Figure 5-23: Stereo-Pair Images of Target Area 8

5.2 Review of DPR

5.2.1 Road Geometric Design

(1) Background of DPR

National Highways and Infrastructure Development Corporation (NHIDCL) proposed the feasibility study, preparation of DPR & providing pre-construction services for up -gradation of selected road stretches /corridors to two lane with paved shoulder NH configuration under BHARATMALA Project and National Highways connectivity to Backward areas /Religious /Tourist places of the country in the state of Tripura. Under this scheme, the consultancy work is awarded to M/s. Technocrats Advisory Services Pvt. Ltd. in association with Vaishnavi Infratech Services Pvt. Ltd. for preparation of Detailed Project Report of Teliamura - Sabroom section (NH-208).

JICA Survey Team (JST) conducted an initial review on Detailed Project Report (DPR) titled "Consultancy services for feasibility study, preparation of DPR & providing pre-construction services for up-gradation of selected road stretches /corridors to Two lane with paved shoulder NH configuration under BHARATMALA Project and National Highways connectivity to Backward areas /Religious /Tourist places of the country in the state of Tripura. Section III: Teliamura - Sabroom Section."

It is decided that this project includes the section between Khowai and Teliamura, which has been excluded from the previous phase (Phase III). Thus, the section name of Khowai - Sabroom is used for this project.

(2) Questionnaire on Road Geometric Design of DPR

JST prepared a questionnaire based on the initial review and sent it to the DPR consultant and conducted a web meeting to exchange opinions. The questionnaire is indicated below.

Table 5-15: Questionnaire on the DPR for NH208 Tripura

No	Items	Questions & Requests	Suggestions /recommendations	Reply/comments by DPR consultant
1	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.	IRCSP73-2018 shall be used.
2	Alignment	Discrepancies in alignment in DPR.	There are discrepancies in alignment between DPR Main Report and Plan & Profile Drawings	This will be corrected.
3	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."	The slope of the country is calculated by using Bentley MXROAD V8i and ground data (topographical survey data).
4	Design Speed	Design speeds do not comply with IRCSP73.	The design speed should be the ruling and the minimum shall be adopted only where site conditions are restrictive and adequate land width is not available. DPR uses various design speeds.	This will be corrected.
5	Cross Sectional Parameters	Shoulder widths do not comply with IRCSP73.	The shoulder widths in DPR do not comply with IRCSP73-2018.	The shoulder widths as per MORTH Circular (17 July 2020) is used.
6	Extra width on sharp horizontal curves	Description about extra widths is not identified.	On horizontal curves with radius up to 300 m, width of pavement and roadway shall be increased as per IRCSP73-2018, 2,7.	This will be corrected.
7	Absolute minimum radius of horizontal curves	Curves smaller than the absolute minimum are observed.	In the DPR, absolute minimum horizontal curves with radius of less than 75m is observed, which should be revised or justified with right reasons.	This will be corrected.
8	Gradients (1)	Gradients steeper than the limiting are observed.	As per IRCSP73, ruling gradients shall be adopted as far as possible. Limiting gradients shall be adopted in difficult situations and for short length. DPR uses gradients steeper than the limiting 6.0%.	This will be corrected.
9	Gradients (2)	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%.	This will be corrected.
10	Gradients (3)	Frequent change of gradient is observed.	As per IRCSP73, grade changes should not be too frequent as to cause kinks and visual discontinuities in the profile. This is commonly called "roller coaster gradients," and shall be avoided.	This will be corrected.
11	Bypass alignment	Bypass alignment option study is missing.	Bypass alignment option study shall be conducted for all seven bypasses.	This will be corrected.
12	Missing document	Cross section drawings.	Some reviews like superelevation for horizontal curves cannot be conducted due to void of cross section drawings.	This will be corrected.

Source: JICA Survey Team based on DPR

5.2.2 Pavement

Pavement design is a major component in road construction, and careful evaluation considering the demand forecast and maintenance cycles should be taken in design of pavement. The project stretch is covered by 2 different DPRs; one is from Khowai to Teliamura, and the other is from Teliamura to Sabroom.

The existing pavement condition is generally poor with presence of potholes, raveling, rutting and patching on the pavement surface. There were no paved shoulders, and earthen shoulders on either side of carriageway were observed almost all along the project stretch. Brick shoulder is present at a few stretches on either side of the carriageway. Shoulder drop as well as pavement edge failure were found at many locations.

(1) Pavement Condition Survey

Inventory of pavement condition survey were carried out by the highway engineer and supporting staff of DPR consultant during September and October, 2015.

According to the survey, the bitumen pavement consisting of average 40mm thickness of bitumen layer and average 220mm thickness of brick soling were observed. The width of bitumen layer ranged from 3.5m to 6.60m, and the width of its shoulder of both sides ranged from 1.0m to 1.50m. However, the earthen shoulders were evaluated as "Poor" conditions, and the riding quality was also concluded to be “Poor” with the speed of 20-25km/hr in the survey stretch except the on-going construction stretch.

Moreover, the visual inspections were conducted and recorded the affected areas of cracking, raveling, potholes, patching, rutting etc. Especially for the cracking, approximately 50% of the area in each chainage was affected. Overall, the cracking was observed in the area of 80% of the survey stretch. Similarly, for the raveling, approximately minimum 30% of the area in each chainage was affected by raveling, and overall, the raveling was observed in the entire survey stretch except the road under construction stretch. Potholes, rutting and patching were observed as well. The details of the pavement conditions are provided in Appendix B-2. Figure 5-24 shows photos of pavement conditions taken by the DPR consultant.

Cracks shown on pavement surface

Pothole of pavement

Raveling on pavement surface

Patching on pavement surface

Source: DPR

Figure 5-24: Pavement Conditions

(2) Sub-grade Investigation, Field and Laboratory Test Results

Field and laboratory tests were conducted on the collected soil samples from the trial pits and associated the pavement composition. Procedures for investigations, sampling and testing of soils and other construction materials are in accordance with MoRTH Specifications, wherever applicable, to determine their suitability.

For the survey stretch from Khowai to Teliamura, trial pits of size 1m x 1m x 1m(depth) were dug at the pavement shoulder surface at 0.5km interval, extending through the pavement layers down to the sub-grade level to assess the visual classification of soil, field density, field moisture content, Atterberg limits, existing pavement composition, and available CBR. The layer compositions of the existing pavement are shown in Table 5-16, and the laboratory test results are shown in Table 5-17. The average bituminous surface was 55mm. California Bearing Ratio (CBR) tests were carried out on the pit samples in the laboratory as per standard procedures. At optimum moisture content (OMC) soil samples were compacted at three different energy levels corresponding to 10 blows, 35 blows, and 65 blows as per IS 2720 Part 8. These compacted unsoaked samples collected from selected locations were also tested. Soaked CBR values at 97% MDD is shown in Table 5-18. The fluctuation of the available CBR was from 3.12 to 21.30, and the average was 6.74.

On the other hand, the survey stretch from Teliamura to Sabroom, the DPR stated that the subgrade investigation by collecting soil samples was carried out, but the survey results were not attached in the DPR. Related survey was conducted; for instance, geotechnical investigations were carried out in DPR after the bridge proposals were finalized. During the feasibility study, the pavement compositions of thicknesses of bitumen layer and brick soling of the existing embankment were recorded every 500m of either Right or left-hand side. However, this was only for the pavement crust composition survey of the depth up to around 250mm, not for sub-grade investigations. The existing pavement compositions of the crust are shown in Appendix B-5. In terms of sub-grade investigation, during the feasibility study and DPR period, the samples from the total 14 locations including borrow areas were exclusively obtained for sub-grade investigations by laboratory tests. The laboratory test results are shown in Table 5-19 and Table 5-20.

Table 5-16: Layer Compositions

TP No.	Chainage	Side	Layer (mm)																										Total Depth digged (mm)
			Bituminous Surface	WBM	BFS	BES	PMC	WBM	BFS	BS	Layer-1		Subgrade																
				Brick Bats	Brick Flat Soling	Brick Edge Soling	Premix Carpet	Brick Bats	Brick Flat Soling	Brick Soling	Yellowish Brown, Silty Sand with mica	Yellowish Brown, Clayey Sandy Silt	Brownish Grey, Silty Clay with Sand Mixture	Brownish Grey, Silty Clay	Reddish Grey, Clayey Sandy Silt	Reddish Grey, Silty Sand wirh mica	Yellow Grey, Clayey Silty Sand with mica	Reddish Brown, Clayey Silt with Sand Mixture	Yellowish Brown, Clayey Silty Sand with mica	Yellowish Grey, Silty Sand with mica	Reddish Brown, Clayey Silty Sand	Brownish Grey, Clay with Sand Mixture	Reddish Grey, Clayey Silty Sand	Yellowish Brown, Silty Sand with mica	Brownish Grey, Clayey Silty Sand with mica	Brownish Grey, Silty Clay with Sand Mixture	Brownish Grey, Silty Clay /Clayey Silt with Sand Mixture	Browish Grey, Clayey Silt with Sand Mixture	
206	103+000	LHS	40	280									680																1,000
207	103+500	RHS	100	240										660															1,000
208	104+000	LHS	40	200	75									685															1,000
209	104+500	RHS	80	150	75									695															1,000
210	105+000	LHS	60	200	75									685															1,020
211	105+400	RHS	70	260										670															1,000
212	106+000	LHS	30	130		125									715														1,000
213	106+500	RHS	60	200												740													1,000
214	107+000	LHS	70	140			20	80	75							615													1,000
215	107+500	RHS	80	200													720												1,000
216	108+000	LHS	20	200														780											1,000
217	108+400	RHS	30	300														670											1,000
218	109+000	LHS	40	200															760										1,000
219	109+500	RHS	40	150																810									1,000
220	110+000	LHS	60	250																	690								1,000
221	110+500	RHS	60	200																		740							1,000
222	111+000	LHS	60	200																			740						1,000
223	111+500	RHS	60	300																			640						1,000
224	112+000	LHS	60	200																				740					1,000
225	112+500	RHS	40	350															610										1,000
226	112+900	LHS	60	150																				790					1,000
227	113+500	RHS	50	200									750																1,000
228	114+000	LHS	30	300										670															1,000
229	114+500	RHS	40	100																					860				1,000
230	115+000	LHS	40	200							200															560			1,000
231	115+500	RHS	60	150									790																1,000
232	116+000	LHS	80	150	100								670																1,000
233	116+500	RHS	60	180																							760		1,000
234	117+000	LHS	50	250																							670		970
235	117+500	RHS	90	150								100																660	1,000
236	118+000	LHS	70	280									650																1,000
237	118+500	RHS	60							350			590																1,000
	Average		55.9																										

Source: JICA Survey Team based on DPR

Table 5-17: Laboratory Test Results-1 (Khowai- Teliamura)

SL No.	Chainage (km)	Sieve Analysis (% passing by weight)						Atterberg Limit			I.S. Classification	Differential Free Swell Index %
		20 mm	10 mm	4.75 mm	2.00 mm	425 m	75 m	LL (%)	PL (%)	PI (%)		
206	103.000	100	100	100	100	93	77	33	21	12	CL	2.22
207	103.500	100	100	100	100	99	95	37	18	19	CI	4.36
208	104.000	100	100	100	100	99	94	54	26	28	CH	16.35
209	104.500	100	100	100	100	99	96	48	25	23	CI	14.45
210	105.000	100	100	100	100	100	94	45	21	24	CI	10.36
211	105.400	100	100	100	100	95	87	56	29	27	CH	20.00
212	106.000	100	100	100	100	95	81	53	23	30	CH	18.36
213	106.500	100	100	100	100	88	64	46	25	21	CI	9.36
214	107.000	100	100	100	100	86	57	34	18	16	CL	0.00
215	107.500	100	100	100	100	85	61	33	18	15	CL	7.85
216	108.000	100	100	100	100	95	81	34	22	12	CL	8.47
217	108.400	100	100	100	100	91	68	37	19	18	CI	10.38
218	109.000	100	100	100	100	87	59	38	22	16	CI	6.69
219	109.500	100	100	100	100	87	61	36	21	15	CI	8.57
220	110.000	100	100	100	100	89	69	33	18	15	CL	6.58
221	110.500	100	100	100	100	91	74	43	21	22	CI	7.88
222	111.000	100	100	100	100	91	61	37	20	17	CI	9.52
223	111.500	100	100	100	100	93	67	38	23	15	CI	10.65
224	112.000	100	100	100	100	92	62	37	22	15	CI	8.75
225	112.500	100	100	100	100	92	58	36	18	18	CI	9.75
226	112.900	100	100	100	100	88	38	24	16	8	SC	0.00
227	113.500	100	100	100	100	100	86	37	17	20	CI	7.55
228	114.000	100	100	100	100	100	90	44	22	22	CI	8.75
229	114.500	100	100	100	100	86	55	38	18	20	CI	10.36
230	115.000	100	100	100	100	94	86	36	20	16	CI	0.00
231	115.600	100	100	100	100	94	87	38	22	16	CI	7.65
232	116.000	100	100	100	100	93	76	42	25	17	CI	9.36
233	116.500	100	100	100	100	95	79	51	26	25	CH	12.36
234	117.000	100	100	100	100	94	81	43	24	19	CI	0.00
235	117.500	100	100	100	100	95	82	45	20	25	CI	6.87
236	118.000	100	100	100	100	99	93	49	25	24	CI	5.68
237	118.500	100	100	100	100	99	88	48	26	22	CI	7.14

Source: DPR

Table 5-18: Laboratory Test Results-2 (Khowai-Teliamura)

SL. No.	Chainage (km)	MDD (gm/cc)	OMC (%)	Soaked CBR at 97% of MDD
206	103.000	1.896	15.12	6.59
207	103.500	1.813	16.13	4.15
208	104.000	1.870	15.87	3.12
209	104.500	1.768	15.82	3.83
210	105.000	1.870	15.86	4.10
211	105.400	1.884	13.12	4.09
212	106.000	1.905	13.88	4.02
213	106.500	1.949	12.96	6.82
214	107.000	1.912	13.40	8.15
215	107.500	1.860	13.77	8.19
216	108.000	1.904	13.87	6.15
217	108.400	1.894	14.83	7.45
218	109.000	1.916	13.42	8.15
219	109.500	1.860	13.77	8.25
220	110.000	1.894	14.83	7.67
221	110.500	1.868	13.93	5.67
222	111.000	1.962	12.43	8.55
223	111.500	1.856	15.12	8.76
224	112.000	1.963	12.44	8.34
225	112.500	1.978	12.76	8.67
226	112.900	1.987	10.56	21.30
227	113.500	1.817	15.83	5.48
228	114.000	1.813	16.13	4.74
229	114.500	1.976	10.90	8.17
230	115.000	1.864	14.59	6.56
231	115.600	1.884	13.12	6.31
232	116.000	1.862	15.22	6.92
233	116.500	1.897	15.15	4.69
234	117.000	1.910	12.25	5.96
235	117.500	1.866	15.75	5.46
236	118.000	1.870	15.88	3.90
237	118.500	1.890	13.70	5.31

Source: DPR

Table 5-19: Laboratory Test Results-1

SI. No.	Chainage No. (Km)	MDD (g/cc)	OMC (%)	Unsoaked CBR (%)	Soaked CBR (%)	Swelling Index (%)
1	10	1.756	15.71	15.43	7.54	3.86
2	20	1.878	11.55	18.86	8.14	2.65
3	30	1.782	15.26	16.50	7.86	3.79
4	55	1.794	14.78	17.43	7.98	3.79
5	65	1.802	13.92	18.58	8.04	2.98
6	75	1.816	14.11	18.61	8.11	2.78
7	95	1.823	13.75	17.93	7.96	2.71
8	105	1.787	15.78	16.76	7.89	3.73
9	115	1.796	14.74	17.36	7.85	3.81
10	Borrow Area near Km 44.00	1.778	15.55	17.26	8.43	3.77
11	Borrow Area near Km 82.00	1.800	13.76	17.78	8.21	3.02

Source: DPR

Table 5-20: Laboratory Test Results-2

Chainage No. (Km)	Soil Classification	Insitu Dry Density (g/cc)	Insitu Moisture (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	MDD (g/cc)	OMC (%)	Unsoaked CBR (%)	Soaked CBR (%)	Swelling Index (%)
7+000	CL	1.14	14.15	39	41	20	26	18	8	1.84	14.9	21.5	12.43	3.9
14+000	CL	1.13	18.15	37	23	40	29	19	10	1.808	15.6	19.71	10.28	4.1
20+500	SM	1.27	12.33	77	13	10	19	16	3	1.82	16.9	21.85	11.71	1.8

Source: DPR

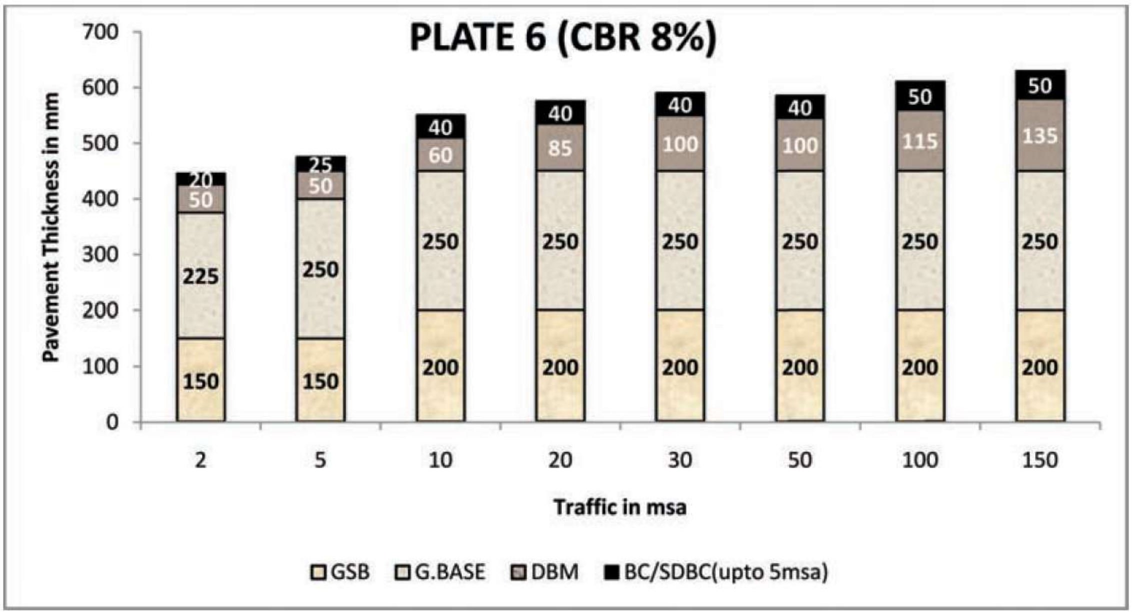
(3) Design of New Flexible Pavement

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. The Survey stretch was designed 2-lane with paved shoulder configuration; generally, such as 14m (i.e. 7.0m carriageway + 2x1.5m paved shoulder + 2x2.0m earthen shoulder. Therefore, in the DPRs, IRC SP73[43] was adopted. As it was mentioned earlier, the Project stretch was covered by 2 different DPRs.

For the Survey stretch from Khowai to Teliamura, the DPR consultant adopted IRC 37-2012[44] for the design of flexible pavements in accordance with IRC SP 73-2015. As per the Clause 5.4.1 of IRC SP 73-2015, The 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.

In the Section 10 of IRC 37-2012, five different combinations of traffic and materials properties have been considered for which pavement composition have been supported with illustration to compare the proposed design thickness in the design catalogue with that given by IITPAVE, the pavement analysis software.

The DPR consultant proposed the combination of granular base and granular subbase, and 20 msa of Design Traffic and 8% of design CBR were applied to the pavement thickness design. Therefore, Plate 6 of IRC 37-2012 was selected and shown as follows.



Source: IRC 37-2012

Figure 5-25: Catalogue for Pavement Thickness as per IRC 37-2012 (Plate 6)

In the Survey stretch, reconstruction of existing pavement is recommended due to the poor pavement surface of extensive cracking, raveling, rutting, potholes etc., besides, the proposed cutting and filling of vertical profile. Hence, a new pavement thickness of BC=40mm, DBM=85mm, WMM (in two layer)=250mm and GSB=200mm are proposed on existing portion

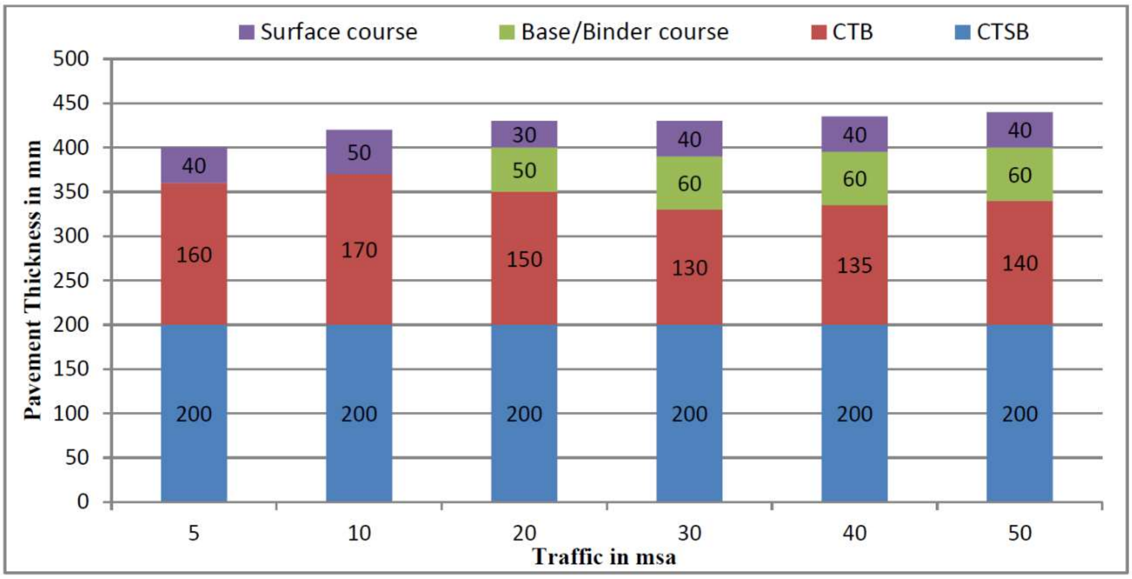
43 IRC SP73: Manual of Specifications and Standards for Two Laning of Highways with Paved Shoulder
44 IRC 37-2012: Guidelines for the Design of Flexible Pavements

after removal of existing pavement layer up to a required depth based on the profile design with exposed pavement layer treated as subgrade course after compaction.

Besides the new pavement design, the overlay design was conducted. The rebound deflections were measured using Benkelman Beam Deflection (BBD) method as per IRC 81-1997. The calculation of characteristic deflections which will be required for overlay design of the existing pavement was conducted in the DPR; however, JICA Survey Team has not received the result from the DPR consultant.

On the other hand, for the Survey stretch from Teliamura to Sabroom, the DPR consultant adopted IRC 37-2018 for the design of flexible pavements in accordance with IRC SP 73-2018. As per the Clause 5.4.1 of IRC SP 73-2018, the flexible pavement shall be designed for a minimum design period of 15 years, subject to the condition that design traffic shall not be less than 20 msa. In the Section 12 of IRC 37-2018, six categories of pavements have been given.

The DPR consultant proposed the combination of bituminous surface course with Cement Treated Sub Base (CTSB), Cement Treated Base (CTB) and Stress Absorbing Membrane Interlayer (SAMI). For the layers of CTBS and CTB, Jhama Brick Base (JBB) and Jhama Brick Sub Base (JBSB) were proposed, respectively. In addition, 20 msa of Design Traffic and 8% of design CBR were applied to the pavement thickness design. Therefore, Plate 20 of IRC 37-2018 was selected and shown as follows.



Source: IRC 37-2018

Figure 5-26: Catalogue for Pavement Thickness as per IRC 37-2018 (Plate 20)

The existing pavement is composite of 20-40mm thickness of bituminous layer over brick work. Since the entire length is proposed as new pavement, the Benkelman Beam Deflection (BBD) survey was not conducted in the DPR.

The following table shows the comparison of the pavement composition.

Table 5-21: Comparison of Pavement Compositions

Survey Stretch	DPR consultant conformed/followed Design Standards	Design Traffic (msa)	Design CBR (%)	Bituminous layer (mm)	Base/Sub-base (mm)		Sub-grade (mm)	Total Thickness (mm)
Khowai-Teliamura	IRC SP 73 2015, IRC 37-2012	20	8	BC	DBM	WMM	GSB	575
				40	85	250	200	
Teliamura-Sabroom	IRC SP 73 2018, IRC 37-2018	20	8	BC	DBM	JBB	JBSB	430
				30	50	150	200	

Source: JICA Survey Team

(4) Quarry Material

The material investigation for road construction was carried out to identify the potential sources of construction materials and to assess their general availability, engineering properties and quantities.

For the Survey stretch from Khowai to Teliamura, the material investigation was conducted by the DPR consultant for coarse aggregate, fine aggregate and bitumen.

Coarse Aggregate

Hard stone aggregate, fulfilling the requirements of concrete works, base, sub base and asphaltic works are considered from Dharmanagar with an average lead of 86km respectively from project C.G.

Fine Aggregate

Fine sand or coarse sand is collected from local river/Cherra, filling the requirements of concrete works and filling works. The approximate lead distance from project C.G. is taken as 10 km. The details of coarse/fine aggregate sources are shown as follows.

Table 5-22: Details of Coarse/Fine Aggregate Sources

Material	Quarry Location	Approx. lead to the Project C.G.	Probable purpose of use of material
Coarse Aggregate	Dharmanagar	86 km	GSB, WMM, Bituminous and concrete works
Fine Aggregate	Local river/ Cherra	10 km	Filling works

Source: DPR

Bitumen

Bitumen of viscosity grade VG-30 is available from Guwahati IOCL. The average lead from Project C.G. is 506 km.

On the other hand, for the Survey stretch from Teliamura to Sabroom, the DPR consultant listed the source of materials as follows.

- Aggregate quarry for structural and road works is identified at Churaibari which is approx. 200km away from Teliamura.
- Sand source has been located from local river with average lead of 20km.
- Borrow earth can be obtained from number of locations along the Project road.
- Bitumen supply is considered from Guwahati IOCL with lead of approx. 550km.

5.2.3 Slope Protection

At the beginning, DPR for slope protection was quite incomplete. Cross sections were not provided by the DPR consultant except for the longitudinal section. As for the typical cross sections, the gradient of cut slope and slope protection measures above the breast walls were not shown, while the breast walls and retaining wall were drawn.

In the preliminary design report of NH 208 Kailashahar–Teliamura, the cut slope gradient is shown in Table 5-23 based on "IRC:SP:48-1998 Hill Road Manual". The Project Road of NH 208 Teliamura–Sabroom is the southern extension of NH 208 Kailashahar–Teliamura, and the topographic and geological features of NH 208 Teliamura–Sabroom are the same as NH 208 Kailashahar–Teliamura. Therefore, we proposed to the DPR consultant to design the cut slope gradient based on Table 5-23, and the DPR consultant accepted this suggestion.

Table 5-23: Cut Slope Design

Items	Design
Cut slope gradient	0.5H : 1V
Height of bench	6 m
Width of bench	2 m

Source: JICA Survey Team based on the DPR

In the recently provided cross sections, the gradient of embankment slopes are designed for 1.5H : 1V. According to IRC:SP:84-2014 "Manual of Specifications & Standards", the gradient of embankment slopes is described as follows: "Side slopes shall not be steeper than 2H : 1V unless soil is retained by suitable soil retaining structure". The gradient of 1.5H : 1V is contradictory to the above manual. The gradient of embankment slopes should be corrected to 2H : 1V.

According to the cost estimation of DPR, hydroseeding is suggested for slope protection measures. The Surma Group, which is distributed in the hilly terrain, have some problems of long-term stability, if cut slopes show dip slope structure and large scaled cut slopes are planned. Hydroseeding is not applicable for cut slopes under the above conditions, because hydroseeding is aimed at preventing surface erosion of cut slope.

DPR does not refer to landslide topography. As mentioned in Chapter 5.1.5, landslides A and B are inferred in the target areas 5 and 6. Therefore, it is necessary to take measures such as adding design of landslide prevention measures or shifting of the Project Road to avoid the landslides.

5.2.4 Bridges and Structures

(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) 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 Table 5-24.)

Table 5-24: 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:73-2018	Manual of Specifications and Standards for Two Laning of Highways with Paved Shoulder (Second Revision)
IRC:SP-84-2019	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. 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 the 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 two-lane bridges in the urban area shall have footpaths on either side. The clear carriageway width shall be exactly as per the road formation width (excluding railing). In case of footpath, the carriageway width shall be 13 m including kerb shyness. At the inner edge of footpaths pedestrian railings and at the outer edge crash barrier shall be provided. The width of footpath clear of crash barrier and railings shall be 1.5 m minimum, which ensure the continuity of Metal Beam crash barrier installed on the bridge approaches. The width of footpath clear of crash barrier and railings shall be 1.5 m minimum.

Typical cross sections of new two-lane bridge with footpath for a 2-lane Project Highway is given in Figure 5-27.

List of bridge structures to be reconstructed and/or widened shall be specified in Schedule 'B' of the Concession Agreement. However, rehabilitation of bridges including repair/replacement of bearing, expansion joints, railing, wearing coat etc. shall be done on the existing bridge irrespective of its mention in Schedule ‘B’. Concessionaire must ensure its rehabilitation before COD.

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

(a) Reconstruction/ New construction in Open country – Plain/rolling terrain

- Total Width = 18.0m
- Carriageway Width = 13.0 m
- Footpath width = 3.0m (2x1.5m)
- Width of Crash Barrier = 1.0m (2x0.5m)
- Width of Kerb +Railing = 1.0m (2x0.5m)

(b) ROB in all location -all terrain

- Total Width = 18.0m
- Carriageway Width = 13.0m
- Footpath width = 3.0m (2x1.5m)
- Width of Crash Barrier = 1.0m (2x0.5m)
- Width of Steel Barrier = 1.0m (2x0.5m)

(c) Existing Bridge retained, additional 2 lane bridge in built-up area- plain/rolling terrain

- Total Width = 11.0m
- Carriageway Width = 8.0 m
- Footpath width = 1.5m (1x1.5m)
- Width of Crash Barrier = 1.0m (2x0.5m)
- Width of Steel Barrier = 0.5m (1x0.5m)

(d) Existing Bridge retained, additional 2 lane bridge in open country – all terrain

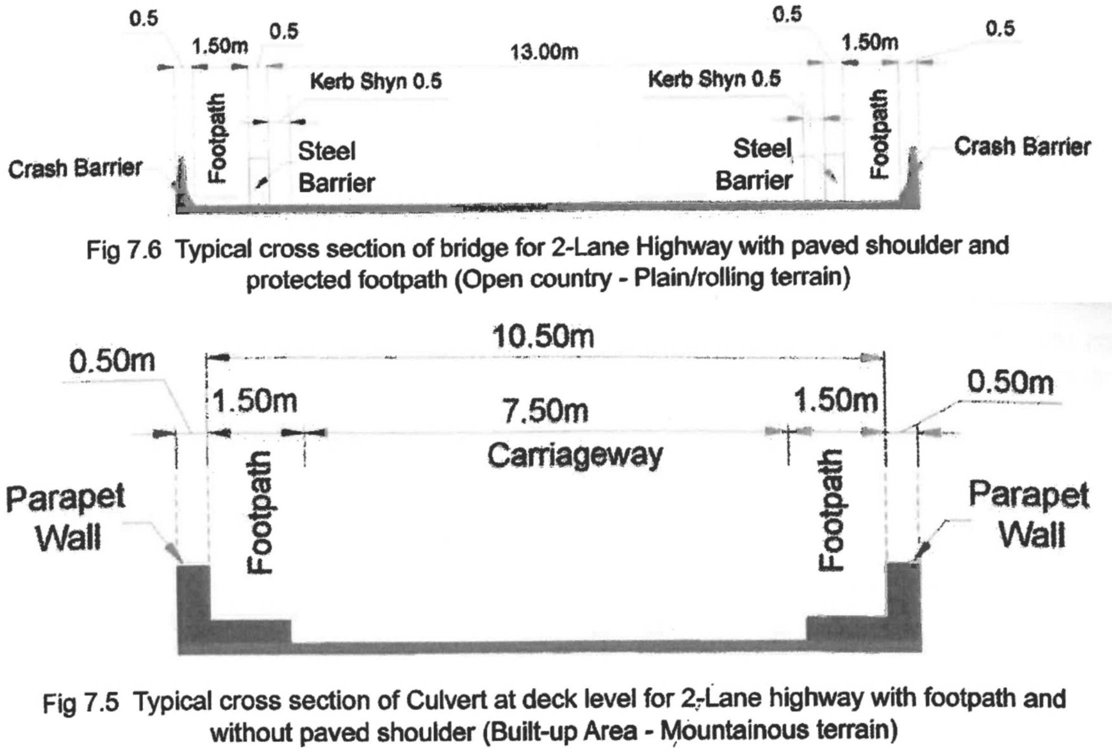
- Total Width = 13.0m
- Carriageway Width = 10.0 m
- Footpath width = 1.5m (1x1.5m)
- Width of Crash Barrier = 1.0m (2x0.5m)
- Width of Steel Barrier = 0.5m (1x0.5m)

(e) 2-lane Grade separated structure in open country-plain/rolling terrain

- Total Width = 12.0m
- Carriageway Width = 11.0 m
- Width of Crash Barrier = 1.0m (2x0.5m)

(f) Culvert in built-up area – mountainous terrain

- Total Width = 11.5m
- Carriageway Width = 7.5 m
- Footpath width = 3.0m (2x1.5m)
- Width of Crash Barrier = 1.0m (2x0.5m)



Source: IRC SP73-2018

Figure 5-27: Carriageway Configuration

(4) Classification of Existing Bridges

All the existing bridges which are structurally distressed shall be reconstructed as new bridges.

Components like bearings, expansion joints, railings, crash barriers, wearing surface, etc., which are not in sound condition, shall be replaced. Minor non-structural works shall be suitably repaired.

If the width of additional widening is less than 0.5 m on either side, 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 30 on either side approaches.

List of bridge structures to be reconstructed and/or widened shall be specified in Schedule 'B' of the Concession Agreement. However, rehabilitation of bridges including repair/replacement of bearing, expansion joints, railing, wearing coat etc. shall be done on the existing bridge irrespective of its mention in Schedule 'B'. Concessionaire must ensure its rehabilitation before COD.

All the 32 existing bridges are out of the planned alignment and will be retained. The 46 additional bridges are proposed to be newly constructed on the realignment and bypass. Details of existing bridge are given in "annexure 1.5 (a)" of Bridge inventory.

2 two major bridge were proposed at CH 53+500 and CH 60+450.

Table 5-25: List of Bridges in Tripura

No.	Chainage	Span Length (m)	Bridge Length (m)	Existing Bridge	Under Bridge	Structure Type	Measures
1	12+915	2x25m	50		Nala	PSC + RC Slab	New
2	17+900	1x25m	25		Nala	PSC + RC Slab	New
3	18+800	2x20m	40		River	RCC	New
4	19+770	2x8m	16		Nala	RC Box	New
5	21+320	1x21m	21		Nala	RCC	New
6	24+060	2x25m	50		Nala	PSC + RC Slab	New
7	24+760	1x21m	21		Nala	RCC	New
8	24+930	1x21m	21		Nala	RCC	New
9	25+340	2x20m	40			RCC	New
10	29+470	2x10m	20		Nala	RC Box	New
11	31+050	2x25m	50		Nala	PSC + RC Slab	New
12	32+870	1x20m	20		Nala	RCC	New
13	34+450	1x20m	20		Nala	RCC	New
14	36+290	1x35m	35		Nala	PSC + RC Slab	New
15	37+280	1x12m	12		Nala	RC Box	New
16	39+705	1x35m	35		Nala	PSC + RC Slab	New
17	40+960	1x25m	25		Nala	PSC + RC Slab	New
18	43+430	2x20m	40		Nala	RCC	New
19	43+900	1x25m	25		Nala	PSC + RC Slab	New
20	46+070	2x8.0m	16		Nala	RC Box	New
21	50+775	1x10m	10		Nala	RC Box	New
22	52+100	1x25m	25		Nala	PSC + RC Slab	New
23	53+500	3x25m	***75***		Nala	PSC + RC Slab	New
24	58+987	1x12m	12		Nala	RC Box	New
25	59+970	2x7.5m	15		Nala	RC Box	New
26	60+450	1x30m	30		Nala	PSC + RC Slab	New
27	62+625	2x8m	16		Nala	RC Box	New
28	63+780	2x8.5m	17		Nala	RC Box	New
29	64+045	3x8m	24		Nala	RC Box	New
30	69+895	2x8m	16		Nala	RC Box	New
31	70+930	2x8m	16		Nala	RC Box	New
32	72+400	1x10m	10		Nala	RC Box	New
33	73+600	2x8m	16		Nala	RC Box	New
34	76+600	2x11.5m	23		Nala	RC Box	New
35	77+000	2x8m	16		Nala	RC Box	New
36	80+270	3x9m	27		Nala	RC Box	New
37	83+400	2x7.5m	15		Nala	RC Box	New
38	85+270	1x10m	10		Nala	RC Box	New
39	85+445	1x12.5m	13		Nala	RC Box	New
40	85+725	1x10m	10		Nala	RC Box	New
41	91+610	2x25m	50		Nala	PSC + RC Slab	New
42	98+240	2x22.7m	45		Nala	RCC	New
43	98+420	1x20m	20		Nala	RCC	New
44	99+330	2x22.7m	45		Nala	RCC	New
45	99+495	2x11.33m	23		Nala	RC Box	New
46	104+600	1x25.354m	25		Nala	PSC + RC Slab	New

Source: JICA Survey Team

(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.

Table 5-26: Bridge Length in Tripura

No.	Chainage	Discharge (cu.m)	Regime width (m)	Bridge Length (m)
1	12+915	316.35	85.374	50
2	17+900	156.72	60.091	25
3	18+800	231.64	73.054	40
4	19+770	32.96	27.558	16
5	21+320	109.28	50.178	21
6	24+060	193.90	66.839	50
7	24+760	70.49	40.299	21
8	24+930	83.79	43.938	21
9	25+340	125.83	53.843	40
10	29+470	56.01	35.923	20
11	31+050	319.40	85.784	50
12	32+870	104.97	49.179	20
13	34+450	59.16	36.919	20
14	36+290	212.39	69.953	35
15	37+280	31.47	26.927	12
16	39+705	227.35	72.375	35
17	40+960	121.28	52.860	25
18	43+430	275.94	79.735	40
19	43+900	140.60	56.916	25
20	46+070	36.19	28.876	16
21	50+775	36.19	28.877	10
22	52+100	74.65	41.472	25
23	53+500	744.71	130.989	75
24	58+987	41.43	30.894	12
25	59+970	37.00	29.196	15
26	60+450	195.44	67.103	30
27	62+625	42.49	31.289	16
28	63+780	35.68	28.673	17
29	64+045	61.83	37.744	24
30	69+895	31.15	26.790	16
31	70+930	58.64	36.758	16
32	72+400	27.85	25.330	10
33	73+600	65.77	38.926	16
34	76+600	37.17	29.266	23
35	77+000	55.85	35.870	16
36	80+270	95.95	47.017	27
37	83+400	28.49	25.622	15
38	85+270	13.31	17.509	10
39	85+445	19.30	21.087	13
40	85+725	15.04	18.616	10
41	91+610	202.56	68.315	50
42	98+240	52.54	34.792	45
43	98+420	61.08	37.512	20
44	99+330	65.04	38.711	45
45	99+495	50.45	34.094	23
46	104+600	59.36	36.981	25

Source: JICA Survey Team

(6) Vertical Clearance

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

Table 5-27: 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 5-28: Span and Vertical Clearance as per IRC: SP13-2004

Discharge in cu.m/sec	Minimum vertical clearance in 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 and summarize them in Table 5-29. All bridges satisfied the required clearance. Minimum vertical clearance corresponding to discharge (m3 / sec) is mentioned in Table 5-28, and actual vertical clearance is mentioned in 6th row in Table 5-29.

Table 5-29: Vertical Clearance in Tripura

No.	Chainage	Discharge (cu.m)	Minimum Vertical Clearance (m)	H.F.L. (m)	Vertical Clearance (m)
1	12+915	316.35	1.200	53	4.440
2	17+900	156.72	0.900	45	1.542
3	18+800	231.64	0.900	43	3.136
4	19+770	32.96	0.900	57	5.087
5	21+320	109.28	0.900	49	1.208
6	24+060	193.90	0.900	43	1.312
7	24+760	70.49	0.900	42	1.433
8	24+930	83.79	0.900	42	1.079
9	25+340	125.83	0.900	42	1.052
10	29+470	56.01	0.900	44	2.342
11	31+050	319.40	1.200	35	1.590
12	32+870	104.97	0.900	32	1.034
13	34+450	59.16	0.900	32	1.847
14	36+290	212.39	0.900	34	1.100
15	37+280	31.47	0.900	31	1.747
16	39+705	227.35	0.900	36	0.899
17	40+960	121.28	0.900	35	1.127
18	43+430	275.94	0.900	38	1.223
19	43+900	140.60	0.900	46	1.313
20	46+070	36.19	0.900	69	5.662
21	50+775	36.19	0.900	44	3.824
22	52+100	74.65	0.900	41	1.132
23	53+500	744.71	1.200	42	1.490
24	58+987	41.43	0.900	60	1.928
25	59+970	37.00	0.900	59	2.167
26	60+450	195.44	0.900	61	1.012
27	62+625	42.49	0.900	56	2.347
28	63+780	35.68	0.900	59	2.146
29	64+045	61.83	0.900	59	2.777
30	69+895	31.15	0.900	53	3.126
31	70+930	58.64	0.900	51	2.423
32	72+400	27.85	0.600	55	2.069
33	73+600	65.77	0.900	57	2.454
34	76+600	37.17	0.900	47	2.101
35	77+000	55.85	0.900	49	1.232
36	80+270	95.95	0.900	39	2.456
37	83+400	28.49	0.600	45	2.056
38	85+270	13.31	0.600	51	1.451
39	85+445	19.30	0.600	52	2.806
40	85+725	15.04	0.600	51	2.432
41	91+610	202.56	0.900	46	6.702
42	98+240	52.54	0.900	46	1.439
43	98+420	61.08	0.900	45	1.046
44	99+330	65.04	0.900	39	1.158
45	99+495	50.45	0.900	38	3.182
46	104+600	59.36	0.900	25	1.840

Source: JICA Survey Team

5.2.5 Drainages

(1) Design Standards

The structural planning of culverts are guided by the layout of existing structures.

The preliminary designs of the proposed culverts are carried out in accordance with the provisions of the following IRC Codes/guidelines.

For aspects not covered by IRC and BIS Standards, relevant recommendations of the International Standards or Sound Engineering Practice will be followed.

Various designs will be prepared as per the following detailed methodology given in the following standards:

Table 5-30: List of Major Design Standards

Code No.	Title
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

(2) Classification of Existing Culvert

There are 232 numbers of existing culverts (162 HP culverts, 51 nos slab culvert & 19 nos Box Bridges) along the Survey Road.

Table 5-31: List of Existing Culvert Type

	NH280 (Khowai-Sabroom)
EXISTING Culvert	232
PIPE Culvert	162
Slab Culvert	51
Box Culvert	19

Source: JICA Survey Team based on DPR

The list of culverts confirmed by the field survey is shown below.

Table 5-32: List of Existing Culvert in Tripura (1)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
1	21.170	21.175	Pipe	2× 1.2
2	21.245	21.250	Pipe	1× 1.2
3	21.315	21.318	Pipe	1× 1.2
4	21.549	21.554	Pipe	1× 0.6
5	21.715	21.720	Pipe	1× 1.2
6	24.861	24.290	Pipe	2× 1.0
7	25.354	24.783	Pipe	2× 0.9
8	26.451	25.835	Box	1× 1.5
9	26.764	26.147	Pipe	2× 1.0
10	27.195	26.569	Pipe	2× 1.0
11	27.357	26.730	Pipe	2× 0.75
12	27.663	26.976	Pipe	1× 1.0
13	27.818	27.132	Pipe	2× 1.2
14	27.878	27.192	Pipe	1× 0.9
15	27.965	27.279	Pipe	1× 1.0
16	28.151	27.465	Pipe	1× 1.5

Source: JICA Survey Team based on DPR

Table 5-33: List of Existing Culvert in Tripura (2)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
17	28.232	27.546	Pipe	1× 1.0
18	28.279	27.593	Pipe	1× 1.5
19	28.347	27.658	Pipe	1× 0.75
20	28.415	27.727	Pipe	1× 0.75
21	28.466	27.779	Pipe	1× .9
22	28.543	27.856	Pipe	1× 0.6
23	28.620	27.932	Pipe	1× 1.5
24	28.723	28.037	Pipe	1× 1.2
25	28.813	28.127	Pipe	1× 1.0
26	28.938	28.251	Pipe	1× 0.75
27	28.998	28.311	Pipe	1× 1.2
28	29.056	28.368	Pipe	1× 0.3
29	29.155	28.468	Pipe	1× 0.6
30	29.210	28.521	Pipe	1× 0.9
31	29.284	28.597	Slab	1× 5.0
32	29.372	28.685	Pipe	1× 0.9
33	30.514	29.716	Pipe	1× 1.0
34	30.794	29.997	Pipe	2× 0.9
35	31.973	31.126	Pipe	1× 0.9
36	32.415	31.520	Pipe	1× 0.9
37	32.700	31.809	Pipe	1× 1.2
38	33.013	32.067	Pipe	1× 0.6
39	33.458	32.549	Slab	1× 2.6
40	33.976	33.045	Pipe	1× 1.0
41	34.496	33.391	Pipe	2× 0.9
42	35.195	34.053	Pipe	1× 0.9
43	34.432	34.430	slab	1× 0.9
44	36.000	34.694	Pipe	1× 1.0
45	36.482	35.080	Box	1× 1.0
46	36.608	35.590	Pipe	2× 0.9
47	37.346	35.948	Pipe	1× 1.2
48	38.235	36.775	Pipe	
49	39.097	37.721	Pipe	1× 1.0
50	39.254	37.870	Pipe	1× 0.9
51	39.532	38.139	Pipe	1× 1.2
52	39.950	38.553	Pipe	2× 0.9
53	40.075	38.675	Pipe	1× 1.0
54	40.379	38.975	Pipe	2× 0.9
55	40.435	39.030	Pipe	1× 1.0
56	40.495	39.086	Pipe	2× 0.9
57	40.642	39.228	Pipe	2× 1.0
58	40.703	39.297	Pipe	1× 1.0
59	40.788	39.381	Pipe	3× 0.9
60	41.068	39.610	Pipe	2× 1.0
61	41.401	39.895	Pipe	1× 0.9
62	41.575	40.075	Pipe	2× 0.9
63	41.704	40.203	Slab	1× 1.2
64	42.711	41.158	Pipe	1× 1.2

Source: JICA Survey Team based on DPR

Table 5-34: List of Existing Culvert in Tripura (3)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
65	42.855	41.284	Pipe	1× 0.9
66	48.104	46.200	Pipe	1× 0.6 + 1× 0.9
67	48.985	47.055	Pipe	1× 1.2
68	49.498	47.494	Pipe	1× 0.9
69	50.198	48.150	Pipe	2× 1.2 Not visible
70	50.375	48.300	Pipe	Not visible
71	51.503	49.250	Pipe	2× 0.9
72	51.960	49.700	Pipe	3× 0.9
73	52.055	49.770	Pipe	1× 0.9 Not visible
74	52.480	50.167	Pipe	1× 0.9 Not visible
75	52.680	50.266	Pipe	1× 0.9
76	52.980	50.657	Pipe	2× 0.9
77	54.120	51.688	Pipe	3× 0.6
78	56.780	53.984	Pipe	1× 1.0
79	58.425	55.185	Pipe	1× 0.6
80	58.474	55.232	Pipe	1× 0.9
81	58.560	55.300	Slab	1× 1.0
82	60.400	56.786	Pipe	1× 0.9
83	61.770	58.148	Pipe	1× 1.2
84	61.935	58.300	Slab	2× 1.0
85	62.200	58.566	Pipe	1× 1.0
86	63.248	59.410	Box	1× 1.0
87	64.846	60.423	Pipe	1× 1.5
88	65.302	60.850	Pipe	2× 0.9
89	65.527	61.056	Pipe	1× 0.9
90	65.812	61.314	Pipe	2× 1.0
91	65.932	61.403	Pipe	1× 1.0
92	68.065	63.262	Pipe	1× 1.0
93	68.406	63.595	Pipe	1× 1.2
94	68.710	63.867	Pipe	2× 0.9
95	68.800	63.951	Pipe	1× 0.6
96	68.873	64.064	Pipe	1× 0.3
97	69.102	64.280	Pipe	1× 0.9
98	69.210	64.380	Pipe	2× 0.9
99	69.306	64.467	Slab	1× 1.0
100	69.460	64.570	Slab	1× 1.0
101	70.180	65.185	Pipe	1× 0.9
102	70.330	65.330	Pipe	1× 1.0
103	70.687	65.665	Pipe	1× 0.9
104	70.760	65.735	Pipe	1× 0.6
105	70.923	65.900	Pipe	1× 0.9
106	71.075	66.015	Pipe	1× 1.2
107	71.382	66.303	Slab	1× 1.0
108	71.546	66.456	Pipe	1× 0.6
109	71.620	66.533	Pipe	2× 1.2
110	71.855	66.768	Pipe	1× 0.3
111	71.948	66.863	Pipe	1× 0.3
112	72.172	67.086	Pipe	1× 0.9
113	72.247	67.160	Pipe	1× 0.6

Source: JICA Survey Team based on DPR

Table 5-35: List of Existing Culvert in Tripura (4)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
114	72.630	67.546	Pipe	1× 1.2
115	72.930	67.842	Pipe	2× 1.0
116	73.307	68.226	Pipe	1× 0.9
117	75.115	69.692	Slab	1× 1.5
118	76.031	70.608	Box	1× 1.0
119	76.357	70.934	Slab	1× 1.0
120	77.388	71.971	Pipe	1× 0.6
121	77.411	71.993	Pipe	1× 0.6
122	78.478	73.040	Slab	1× 3.0
123	78.654	73.266	Pipe	1× 0.9
124	78.821	73.397	Pipe	1× 0.6
125	78.966	73.528	Pipe	1× 1.2
126	84.469	78.910	Slab	1× 1.0
127	84.807	79.242	Slab	1× 1.0
128	84.996	79.396	Slab	1× 1.0
129	89.031	83.025	Pipe	1× 1.5
130	89.125	83.136	Slab	1× 2.0
131	89.279	83.245	Slab	1× 2.0
132	89.393	83.379	Pipe	1× 0.9
133	91.671	85.344	Slab	1× 1.0
134	92.016	85.620	Pipe	1× 1.2
135	92.163	85.812	Pipe	1× 0.9
136	94.500	87.950	Box	1× 1.0
137	94.646	88.096	Pipe	1× 0.3
138	95.225	88.678	Slab	1× 2.5
139	96.328	89.712	Box	1× 1.0
140	96.429	89.887	Box	1× 1.0
141	96.512	90.040	Pipe	1× 0.6
142	96.673	90.180	Box	1× 1.0
143	96.815	90.270	Box	1× 1.0
144	96.920	90.330	Box	1× 1.5
145	97.037	90.551	Box	1× 2.5
146	97.363	90.968	Pipe	1×0.6
147	97.735	91.250	Pipe	1× 0.6
148	98.054	91.380	Pipe	1× 0.6
149	98.183	91.457	Box	1× 0.9
150	98.261	91.669	Slab	1× 1.5
151	98.453	91.797	Box	1× 1.5
152	98.612	91.934	Pipe	1× 1.2
153	98.750	91.990	Box	1× 1.5
154	98.802	92.277	Pipe	1× 1.0
155	99.095	92.475	Pipe	3× 1.5
156	99.297	92.683	Box	1× 2.0
157	99.505	92.780	Box	1× 1.5
158	99.620	92.913	Pipe	1× 1.2
159	99.735	93.145	Box	1× 3.0
160	99.772	93.175	Slab	1× 0.4
161	100.220	93.596	Pipe	1× 0.6
162	100.281	93.657	Pipe	1× 0.6
163	100.471	93.830	Pipe	1× 0.6

Source: JICA Survey Team based on DPR

Table 5-36: List of Existing Culvert (5)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
164	100.512	93.870	Pipe	1× 0.6
165	101.018	94.351	Pipe	1× 0.9
166	101.223	94.558	Pipe	1× 0.6
167	101.569	94.890	Pipe	1× 1.2
168	101.679	94.995	Pipe	1× 0.6
169	102.820	95.924	Slab	1× 1.5
170	103.703	96.816	Pipe	1× 1.5
171	104.458	97.040	Pipe	1× 0.9
172	104.800	97.315	Slab	1× 1.5
173	104.800	98.168	Pipe	1× 1.5
174	105.128	98.725	Pipe	1× 1.5
175	111.878	102.121	Slab	1× 1.5
176	112.875	103.100	Pipe	1× 1.0
177	113.291	103.535	Slab	1× 1.0
178	114.221	104.450	Slab	1× 1.0
179	118.082	107.474	Pipe	1× 0.9
180	118.329	107.718	Slab	1× 0.8
181	119.975	109.365	Slab	1× 1.0
182	120.482	109.875	Slab	1× 0.8
183	120.973	110.362	Slab	1× 1.0
184	124.037	113.135	Pipe	1× 0.6
185	125.653	114.750	Slab	1× 2.0
186	126.635	115.750	Pipe	1× 1.2
187	128.075	116.931	Pipe	1× 1.5
188	129.083	117.805	Pipe	1× 0.6
189	129.336	118.080	Slab	1× 1.0
190	129.589	118.290	Pipe	1× 0.9
191	129.663	118.350	Pipe	1× 0.6
192	129.840	118.578	Pipe	4× 1.2
193	130.710	119.184	Slab	1× 0.8
194	131.599	119.990	Slab	1× 1.0
195	131.733	120.112	Pipe	1× 1.0
196	132.207	120.454	Pipe	1× 1.0
197	132.377	120.622	Pipe	1× 1.0
198	133.292	121.510	Slab	1× 0.8
199	133.541	121.759	Slab	1× 1.8
200	134.008	122.227	Pipe	1× 1.0
201	134.227	122.440	Pipe	2× 0.6
202	134.872	123.082	Slab	1× 1.2
203	135.312	123.518	Slab	1× 1.0
204	136.413	124.611	Pipe	1× 1.2
205	136.621	124.820	Pipe	2× 0.6
206	138.590	126.719	Slab	1× 0.8
207	139.010	127.135	Slab	1× 1.5

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 5-37: Existing Culvert Not Required in Tripura

Sl No.	Survey Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)
1	21.101	Slab	1×2.0
2	39.604	Pipe	1× 1.2
3	40.578	Pipe	1× 1.0
4	42.360	Pipe	1× 0.9
5	53.269	Pipe	3× 0.9
6	53.913	Slab	1× 1.0
7	54.615	Pipe	1× 0.9
8	54.782	Pipe	1× 0.9
9	55.150	Slab	1× 1.2
10	55.616	Slab	1× 2.1
11	56.900	Pipe	1× 1.0
12	57.800	Pipe	1× 0.9
13	57.877	Box	1× 1.0
14	57.922	Pipe	1× 0.9
15	58.092	Pipe	1× 0.9
16	59.528	Slab	1× 1.0
17	60.708	Slab	1× 1.0
18	63	Slab	1× 2.0
19	63	Box	1× 1.5
20	63	Pipe	1× 1.0
21	75	Pipe	2× 1.2
22	115	Slab	1× 1.0
23	128	Slab	1× 5.7
24	133	Pipe	2× 0.9

Source: JICA Survey Team based on DPR

5.2.6 Safety Measures

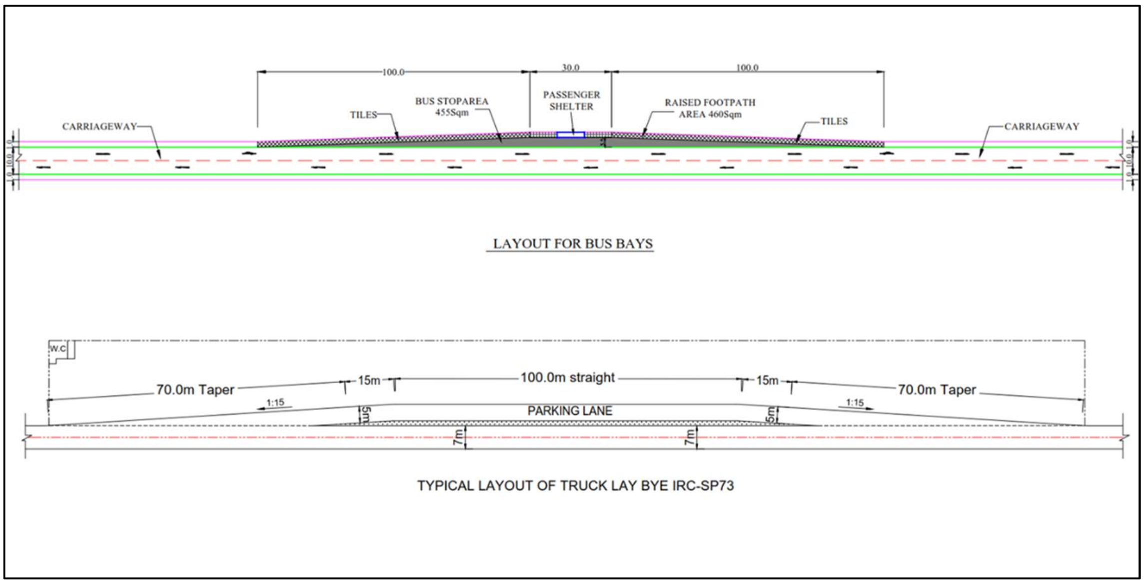
When the Survey Road is completed and opened to traffic, increases in traffic volume and vehicles' running speed are anticipated and due efforts to prevent accidents shall be appropriately made. The design of DPR covers accident preventing measures in general and all the modifications pointed out by the JICA Survey Team need to be conducted completely. Those points are itemized below.

Accident Preventing Measures in General

- Installation of a bus bay and a passenger shelter at a bus stop
- Installation of a truck layby
- Installation of kilo-post to indicate road distance
- Installation of guard rail and passenger crossings

Accident Preventing Measures for Sharp Curves and Steep Gradients

- Appropriate speed control and traffic management (appropriate speed limits and traffic control signs)
- Safety design of sharp curves (carriageway widening, superelevation, safe sight distances)
- Warnings for sharp curves (additional warning signs, road markings, delineators, etc.)
- Alleviation of small horizontal curves and securing safe sight distances



Source: DPR

Figure 5-28: Design of Bus Bay and Truck Layby in DPR

5.2.7 Miscellaneous Facilities

In order to achieve safe, efficient and economical travel, certain provisions for traffic guidance and safety were implemented. The safety measures and devices as proposed by the DPR consultant along the highway is described as follows.

(1) Roadside Furniture

For notification of road features and also for safety and guidance of the road users, all necessary traffic control and safety devices should be provided on the Project Road.

- Traffic Signs and Pavement Markings
  Traffic signs and pavement markings shall include roadside signs, overhead signs, curve mounted signs and road marking on the project road. The locations for these provisions shall be based as per IRC 35-1997 and IRC 67-2012, respectively.
- Road Delineators
- Pedestrian Guard Railing
- Metal Beam Crash Barrier
  Metal beam crash barrier shall be provided on both edges of the road where road height is equal to or exceeds 3m and on outer edges of sharp curves. Suitable reflectors have been proposed to be fixed on the beam at 3m center-to-center for proper delineation of the barrier line,
- Traffic safety Devices wherever required
- Boundary Stones
- Hectometer / Kilometer / 5th Kilometer stones
- Traffic Blinker Signal (LED) at intersections

(2) Street Lighting

- Adequate lighting should be provided for bus bays and truck lay bays.
- Street Lighting will also be provided for highway alignment passing through potentially hazardous locations such as built-up area, junctions and rotaries.

(3) Landscape and Tree Plantation

- Landscaping of the highway should be done at suitable locations. The purpose of landscaping is conservation of existing natural or manmade features.
- Landscaping will address the issue of drainage to ensure minimum disturbance to the natural drainage and at the same time ensure protection of natural surfaces from erosion.
- Proper landscaping will be provided for highway alignment to fit-in with surroundings for pleasing appearance, reducing headlight glare and adverse environmental effects such as air pollution, noise pollution and visual instruction.
- Landscaping will include stabilization of embankment by pitching and/or turfing / plantation. The treatment of embankment slopes along the highway will be as per recommendations of IRC 56-1974, depending upon soil type involved. Planting of shrubs, hedges and trees on medians and sides for highways of reducing glare effect, reducing visual intrusion, noise pollution and air pollution.
- Trees, their spacing and arrangement in different situations will be as per IRC 21-1979 and IRC SP 66-1976.

5.3 Preliminary Design of NH208 Tripura

5.3.1 Road Geometric Design

(1) Design Standards

IRCSP73-2018, Clause 1.1 states “This Manual is applicable for Two Laning of Highways (with or without paved shoulders) through Public Private Partnership (PPP), EPC or any other mode. The general planning aspects laid out in this Manual shall be applicable for widening from single /intermediate lane to two-lane or new construction of two-lane highways. The scope of the work shall be as defined in the Concession Agreement. As far as National Highways are concerned, two laning in this Manual shall mean two-lane with paved shoulders as per ministry’s Guidelines unless otherwise specified.”

IRCSP73-2018, 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 IRCSP73-2015[45] for geometric design of the Survey Road. JICA Survey Team pointed this out and the DPR consultant has modified the as per IRCSP73-2018. The main differences between IRCSP73-2015 and IRCSP73-2018 are (1) the width of shoulders, and (2) the use of minimum sight distances as indicated in the Table below. Regarding ROW, IRCSP73-2018 also states (3) “ROW of 30 m shall be acquired by the Authority.” These changes shall be incorporated into the redesign of road cross-sectional parameters, the design of offset distances for horizontal curves and the design of ROW.

Table 5-38: Width of Shoulders in IRCSP73-2018 and (IRCSP73-2015)

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 (2.5)	-	2.5 (2.5)
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 5-39: Sight Distances in IRCSP73-2018 and (IRCSP73-2015)

Speed (km/h)	Stopping Sight Distance (m)	Intermediate Sight Distance (m)	Overtaking Sight Distance (m)
100	- (180)	360 (360)	640 (640)
80	- (120)	240 (240)	470 (470)
60	- (90)	180 (180)	340 (340)
40	- (45)	90 (90)	165 (165)

Source: JICA Survey Team

A circular entitled “Width of shoulder (Paved and Earthen) for two laning of National Highways”[46] was issued by MORTH on 17 July 2020, designating the width of shoulders for designing as shown in the Table below.

[45] IRCSP73-2015 Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder
[46] The full text of the Circular is attached in Appendix E-1.

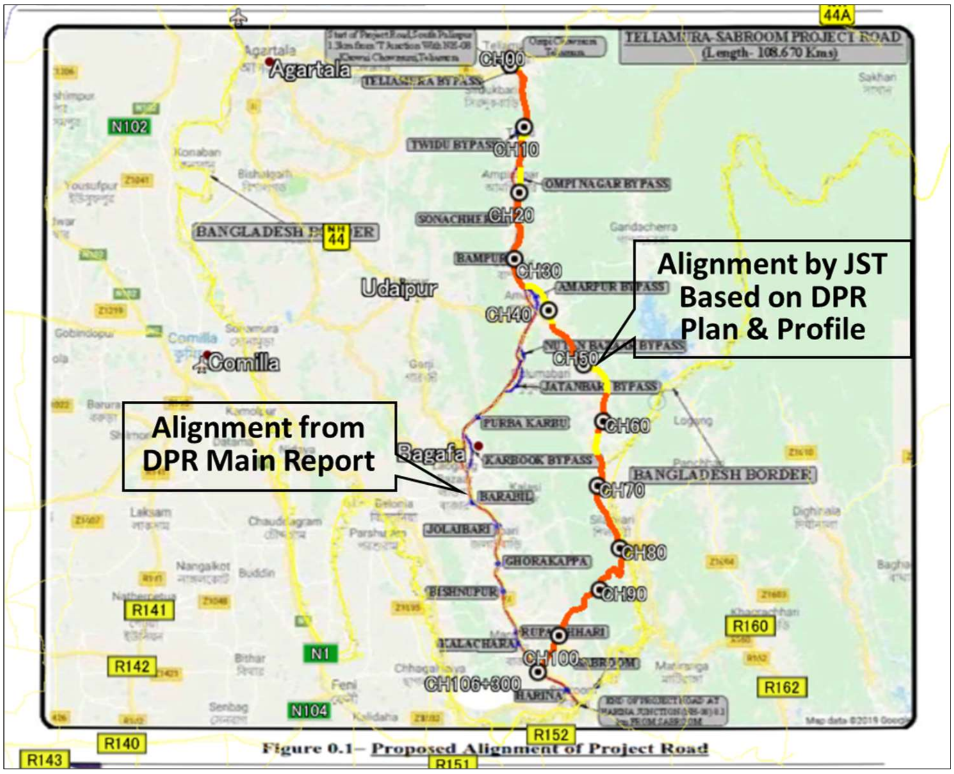
Table 5-40: Width of Shoulders as per MORTH Circular (17 July 2020)

Type of Section	Width of Shoulder (m) in Plain and Rolling Terrain		
	Paved	Earthen	Total
Open country with isolated built up area	1.5	1.0	2.5
Built up area	2.5	-	2.5
Approaches to grade separated structures	1.5	-	1.5
Approaches to bridges	1.5	1.0	2.5

Source: JICA Survey Team

(2) Road Alignment

JICA Survey Team (JST) has pointed out the discrepancy in the alignment between the Location Map and Plan & Profile in Detailed Project Report (DPR) as indicated in the Figure below.



Source: JICA Survey Team

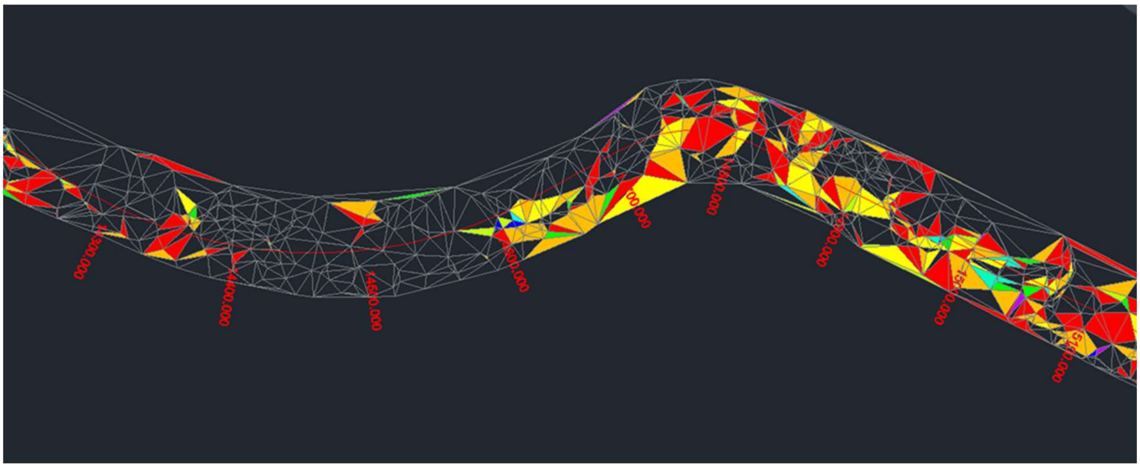
Figure 5-29: Discrepancies in Alignment of NH208 Tripura in DPR

(3) Terrain Classification

By e-mail dated June 22, 2020, the DPR consultant reported on the method they applied to determine the terrain classification with supporting materials as follows:

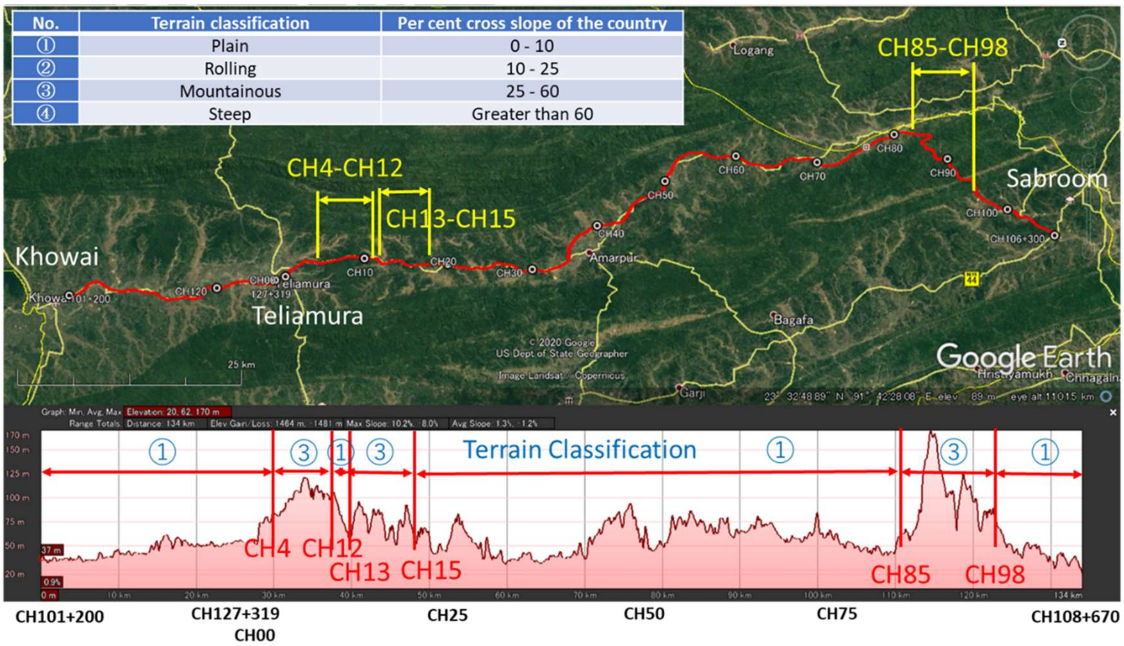
- The output for Cross slope is taken from Bentley MXROAD V8i software with the help of ground data (Topographical survey data),
- An AutoCAD file is attached herewith showing the ground triangle generated with topographical survey data,
- In this triangle, the slope area of ground having slope more than 25percent are showing with different colours, the blank cells are less than 25 percent slope,
- As per majority of colour filled sections and as per site visit also, it is defined the terrain according to above said Table 3-1.

JICA Survey Team examined the method applied by the DPR consultant and concluded that the method is also applicable with satisfactory results. Consequently, the sections which have been classified as Mountainous are the three sections of CH4+850-CH12+000, CH13+600-CH15+200, CH85+100-CH98+000, and the remaining sections are classified as Plain and Rolling.



Source: DPR

Figure 5-30: Colored Triangles for Determining Terrain



Source: JICA Survey Team

Figure 5-31: Modified Terrain Classification

(4) 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."

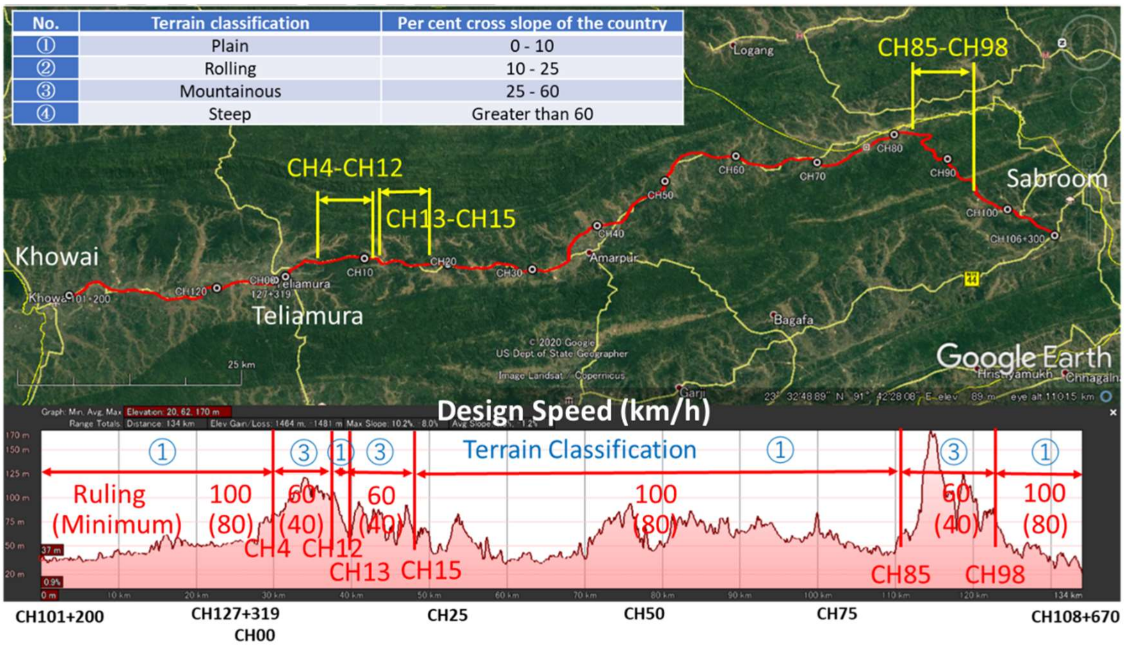
As per IRCSP73-2018, 2.2, design speed is stipulated as indicated in the table below. The clause 2.2.1 explains that short stretches (approx. less than 1 km) of varying terrain met with on the road stretch shall not be taken into consideration while deciding the terrain classification for a give section of Project Highway.

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 5-32 below shows the design speed (km/h) for NH208 Tripura.

Table 5-41: Design Speed as per IRCSP73-2018

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 IRCSP73-2018



Source: JICA Survey Team

Figure 5-32: Design Speed (km/h) for NH208 Tripura

The table below is an excerpt from the DPR for the section of CH00+128 through CH09+380. The design speed should be the ruling 100 km/h and the minimum 80 km/h shall 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 shall be indicated as deviation in Schedule 'D' of the Concession Agreement.

IRC73-1980 states "The design speed should preferably uniform along a highway". Whereas DPR uses various design speed like 50, 65, 40, etc. in its horizontal alignment design submitted on 30th September 2020.

Table 5-42: Design Speeds in the DPR for NH208 Tripura

Sl. No.	HORIZONTAL CURVE				Terrain	Transition length	Speed (Kmph)	Reason for Deviation
	Start Chainage	End Chainage	Radius	Direction				
9	4+294.157	4+350.609	250	Left	Plain	90	80	
10	4+657.901	4+781.670	800	Left	Plain	60	100	
11	4+872.000	4+906.430	75	Right	Hill	30	40	
12	4+970.383	5+062.749	75	Left	Hill	30	40	
13	5+108.072	5+188.064	125	Right	Hill	15	40	
14	5+608.954	5+641.001	150	Left	Hill	30	50	
15	5+799.979	5+864.850	150	Right	Hill	30	50	
16	6+156.127	6+305.712	400	Left	Hill	20	50	
17	6+571.660	6+628.751	300	Right	Hill	20	65	
18	6+759.957	6+769.582	80	Left	Hill	25	40	
19	7+194.796	7+252.657	80	Right	Hill	25	40	
20	7+359.932	7+460.994	80	Left	Hill	25	40	
21	7+581.661	7+711.885	150	Right	Hill	30	50	
22	8+232.089	8+296.623	80	Left	Hill	25	40	
23	8+393.893	8+491.034	80	Right	Hill	25	40	
24	8+665.305	8+732.076	150	Left	Hill	30	50	
25	8+826.022	8+850.531	80	Right	Hill	25	40	
26	9+000.991	9+008.033	80	Left	Hill	25	40	
27	9+157.806	9+203.680	400	Right	Hill	15	50	
28	9+326.276	9+383.248	80	Left	Hill	25	40	
29	9+434.672	9+527.116	80	Right	Hill	25	40	
30	9+822.168	9+891.689	100	Left	Hill	45	50	
31	10+017.055	10+115.932	100	Right	Hill	45	50	
32	10+233.841	10+420.449	150	Left	Hill	40	65	
33	10+560.956	10+640.064	100	Right	Hill	55	65	
34	10+812.456	10+897.103	100	Left	Hill	55	65	
35	11+023.317	11+077.957	80	Right	Hill	25	40	
36	11+155.129	11+369.591	400	Left	Hill	10	50	
37	11+478.997	11+930.098	400	Right	Plain	55	80	
38	12+217.662	12+678.408	500	Left	Plain	45	80	
39	13+010.587	13+189.139	300	Left	Plain	75	80	
40	13+322.908	13+521.848	400	Right	Plain	55	80	
41	13+673.972	13+803.024	300	Left	Hill	20	65	
42	13+911.715	13+979.207	100	Right	Hill	55	65	
43	14+176.342	14+544.929	350	Left	Hill	30	65	
44	14+653.475	14+694.046	100	Right	Hill	55	65	
45	15+084.875	15+181.884	400	Right	Plain	55	80	
46	15+531.325	15+799.487	400	Left	Plain	55	80	
47	16+538.364	16+648.352	1500	Left	Plain	35	100	

Source: Detailed Project Report

(5) Cross Sectional Parameters

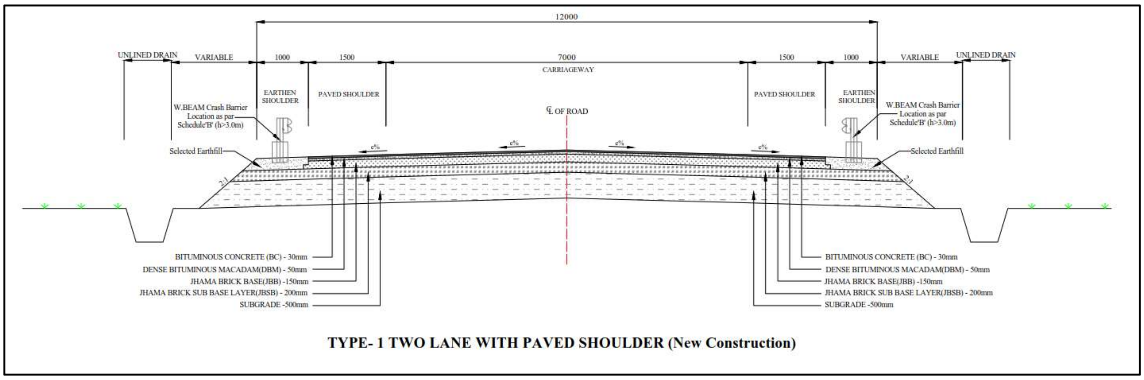
(a) Cross Fall/Camber

IRCSP73-2018, Clause 2.8.1 states "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."



Source: JICA Survey Team based on DPR

Figure 5-33: Typical Cross Section in DPR

(b) ROW

Regarding the width of ROW, IRCSP73-2018, Clause 2.3 states "Two laning shall be accommodated within the existing ROW to the extent possible. However, additional land, if required for accommodating the two laning cross sections, improvement of geometries, realignment, junctions, bypasses etc., ROW of 30 m shall be acquired by the Authority. For bypasses, Right of Way shall be 45-60 m depending upon the provision of the carriageway. The existing and proposed ROW shall be indicated in Schedule 'A' of the Concession Agreement. The consideration for planning, design and construction described in para 1.13 shall apply."

However, DPR designs show many sections of the Survey Road with narrower ROW than the above stated ROW of 30 m for ordinary sections and 45-60 m ROW for bypasses as indicated in the table below.

At the web-conference held on 20 October 2020, the DPR consultant stated that the ROW width was decided as per discussion with the General Manager of NHIDCL during joint site visit in 2019.

Table 5-43: ROW Designed in DPR

Table 7.10: Details of PROW

Sl. No.	Chainage		Length	PROW		Total PROW	Remarks
	From	To		LHS	RHS		
1	0	550	550	22.5	22.5	45	
2	550	900	350	12.5	12.5	25	
3	900	1340	440	22.5	22.5	45	
4	1340	2600	1260	15	15	30	
5	2600	3100	500	10	10	20	
6	3100	4600	1500	15	15	30	
7	4600	4900	300	10	10	20	
8	4900	7320	2420	15	15	30	
9	7320	7440	120	20	20	40	
10	7440	11320	3880	15	15	30	
11	11320	12850	1530	22.5	22.5	45	
12	12850	13500	650	10	10	20	
13	13500	15200	1700	15	15	30	

Source: JICA Survey Team based on DPR

<u>(c) Extra Width of Pavement and Roadway</u>

IRC38-1988,[47] 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.

IRCSP73-2018, Clause 2.7 states "The width of roadway shall be the sum of the width of carriageway and shoulders in case of 2-lane. On horizontal curves with radius up to 300 m, width of pavement and roadway shall be increased as per the table below."

Table 5-44: 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)

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

(6) Horizontal Alignment

IRC73-1980 and 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 5-45 and Figure 5-34 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."

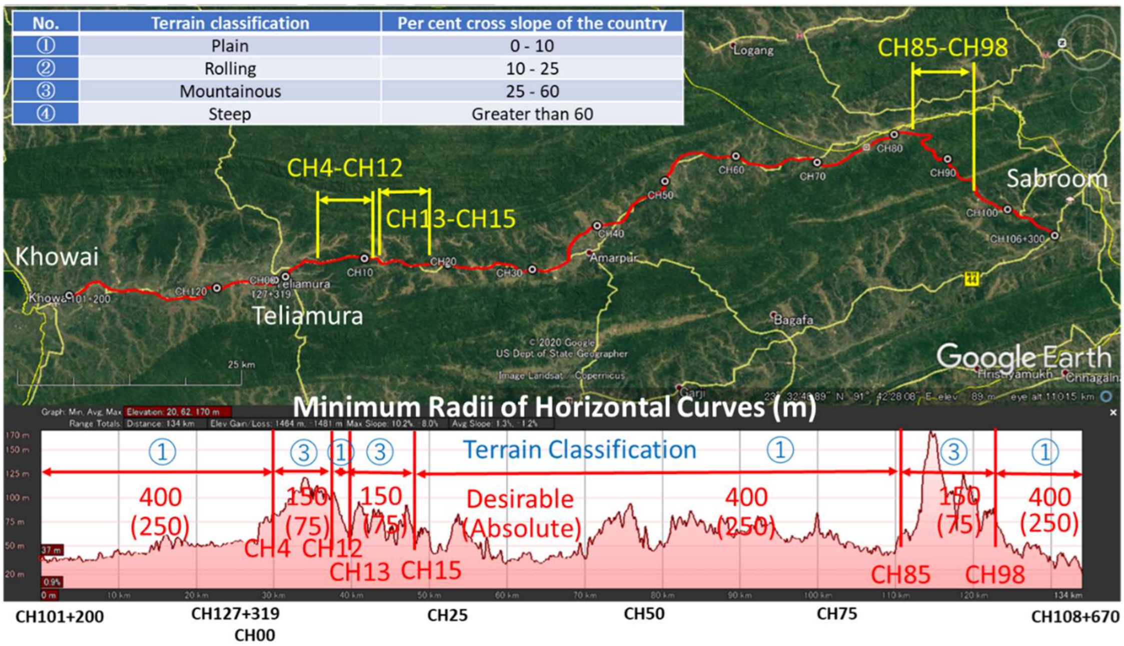
(f) Absolute Minimum Radius

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 5-45 and Figure 5-34 of this report present the absolute minimum radius by type of terrain.

Table 5-45: Minimum Radii of Horizontal Curves as per IRCSP73-2018

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 IRCSP73-2018



Source: JICA Survey Team

Figure 5-34: Desirable and Absolute Minimum Radii of Horizontal Curves (m)

<u>(g) Number of Curves Smaller than the Minimum Radius</u>

The horizontal alignment of DPR shall be redesigned because there are many small horizontal curves as indicated in the table below with radius smaller than the minimum radius stipulated by IRCSP73-2018. Redesigning the horizontal alignment will affect all the other road design components such as Right of Way (ROW), bridges, drainage, cost of the project, etc. It will also affect the work of EIA and SIA, and consequently will cause the delay of the signing of the loan agreement between India and Japan. The details of the curves can be referred to Appendix B-6: Number of Horizontal Curves Smaller than Minimum Radius in DPR for NH208 Tripura (Khowai - Sabroom).

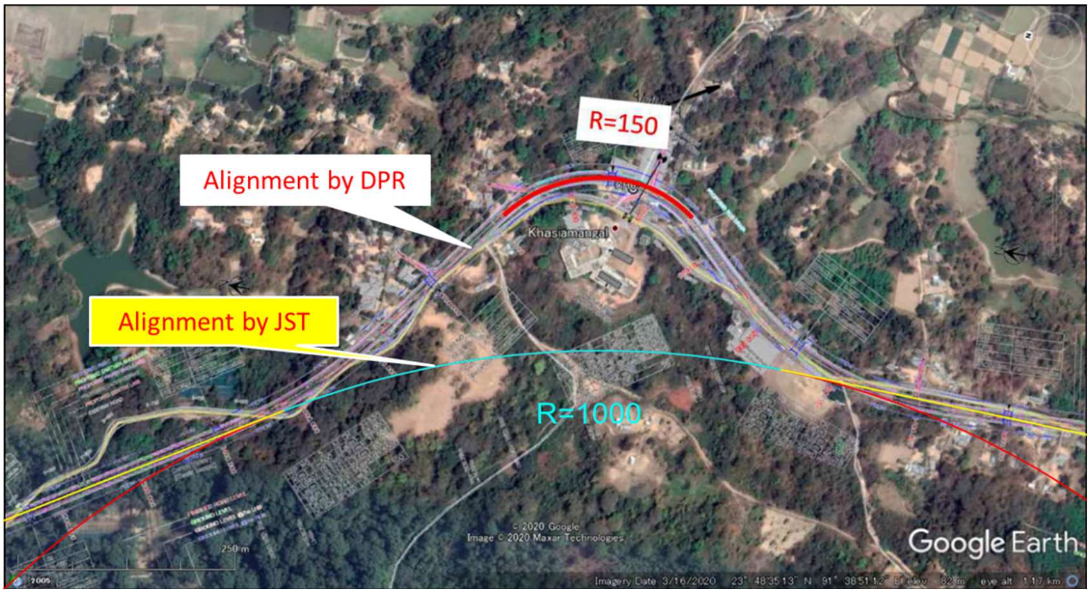
Table 5-46: Number of Curves Smaller than Minimum Radius in DPR

	Type of Minimum Radius	
	Desirable Minimum Radius	Absolute Minimum Radius
Radius (m)	Plain 400m／Mountainous 150m	Plain 250m／Mountainous 75m
Applicability of Smaller Curves	Applicable with Justifiable Reasons	Absolutely not Applicable
Number of Smaller Curves	37	43

Source: JICA Survey Team

<u>(h) Improvement in horizontal alignment of DPR</u>

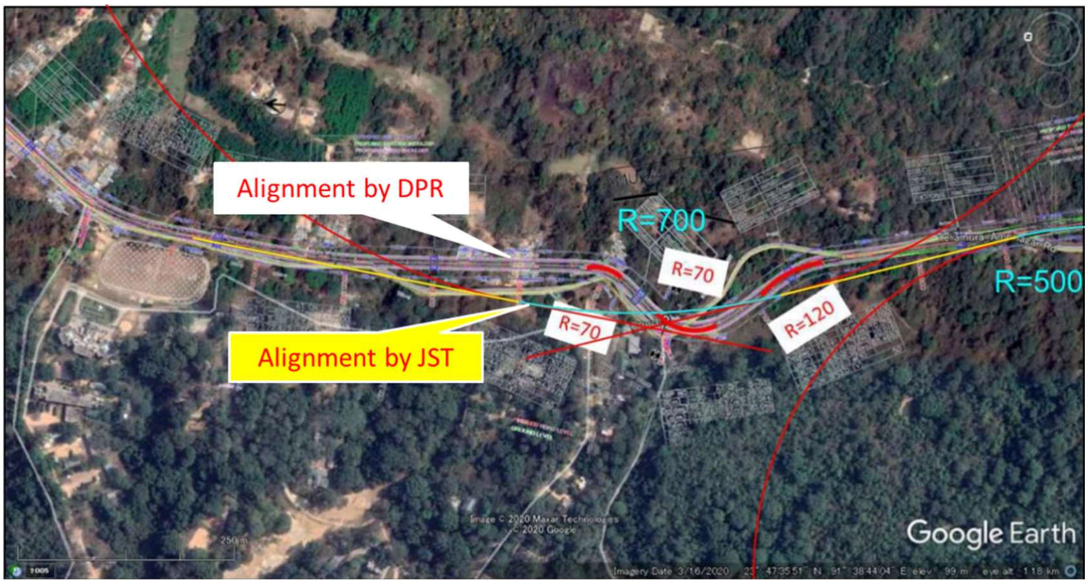
The horizontal alignment of DPR goes along the existing road as much as possible using small radius curve of 150 m (CH2+824), while the desirable minimum radius is 400 m. The yellow and blue line are proposed by the JICA Survey Team based on DPR for improvement.



Source: JICA Survey Team based on DPR

Figure 5-35: Improvement Proposal (CH2+824)

The horizontal alignment of DPR goes along the existing road as much as possible using small radius curves such as 70 m, 70 m, 120 m (CH4+876, CH4+975, CH5+121), while the desirable minimum radius is 400 m. The yellow line and blue line are proposed by the JICA Survey Team for improvement.



Source: JICA Survey Team based on DPR

Figure 5-36: Improvement Proposal (CH4+876, CH4+975, CH5+121)

By e-mail dated June 22, 2020, the DPR consultant reported on the revised horizontal curves with justifiable reasons for all those curves with radius smaller than the desirable minimum radius as indicated in the table below, which JICA Survey Team has found fine and acceptable.

Table 5-47: Revised Horizontal Curves by DPR Consultant

DPR [Draft]:

Preparation of DPR providing pre-construction services for up-gradation of selected road stretches/corridors to Two lane with paved shoulder NH configuration in the state of Tripura.

HORIZONTAL ALIGNMENT REPORT [Taliamura-Sabroom]

Curve No.	HORIZONTAL CURVE										Terrain	Horizontal Intersection Point (HIP)			Transition Length (m)	Speed	Reason for Deviation
	Start design Chainage (Km)	Ex Chainage (Km)	End design Chainage (Km)	Start Easting	Start Northing	End Easting	End Northing	Radius	Modified Radius	Direction		Chainage (Km)	Easting	Northing		(Kmph)	
1	2+824.289	4+200	3+054.715	362318.852	2633876.74	362337.504	2633669.15	150		Right	Plain	2+969.183	362428.44	2633781.95	30	40	Ex. Road followed to avoid the school land at existing km 4+300 & 4+600, from ex km 4+150 to km 4+500 (RHS) the existing road will use as service road, on RHS of Proposed alignment, market area exists so the minimum radius of 150 m proposed. This alignment was discussed and approved at site with PWD & NHIDCL officials
2	4+011.148	5+400	4+104.364	362212.832	2632761.77	362184.821	2632673.43	250		Right	Plain	4+058.304	362207.158	2632714.96	90	80	Used the existing road alignment with absolute minimum radius & 80kmph speed.
3	4+294.158	5+650	4+350.610	362075.231	2632518.81	362054.306	2632466.51	250		Left	Plain	4+322.505	362061.803	2632493.84	90	80	Built-up section, Used the existing road alignment with absolute minimum radius & 80kmph speed.
4	4+876.121	6+250	4+906.666	362036.739	2631943.74	362028.075	2631914.7	70	75	Right	Hill	4+891.641	362035.626	2631928.26	30	40	on RHS - Army land (no land acquisition is possible) & on LHS - deep valley, Radius modified as 75m
5	4+975.333	6+350	5+058.234	361986.06	2631860.57	361992.618	2631782.71	70	75	Left	Hill	5+022.420	361963.15	2631819.43	30	40	on RHS - Army land (no land acquisition is possible) & on LHS - deep valley, Radius modified as 75m
6	5+121.607	6+500	5+179.943	362039.61	2631740.33	362068.432	2631690.27	120	125	Right	Hill	5+151.363	362060.227	2631718.87	30	40	Designed as per Hilly Terrain
7	5+610.193	7+050	5+642.278	362136.777	2631265.55	362148.096	2631235.59	150		Left	Hill	5+626.297	362140.828	2631249.96	30	50	Designed as per Hilly Terrain
8	5+801.236	7+400	5+866.107	362231.92	2631100.59	362247.969	2631038.26	150		Right	Hill	5+834.187	362246.791	2631071.19	30	50	Designed as per Hilly Terrain
9	6+572.917	8+200	6+630.008	362329.317	2630346.59	362339.592	2630290.52	300		Right	Hill	6+601.549	362337.13	2630319.04	20	65	Designed as per Hilly Terrain
10	6+761.215	8+400	6+770.840	362348.025	2630159.64	362350.583	2630150.36	80		Left	Hill	6+766.033	362349.025	2630154.92	25	40	designed based on minimum speed & radius, Valley on left side, alignment designed near existing road
11	7+196.053	8+900	7+253.915	362546.676	2629773.19	362544.846	2629716.62	80		Right	Hill	7+226.315	362556.462	2629744.56	25	40	designed based on minimum speed & radius, Valley on right side, alignment designed near existing road
12	7+361.190	9+200	7+462.252	362491.036	2629623.92	362513.28	2629532.1	80		Left	Hill	7+419.720	362468.569	2629569.87	25	40	used existing road, both side valley
13	7+582.919	9+400	7+713.142	362615.181	2629467.6	362674.727	2629356.36	150		Right	Hill	7+652.454	362670.737	2629425.78	30	50	Designed as per Hilly Terrain
14	8+233.346	10+200	8+297.881	362654.878	2628836.62	362685.919	2628782.03	80		Left	Hill	8+267.485	362658.75	2628802.71	25	40	used existing road, both side valley
15	8+395.150	10+350	8+492.291	362770.209	2628733.66	362798.334	2628646.82	80		Right	Hill	8+450.723	362814.434	2628700.01	25	40	designed with minimum radius & speed of hilly terrain
16	8+666.562	10+700	8+733.333	362724.616	2628489	362716.189	2628423.31	150		Left	Hill	8+700.510	362712.969	2628457.11	30	50	Designed as per Hilly Terrain
17	8+827.279	10+850	8+851.789	362732.116	2628330.79	362729.328	2628306.54	80		Right	Hill	8+839.631	362732.595	2628318.45	25	40	Valley on RHS, tried to be near of existing road with minimum raidus & speed
18	9+002.248	11+000	9+009.291	362669.862	2628168.44	362668.3	2628161.57	80		Left	Hill	9+005.772	362668.93	2628165.04	25	40	Designed as per Hilly Terrain
19	9+327.533	11+350	9+384.506	362638.829	2627845.42	362657.26	2627792.77	80		Left	Hill	9+357.288	362638.255	2627815.67	25	40	Designed as per Hilly Terrain
20	9+435.930	11+500	9+528.373	362694.055	2627756.93	362704.09	2627670.12	80		Right	Hill	9+488.089	362727.371	2627716.8	25	40	Designed as per Hilly Terrain
21	9+825.262	11+900	9+892.188	362535.809	2627425.84	362531.916	2627360.27	100		Left	Hill	9+860.033	362522.463	2627393.73	45	50	Designed as per Hilly Terrain
22	10+038.441	12+100	10+119.877	362597.076	2627229.62	362574.665	2627156.04	70	100	Right	Hill	10+084.471	362610.064	2627185.46	30	40	R/s Valley, improved as maximum feasible
23	10+229.970	12+300	10+295.091	362478.731	2627102.32	362446.801	2627047.62	80	150	Left	Hill	10+264.456	362450.976	2627081.86	25	40	Designed as per Hilly Terrain
24	10+460.244	12+550	10+550.242	362453.252	2626882.78	362516.03	2626825.92	75	Deleted	Left	Hill	10+511.553	362465.194	2626832.88	30	40	merge with curve at ex km 12+700
25	10+592.029	12+700	10+662.658	362556.087	2626815.12	362577.032	2626753.69	50	100	Right	Hill	10+634.684	362592.762	2626793.34	40	40	R/s Valley, improved as maximum feasible
26	10+901.260	13+050	10+989.390	362417.687	2626577.21	362412.398	2626492.07	100		Left	Hill	10+948.418	362394.967	2626535.89	55	65	Designed as per Hilly Terrain
27	11+112.554	13+250	11+167.194	362481.987	2626390.83	362490.305	2626337.9	80		Right	Hill	11+140.988	362495.553	2626365.84	25	40	Designed as per Hilly Terrain

1 of 3 TASPL

Source: JICA Survey Team based on DPR

(7) Sight Distance

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

IRCSP73-2018 has removed the underlined description from IRCSP73-2015, Clause 2.9.6. ii) as indicated below, prohibiting the use of the safe stopping sight distance instead stipulating the intermediate sight distance as the minimum sight distance.

Table 5-48: Comparison of Sight Distance between IRCSP73-2015 and 2018

IRCSP	Clause 2.9.6 Sight Distance, ii)
73-2015	On two-lane roads, normally intermediate sight distance should be available throughout. The attempt should, however, be to provide overtaking sight distance in as much length of the road as possible. <u>In stretches where even intermediate sight distance is not available, the safe stopping sight distance should be provided as a last resort. Such sections shall be specified in Schedule 'B'. Traffic signs depicting "Overtaking Prohibited:" shall be installed at all such locations.</u>
73-2018	On two-lane roads, at least twice the safe stopping sight distance shall be available throughout. The attempt should, however, be to provide overtaking sight distance in as much length of the road as possible.

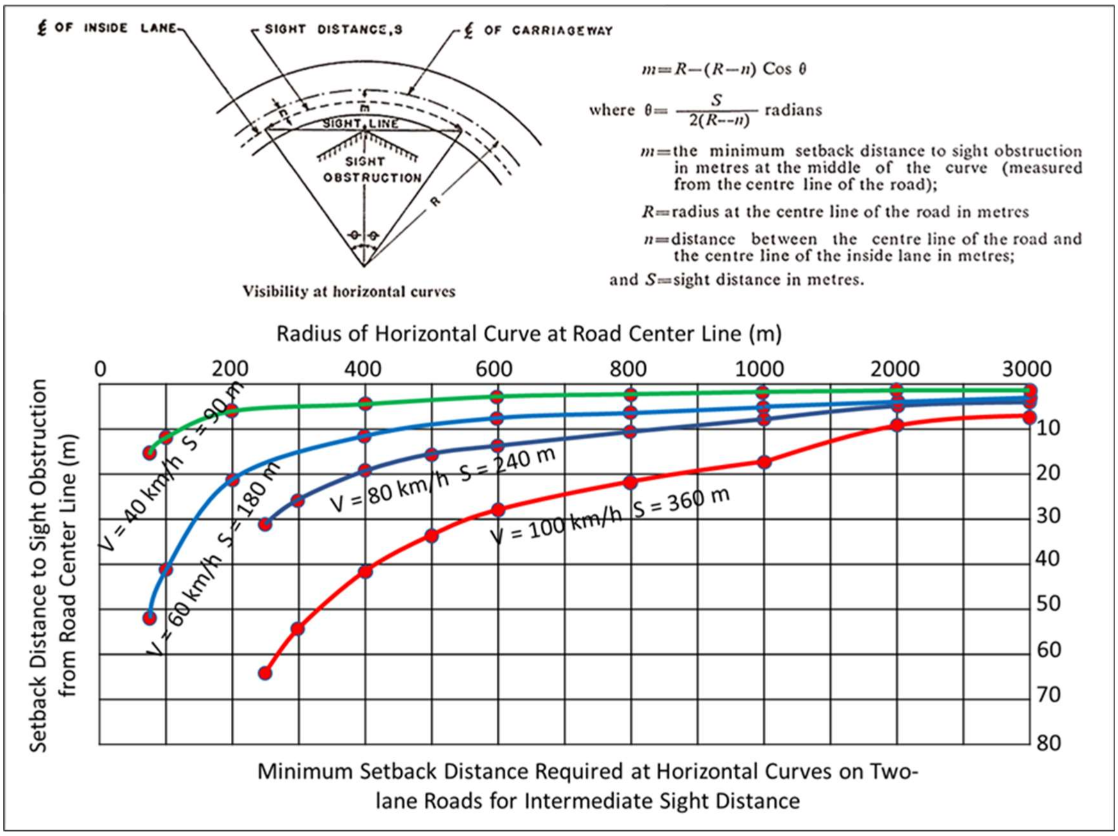
Source: JICA Survey Team based on IRCSP73-2015, 2018

Table 5-49: Sight Distances for Various Speeds as per IRCSP73-2018

Speed (km/h)	Minimum Sight Distance (m)	Overtaking Sight Distance (m)
100	360	640
80	240	470
60	180	340
40	90	165

Source: JICA Survey Team based on IRCSP73-2018

Setback distances for the intermediate sight distance are much larger than those of safe stopping sight distance. The value of the setback distance for 100km/h design speed and horizontal curve of 400 m radius is about 12 m in case of the safe stopping sight distance, whereas it is about 41 m for the intermediate sight distance as indicated in the figure below. It is, therefore, necessary for designers to be careful in designing horizontal curves paying due attention to the available ROW. The details of the calculation for the intermediate sight distance can be referred to Appendix D-1: Minimum Setback Distance Required at Horizontal Curves on Two-lane Roads for Intermediate Sight Distance.



Source: JICA Survey Team based on DPR

Figure 5-37: Setback Distance for Intermediate Sight Distance

(8) 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 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.

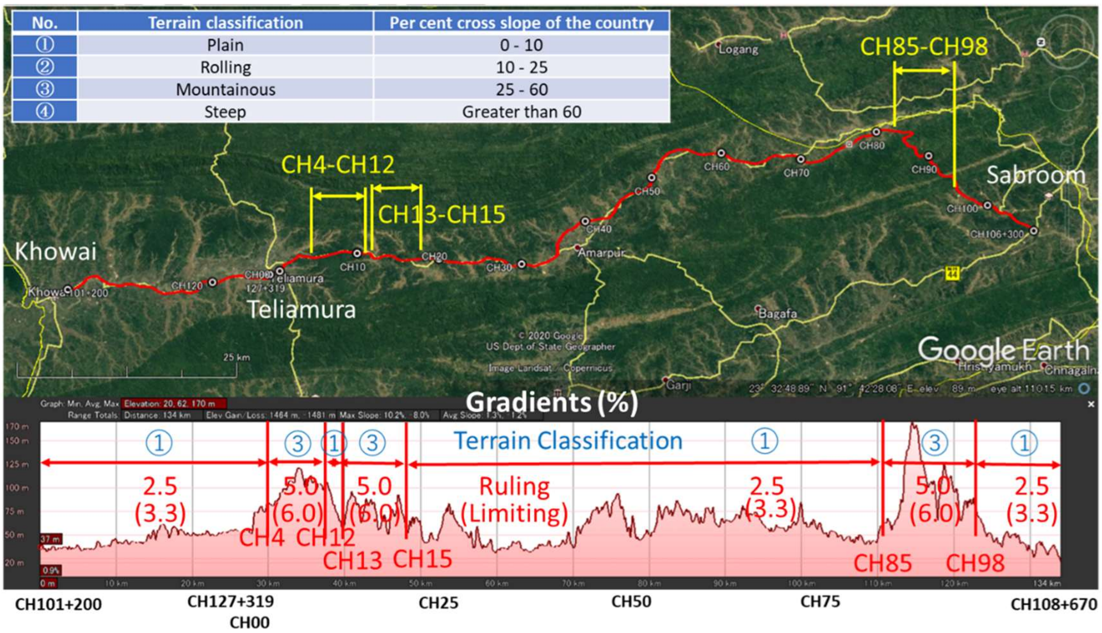
IRCSP73-2018, Clause 2.9.7 states "The vertical alignment should provide for a smooth longitudinal profile. Grade changes should not be too frequent as to cause kinks and visual discontinuities in the profile. The ruling and limiting gradients are given in the table below. Ruling gradients shall be adopted as far as possible. Limiting gradients shall be adopted in difficult situations and for short lengths."

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 5-50: Gradients as per IRCSP73-2018

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 IRCSP73-2018



Source: JICA Survey Team

Figure 5-38: Ruling and Limiting Gradients (%)

The following points are observed on the vertical alignment design in the DPR. All these three points pointed out by JICA Survey Team were removed in the revised drawings as shown in the table below, submitted by the DPR consultant on September 30, 2020.

① Longitudinal gradient of less than 0.3% is observed.
② Longitudinal gradient of more than Limiting Gradient of 6% is observed.
③ Frequent change of gradients is observed.

Table 5-51: Gradients use in DPR

Vertical improvements –

Table 8.5-Vertical Report

PVI	PVI		Curve Length	Gradient (%)		Chainage(m)		Level (m)		Type of Curve	K Value
No	Design Chainage (m)	Level (m)		IN	OUT	Start of Curve	End of Curve	Start of Curve	End of Curve		
1	0+500.529	50.583	200	0.367	2.406	0+400.529	0+600.529	50.216	52.989	Sag	98.105
2	1+591.364	76.825	475	2.406	-1.943	1+353.864	1+828.864	71.111	72.209	Hog	109.226
3	2+154.383	65.884	250	-1.943	1.097	2+029.383	2+279.383	68.313	67.256	Sag	82.229
4	4+540.483	92.063	500	1.097	-0.635	4+290.483	4+790.483	89.32	90.475	Hog	288.657
5	5+812.726	83.984	300	-0.635	2.846	5+662.726	5+962.726	84.937	88.252	Sag	86.192
6	6+771.396	111.264	500	2.846	-4.351	6+521.396	7+021.396	104.15	100.387	Hog	69.479
7	7+565.569	76.711	250	-4.351	3.842	7+440.569	7+690.569	82.149	81.513	Sag	30.513
8	8+323.279	105.824	250	3.842	-0.357	8+198.279	8+448.279	101.021	105.378	Hog	59.536
9	9+490.000	101.661	300	-0.357	-0.702	9+340.000	9+640.000	102.196	100.608	Hog	869.1
10	10+742.699	92.867	400	-0.702	-1.864	10+542.699	10+942.699	94.271	89.139	Hog	344.231
11	11+420.000	80.242	300	-1.864	-3.76	11+270.000	11+570.000	83.038	74.602	Hog	158.216
12	12+060.000	56.177	300	-3.76	0.351	11+910.000	12+210.000	61.817	56.703	Sag	72.977
13	13+010.208	59.51	400	0.351	3.95	12+810.208	13+210.208	58.808	67.409	Sag	111.139
14	13+885.008	94.063	400	3.95	-1.22	13+685.008	14+085.008	86.163	91.622	Hog	77.365
15	14+928.187	81.331	400	-1.22	-4.754	14+728.187	15+128.187	83.772	71.823	Hog	113.205
16	15+444.836	56.77	300	-4.754	2.266	15+294.836	15+594.836	63.901	60.168	Sag	42.738
17	16+090.240	71.392	200	2.266	0.935	15+990.240	16+190.240	69.126	72.327	Hog	150.281
18	16+900.000	78.961	650	0.935	-3.343	16+575.000	17+225.000	75.923	68.097	Hog	151.959
19	17+678.041	52.953	150	-3.343	-0.334	17+603.041	17+753.041	55.46	52.703	Sag	49.848
20	19+060.331	48.342	200	-0.334	2.826	18+960.331	19+160.331	48.676	51.168	Sag	63.299
21	19+554.839	62.317	350	2.826	0.337	19+379.839	19+729.839	57.371	62.906	Hog	140.59
22	20+407.818	65.19	400	0.337	-1.548	20+207.818	20+607.818	64.516	62.095	Hog	212.249
23	21+120.000	54.168	100	-1.548	-0.425	21+070.000	21+170.000	54.942	53.956	Sag	89.061
24	21+549.132	52.345	100	-0.425	1.461	21+499.132	21+599.132	52.557	53.076	Sag	53.014

Source: JICA Survey Team based on DPR

5.3.2 Intersection Design

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 reviewed and analyzed by the DPR consultant, with respect to vehicular movements and vehicular turning movements based on traffic study for providing appropriate grade for cross and turning traffic.

(1) Khowai – Teliamura

There are 4 proposed major at-grade intersections from Khowai to Teliamura along the Project stretch. The terrain conditions for 4 major intersections are mostly flat and the design speed of 80 km/h or 100 km/h is applied.

Table 5-52: Details of Proposed Major Intersection

Sl. No	Existing Chainage (km)	Design Chainage (km)	Side	Type	Remarks
5	103+220	96+120	Right	3 legged	Junction is provided at the start point of Bypass at khowai
6	111+150	101+110	Right	3 legged	Junction is provided at the end point of Bypass at khowai
7	117+800	106+970	Right	3 legged	Road leads to Ramchandra Ghat Market
8	139+425	127+319	Right	3 legged	Road leads to Agartala

Source: JICA Survey Team based on DPR

On the other hand, 34 minor at-grade intersections from Khowai to Teliamura along the Project stretch were proposed by the DPR consultant.

Table 5-53: Details of Proposed Minor Intersection

Sl. No	Existing Chainage (km)	Design Chainage (km)	Side	Type	Remarks
51	111+390	101+400	Left	3 legged	Road leads to Kalabagan
52	111+810	101+820	Right	3 legged	Road leads to Madhya Sonatala
53	112+870	102+880	Left	3 legged	Road leads to Uttar Sonatala
54	113+110	103+120	Right	3 legged	Road leads to Basutos
55	114+185	104+180	Left	3 legged	Road leads to Kamalpur
56	115+305	105+295	Left	3 legged	Road leads to Sachindranagar
57	116+345	106+300	Left	3 legged	Road leads to Ramchandra Ghat Market
58	119+875	109+030	Right	3 legged	Road leads to Khas Kalyanpur
59	120+300	109+450	Left	3 legged	Road leads to Pandab Para
60	120+960	110+120	Right	3 legged	Road leads to Kamartilla
61	121+025	110+170	Left	3 legged	Road leads to Village
62	122+800	111+660	Left	3 legged	Road leads to Village
63	123+435	112+310	Left	3 legged	Road leads to Kacha Tiilla
64	125+640	114+500	Right	3 legged	Road leads to Kunjaban
65	126+485	115+345	Both	4 legged	Road leads to Sabang in right and Police Station in left
66	127+025	115+700	Left	3 legged	Road leads to Kaltanpur Bazar Colony
67	127+300	115+930	Left	3 legged	Road leads to Village
68	128+115	116+710	Left	3 legged	Road leads to Village
69	128+270	116+870	Left	3 legged	Road leads to Village
70	128+850	117+360	Right	3 legged	Road leads to Gujakha Village
71	129+100	117+600	Left	3 legged	Road leads to Village
72	129+920	118+380	Left	3 legged	Road leads to Village
73	130+520	118+750	Left	3 legged	Road leads to Village
74	130+700	118+940	Right	3 legged	Road leads to Debta Bari
75	131+115	119+350	Left	3 legged	Road leads to Kamalnagar
76	131+250	119+430	Left	3 legged	Road leads to Kamalnagar
77	132+125	120+135	Right	3 legged	Road leads to Village
78	132+525	120+540	Right	3 legged	Road leads to Maragong Para
79	133+330	121+320	Right	3 legged	Road leads to Bishnu Master Para School Road
80	133+750	121+730	Left	3 legged	Road lead to Uttar Maharani
81	135+445	123+420	Right	3 legged	Road lead to Duski
82	136+760	124+725	Right	3 legged	Road lead to Trishabari
83	138+295	126+185	Right	3 legged	Road lead to Hadrai
84	138+890	126+785	Both	4 legged	Road lead to Road leads to Sheabre in right and Karailong in left

Source: JICA Survey Team based on DPR

(2) Teliamura – Sabroom

The DPR Consultant observed a total of 451 junctions on the Project Road including the new junction developed on bypasses or realignment. Out of 451 junctions, 191 junctions are retained due to proposal of realignment or bypass, rest of the 260 junctions are proposed to develop at-grade only. No grade separated intersections with /without ramps were proposed.

2 major junctions as shown below were proposed by the DPR consultant, and the details of minor junctions are shown in Appendix B-4.

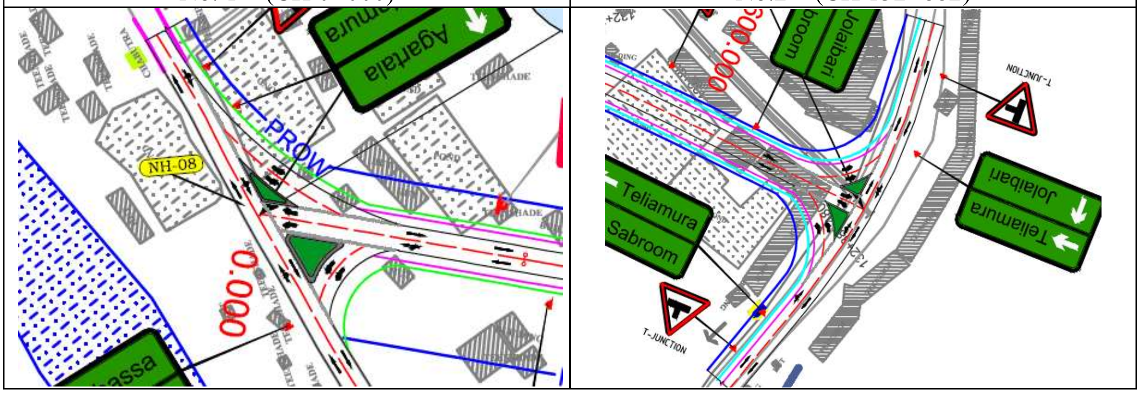
Table 5-54: Details of Major Junctions

Sl. No.	Location (Km)		At grade	Separated	Category of Cross Road			
	From	To			NH	SH	MDR	Others
1.	0+000		√		NH-08			
2.	132.882		√		NH-08			

(NH: National Highway, SH: State Highway, MDR: Major District Road)

Source: DPR

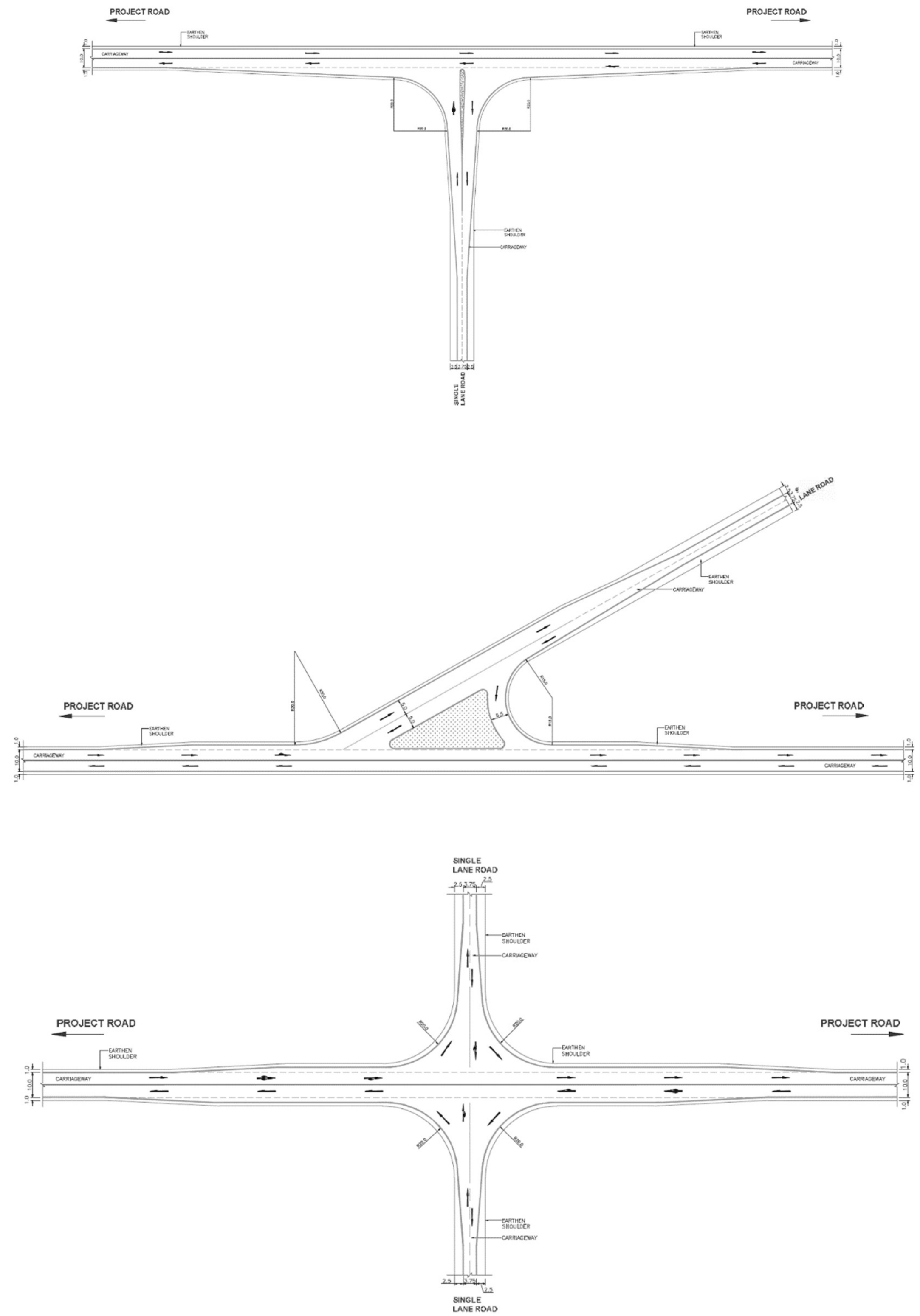
No. 1 (CH 0+000) | No.2 (CH 132+882)



Source: JICA Survey Team based on DPR

Figure 5-39: Major Junction Locations

On the other hand, the DPR consultant proposed typical junctions for three-arm junction, Y-junction and four-arm junction.



Source: DPR

Figure 5-40: Typical Junctions

(3) Basic Design of Intersections

In the design of an intersection, the primary considerations are safety and smooth and efficient flow of traffic. It should be based on the knowledge of what a driver will do rather than what he should do. All the intersection movements should be obvious to the drivers, even if he is a stranger to the area. Therefore, intersections must be designed and operated with simplicity and uniformity.

Sub-clause 3.2.1 of IRC SP 73-2018, the intersection control shall be of 'Stop Control' unless specified otherwise. This will mean that traffic on the minor road must stop prior to entering the major road. Where roads of equal importance intersect, priority will be given to the traffic on the right. Moreover, the sight distance to be adopted shall be at least twice the safe stopping sight distance.

Design standards of intersections shall be as per IRC SP 41. Design speed shall generally be taken as 40 percent of approach speed in built up areas and 60 percent in open areas. The traffic volume for the design of intersection and its distribution, at peak hours shall be assessed. Semi-trailer combination for the design vehicle shall be used in the design of intersections. The number of lanes to be provided at the intersection shall be governed by peak hour traffic volume in each direction of travel and shall be determined based on the projected traffic for the year in which further capacity augmentation is considered. On the other hand, the radii of intersection curves are considered depending on the turning characteristics of design vehicles, their numbers, and the speed at which vehicles enter or exit intersection area.

Sub-clause 4.4.2 of IRC 41-1994 states that selection of appropriate curve radii, influences the vehicle speed at various points. The speed should be such that the vehicle should either be able to stop before the conflict point or accelerate to suitable speed to merge with traffic flow. The following table shows the relationship of inner curve radii for a larger range of design speeds.

Table 5-55: Design Speed & Minimum Radii

Design Speed km/hr	Minimum inner radii (m)
18.5	18
15	23
20	27
30	32
40	37
50	41
75	50
100	57
125	62
150	64
Straight	-

Source: IRC 41-1994

Sub-clause 4.8.2 of IRC 41-1994 states that an acceleration lane should be designed so that vehicle tuning 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. Acceleration lanes also improve capacity by enabling the use of short traffic gaps and by providing storage space for traffic waiting to merge when large traffic gaps occur.

5.3.3 Pavement Design

The pavement design and construction of new pavement sections for the existing pavement shall be carried out in accordance with IRC SP 73-2018 for two-lane carriageway. 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 73-2018.

(1) Flexible Pavement Design

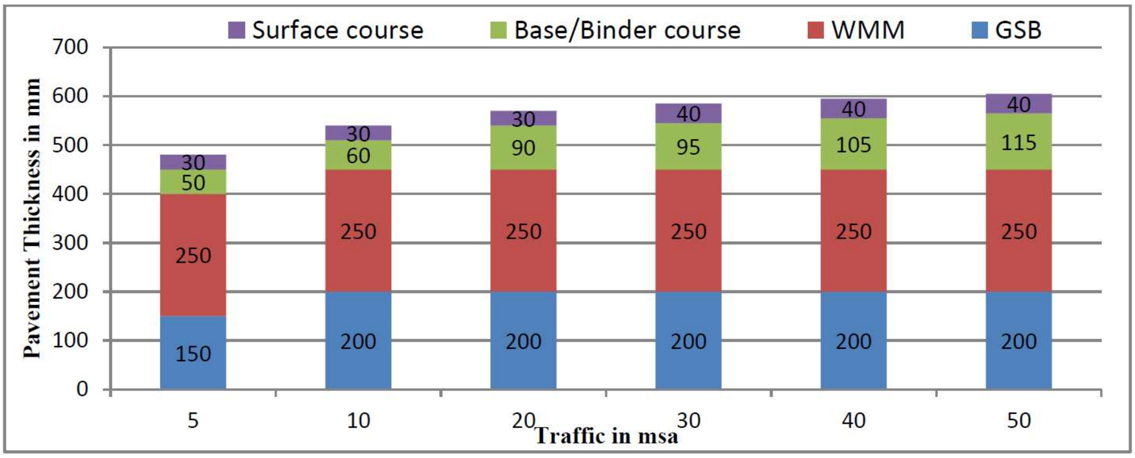
The DPR consultant adopted IRC 37-2012 for the design of flexible pavements in accordance with IRC SP 73-2015 for two-lane highways for the section from Khowai to Teliamura. The Survey stretch from Teliamura to Sabroom, IRC 37-2018 for the flexible pavement in accordance with IRC SP 73-2018. The design standard has been updated to IRC SP 73-2018, and the pavement design of DPR is recommended to be modified as per IRC 37-2018. Since the geometry design standard adopted is IRC SP 73-2018, the pavement design shall also adopt the same guidelines, unless otherwise specified in Schedule 'B' of the Concessionaire Agreement.

For the design period, Sub-clause 5.4.1 in IRC SP 73-2018 stated that flexible pavement shall be designed for a minimum design period of 15 years or operation period, whichever is more. In addition, in Sub-clause 4.3.1 of IRC 37-2018 states that the design period to be adopted for pavement design is the time span considered appropriate for the road pavement to function without major rehabilitation. It is recommended that a design period of 20 years may be adopted for the structural design of pavements for National Highways, State Highways and Urban Roads. Since a new pavement will be applied to the entire Survey stretch , the design period of the minimum 15 years is recommended.

For the pavement structural design, Clause 12 in IRC 37-2018 presents six categories 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.

For the survey stretch from Khowai to Teliamura, the design traffic of 20msa and the design CBR of 8% are applied for the survey stretch. The pavement with bituminous surface course with the unbounded base layer, Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM) and Granular Sub-Base (GSB), has been considered as per predetermined design. Sub-clause 8.1 in IRC 37-2018 states that Wet mix macadam may also consist of blast furnace slag mixed with crushed stone meeting the MoRTH Specifications. Therefore, Plate 4 of IRC 37-2018 is selected and shown as follows.

- 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 5-41: Catalogue for Pavement Thickness as per IRC 37-2018 (Plate 4)

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.

On the other hand, the Survey stretch from Teliamura to Sabroom, the DPR consultant proposed the combination of bituminous surface course with Cement Treated Sub Base (CTSB), Cement Treated Base (CTB) and Stress Absorbing Membrane Interlayer (SAMI). For the layers of CTBS and CTB, Jhama Brick Base (JBB) and Jhama Brick Sub Base (JBSB) were proposed, respectively.

Sub-clause 5.7 in IRC SP 73-2018 states that the pavement construction materials for sub-base, base and bituminous surfacing shall conform to the requirements prescribed in MoRTH Specifications and IRC Standards.

The comparison of pavement thickness is shown in the below table.

Table 5-56: Comparison of Pavement Thickness

Survey Stretch	DPR consultant conformed/followed Design Standards	Design Traffic (msa)	Design CBR (%)	IRC 37-2018 Pavement Catalogue Plate#	Bituminous layer (mm)	Base/Sub-base (mm)		Sub-grade (mm)	Total Thickness (mm)
Khowai-Teliamura	IRC SP 73 2015, IRC 37-2012	20	8	-	BC	DBM	WMM	GSB	575
					40	85	250	200	
Khowai-Teliamura	IRC SP 73 2018, IRC 37-2018	20	8	Plate 4	BC	DBM	WMM	GSB	570
					30	90	250	200	
Teliamura-Sabroom	IRC SP 73 2018, IRC 37-2018	20	8	Plate 20	BC	DBM	JBB	JBSB	430
					30	50	150	200	

Source: JICA Survey Team

(2) Sub-grade

Sub-clause 5.6 in IRC SP 73-2018 provides that the Sub-grade, whether in cut or fill, shall satisfy the requirements stipulated in Clause 305 of MoRTH Specifications.

(3) 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.

5.3.4 Earth Work / Slope Protection / Landslide Prevention Design

Issues of each stratigraphy for slope protection and improvement plan are summarized in Table 5-57. As for earth work and slope protection, the preliminary design is implemented based on Table 5-57. As for landslides, the landslide prevention design is proposed.

Table 5-57: Issues of Each Stratigraphy for Slope Protection and Improvement Plan

Item		Alluvium	Dupitila G.	Tipam G.	Surma G.
Lithology		Sand, Silt, Clay	Mainly Sand	Mainly Sandstone	Alternation of Siltstone and Shale
Degree of Consolidation		Unconsolidated		Weakly Consolidated	Soft Rock
Bedding Plane		Horizontal		Almost Horizontal	Dip of 10 to 60 degree
Problems for Cut Slope		–	Topsoil Collapse Surface Erosion		Topsoil Collapse Shallow Surface Collapse Wedge-Shape Collapse Long–Term Stability (dip slope structure)
D P R	Cut slope Gradient	–	0.5H : 1V		
	Slope Protection	–	Retaining wall, Breast wall, Hydroseeding		
	Drainage	–	Berm Drainage (Catch water drain)		
Recommendation by JICA Survey Team	Cut slope Gradient	–	0.5H : 1V		0.5H : 1V
	Slope Protection	–	Retaining wall, Breast wall, Hydroseeding		Retaining wall, Breast wall, Hydroseeding Mortar Spraying / Shotcrete Rock Bolts with Concrete Crib Works Soil Nailing
	Drainage	–	Berm Drainage (Catch water drain), Drainage at theTtop and Shoulder, and Longitudinal Drainage		

Source: JICA Survey Team (Table 3.5.3 in "Final Report on Basic Information and Data Collection Study on Connectivity Improvement in North Eastern Region of India–NH 208 (Kailashahar–Teliamura)–" was modified)

(1) Earth Work

The Dupitila Group, which is distributed in the valley bottom plain like fluvial terraces, is unconsolidated deposits. The Tipam Group, which is distributed in the undulating plain called "Rolling", is weakly consolidated deposits. It is possible to excavate these deposits directly with bulldozer. The Surma Group is composed of soft rocks. It is possible to excavate this rock with bulldozer and ripper.

(2) Slope Protection

As shown in Table 5-57, DPR suggests uniformly retaining wall, breast wall, and hydroseeding through the entire Project Road. The gradient of cut slope is 0.5H : 1V for every stratigraphy. Berm drainage (catch water drain) is suggested for drainage plan.

Retaining wall and breast wall suggested in the DPR are appropriate. The critical problem is whether hydroseeding is applicable or not through the entire Project Road.

Hydroseeding is applicable for slope protection on the cut slopes where the Dupitila Group and Tipam group are distributed because bedding planes of these layers are almost horizontal, and existing cut slopes are stable. On the cut slopes where the Tipam group is distributed, the height of cut slope is sometimes more than 20 m at the center of the Project Road. However, the cut slopes will not become so large-scaled like cutting work on the steep slopes, because "Rolling" shows undulating topography and the top is almost flat.

It is difficult to apply hydroseeding to the cut slopes composed of the Surma Group, because the Surma Group is an impermeable layer and topsoil is a high permeable layer. Vegetation is easy to slide during heavy rain. As for the Surma Group, vegetation is not an ideal method for slope protection due to the properties of soft rocks. Instead of hydroseeding, mortar/concrete spraying is desirable for slope protection measures. As for the large-scaled cut slopes with dip slope structure, the internal reinforcing methods of soil nailing with mortar/concrete spraying and/or rock bolts with concrete crib works are desirable, because the gradient of 0.5H : 1V is not stable. However, the cost of mortar/concrete spraying is approximately ten times more expensive compared with that of hydroseeding in Tripura State. Therefore, it is not practical to adopt mortar/concrete spraying for all the cut slopes considering its cost.

In the final report of NH 208 (Kailashahar–Teliamura), the internal reinforcing methods are applied to the slopes, satisfying the following criteria; 1) the maximum height of cut slope is more than 18 m (equal to 3 steps) and 2) cut slope with dip slope structure.

On this Project Road, as mentioned in Chapter 5.1.5 "Satellite Image Interpretation", cut slopes in the target areas 1, 2, 5, and 6 show dip slope structure. However, cut slopes in the target areas 1 and 2 are not so high. In the target areas 5 and 6, landslides A and B are inferred, and it is recommended to shift the Project Road away from landslides, as mentioned later. Therefore, in the present design, there are no cut slopes where the internal reinforcing methods are recommended. Accompanying the shift of the Project Road in the target areas 5 and 6, some cut slopes may meet the above criteria 1) and 2), and large-scaled cut slopes with dip slope structure may appear. If so, it is recommended to apply the internal reinforcing measures.

There are a lot of topsoil collapses in the existing road of NH 208 (Kailashahar–Teliamura). The slope protection measures of topsoil collapses are a critical issue through the entire Project Road. It is desirable to plan not only berm drainage but also drainage at the top and shoulder together with the longitudinal drainage in order to drain smoothly surface water flowing into cut slope from adjacent natural slopes (Table 5-57).

(3) Landslide Prevention Design

- **Landslide Distribution**

The topographic survey was performed by the stereo-view of satellite images in the hilly area of the Project Road. As a result, several landslides were found around the Project Road. Among these the Project Road crosses or goes through alongside landslides in target area 5 (CH89800 to CH90500) and target area 6 (CH91100 to CH91600) (Figure 5-13, Figure 5-16, Figure 5-18 and Figure 5-21 in Chapter 5.1.5 Satellite Image Interpretation).

- **Current DPR Design**

Landslides of A-1 to A-5 are inferred in target area 5. Embankments are planned on the heads of landslides of A-1, A-4, and A-5 (Figure 5-17).

Landslides of B-1 to B-4 are inferred in target area 6. Embankments are planned on the middle part of landslides of B-1, B-2, and B-4, and cutting is planned on the middle part of landslide of B-3 (Figure 5-22).

Embankments will trigger the instability of these landslides once the embankment started. The whole road structure on the landslides might become instable by building up of embankments and heavy rains during road construction or future maintenance period even if the landslides are stable at present.

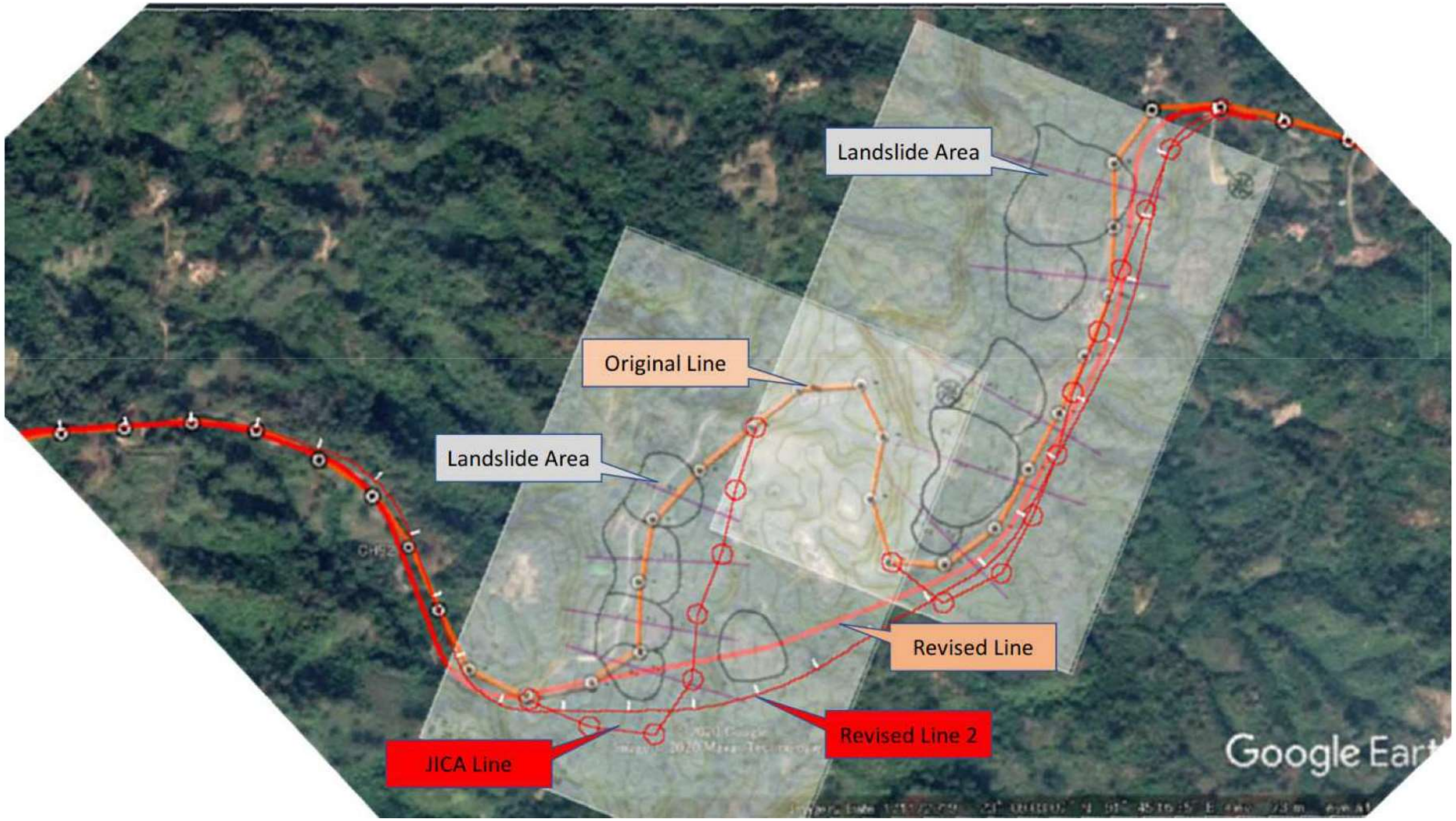
- **Realignment of the Project Road in Target Area 5 and 6**

The secure and reliable countermeasure for landslide prevention is a change of the alignment in target area 5 and 6. JICA Survey Team strongly recommended DPR consultant to realign the Project Road ("JICA Line" in Figure 5-42). Against this recommendation DPR consultant suggested "Revised Line". However, JICA Survey Team recommended the reconsideration of the realignment because this line still goes through two landslides. DPR consultant agreed with this suggestion and submitted another line of "Revised Line 2" (Figure 5-42). JICA Survey Team approved this line. Although it might need additional time and cost for topographic survey and design, it is worth redesigning if we consider more costs for landslide prevention measures and possible landslide disasters after opening traffic.

- **Landslide Prevention Measures for Reference**

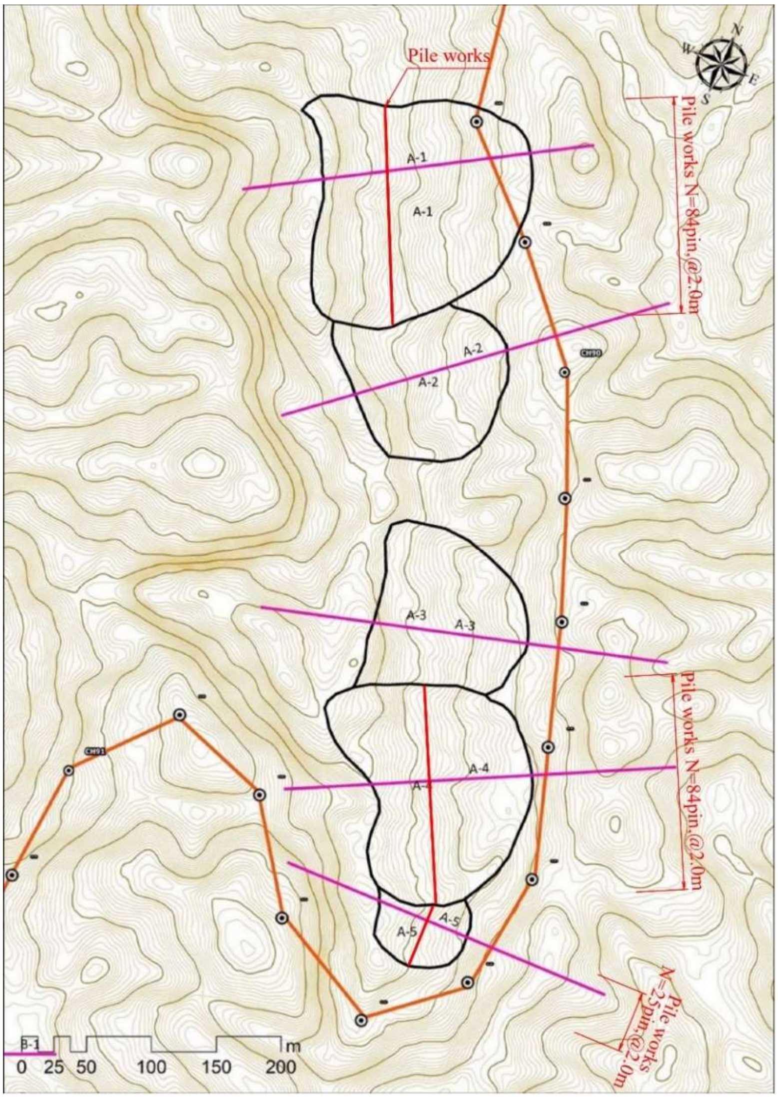
If the current Project Road design is adopted, the landslide prevention design such as pile works or anchor works and the installation works are necessary. There will be additional costs for temporary road as well as longer project period required.

Steel pipe pile works for landslide prevention measures were roughly designed as shown in Figure 5-43, Figure 5-44, Figure 5-45, Figure 5-46 and Table 5-58. If the landslide mass is 18m thick, and the required preventive force to be provided by the pile is 1,000 kN/m, it is necessary to install a steel pipe with diameter of φ500 mm, thickness of t=25 mm, and length of L=27.0 m at intervals of 2.0 m. The unit price of a pile is about 36,350 USD (Table 5-58). 193 steel pipe piles and 182 steel pipe piles are necessary in the target area 5 and 6, respectively (Figure 5-43 and Figure 5-45). The total number is 375 piles, and the rough cost estimation for pile works reaches 13.6 million USD (1,500 million JPY).



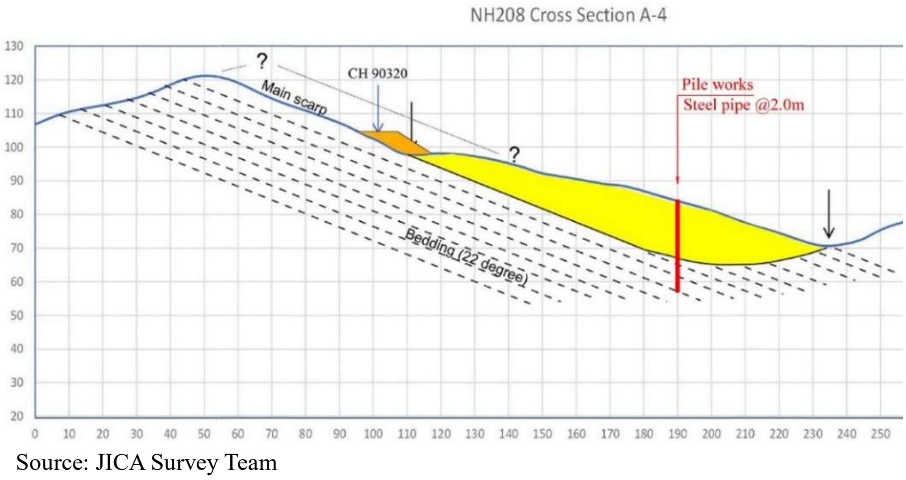
Source: JICA Survey Team

Figure 5-42: Realignment of the Project Road in Target Area 5 and 6



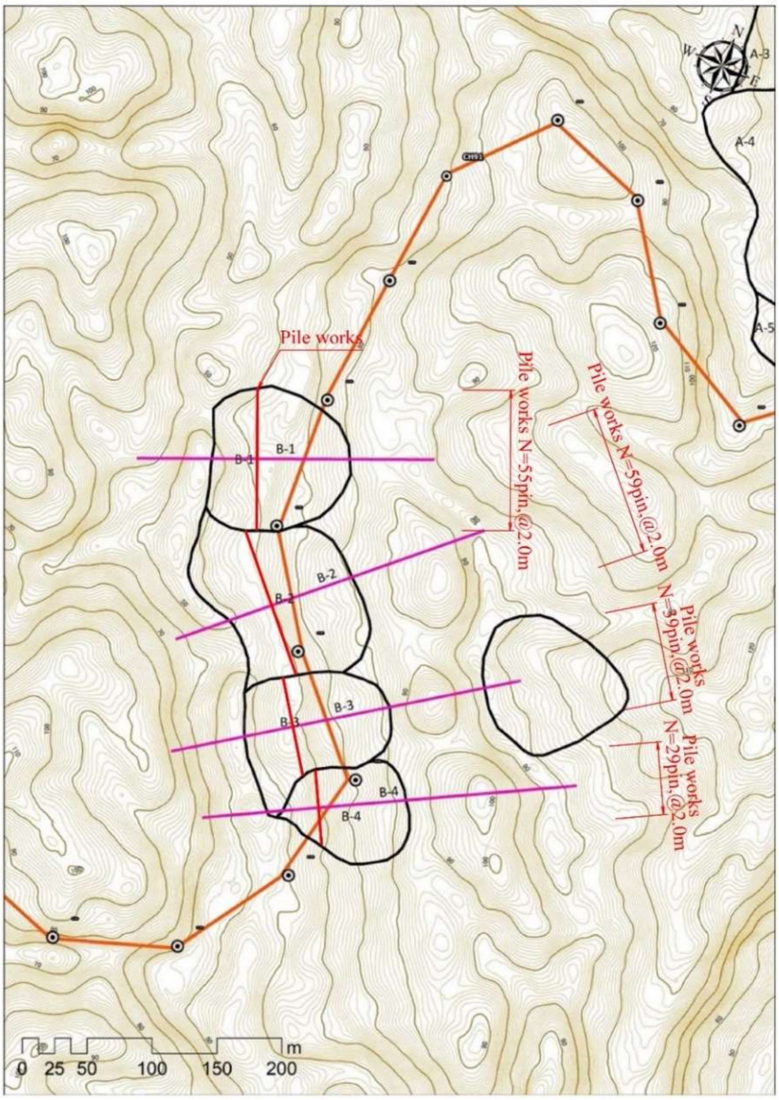
Source: JICA Survey Team

Figure 5-43: Layout of Pile Works in Target Area 5



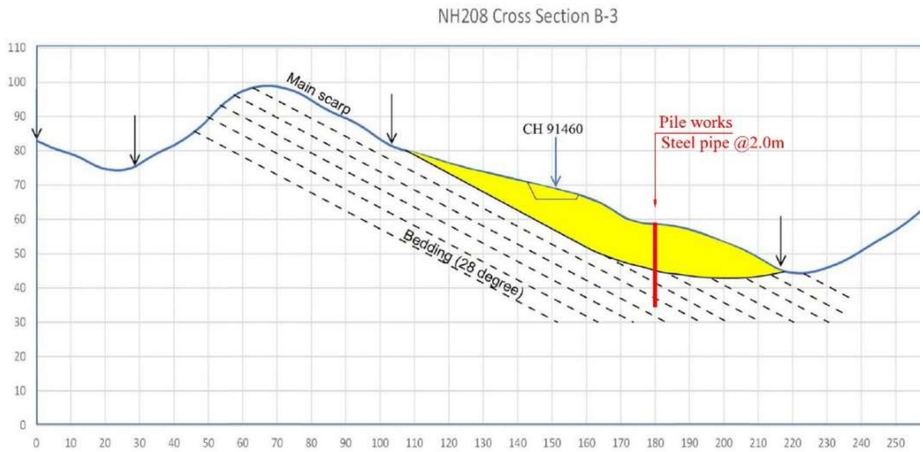
Source: JICA Survey Team

Figure 5-44: Cross-Sectional Layout of Pile on Landslide A-4



Source: JICA Survey Team

Figure 5-45: Layout of Pile Works in Target Area 6



Source: JICA Survey Team

Figure 5-46: Cross-Sectional Layout of Pile on Landslide B-3

Table 5-58: Rough Estimation of Unit Price for Pile Work

Type of Work	Specification	Quantity	Cost (USD)
Large borehole drilling	ϕ 550 mm, L=27.0 m	1	20,450
Steel pipe	SM570, ϕ 500 mm, t=25 mm, L=27.0 m	1	15,000
Temporary stage	—	1	900
Total	—	—	36,350

Note; Total cost is US$ 36,350/pile x 375piles = US$ 13.6 million

5.3.5 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 5-59.

The bridge with its span length of 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. The wearing coat is to conform to Section 2700 of the MORTH Specifications.

Table 5-59: 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).

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.

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 Tripura

The JICA Survey Team reviewed Drawings Part-B: Structural Drawings and summarized the structural dimensions as shown in Table 5-60.

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 5-60: Dimensions of Superstructures in Tripura

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	12+915	Wall	8.302	1.000	18	1.200	22.000	3.600	8.112	1.000	6	1.200	22.000	3.600
2	17+900	Wall	2.541	1.000	15	1.200	22.000	3.600	-	-	-	-	-	-
3	18+800	Wall	3.745	1.000	15	1.200	22.000	3.600	6.564	1.000	6	1.200	22.000	3.600
4	19+770	-	-	-	-	-	-	-	-	-	-	-	-	-
5	21+320	Wall	3.589	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
6	24+060	Wall	4.684	1.000	15	1.200	22.000	3.600	6.118	1.000	6	1.200	22.000	3.600
7	24+760	Wall	3.872	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
8	24+930	Wall	2.669	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
9	25+340	Wall	4.916	1.000	15	1.200	#REF!	3.600	4.894	1.000	6	1.200	22.000	3.600
10	29+470	-	-	-	-	-	22.000	-	-	-	-	-	-	-
11	31+050	Wall	4.921	1.000	15	1.200	22.000	3.600	8.002	1.000	6	1.200	22.000	3.600
12	32+870	Wall	4.281	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
13	34+450	Wall	4.389	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
14	36+290	Wall	4.281	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
15	37+280	-	-	-	-	-	-	-	-	-	-	-	-	-
16	39+705	Wall	2.787	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
17	40+960	Wall	2.705	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
18	43+430	Wall	5.053	1.000	15	1.200	22.000	3.600	8.174	1.000	6	1.200	22.000	3.600
19	43+900	Wall	2.869	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
20	46+070	-	-	-	-	-	-	-	-	-	-	-	-	-
21	50+775	-	-	-	-	-	-	-	-	-	-	-	-	-
22	52+100	Wall	1.236	1.000	18	1.200	22.000	3.600	-	-	-	-	-	-
23	53+500	Wall	0.969	1.000	15	1.200	25.000	3.600	4.975	1.000	6	1.200	25.000	3.600
24	58+987	-	-	-	-	-	-	-	-	-	-	-	-	-
25	59+970	-	-	-	-	-	-	-	-	-	-	-	-	-
26	60+450	Wall	6.061	1.000	15	1.200	22.000	3.600	-	-	6	-	-	-
27	62+625	-	-	-	-	-	-	-	-	-	-	-	-	-
28	63+780	-	-	-	-	-	-	-	-	-	-	-	-	-
29	64+045	-	-	-	-	-	-	-	-	-	-	-	-	-
30	69+895	-	-	-	-	-	-	-	-	-	-	-	-	-
31	70+930	-	-	-	-	-	-	-	-	-	-	-	-	-
32	72+400	-	-	-	-	-	-	-	-	-	-	-	-	-
33	73+600	-	-	-	-	-	-	-	-	-	-	-	-	-
34	76+600	-	-	-	-	-	-	-	-	-	-	-	-	-
35	77+000	-	-	-	-	-	-	-	-	-	-	-	-	-
36	80+270	-	-	-	-	-	-	-	-	-	-	-	-	-
37	83+400	-	-	-	-	-	-	-	-	-	-	-	-	-
38	85+270	-	-	-	-	-	-	-	-	-	-	-	-	-
39	85+445	-	-	-	-	-	-	-	-	-	-	-	-	-
40	85+725	-	-	-	-	-	-	-	-	-	-	-	-	-
41	91+610	Wall	3.336	1.200	15	1.200	20.000	4.000	8.259	1.000	6	1.200	20.000	4.000
42	98+240	Wall	3.629	1.200	15	1.200	20.000	4.000	4.641	1.000	14	1.200	20.000	4.000
43	98+420	Wall	4.702	1.000	15	1.200	18.000	3.600	-	-	-	-	-	-
44	99+330	Wall	4.125	1.200	15	1.200	20.000	4.000	3.660	1.000	14	1.200	20.000	4.000
45	99+495	-	-	-	-	-	-	-	-	-	-	-	-	-
46	104+600	Wall	5.509	1.200	15	1.200	20.000	4.000	-	-	-	-	-	-

Source: JICA Survey Team

(3) Substructure Design

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

Piers in streams and channels should be located 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 following 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 5-61.

Table 5-61: Dimensions of Substructures in Tripura

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	12+915	Wall	8.302	1.000	18	1.200	22.000	3.600	8.112	1.000	6	1.200	22.000	3.600
2	17+900	Wall	2.541	1.000	15	1.200	22.000	3.600	-	-	-	-	-	-
3	18+800	Wall	3.745	1.000	15	1.200	22.000	3.600	6.564	1.000	6	1.200	22.000	3.600
4	19+770	-	-	-	-	-	-	-	-	-	-	-	-	-
5	21+320	Wall	3.589	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
6	24+060	Wall	4.684	1.000	15	1.200	22.000	3.600	6.118	1.000	6	1.200	22.000	3.600
7	24+760	Wall	3.872	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
8	24+930	Wall	2.669	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
9	25+340	Wall	4.916	1.000	15	1.200	#REF!	3.600	4.894	1.000	6	1.200	22.000	3.600
10	29+470	-	-	-	-	-	22.000	-	-	-	-	-	-	-
11	31+050	Wall	4.921	1.000	15	1.200	22.000	3.600	8.002	1.000	6	1.200	22.000	3.600
12	32+870	Wall	4.281	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
13	34+450	Wall	4.389	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
14	36+290	Wall	4.281	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
15	37+280	-	-	-	-	-	-	-	-	-	-	-	-	-
16	39+705	Wall	2.787	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
17	40+960	Wall	2.705	1.000	18	1.200	20.000	3.600	-	-	-	-	-	-
18	43+430	Wall	5.053	1.000	15	1.200	22.000	3.600	8.174	1.000	6	1.200	22.000	3.600
19	43+900	Wall	2.869	1.000	15	1.200	20.000	3.600	-	-	-	-	-	-
20	46+070	-	-	-	-	-	-	-	-	-	-	-	-	-
21	50+775	-	-	-	-	-	-	-	-	-	-	-	-	-
22	52+100	Wall	1.236	1.000	18	1.200	22.000	3.600	-	-	-	-	-	-
23	53+500	Wall	0.969	1.000	15	1.200	25.000	3.600	4.975	1.000	6	1.200	25.000	3.600
24	58+987	-	-	-	-	-	-	-	-	-	-	-	-	-
25	59+970	-	-	-	-	-	-	-	-	-	-	-	-	-
26	60+450	Wall	6.061	1.000	15	1.200	22.000	3.600	-	-	6	-	-	-
27	62+625	-	-	-	-	-	-	-	-	-	-	-	-	-
28	63+780	-	-	-	-	-	-	-	-	-	-	-	-	-
29	64+045	-	-	-	-	-	-	-	-	-	-	-	-	-
30	69+895	-	-	-	-	-	-	-	-	-	-	-	-	-
31	70+930	-	-	-	-	-	-	-	-	-	-	-	-	-
32	72+400	-	-	-	-	-	-	-	-	-	-	-	-	-
33	73+600	-	-	-	-	-	-	-	-	-	-	-	-	-
34	76+600	-	-	-	-	-	-	-	-	-	-	-	-	-
35	77+000	-	-	-	-	-	-	-	-	-	-	-	-	-
36	80+270	-	-	-	-	-	-	-	-	-	-	-	-	-
37	83+400	-	-	-	-	-	-	-	-	-	-	-	-	-
38	85+270	-	-	-	-	-	-	-	-	-	-	-	-	-
39	85+445	-	-	-	-	-	-	-	-	-	-	-	-	-
40	85+725	-	-	-	-	-	-	-	-	-	-	-	-	-
41	91+610	Wall	3.336	1.200	15	1.200	20.000	4.000	8.259	1.000	6	1.200	20.000	4.000
42	98+240	Wall	3.629	1.200	15	1.200	20.000	4.000	4.641	1.000	14	1.200	20.000	4.000
43	98+420	Wall	4.702	1.000	15	1.200	18.000	3.600	-	-	-	-	-	-
44	99+330	Wall	4.125	1.200	15	1.200	20.000	4.000	3.660	1.000	14	1.200	20.000	4.000
45	99+495	-	-	-	-	-	-	-	-	-	-	-	-	-
46	104+600	Wall	5.509	1.200	15	1.200	20.000	4.000	-	-	-	-	-	-

Source: JICA Survey Team

(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 5-62.

Table 5-62: Soil and Foundation

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	12+915	50.713	8	1	Cast-in-Situ Pile
2	17+900	41.895	11	1	Cast-in-Situ Pile
3	18+800	40.729	29	1	Cast-in-Situ Pile
4	19+770	53.827	32	1	-
5	21+320	44.356	6	1	Cast-in-Situ Pile
6	24+060	36.490	2	1	Cast-in-Situ Pile
7	24+760	37.521	5	1	Cast-in-Situ Pile
8	24+930	37.924	2	1	Cast-in-Situ Pile
9	25+340	35.901	2	1	Cast-in-Situ Pile
10	29+470	40.891	4	1	-
11	31+050	36.490	4	1	Cast-in-Situ Pile
12	32+870	26.378	5	1	Cast-in-Situ Pile
13	34+450	27.061	6	1	Cast-in-Situ Pile
14	36+290	30.903	5	1	Cast-in-Situ Pile
15	37+280	28.354	4	1	-
16	39+705	32.932	4	1	Cast-in-Situ Pile
17	40+960	31.767	5	1	Cast-in-Situ Pile
18	43+430	28.554	3	1	Cast-in-Situ Pile
19	43+900	42.031	6	1	Cast-in-Situ Pile
20	46+070	66.083	3	1	-
21	50+775	40.838	6	1	-
22	52+100	38.777	2	1	Cast-in-Situ Pile
23	53+500	40.532	6	1	Cast-in-Situ Pile
24	58+987	55.970	6	1	-
25	59+970	54.413	6	1	-
26	60+450	54.061	7	1	Cast-in-Situ Pile
27	62+625	51.904	10	1	-
28	63+780	54.650	9	1	-
29	64+045	55.495	12	1	-
30	69+895	46.966	14	1	-
31	70+930	45.459	12	1	-
32	72+400	52.055	6	1	-
33	73+600	53.076	5	1	-
34	76+600	43.741	6	1	-
35	77+000	45.209	6	1	-
36	80+270	33.871	4	1	-
37	83+400	33.871	5	1	-
38	85+270	40.266	4	1	-
39	85+445	48.550	6	1	-
40	85+725	44.645	6	1	-
41	91+610	42.029	9	1	Cast-in-Situ Pile
42	98+240	42.126	5	1	Cast-in-Situ Pile
43	98+420	40.299	9	1	Cast-in-Situ Pile
44	99+330	35.265	10	1	Cast-in-Situ Pile
45	99+495	32.641	10	1	-
46	104+600	19.878	8	1	Cast-in-Situ Pile

Source: JICA Survey Team

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

(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 must 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 5-63. The formula in the hydraulic calculation comply with the Catchment-Runoff Method in confirmation of flood records and IRC SP 13-2004.

Table 5-63: Scour Depth

No.	Chainage	Discharge (cu.m/sec)	Max. Scour Level(m)	Bottom of Pile Cap(m)	Depth (m)
1	12+915	316.35	41.51	50.713	9.203
2	17+900	156.72	38.15	41.895	3.745
3	18+800	231.64	32.30	40.729	8.429
4	19+770	32.96	53.26	53.827	0.567
5	21+320	109.28	39.39	44.356	4.966
6	24+060	193.90	32.00	36.490	4.490
7	24+760	70.49	34.77	37.521	2.750
8	24+930	83.79	33.51	37.924	4.414
9	25+340	125.83	30.68	35.901	5.221
10	29+470	56.01	36.87	40.891	4.021
11	31+050	319.40	23.89	36.490	12.600
12	32+870	104.97	22.37	26.378	4.010
13	34+450	59.16	24.93	27.061	2.131
14	36+290	212.39	23.84	30.903	7.063
15	37+280	31.47	25.32	28.354	3.034
16	39+705	227.35	25.85	32.932	7.082
17	40+960	121.28	26.26	31.767	5.507
18	43+430	275.94	20.08	28.554	8.474
19	43+900	140.60	38.78	42.031	3.250
20	46+070	36.19	65.53	66.083	0.553
21	50+775	36.19	37.32	40.838	3.518
22	52+100	74.65	34.65	38.777	4.129
23	53+500	744.71	26.61	40.532	13.922
24	58+987	41.43	52.05	55.970	3.920
25	59+970	37.00	51.32	54.413	3.093
26	60+450	195.44	50.46	54.061	3.601
27	62+625	42.49	49.97	51.904	1.934
28	63+780	35.68	52.64	54.650	2.010
29	64+045	61.83	51.93	55.495	3.565
30	69+895	31.15	47.04	46.966	-0.074
31	70+930	58.64	43.81	45.459	1.649
32	72+400	27.85	55.78	52.055	-3.725
33	73+600	65.77	48.91	53.076	4.166
34	76+600	37.17	39.54	43.741	4.201
35	77+000	55.85	42.40	45.209	2.809
36	80+270	95.95	30.18	33.871	3.691
37	83+400	28.49	38.88	33.871	-5.009
38	85+270	13.31	47.26	40.266	-6.994
39	85+445	19.30	47.04	48.550	1.510
40	85+725	15.04	47.19	44.645	-2.545
41	91+610	202.56	35.01	42.029	7.019
42	98+240	52.54	40.85	42.126	1.276
43	98+420	61.08	38.88	40.299	1.422
44	99+330	65.04	33.22	35.265	2.045
45	99+495	50.45	29.58	32.641	3.061
46	104+600	59.36	18.42	19.878	1.458

Source: JICA Survey Team

(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.

By the time of preparing the Draft Final Report, the JICA Survey Team would like to list the protection works, as shown in Table 5-64.

- 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 list the protection works, as shown in Table 5-64.

Table 5-64: Protection Works

No.	Chainage	Return wall	Flooring	Curtain wall
1	12+915	W11000 X	Stone Pitching (1:1.5)	-
2	17+900	W3500 X	Stone Pitching (1:1.5)	-
3	18+800	W4200 X	Stone Pitching (1:1.5)	-
4	19+770	W12200 X	Floor/Flexible Apron	2500
5	21+320	W3500 X	Stone Pitching (1:1.5)	-
6	24+060	W5500 X	Stone Pitching (1:1.5)	-
7	24+760	W3500 X	Stone Pitching (1:1.5)	-
8	24+930	W3500 X	Stone Pitching (1:1.5)	-
9	25+340	W5900 X	Stone Pitching (1:1.5)	-
10	29+470	W5900 X	Floor/Flexible Apron	2500
11	31+050	W6100 X	Stone Pitching (1:1.5)	-
12	32+870	W3500 X	Stone Pitching (1:1.5)	-
13	34+450	W3500 X	Stone Pitching (1:1.5)	-
14	36+290	W6300 X	Stone Pitching (1:1.5)	-
15	37+280	W6500 X	Floor/Flexible Apron	2500
16	39+705	W4000 X	Stone Pitching (1:1.5)	-
17	40+960	W3500 X	Stone Pitching (1:1.5)	-
18	43+430	W6100 X	Stone Pitching (1:1.5)	-
19	43+900	W3500 X	Stone Pitching (1:1.5)	-
20	46+070	W12300 X	Floor/Flexible Apron	2500
21	50+775	W9600 X	Floor/Flexible Apron	2500
22	52+100	W3500 X	Stone Pitching (1:1.5)	-
23	53+500	W3850 X	-	-
24	58+987	W7400 X	Floor/Flexible Apron	2500
25	59+970	W7300 X	Floor/Flexible Apron	2500
26	60+450	W6100 X	Stone Pitching (1:1.5)	-
27	62+625	W8400 X	Floor/Flexible Apron	2500
28	63+780	W9300 X	Floor/Flexible Apron	2500
29	64+045	W9000 X	Floor/Flexible Apron	2500
30	69+895	W12200 X	Floor/Flexible Apron	2500
31	70+930	W8800 X	Floor/Flexible Apron	2500
32	72+400	W7000 X	Floor/Flexible Apron	2500
33	73+600	W7000 X	Floor/Flexible Apron	2500
34	76+600	W7800 X	Floor/Flexible Apron	2500
35	77+000	W5800 X	Floor/Flexible Apron	2500
36	80+270	W8200 X	Floor/Flexible Apron	2500
37	83+400	W7000 X	Floor/Flexible Apron	2500
38	85+270	W8500 X	Floor/Flexible Apron	2500
39	85+445	W7000 X	Floor/Flexible Apron	2500
40	85+725	W13000 X	Floor/Flexible Apron	2500
41	91+610	W3100 X	Stone Pitching (1:1.5)	-
42	98+240	W2800 X	Stone Pitching (1:1.5)	-
43	98+420	W3500 X	Stone Pitching (1:1.5)	-
44	99+330	W3600 X	Stone Pitching (1:1.5)	-
45	99+495	W8200 X	Floor/Flexible Apron	2500
46	104+600	W6300 X	Stone Pitching (1:1.5)	-

Source: JICA Survey Team

5.3.6 Drainage Design

The JICA Survey Team reviewed and confirmed the DPR and drawings conducted by the DPR Consultant. The shapes of the box culverts shown in the drawings were determined from the capacity calculation of the crossing channel carried out using a typical part as a model. Based on the calculation, the cross drainage design of NH208 adopts the box culvert type.

(1) Cross Drain

There are 232 nos of existing culverts (162 HP culverts, 51 nos slab culvert & 19 nos Box Bridges) along the Survey road. Among them 207 nos of existing culverts are proposed to be reconstructed by Box Bridge & the remaining 25 nos of culverts are omitted due to through cutting and realignment of the Survey road. Additional 34 nos of Box Bridge are proposed in the proposed alignment.

Reconstruction Cross Drains

Table 5-65: Proposed Reconstruction Cross Drains (1)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
1	21.170	21.175	Pipe	2 × 1.200	2.0×2.0× (Single Cell)
2	21.245	21.250	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
3	21.315	21.318	Pipe	1 × 1.200	2.0×3.0× (Single Cell)
4	21.549	21.554	Pipe	1 × 0.600	2.0×3.0× (Single Cell)
5	21.715	21.720	Pipe	1 × 1.200	2.0×3.0× (Single Cell)
6	24.861	24.290	Pipe	2 × 1.000	3.0 × 4.0× (Single Cell)
7	25.354	24.783	Pipe	2 × 0.900	2.0×2.0× (Single Cell)
8	26.451	25.835	Box	1 × 1.500	2.0×2.0× (Single Cell)
9	26.764	26.147	Pipe	2 × 1.000	2.0×3.0× (Single Cell)
10	27.195	26.569	Pipe	2 × 1.000	3.0 × 4.0× (Single Cell)
11	27.357	26.730	Pipe	2 × 0.750	2.0×3.0× (Single Cell)
12	27.663	26.976	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
13	27.818	27.132	Pipe	2 × 1.200	2.0×3.0× (Single Cell)
14	27.878	27.192	Pipe	1 × 0.900	2.0×3.0× (Single Cell)
15	27.965	27.279	Pipe	1 × 1.000	2.0×3.0× (Single Cell)
16	28.151	27.465	Pipe	1 × 1.500	2.0×2.0× (Single Cell)
17	28.232	27.546	Pipe	1 × 1.000	2.0×3.0× (Single Cell)
18	28.279	27.593	Pipe	1 × 1.500	2.0×2.0× (Single Cell)
19	28.347	27.658	Pipe	1 × 0.750	2.0×2.0× (Single Cell)
20	28.415	27.727	Pipe	1 × 0.750	2.0×2.0× (Single Cell)
21	28.466	27.779	Pipe	1 × .900	2.0×3.0× (Single Cell)
22	28.543	27.856	Pipe	1 × 0.600	2.0×3.0× (Single Cell)
23	28.620	27.932	Pipe	1 × 1.500	2.0×2.0× (Single Cell)
24	28.723	28.037	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
25	28.813	28.127	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
26	28.938	28.251	Pipe	1 × 0.750	2.0×2.0× (Single Cell)
27	28.998	28.311	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
28	29.056	28.368	Pipe	1 × 0.300	2.0×2.0× (Single Cell)

Source: JICA Survey Team based on DPR

Table 5-66: Proposed Reconstruction Cross Drains (2)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
29	29.155	28.468	Pipe	1 × 0.600	2.0×2.0× (Single Cell)
30	29.210	28.521	Pipe	1 × 0.900	2.0×3.0× (Single Cell)
31	29.284	28.597	Slab	1 × 5.000	4.0 × 4.0× (Single Cell)
32	29.372	28.685	Pipe	1 × 0.900	2.0×3.0× (Single Cell)
33	30.514	29.716	Pipe	1 × 1.000	2.0×3.0× (Single Cell)
34	30.794	29.997	Pipe	2 × 0.900	3.0 × 4.0× (Single Cell)
35	31.973	31.126	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
36	32.415	31.520	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
37	32.700	31.809	Pipe	1 × 1.200	2.0×3.0× (Single Cell)
38	33.013	32.067	Pipe	1 × 0.600	2.0×2.0× (Single Cell)
39	33.458	32.549	Slab	1 × 2.600	2.0×2.0× (Single Cell)
40	33.976	33.045	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
41	34.496	33.391	Pipe	2 × 0.900	2.0×3.0× (Single Cell)
42	35.195	34.053	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
43	34.432	34.430	slab	1× 0.900	2.0×2.0× (Single Cell)
44	36.000	34.694	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
45	36.482	35.080	Box	1 × 1.000	4.0 × 5.0× (Single Cell)
46	36.608	35.590	Pipe	2 × 0.900	2.0×3.0× (Single Cell)
47	37.346	35.948	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
48	38.235	36.775	Pipe		2.0×3.0× (Single Cell)
49	39.097	37.721	Pipe	1 × 1.000	3.0 × 4.0× (Single Cell)
50	39.254	37.870	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
51	39.532	38.139	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
52	39.950	38.553	Pipe	2 × 0.900	2.0×3.0× (Single Cell)
53	40.075	38.675	Pipe	1 × 1.000	2.0×3.0× (Single Cell)
54	-	-	-	-	-
55	40.435	39.030	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
56	40.495	39.086	Pipe	2 × 0.900	2.0×2.0× (Single Cell)
57	40.642	39.228	Pipe	2 × 1.000	2.0×2.0× (Single Cell)
58	40.703	39.297	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
59	40.788	39.381	Pipe	3 × 0.900	2.0×3.0× (Single Cell)
60	41.068	39.610	Pipe	2 × 1.000	2.0×2.0× (Single Cell)
61	41.401	39.895	Pipe	1 × 0.900	2.0×3.0× (Single Cell)
62	41.575	40.075	Pipe	2 × 0.900	2.0×3.0× (Single Cell)
63	41.704	40.203	Slab	1 × 1.200	2.0×3.0× (Single Cell)
64	42.711	41.158	Pipe	1 × 1.2	2.0×2.0× (Single Cell)
65	42.855	41.284	Pipe	1 × 0.9	2.0×2.0× (Single Cell)
66	48.104	46.200	Pipe	1 × 0.6 + 1 ×	4.0 × 5.0× (Single Cell)
67	48.985	47.055	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
68	49.498	47.494	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
69	50.198	48.150	Pipe	2 × 1.2 Not	2.0×3.0× (Single Cell)

Source: JICA Survey Team based on DPR

Table 5-67: Proposed Reconstruction Cross Drains (3)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
70	50.375	48.300	Pipe	Not visible	2.0×3.0× (Single Cell)
71	51.503	49.250	Pipe	2 × 0.9	4.0 × 5.0× (Single Cell)
72	51.960	49.700	Pipe	3 × 0.9	3.0 × 4.0× (Single Cell)
73	52.055	49.770	Pipe	1× 0.9 Not	4.0 × 5.0× (Single Cell)
74	52.480	50.167	Pipe	1× 0.9 Not	2.0×2.0× (Single Cell)
75	52.680	50.266	Pipe	1 × 0.9	2.0×2.0× (Single Cell)
76	52.980	50.657	Pipe	2 × 0.9	2.0×3.0× (Single Cell)
77	54.120	51.688	Pipe	3 × 0.600	4.0 × 5.0× (Single Cell)
78	56.780	53.984	Pipe	1 × 1.000	3.0 × 4.0× (Single Cell)
79	58.425	55.185	Pipe	1 × 0.6	2.0×2.0× (Single Cell)
80	58.474	55.232	Pipe	1 × 0.900	3.0 × 4.0× (Single Cell)
81	58.560	55.300	Slab	1 × 1.00	4.0 × 5.0× (Single Cell)
82	60.400	56.786	Pipe	1 × 0.9	3.0 × 4.0× (Single Cell)
83	61.770	58.148	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
84	61.935	58.300	Slab	2 × 1.000	2.0×2.0× (Single Cell)
85	62.200	58.566	Pipe	1 × 1.000	2.0×3.0× (Single Cell)
86	63.248	59.410	Box	1 × 1.000	2.0×2.0× (Single Cell)
87	64.846	60.423	Pipe	1 × 1.500	2.0×3.0× (Single Cell)
88	65.302	60.850	Pipe	2 × 0.900	4.0 × 5.0× (Single Cell)
89	65.527	61.056	Pipe	1 × 0.900	4.0 × 5.0× (Single Cell)
90	65.812	61.314	Pipe	2 × 1.000	3.0 × 4.0× (Single Cell)
91	65.932	61.403	Pipe	1 × 1.000	3.0 × 4.0× (Single Cell)
92	68.065	63.262	Pipe	1 × 1.000	3.0 × 4.0× (Single Cell)
93	68.406	63.595	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
94	68.710	63.867	Pipe	2 × 0.900	2.0×3.0× (Single Cell)
95	68.800	63.951	Pipe	1 × 0.600	2.0×2.0× (Single Cell)
96	68.873	64.064	Pipe	1 × 0.300	2.0×3.0× (Single Cell)
97	69.102	64.280	Pipe	1 × 0.900	2.0×3.0× (Single Cell)
98	69.210	64.380	Pipe	2 × 0.900	2.0×2.0× (Single Cell)
99	69.306	64.467	Slab	1 × 1.000	2.0×2.0× (Single Cell)
100	69.460	64.570	Slab	1 × 1.000	2.0×3.0× (Single Cell)
101	70.180	65.185	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
102	70.330	65.330	Pipe	1 × 1.000	2.0×2.0× (Single Cell)
103	70.687	65.665	Pipe	1 × 0.900	2.0×2.0× (Single Cell)
104	70.760	65.735	Pipe	1 × 0.600	2.0×2.0× (Single Cell)
105	70.923	65.900	Pipe	1 × 0.900	3.0 × 4.0× (Single Cell)
106	71.075	66.015	Pipe	1 × 1.200	2.0×2.0× (Single Cell)
107	71.382	66.303	Slab	1 × 1.000	2.0×2.0× (Single Cell)
108	71.546	66.456	Pipe	1 × 0.600	2.0×2.0× (Single Cell)

Source: JICA Survey Team based on DPR

Table 5-68: Proposed Reconstruction Cross Drains (4)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
109	71.620	66.533	Pipe	2 x 1.200	2.0X3.0X (Single Cell)
110	71.855	66.768	Pipe	1 x 0.300	2.0X2.0X (Single Cell)
111	71.948	66.863	Pipe	1 x 0.300	2.0X2.0X (Single Cell)
112	72.172	67.086	Pipe	1 x 0.900	2.0X2.0X (Single Cell)
113	72.247	67.160	Pipe	1 x 0.600	2.0X2.0X (Single Cell)
114	72.630	67.546	Pipe	1 x 1.200	2.0X2.0X (Single Cell)
115	72.930	67.842	Pipe	2 x 1.000	2.0X3.0X (Single Cell)
116	73.307	68.226	Pipe	1 x 0.900	2.0X3.0X (Single Cell)
117	75.115	69.692	Slab	1 x 1.500	2.0X2.0X (Single Cell)
118	76.031	70.608	Box	1 x 1.0	2.0X2.0X (Single Cell)
119	76.357	70.934	Slab	1 X 1.00	2.0X2.0X (Single Cell)
120	77.388	71.971	Pipe	1 X 0.600	2.0X2.0X (Single Cell)
121	77.411	71.993	Pipe	1 X 0.600	2.0X2.0X (Single Cell)
122	78.478	73.040	Slab	1 X 3.0	4.0X3.0X (Single Cell)
123	78.654	73.266	Pipe	1 X 0.900	3.0 X 4.0X (Single Cell)
124	78.821	73.397	Pipe	1 X 0.600	2.0X3.0X (Single Cell)
125	78.966	73.528	Pipe	1 X 1.200	2.0X2.0X (Single Cell)
126	84.469	78.910	Slab	1 X 1.00	2.0X2.0X (Single Cell)
127	84.807	79.242	Slab	1 X 1.00	2.0X2.0X (Single Cell)
128	84.996	79.396	Slab	1 X 1.00	2.0X2.0X (Single Cell)
129	89.031	83.025	Pipe	1 X 1.500	2.0X2.0X (Single Cell)
130	89.125	83.136	Slab	1 X 2.0	2.0X3.0X (Single Cell)
131	89.279	83.245	Slab	1 X 2.0	2.0X2.0X (Single Cell)
132	89.393	83.379	Pipe	1 X 0.900	2.0X3.0X (Single Cell)
133	91.671	85.344	Slab	1 X 1.00	2.0X2.0X (Single Cell)
134	92.016	85.620	Pipe	1 X 1.2	2.0X2.0X (Single Cell)
135	92.163	85.812	Pipe	1 X 0.900	2.0X3.0X (Single Cell)
136	94.500	87.950	Box	1 X 1.00	2.0X3.0X (Single Cell)
137	94.646	88.096	Pipe	1 X 0.300	2.0X2.0X (Single Cell)
138	95.225	88.678	Slab	1 X 2.5	4.0 X 4.0X (Single Cell)
139	96.328	89.712	Box	1 X 1.0	2.0X3.0X (Single Cell)
140	96.429	89.887	Box	1 X 1.0	2.0X2.0X (Single Cell)
141	96.512	90.040	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
142	96.673	90.180	Box	1 X 1.0	2.0X2.0X (Single Cell)
143	96.815	90.270	Box	1 X 1.0	2.0X2.0X (Single Cell)
144	96.920	90.330	Box	1 X 1.5	2.0X2.0X (Single Cell)
145	97.037	90.551	Box	1 X 2.5	2.0X2.0X (Single Cell)
146	97.363	90.968	Pipe	1 X.600	2.0X3.0X (Single Cell)
147	97.735	91.250	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
148	98.054	91.380	Pipe	1 X 0.6	2.0X2.0X (Single Cell)

Source: JICA Survey Team based on DPR

Table 5-69: Proposed Reconstruction Cross Drains (5)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
148	98.054	91.380	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
149	98.183	91.457	Box	1 X 0.9	2.0X2.0X (Single Cell)
150	98.261	91.669	Slab	1 X 1.5	2.0X2.0X (Single Cell)
151	98.453	91.797	Box	1 X 1.5	2.0X2.0X (Single Cell)
152	98.612	91.934	Pipe	1 X 1.2	2.0X3.0X (Single Cell)
153	98.750	91.990	Box	1 X 1.5	2.0X3.0X (Single Cell)
154	98.802	92.277	Pipe	1 X 1.0	3.0 X 4.0X (Single Cell)
155	99.095	92.475	Pipe	3 X 1.5	4.0X3.0X (Single Cell)
156	99.297	92.683	Box	1 X 2.0	2.0X3.0X (Single Cell)
157	99.505	92.780	Box	1 X 1.5	2.0X3.0X (Single Cell)
158	99.620	92.913	Pipe	1 X 1.2	2.0X2.0X (Single Cell)
159	99.735	93.145	Box	1 X 3.0	4.0 X 5.0X (Single Cell)
160	99.772	93.175	Slab	1 X 0.4	2.0X2.0X (Single Cell)
161	100.220	93.596	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
162	100.281	93.657	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
163	100.471	93.830	Pipe	1 X 0.6	2.0X3.0X (Single Cell)
164	100.512	93.870	Pipe	1 X 0.6	2.0X3.0X (Single Cell)
165	101.018	94.351	Pipe	1 X 0.9	2.0X2.0X (Single Cell)
166	101.223	94.558	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
167	101.569	94.890	Pipe	1 X 1.2	2.0X2.0X (Single Cell)
168	101.679	94.995	Pipe	1 X 0.6	2.0X2.0X (Single Cell)
169	102.820	95.924	Slab	1 X 1.5	2.0X2.0X (Single Cell)
170	103.703	96.816	Pipe	1 X 1.5	4.0 X 5.0X (Single Cell)
171	104.458	97.040	Pipe	1 X 0.9	3.0 X 4.0X (Single Cell)
172	104.800	97.315	Slab	1 X 1.5	4.0 X 5.0X (Single Cell)
173	104.800	98.168	Pipe	1 X 1.5	2.0X2.0X (Single Cell)
174	105.128	98.725	Pipe	1 X 1.5	2.0X2.0X (Single Cell)
175	111.878	102.121	Slab	1 X 1.5	2.0X3.0X (Single Cell)
176	112.875	103.100	Pipe	1 X 1.0	2.0X2.0X (Single Cell)
177	113.291	103.535	Slab	1 X 1.0	3.0 X 4.0X (Single Cell)
178	114.221	104.450	Slab	1 X 1.0	3.0 X 4.0X (Single Cell)
179	118.082	107.474	Pipe	1 X 0.9	2.0X3.0X (Single Cell)
180	118.329	107.718	Slab	1 X 0.8	2.0X3.0X (Single Cell)
181	119.975	109.365	Slab	1 X 1.0	2.0X3.0X (Single Cell)
182	120.482	109.875	Slab	1 X 0.8	2.0X2.0X (Single Cell)
183	120.973	110.362	Slab	1 X 1.0	2.0X2.0X (Single Cell)
184	124.037	113.135	Pipe	1 X 0.600	2.0X2.0X (Single Cell)
185	125.653	114.750	Slab	1 X 2.0	2.0X3.0X (Single Cell)
186	126.635	115.750	Pipe	1 X 1.200	4.0 X 5.0X (Single Cell)
187	128.075	116.931	Pipe	1 X 1.5	2.0X3.0X (Single Cell)
188	129.083	117.805	Pipe	1 X 0.600	2.0X3.0X (Single Cell)

Source: JICA Survey Team based on DPR

Table 5-70: Proposed Reconstruction Cross Drains (6)

Sl No.	Survey Chainage (km)	Design Chainage (km)	Type of Existing Structure	Span of Existing Structure (M)	Proposed Box Size (m x m)
187	128.075	116.931	Pipe	1 X 1.5	2.0X3.0X (Single Cell)
188	129.083	117.805	Pipe	1 X 0.600	2.0X3.0X (Single Cell)
189	129.336	118.080	Slab	1 X 1.000	4.0 X 5.0X (Single Cell)
190	129.589	118.290	Pipe	1 X 0.900	4.0 X 5.0X (Single Cell)
191	129.663	118.350	Pipe	1 X 0.600	4.0 X 5.0X (Single Cell)
192	129.840	118.578	Pipe	4 X 1.200	4.0 X 5.0X (Single Cell)
193	130.710	119.184	Slab	1 X 0.800	2.0X2.0X (Single Cell)
194	131.599	119.990	Slab	1 X 1.000	3.0 X 4.0X (Single Cell)
195	131.733	120.112	Pipe	1 X 1.000	2.0X2.0X (Single Cell)
196	132.207	120.454	Pipe	1 X 1.000	2.0X3.0X (Single Cell)
197	132.377	120.622	Pipe	1 X 1.000	2.0X2.0X (Single Cell)
198	133.292	121.510	Slab	1 X 0.800	2.0X3.0X (Single Cell)
199	133.541	121.759	Slab	1 X 1.8	2.0X2.0X (Single Cell)
200	134.008	122.227	Pipe	1 X 1.0	2.0X2.0X (Single Cell)
201	134.227	122.440	Pipe	2 X 0.6	2.0X2.0X (Single Cell)
202	134.872	123.082	Slab	1 X 1.2	3.0 X 4.0X (Single Cell)
203	135.312	123.518	Slab	1 X 1.0	2.0X2.0X (Single Cell)
204	136.413	124.611	Pipe	1 X 1.2	3.0 X 4.0X (Single Cell
205	136.621	124.820	Pipe	2 X 0.600	2.0X3.0X (Single Cell)
206	138.590	126.719	Slab	1 X 0.8	2.0X2.0X (Single Cell)
207	139.010	127.135	Slab	1 X 1.5	3.0 X 4.0X (Single Cell)

Source: JICA Survey Team based on DPR

New Construction Cross Drains

Table 5-71: Proposed New Construction Cross Drains (1)

No	Design Chainage (km)	Proposed Box Size (m x m)
1	0+280	1×2×3
2	0+560	1×2×3
3	0+770	1×2×2
4	0+980	1×3×4
5	1+010	1×4×5
6	1+260	1×2×3
7	1+600	1×2×2
8	1+900	1×3×4
9	2+400	1×2×2
10	2+700	1×2×2
11	2+950	1×2×2

Source: JICA Survey Team based on DPR

Table 5-72: Proposed New Construction Cross Drains (2)

No	Design Chainage (km)	Proposed Box Size (m x m)
12	3+250	1×2×2
13	3+500	1×2×2
14	3+750	1×2×2
15	3+970	1×2×2
16	4+200	1×2×2
17	4+450	1×2×2
18	4+700	1×4×5
19	4+950	1×4×5
20	5+150	1×2×2
21	5+350	1×2×2
22	5+600	1×2×2
23	5+800	1×2×2
24	6+100	1×2×2
25	6+400	1×2×2
26	6+650	1×2×2
27	6+900	1×2×2
28	7+150	1×4×5
29	7+600	1×2×2
30	7+800	1×2×2
31	8+030	1×2×2
32	8+280	1×4×5
33	8+800	1×2×2
34	8+900	1×4×5
35	9+200	1×2×2
36	9+450	1×2×2
37	9+700	1×4×5
38	9+950	1×2×2
39	10+200	1×2×2
40	10+580	1×2×2
41	10+780	1×2×2
42	10+900	1×2×2
43	11+200	1×2×2
44	11+520	1×4×5
45	11+650	1×4×5
46	11+900	1×2×2
47	12+200	1×2×2
48	12+750	1×2×2
49	12+980	1×4×5
50	13+250	1×2×2
51	13+500	1×2×2

Source: JICA Survey Team based on DPR

Table 5-73: Proposed New Construction Cross Drains (3)

No	Design Chainage (km)	Proposed Box Size (m x m)
52	13+750	1×2×2
53	13+950	1×2×2
54	14+200	1×2×2
55	14+450	1×2×2
56	14+650	1×2×2
57	15+040	1×4×5
58	15+500	1×2×2
59	15+800	1×2×2
60	16+080	1×2×2
61	16+300	1×2×2
62	16+850	1×2×2
63	17+150	1×2×2
64	17+700	1×4×5
65	17+950	1×2×2
66	18+550	1×2×2
67	18+750	1×2×2
68	18+980	1×2×2
69	19+500	1×2×3
70	19+750	1×2×2
71	19+950	1×2×2
72	20+150	1×2×2
73	20+400	1×2×2
74	20+600	1×2×2
75	21+100	1×2×2
76	21+400	1×2×2
77	21+650	1×2×2
78	21+900	1×2×2
79	22+050	1×2×2
80	22+500	1×2×2
81	23+100	1×3×4
82	23+900	1×2×2
83	25+200	1×2×2
84	25+700	1×2×2
85	25+950	1×2×2
86	26+200	1×2×2
87	26+500	1×2×2
88	26+750	1×2×2
89	26+950	1×2×2
90	27+100	1×2×2
91	27+350	1×2×2

Source: JICA Survey Team based on DPR

Table 5-74: Proposed New Construction Cross Drains (4)

No	Design Chainage (km)	Proposed Box Size (m x m)
92	27+650	1×2×3
93	27+950	1×2×2
94	28+250	1×2×3
95	28+500	1×2×2
96	28+750	1×2×2
97	28+930	1×4×5
98	29+080	1×2×2
99	29+370	1×2×3
100	29+700	1×4×5
101	29+950	1×2×2
102	30+150	1×2×2
103	30+650	1×3×4
104	30+950	1×3×4
105	31+200	1×2×2
106	31+500	1×2×2
107	31+950	1×2×2
108	32+450	1×4×5
109	33+350	1×3×4
110	33+650	1×4×5
111	34+050	1×4×5
112	34+350	1×3×4
113	34+650	1×2×2
114	34+900	1×2×2
115	35+150	1×2×2
116	35+400	1×2×2
117	35+900	1×4×5
118	36+100	1×4×5
119	36+350	1×3×4
120	36+800	1×4×5
121	36+850	1×4×5
122	37+050	1×4×5
123	37+300	1×4×5
124	37+560	1×3×4
125	37+780	1×3×4
126	38+050	1×2×2
127	38+350	1×2×2
128	38+600	1×2×2
129	38+850	1×2×2
130	39+250	1×2×2

Source: JICA Survey Team based on DPR

Table 5-75: Proposed New Construction Cross Drains (5)

No	Design Chainage (km)	Proposed Box Size (m x m)
131	39+500	1×2×2
132	39+720	1×4×5
133	40+100	1×4×5
134	40+450	1×2×2
135	40+950	1×2×2
136	41+200	1×2×2
137	41+450	1×4×5
138	41+700	1×3×4
139	41+950	1×4×5
140	42+200	1×2×2
141	42+500	1×4×5
142	42+950	1×2×2
143	43+950	1×2×2
144	44+260	1×2×2
145	44+500	1×2×2
146	44+750	1×2×2
147	44+950	1×2×2
148	45+500	1×2×2
149	45+750	1×2×2
150	45+950	1×4×5
151	46+100	1×2×2
152	46+350	1×4×5
153	46+600	1×2×2
154	46+900	1×2×2
155	47+050	1×2×2
156	47+300	1×3×4
157	47+550	1×2×2
158	47+850	1×2×2
159	48+050	1×2×2
160	48+350	1×2×2
161	48+900	1×2×2
162	49+120	1×3×4
163	49+450	1×2×2
164	49+650	1×2×2
165	49+820	1×3×4
166	50+100	1×2×2
167	50+400	1×2×2
168	51+260	1×4×5
169	51+550	1×2×3

Source: JICA Survey Team based on DPR

Table 5-76: Proposed New Construction Cross Drains (6)

No	Design Chainage (km)	Proposed Box Size (m x m)
170	51+850	1×2×3
171	52+200	1×4×5
172	52+650	1×4×5
173	52+900	1×4×5
174	53+200	1×2×2
175	53+550	1×2×2
176	53+750	1×2×2
177	53+950	1×2×2
178	54+200	1×2×3
179	54+450	1×2×2
180	54+700	1×3×4
181	54+950	1×4×5
182	55+150	1×2×2
183	55+450	1×4×5
184	55+700	1×2×2
185	55+950	1×2×2
186	56+200	1×2×2
187	56+450	1×2×2
188	56+730	1×4×5
189	56+830	1×4×5
190	57+050	1×2×2
191	57+300	1×2×3
192	57+550	1×2×2
193	57+800	1×2×2
194	58+040	1×2×3
195	58+550	1×2×2
196	58+810	1×2×2
197	59+900	1×2×2
198	60+100	1×2×2
199	60+430	1×2×3
200	60+700	1×2×2
201	60+950	1×2×3
202	61+180	1×2×2
203	61+430	1×3×4
204	61+900	1×2×2
205	62+100	1×3×4
206	62+350	1×2×2
207	62+680	1×3×4
208	63+350	1×2×3

Source: JICA Survey Team based on DPR

Table 5-77: Proposed New Construction Cross Drains (7)

No	Design Chainage (km)	Proposed Box Size (m x m)
209	63+600	1×4×5
210	63+900	1×2×2
211	64+450	1×2×2
212	64+700	1×2×2
213	64+950	1×2×2
214	65+150	1×2×2
215	65+420	1×4×5
216	65+700	1×2×2
217	65+950	1×2×2
218	66+150	1×2×2
219	66+700	1×2×2
220	66+950	1×2×2
221	67+200	1×4×5
222	67+450	1×2×2
223	67+830	1×3×4
224	68+050	1×2×2
225	68+280	1×2×2
226	68+650	1×2×3
227	69+250	1×4×5
228	69+510	1×4×5
229	69+720	1×2×2
230	70+200	1×2×2
231	70+450	1×3×4
232	70+700	1×2×2
233	70+950	1×2×3
234	71+200	1×2×3
235	71+450	1×4×5
236	71+600	1×4×5
237	71+700	1×3×4
238	72+050	1×2×2
239	72+350	1×2×2
240	72+900	1×2×2
241	73+200	1×3×4
242	73+440	1×2×2
243	73+700	1×2×2
244	73+950	1×2×2
245	74+200	1×2×2
246	74+500	1×2×2
247	74+900	1×2×2

Source: JICA Survey Team based on DPR

Table 5-78: Proposed New Construction Cross Drains (8)

No	Design Chainage (km)	Proposed Box Size (m x m)
248	75+250	1×2×3
249	75+590	1×2×3
250	75+900	1×3×4
251	76+350	1×2×2
252	76+600	1×3×4
253	76+800	1×2×3
254	77+050	1×2×3
255	77+300	1×2×2
256	77+550	1×2×2
257	77+800	1×2×2
258	78+020	1×2×3
259	78+350	1×2×2
260	78+650	1×2×2
261	78+770	1×2×2
262	79+050	1×2×2
263	79+650	1×2×3
264	79+900	1×2×2
265	80+150	1×2×2
266	80+650	1×2×2
267	80+900	1×3×4
268	81+150	1×2×2
269	81+300	1×2×3
270	81+550	1×2×2
271	81+800	1×2×2
272	83+100	1×2×2
273	83+350	1×2×2
274	83+600	1×2×2
275	83+850	1×2×2
276	84+100	1×4×5
277	85+600	1×2×2
278	85+950	1×2×2
279	86+400	1×2×2
280	86+700	1×2×2
281	86+950	1×4×5
282	87+200	1×4×5
283	87+600	1×3×4
284	88+410	1×2×3
285	88+900	1×2×2
286	89+250	1×2×2

Source: JICA Survey Team based on DPR

Table 5-79: Proposed New Construction Cross Drains (9)

No	Design Chainage (km)	Proposed Box Size (m x m)
287	89+600	1×2×2
288	89+900	1×2×2
289	90+300	1×2×2
290	90+700	1×2×2
291	91+000	1×2×2
292	91+250	1×2×2
293	91+550	1×2×2
294	91+800	1×2×2
295	92+250	1×2×2
296	92+500	1×2×2
297	92+800	1×4×5
298	93+000	1×2×2
299	93+500	1×2×2
300	93+800	1×2×2
301	94+000	1×2×2
302	94+250	1×4×5
303	94+600	1×2×3
304	94+900	1×2×2
305	95+200	1×2×2
306	95+550	1×2×2
307	95+750	1×2×2
308	95+950	1×2×2
309	96+250	1×4×5
310	97+000	1×2×2
311	97+250	1×2×2
312	97+940	1×2×2
313	98+040	1×2×3
314	98+200	1×2×2
315	98+450	1×2×2
316	98+650	1×3×4
317	99+000	1×2×2
318	99+300	1×2×2
319	99+650	1×2×2
320	99+950	1×2×2
321	100+200	1×4×5
322	100;450	1×4×5
323	100+700	1×2×2
324	100+950	1×4×5
325	101+200	1×2×2

Source: JICA Survey Team based on DPR

Table 5-80: Proposed New Construction Cross Drains (10)

No	Design Chainage (km)	Proposed Box Size (m x m)
326	101+500	1×3×4
327	101+700	1×4×5
328	101+950	1×2×2
329	102+200	1×2×2
330	102+450	1×2×2
331	102+880	1×2×2
332	103+200	1×2×2
333	103+450	1×2×2
334	103+700	1×2×2
335	103+980	1×2×2
336	104+250	1×2×3
337	104+750	1×2×2
338	104+950	1×4×5
339	105+200	1×2×2
340	105+450	1×2×2
341	105+700	1×2×2
342	105+900	1×3×4

Source: JICA Survey Team based on DPR

(2) Drainage Work

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

Since the DPR has not been completed, the JICA Survey Team will carry out a recheck in the future and propose an optimal road drainage system.

The road drainage used on this line is shown below.

- Footpath cum cover drain of 2.0m width has been proposed in built up area.
- Cover drain of 1.0m width has been proposed in ROB approaches for service road
- Brick Masonry drain has been proposed on hill side
- Catch water drain has been proposed on hill side for proper drainage purpose.

Details are given bellow.

Table 5-81: Drainage Work

No	Type of drainage	Length(m)
1	2.0m width RCC Cover drain	12,800
2	1.0m Width RCC Cover Drain for Service Road	2,500
3	Brick Masonry Drain	41,133
4	Catch Water Drain	21,525

Source: JICA Survey Team based on DPR

Table 5-82: Details of RCC Cover Drain

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
1	21,100	21,650	Both	1,100
2	27,550	28,790	Both	2,480
3	42,175	42,425	Both	500
4	66,150	66,400	Both	500
5	71,000	73,670	Both	5,340
6	87,975	88,200	Both	450
7	92,760	93,000	Both	480
8	93,300	93,425	Both	250
9	94,080	94,930	Both	1,700
Total				12,800

Source: JICA Survey Team based on DPR

Table 5-83: Details of 1.0m Width RCC Cover Drain for Service Road

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
1	123,700	124,950	Both	2,500
			Total	2,500

Source: JICA Survey Team based on DPR

Table 5-84: Details of Brick Masonry Drains (1)

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
1	34,450	34,650	Both	400
2	34,750	34,850	Right	100
3	34,950	35,000	Both	100
4	35,000	35,075	Right	75
5	35,075	35,325	Both	500
6	35,900	35,975	Left	75
7	-	-	-	-
8	37,750	38,000	Right	250
9	38,250	38,400	Both	300
10	38,725	38,825	Left	100
11	38,825	38,925	Right	100
12	39,675	39,950	Right	275
13	40,325	40,425	Right	100
14	41,175	41,225	Left	50
15	42,425	42,475	Right	50
16	42,675	42,825	Both	300
17	43,025	43,150	Both	250
18	43,325	43,450	Both	250
19	43,450	43,575	Left	125
20	43,625	43,875	Left	250

Source: JICA Survey Team based on DPR

Table 5-85: Details of Brick Masonry Drains (2)

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
21	43,975	44,000	Both	50
22	44,425	44,475	Right	50
23	45,325	45,500	Both	350
24	45,575	45,800	Both	450
25	46,600	46,875	Both	550
26	46,875	47,000	Left	125
27	47,000	47,200	Both	400
28	47,250	47,450	Right	200
29	47,450	47,550	Both	200
30	47,550	47,650	Right	100
31	47,650	47,700	Left	50
32	47,750	47,800	Left	50
33	47,900	47,950	Right	50
34	47,950	48,100	Both	300
35	48,150	48,350	Left	200
36	48,400	48,450	Both	100
37	48,450	48,550	Right	100
38	48,650	48,700	Both	100
39	49,050	49,200	Both	300
40	49,250	49,650	Both	800
41	49,700	49,800	Both	200
42	49,900	50,700	Both	1600
43	50,750	50,850	Right	100
44	50,850	50,900	Left	50
45	50,900	50,950	Both	100
46	50,950	51,000	Right	50
47	51,000	51,600	Both	1200
48	51,700	51,750	Right	50
49	51,750	51,900	Both	300
50	51,900	51,950	Right	50
51	52,150	52,350	Right	200
52	52,350	52,450	Both	200
53	52,450	52,500	Left	50
54	52,500	52,600	Left	100
55	52,600	52,650	Right	50
56	52,700	53,150	Left	450
57	53,150	53,250	Right	100
58	53,250	53,300	Both	100
59	53,300	53,350	Right	50
60	53,350	53,450	Both	200
61	53,450	53,600	Left	150
62	53,600	53,900	Both	600

Source: JICA Survey Team based on DPR

Table 5-86: Details of Brick Masonry Drains (3)

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
63	53,900	53,950	Right	50
64	55,550	55,800	Right	250
65	55,900	56,300	Both	800
66	56,300	56,350	Right	50
67	56,350	56,650	Both	600
68	56,650	56,700	Right	50
69	56,700	57,550	Both	1700
70	57,550	57,950	Left	400
71	57,950	58,000	Right	50
72	58,000	58,250	Both	500
73	58,300	58,750	Both	900
74	59,350	59,550	Left	200
75	59,600	59,650	Both	100
76	59,650	59,850	Left	200
77	60,000	60,100	Left	100
78	60,300	60,350	Left	50
79	60,350	60,450	Both	200
80	60,500	60,550	Left	50
81	60,550	60,650	Right	100
82	60,650	60,750	Both	200
83	61,000	61,250	Left	250
84	61,250	61,300	Left	50
85	61,300	61,350	Both	100
86	61,350	61,450	Left	100
87	61,450	61,550	Both	200
88	61,700	61,800	Both	200
89	61,800	61,850	Left	50
90	62,150	62,950	Both	1600
91	62,950	63,050	Left	100
92	63,050	63,450	Left	400
93	63,450	63,700	Both	500
94	75,890	76,060	Both	340
95	76,060	76,190	Both	260
96	76,460	76,625	Both	330
97	76,775	77,075	Both	600
98	77,125	77,260	Both	270
99	77,370	77,410	Right	40
100	77,410	77,480	Both	140
101	77,480	77,515	Left	35

Source: JICA Survey Team based on DPR

Table 5-87: Details of Brick Masonry Drains (4)

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
102	77,515	77,585	Right	70
103	77,690	77,732	Right	42
104	77,732	77,760	Both	56
105	77,760	77,815	Left	55
106	77,910	77,960	Left	50
107	77,960	78,010	Both	100
108	78,010	78,110	Left	100
109	78,110	78,210	Both	200
110	78,210	78,260	Left	50
111	78,260	78,410	Both	300
112	78,575	78,710	Both	270
113	78,710	78,860	Right	150
114	78,860	78,910	Left	50
115	78,910	78,960	Right	50
116	78,960	79,010	Right	50
117	79,010	79,060	Right	50
118	79,060	79,210	Both	300
119	79,210	79,260	Both	100
120	79,310	79,410	Both	200
121	79,610	79,790	Both	360
122	79,790	79,860	Right	70
123	79,860	80,110	Right	250
124	80,110	80,410	Both	600
125	80,560	80,610	Left	50
126	81,010	81,210	Both	400
127	81,210	81,260	Right	50
128	81,260	81,510	Both	500
129	81,510	81,560	Right	50
130	81,560	81,610	Left	50
131	81,610	81,690	Both	160
132	8,1690	81,740	Left	50
133	81,740	81,960	Both	440
134	82,010	82,110	Right	100
135	82,110	82,440	Both	660
136	82,460	82,580	Both	240
137	82,910	82,960	Both	100
138	83,110	83,160	Both	100
139	83,160	83,210	Right	50
140	83,210	83,260	Left	50
141	83,260	83,360	Right	100
142	83,360	83,570	Left	210
143	83,610	83,660	Left	50

Source: JICA Survey Team based on DPR

Table 5-88: Details of Brick Masonry Drains (5)

Sl No	Design Chainage(m)		Side	Length (m)
	From (m)	To (m)		
144	83,660	83,710	Both	100
145	84,050	84,160	Both	220
146	84,635	84,730	Both	190
147	84,910	85,060	Both	300
148	85,140	85,235	Both	190
149	85,235	85,285	Left	50
150	85,390	85,495	Both	210
151	85,495	85,660	Right	165
152	85,710	86,035	Both	650
153	86,360	86,655	Both	590
154	86,760	86,885	Both	250
155	87,260	87,565	Both	610
156	87,610	87,710	Both	200
157	88,335	88,410	Right	75
158	88,410	88,460	Both	100
159	88,715	88,915	Both	400
160	89,275	89,660	Both	770
161	89,760	89,815	Both	110
162	89,815	90,010	Right	195
163	90,335	90,435	Left	100
164	90,610	90,685	Both	150
165	90,685	90,760	Right	75
166	90,760	90,830	Both	140
167	90,830	90,935	Right	105
168	91,060	91,170	Both	220
169	91,935	92,060	Right	125
170	93,175	93,300	Both	250
171	93,425	93,580	Both	310
172	93,580	93,680	Left	100
173	93,680	93,860	Both	360
174	93,980	94,080	Right	100
175	94,930	94,980	Both	100
Total=				41133

Source: JICA Survey Team based on DPR

5.3.7 Road Appurtenances Plan

Road Appurtenances include a wide range of facilities, such as traffic signs, kilometer stones and bus bay to maintain the road efficiency and safety.

Currently, traffic signs are missing at many locations on the Survey stretch. No warning signs are installed before the approach of a junction and approach of curves. Directional signs are installed at a few locations. In order to improve the safety conditions, the road appurtenances conformed with the following guidelines are recommended.

Table 5-89: 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 35-2015 (IRC 35-1997)	Code of Practice for Road Markings
IRC 56-2011	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control
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 80-1981	Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways
IRC 93-1985	Guidelines on Design and Installation of Road Traffic Signals
IRC 103-2012 (IRC 103-1988)	Guidelines for Pedestrian Facilities
IRC 119-2015	Guidelines for Traffic Safety Barriers

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 the 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. They 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 adequate 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 environment along the 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 the 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.

5.3.8 Preliminary Study of Bypass Routes

The Project route consists of sparsely built-up and open portions. IRCSP73-2018, Clause 2.1, iii) states "Where there is constraint of existing ROW width or difficulty in acquiring land along the existing alignment in built up areas, the Authority may decide for construction of a bypass. The alignment of the bypass shall be given in Schedule 'B' and placed eccentrically with respect of the ROW to facilitate proper widening to four lanes in future."

In view of minimizing social impacts and land acquisition, seven 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 impact on existing built-up structures, deviation from settlement areas, and the most economical project cost among the others.

Table 5-90: Bypass Locations and Length

No	Bypass Location	Length (m)	Name of Bypass
1	0+000 – 1+300	1,300	Teliamura
2	11+300 – 12+830	1,530	Twidu
3	17+075 – 19+840	2,765	Ompi Nagar
4	35+240 – 42+760	7,520	Amarpur
5	51+640 – 53+200	1,560	Nutan Bazar
6	53+200 – 56+900	3,700	Jatambari
7	63+100 – 66+450	3,350	Karbook
	Total	21,725	

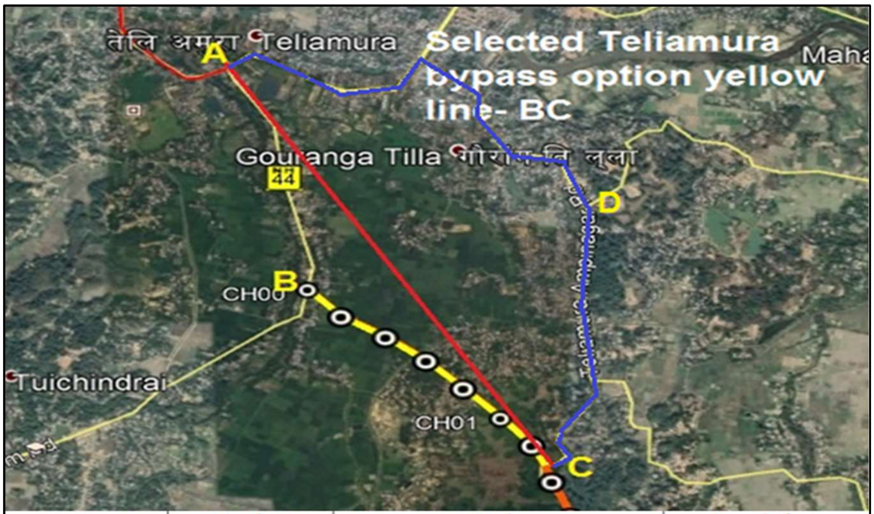
Source: JICA Survey Team base on DPR

(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 with maximum avoidance of involuntary resettlement. Try to acquire Govt. land as much as possible and minimum acquisition of existing structures has been used for fixation of proposed alignment.
- Social Impact & Severance:
  The proposed alignment has minimized effect upon the existing structures which minimizes the resettlement and rehabilitation 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.
- Environment:
  The proposed alignment requires the least lost forest land and expected pollution.

(2) Alternative Alignment Option Study for Teliamura Bypass



Options	Symbol	Node	Length (km)
Option 1	(blue line)	A-D-C	3.4
Option 2	(red line)	A-C	2.45
Option 3	(yellow line)	B-C	1.3

Source: JICA Survey Team base on DPR

Figure 5-47: Alignment Options for Teliamura Bypass

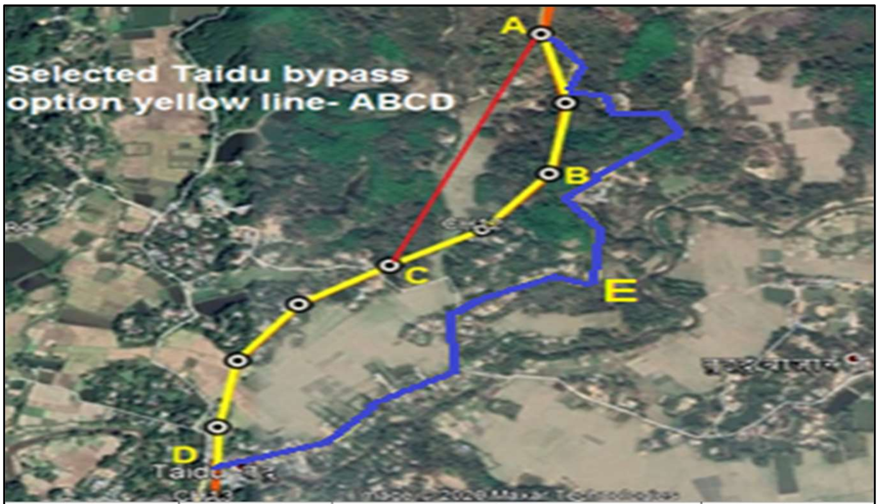
Alignment Option 3 is the best because a) the shortest length and the least area of land acquisition, b) utilizing the widened section of road from A to B, c) the least number of trees to be cut, and d) the least number of affected structures, and e) the least number of affected families.

Table 5-91: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	3.4 km	2.45 km	1.3 km
3	Land Acquisition	9.1 ha	9.5 ha	4.9 ha
4	Description of alignment	Existing alignment	Directly connecting A to C	Utilizing the widened section, A to B
5	Environment-Lost Forest land	No forest lands App. 210 trees	No forest lands App. 97 trees	No forest lands App. 54 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 197 structures	App. 70 structures	App. 37 structures
8	Affected Family	App. 118 families	App. 42 families	App. 22 families
9	Structures and Protective Works	12 box culverts	3 box culverts	4 box culverts

Source: JICA Survey Team base on DPR

(3) Alternative Alignment Option Study for Twidu Bypass



Options	Symbol	Node	Length (km)
Option 1	(blue line)	A-E-D	2.0
Option 2	(red line)	A-C-D	1.4
Option 3	(yellow line)	A-B-C-D	1.54

Source: JICA Survey Team base on DPR

Figure 5-48: Alignment Options for Twidu Bypass

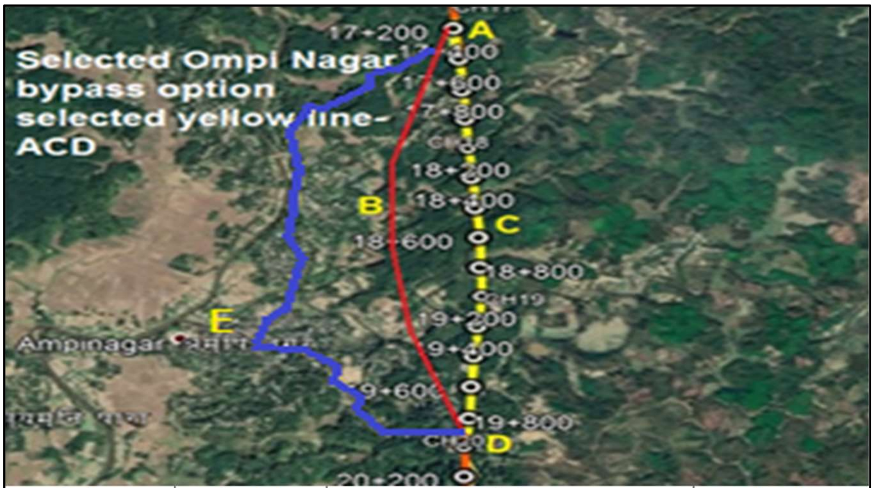
Alignment Option 3 is the best because a) the least area of forest lands and number of trees to be cut, b) the least number of affected structures, c) the least number of affected families, and e) the least number of required box culverts.

Table 5-92: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	2.0 km	1.4 km	1.54 km
3	Land Acquisition	7.2 ha	6.3 ha	6.9 ha
4	Description of alignment	Existing alignment	Directly connecting A to C and D	Connecting A, B, C, and D
5	Environment-Lost Forest land	4.2 ha forest lands App. 212 trees	3.5 ha forest lands App. 146 trees	2.6 ha forest lands App. 120 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 62 structures	App. 26 structures	App. 20 structures
8	Affected Family	App. 47 families	App. 18 families	App. 12 families
9	Structures and Protective Works	9 box culverts	6 box culverts	5 box culverts

Source: JICA Survey Team base on DPR

(4) Alternative Alignment Option Study for Ompi Nagar Bypass



Options	Symbol	Node	Length
Option 1	(blue line)	A-E-D	3.9
Option 2	(red line)	A-B-D	2.8
Option 3	(yellow line)	A-C-D	2.75

Source: JICA Survey Team base on DPR

Figure 5-49: Alignment Options for Ompi Nagar Bypass

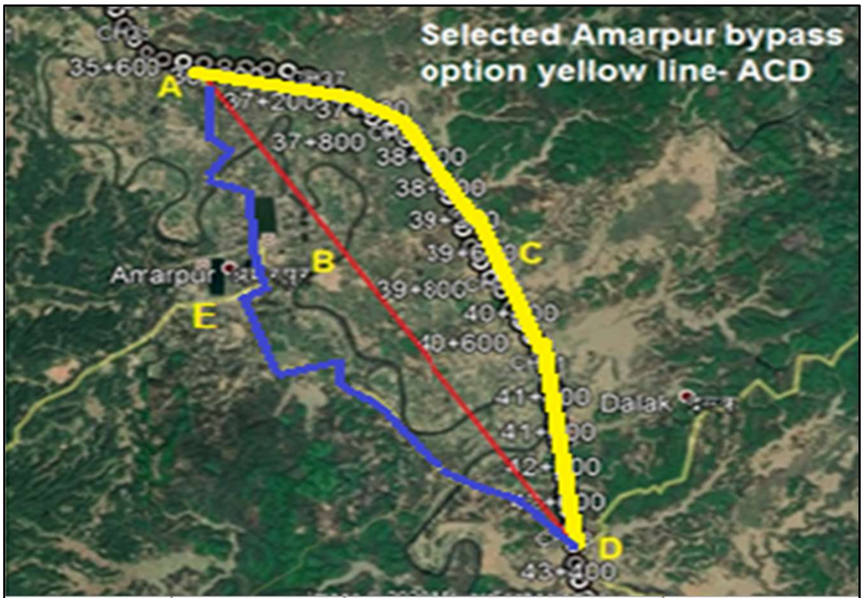
Alignment Option 3 is the best because a) the shortest length and the least area of land acquisition, b) the least area of forest lands and the least number of trees to be cut, c) the least number of affected structures, d) the least number of affected families, and e) the least number of required bridges and box culverts.

Table 5-93: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	3.9 km	2.8 km	2.75 km
3	Land Acquisition	13.6 ha	12.6 ha	12.4 ha
4	Description of alignment	Existing alignment	Connecting A, B, and D	Connecting A, C, and D
5	Environment-Lost Forest land	7.2 ha forest lands App. 873 trees	6.9 ha forest lands App. 690 trees	6.33 ha forest lands App. 540 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 132 structures	App. 74 structures	App. 38 structures
8	Affected Family	App. 85 families	App. 37 families	App. 14 families
9	Structures and Protective Works	4 major bridges 10 box culverts	5 major bridges 8 box culverts	3 major bridges 7 box culverts

Source: JICA Survey Team base on DPR

(5) Alternative Alignment Option Study for Amarpur Bypass



Options	Symbol	Node	Length (km)
Option 1	(blue line)	A-E-D	8.2
Option 2	(red line)	A-B-D	6.7
Option 3	(yellow line)	A-C-D	7.5

Source: JICA Survey Team base on DPR

Figure 5-50: Alignment Options for Amarpur Bypass

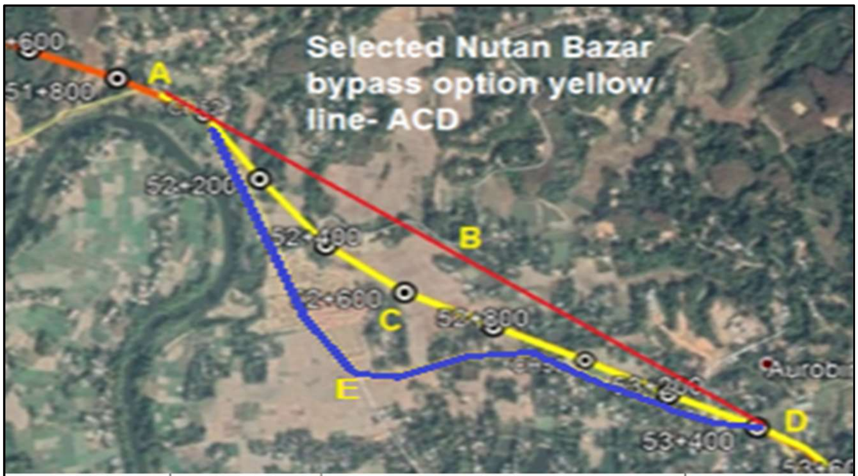
Alignment Option 3 is the best because a) the least number of trees to be cut, b) the least number of affected structures, and c) the least number of affected families.

Table 5-94: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	8.2 km	6.7 km	7.5 km
3	Land Acquisition	28.7 ha	30.2 ha	33.8 ha
4	Description of alignment	Existing alignment	Connecting A , B, D	Connecting A, C, and D
5	Environment-Lost Forest land	No forest lands App. 2162 trees	No forest lands App. 1235 trees	No forest lands App. 810 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 247 structures	App. 210 structures	App. 114 structures
8	Affected Family	App. 148 families	App. 122 families	App. 67 families
9	Structures and Protective Works	20 box culverts	3 minor bridges 8 major bridges 20 box culverts	1 minor bridge 5 major bridges 23 box culverts

Source: JICA Survey Team base on DPR

(6) Alternative Alignment Option Study for Nutan Bazar Bypass



Options	Symbol	Node	Length (km)
Option 1		A-E-D	1.7
Option 2		A-B-D	1.3
Option 3		A-C-D	1.6

Source: JICA Survey Team base on DPR

Figure 5-51: Alignment Options for Nutan Bazar Bypass

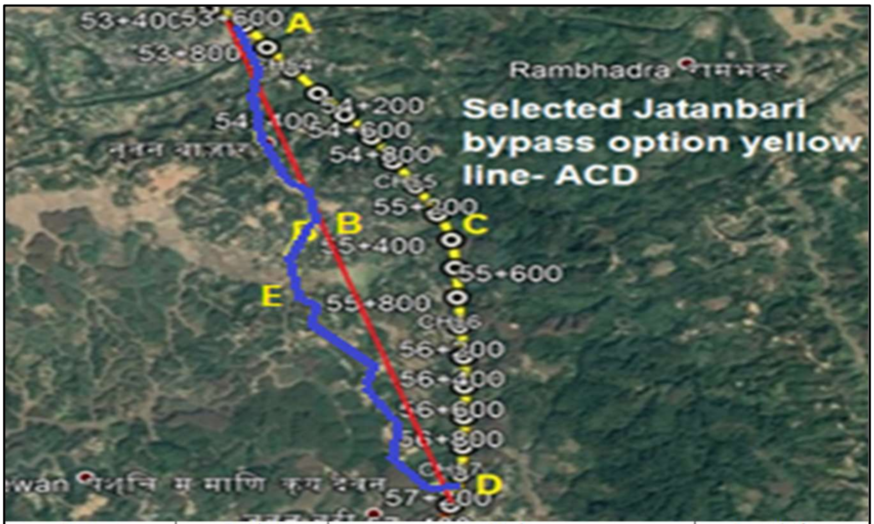
Alignment Option 3 is the best because a) the least number of trees to be cut, b) the least number of affected structures, and c) the least number of affected families.

Table 5-95: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	1.7 km	1.3 km	1.6 km
3	Land Acquisition	2.9 ha	4.1 ha	5.0 ha
4	Description of alignment	Existing alignment	Connecting A, B, D	Connecting A, C, and D
5	Environment-Lost Forest land	No forest lands App. 190 trees	No forest lands App. 154 trees	No forest lands App. 98 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 48 structures	App. 42 structures	App. 30 structures
8	Affected Family	App. 28 families	App. 24 families	App. 15 families
9	Structures and Protective Works	7 box culverts	1 minor bridge 4 box culverts	1 major bridge 5 box culverts

Source: JICA Survey Team base on DPR

(7) Alternative Alignment Option Study for Jatanbari Bypass



Options	Symbol	Node	Length (km)
Option 1	blue line	A-E-D	4.0
Option 2	red line	A-B-D	3.4
Option 3	yellow line	A-C-D	3.7

Source: JICA Survey Team base on DPR

Figure 5-52: Alignment Options for Jatanbari Bypass

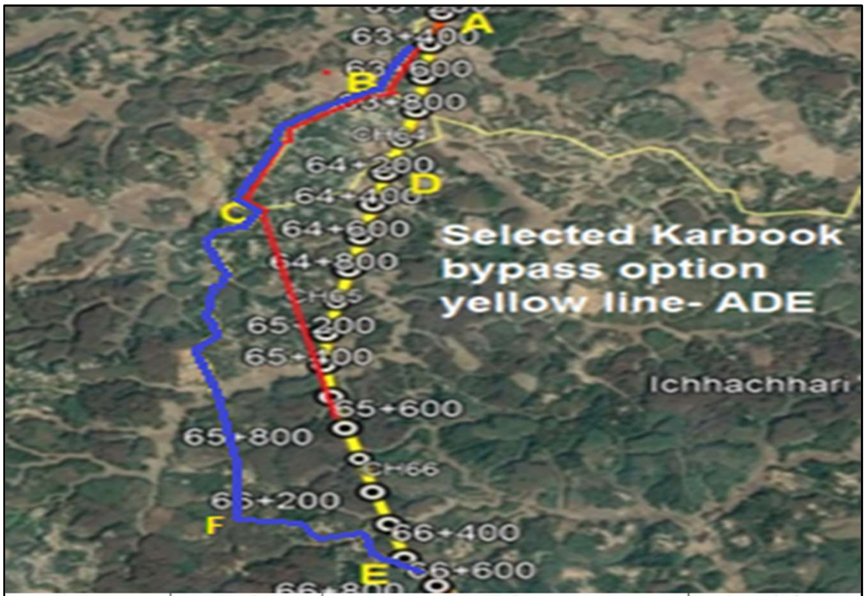
Alignment Option 3 is the best because a) the least number of trees to be cut, b) the least number of affected structures, and c) the least number of affected families.

Table 5-96: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	4.0 km	3.4 km	3.7 km
3	Land Acquisition	14.0 ha	15.3 ha	16.7 ha
4	Description of alignment	Existing alignment	Connecting A, B, D	Connecting A, C, D
5	Environment-Lost Forest land	1.2 ha forest lands App. 1275 trees	1.82 ha forest lands App. 1120 trees	1.67 ha forest lands App. 980 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 134 structures	App. 115 structures	App. 72 structures
8	Affected Family	App. 80 families	App. 68 families	App. 35 families
8	Structures and Protective Works	8 box culverts	1 minor bridge 2 major bridges 14 box culverts	2 major bridges 11 box culverts

Source: JICA Survey Team base on DPR

(8) Alternative Alignment Option Study for Karbook Bypass



Options	Symbol	Node	Length (km)
Option 1		A-B-C-F-E	4.3
Option 2		A-B-C-E	3.6
Option 3		A-D-E	3.3

Source: JICA Survey Team base on DPR

Figure 5-53: Alignment Options for karbook Bypass

Alignment Option 3 is the best because a) the least number of trees to be cut, b) the least number of affected structures, c) the least number of affected families, and d) the least number of required bridges and box culverts.

Table 5-97: Comparison of Alignment Options

No.	Parameters	Alignment Option 1	Alignment Option 2	Alignment Option 3
1	Design Speed	60 to 80 kmph	100 kmph	100 kmph
2	Total Length	4.3 km	3.6 km	3.3 km
3	Land Acquisition	14.8 ha	16.2 ha	15.0 ha
4	Description of alignment	Existing alignment	Connecting A, B C, F, E	Connecting A, D, E
5	Environment-Lost Forest land	No forest lands App. 1047 trees	No forest lands App. 782 trees	No forest lands App. 526 trees
6	Environment-Expected Pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution	Air, water, noise, and vibration pollution
7	Social Impact and R&R	App. 138 structures	App. 102 structures	App. 57 structures
8	Affected Family	App. 86 families	App. 67 families	App. 28 families
8	Structures and Protective Works	4 minor bridges 14 box culverts	3 minor bridges 10 box culverts	3 minor bridges 8 box culverts

Source: JICA Survey Team base on DPR

5.3.9 Preliminary Study of Spoil Bank

To be included in Final Report.

5.3.10 Preliminary Study of Alignment to Avoid Landslide Areas

(1) Identification of Landslide Areas along the Project Road

Several landslide areas are identified on and near the Project Road. The type of the landslide is a combination of a rotational landslide and a translational landslide as per the classification by IRCSP106-2015[48]. The landslide areas that may pose large-scale countermeasures extend along the Project Road from CH89+600 to CH90+600 (1,000 m) and from CH91+100 to CH91+800 (700 m). The mitigation measures would become very costly if the alignment of the Project Road were not changed. Any roads along landslide areas would also cause problems about the unstable ground during construction and then through operations.

Rotational Landslide

Translational Landslide

Source: IRCSP106-2015

Figure 5-54: Landslide Types as per IRCSP106-2015

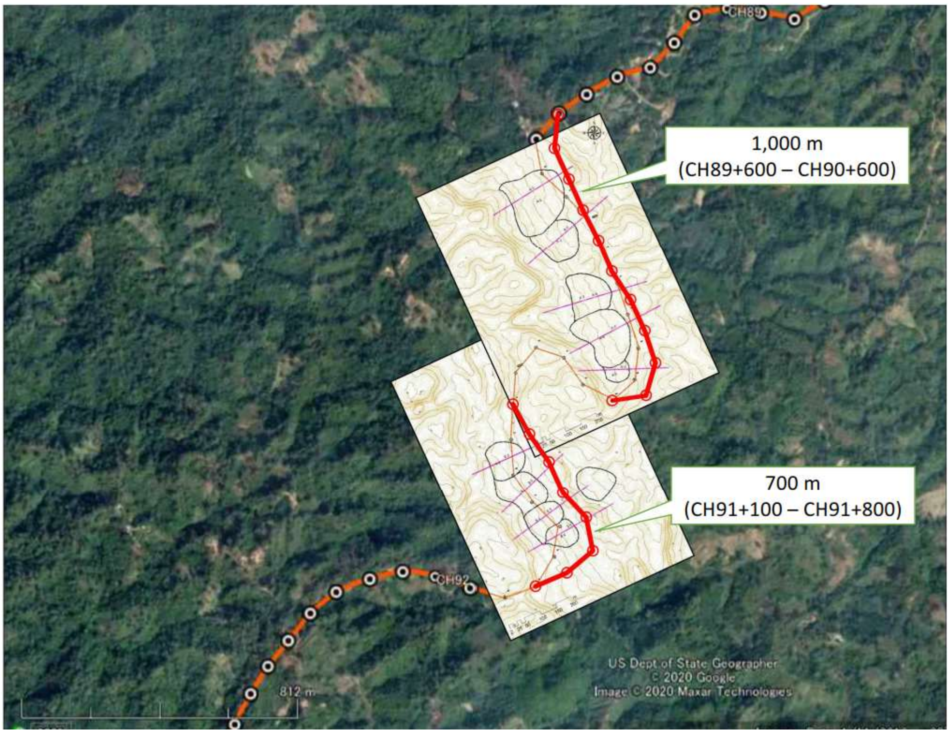
Regarding alignment selection as per IRCSP106-2015, it stipulates in 7.1.1.1 as follows: "Planning of a new highway is a repetitive process which involves transport, highway, environmental, geological, and geotechnical professionals. The purpose here is to find a safe alignment or review options for alignments. This involves defining potential hazardous zones in the landscape, avoiding them where possible or identifying appropriate design options where avoidance is not possible. Decisions made at the route selection stage for highways may have long-term effects on road construction and maintenance costs, user safety, and other resources. Routes must be selected and located to meet the objectives of higher-level plans within the constraints of any approved operational plans or permits."

(2) Proposal to Change the Alignment

JICA Survey Team proposed to change the alignment to avoid landslide areas along the sections of the Project Road from CH89+600 to CH90+600 (1,000 m) and from CH91+100 to CH91+800 (700 m) because a) landslide mitigation measures will be very costly and b) even with mitigation measures the highway may have long-term effects on road construction and maintenance costs.

The DPR consultant responded by e-mail dated 25 Nov 2020 saying, "the alignment has been approved and all site activities like topo graphical survey, inventories have been completed, to change the alignment will take enough time like design of fresh alignment."

[48] IRCSP106-2015 Engineering Guidelines on Landslide Mitigation Measures for Indian Roads

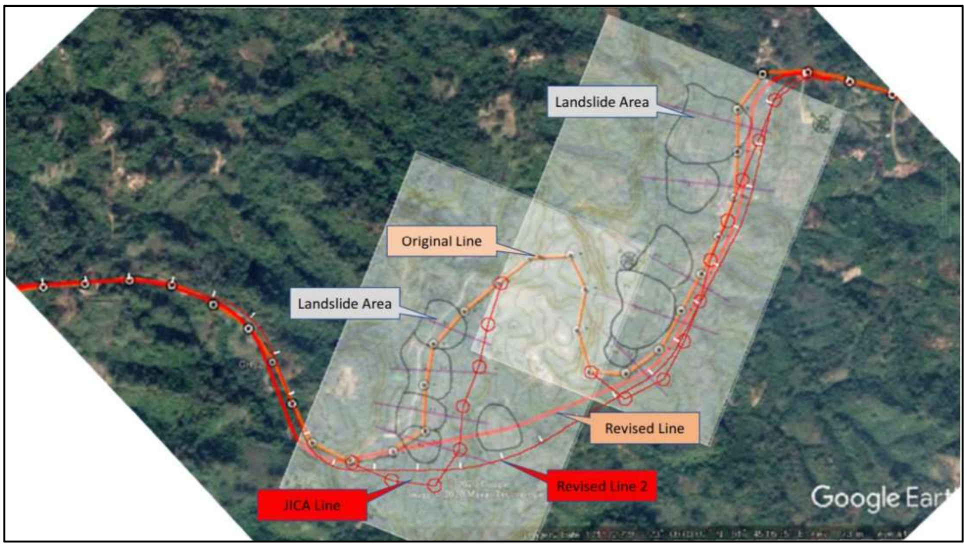


Source: JICA Survey Team

Figure 5-55: Proposal to Change the Alignment

(3) Final Alignment to Avoid Landslide Areas

Through several discussions between the DPR consultant and the JICA Survey Team about the great benefit accrue from the changing alignment to avoid landslide areas, the alignment of Revised Line-2, which is indicated in the Figure below, has been finally accepted with the reservation of "Revised Line-2 is fine avoiding all landslide areas. The detailed design of the horizontal and the vertical alignment shall be conducted paying due attention to that the horizontal curves shall be larger than 75 m and the vertical gradients shall be less than 6.0% (IRCSP73-2018, Mountainous Terrain)".



Source: JICA Survey Team

Figure 5-56: Final Alignment to Avoid Landslide Areas

Chapter 6 Preliminary Project Cost Estimate of NH208 Tripura (Khowai -Sabroom)

6.1 Preliminary Project Cost of NH208 Tripura (Khowai-Sabroom) of the Project

6.1.1 Description of Civil Construction Works of NH208 Tripura Description of Civil Construction Works

The road project is to construct & upgrade the NH208 Tripura Section starting from Khowai to Subroom with two lanes flexible pavement. The new road is generally on/along the existing road alignment without 7(seven) Bypasses. The total design length is 108.191km which is planned to be divided into 10(ten) construction packages. The construction includes earthworks, roadworks, drainage, bridges, culverts, retaining walls, slope protection, Bus Bay, Truck Lay Bye, safety facilities/road appurtenances and other miscellaneous works that can make the highway be properly function. Rail Over bridge is not required. The major quantities of the works is summarized in Table6-1 below.

Table6-1: Major Quantities

Activities		Quantity	
Design Length		108.191	km
Design Lane		2	no.
Excavation for road	for re-use	2,840,000	m3
	for disposal	2,530,000	m3
Embankment fill	from excavation	2,840,000	m3
	from borrow pit	0	m3
Sub Grade	from borrow pit	920,000	m3
Flex paving		1,260,000	m2
Bridges	Major	1	no.
	Minor	58	no.
Culverts	Reconstruction	28	no.
	New proposal	273	no.
Retaining Wall		48,000	m
Crash Barrier		82,000	m
Drains (RC & PCC)		55,000	m
Bus-Bay		16	no.
Truck Lay Bye		2	no.
Junction/Intersection	Major & Minor	451	no.
Toll Plaza		Nil	no.
Turfing		660,000	m2
Hydroseeding		58,000	m2

Source: DPR, summarized by JICA Survey Team

Note：The figures may be amended subject to the final DPR.

6.1.2 Major Construction Materials

Procurement condition of major construction materials are summarised as Table 6-22. JICA SurveyTeam 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	

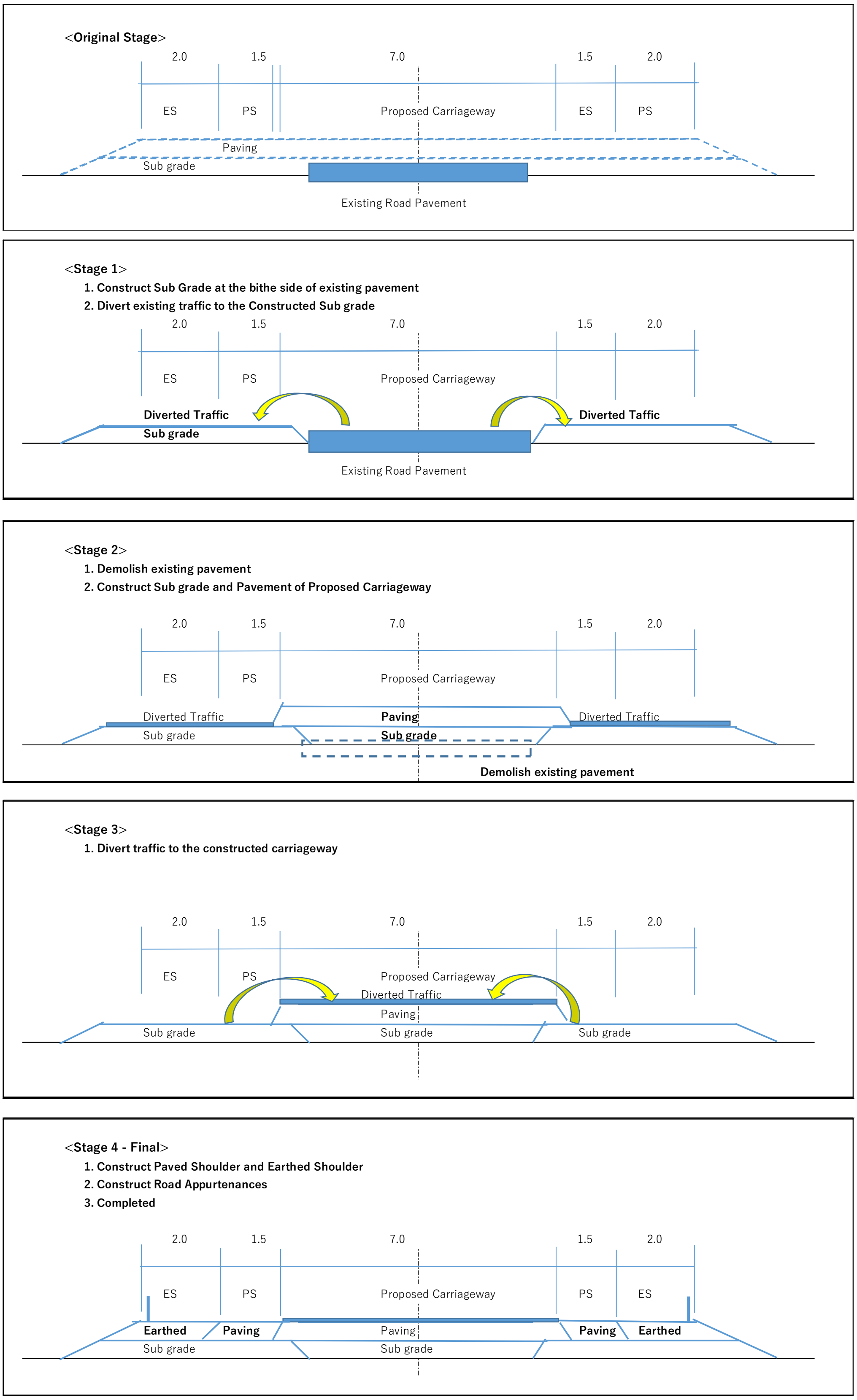
Source: DPR, Summarized by JICA Survey Team

6.1.3 Construction Technique

To the extent of the DPR, JICA Survey Team 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, JICA Survey Team 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-.
2) It is specified to use prestress concrete beams/Steel Girder/Truss Bridge for the construction of medium/major bridges. 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 or Steel fabrication 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 medium/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) 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. Please see the Fig 6-1 below showing the typical diversion scheme. As 7 (seven) bypasses are planned in the Project, road diversion will not be required there where the designed road is totally separated from the existing road.



Source: JICA Survey Team

Fig. 6-1 Typical temporary diversion scheme of existing road during construction – Original Stage and Stage 1 to 4

6.1.4 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) Major Bridge (work at height and lifting appliance)
2) Traffic Management including temporary traffic diversion (public safety)
3) Slope work (work at height)

The Authority's Engineer reviews 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 requirements.

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 Authoritys 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.

6.1.5 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. Table 6-3 shows Cut &fill balance of each Package and total.As a whole 4,900,000 m3 soil is required to be excavated and 3,200,000m3 can be re-used. 1,700,000m3 is subject to disposal however, the volume is well shared by 10 packages and earth work volume is not so much in view of individual Package. JICA Survey Team concludes that the design is well prepare with the point of view of earth work balance and there is no significant affect to the construction schedule.

<**Note**: Coloured portion may be reviewed subject to the final DPR>

Table 6-3 Soil balance of 5 Packages -NH208 Tripura

Package	CH		Length (km)	(A)	(B)	(C)=(A)-(B)	
	Start	End		Cut (ｍ3)	Fill (m3)	Balance (m3)	Note
P-1	0+000	11+400	11.400	417,000	177,000	240,000	Disposal
p-2	11+400	22+000	10.600	954,000	227,000	727,000	Disposal
p-3	22+000	33+800	11.800	563,000	245,000	318,000	Disposal
p-4	33+800	45+000	11.200	201,000	439,000	▲ 238,000	**Borrow**
p-5	45+000	57+200	12.200	691,000	297,000	394,000	Disposal
p-6	57+200	68+000	10.800	196,000	513,000	▲ 317,000	**Borrow**
p-7	68+000	79+000	11.000	167,000	426,000	▲ 259,000	**Borrow**
p-8	79+000	90+000	11.000	650,000	252,000	398,000	Disposal
p-9	90+000	101+200	11.200	918,000	307,000	611,000	Disposal
p-10	101+200	108+670	7.470	126,000	264,000	▲ 138,000	**Borrow**
Total	0+000	108+670	108.670	4,883,000	3,146,000	1,737,000	Disposal

Source: DPR, summarized by JICA Survey Team

6.1.6 Construction Schedule of NH208 Tripura

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 10 Packages with the following considerations (Table 6-4).

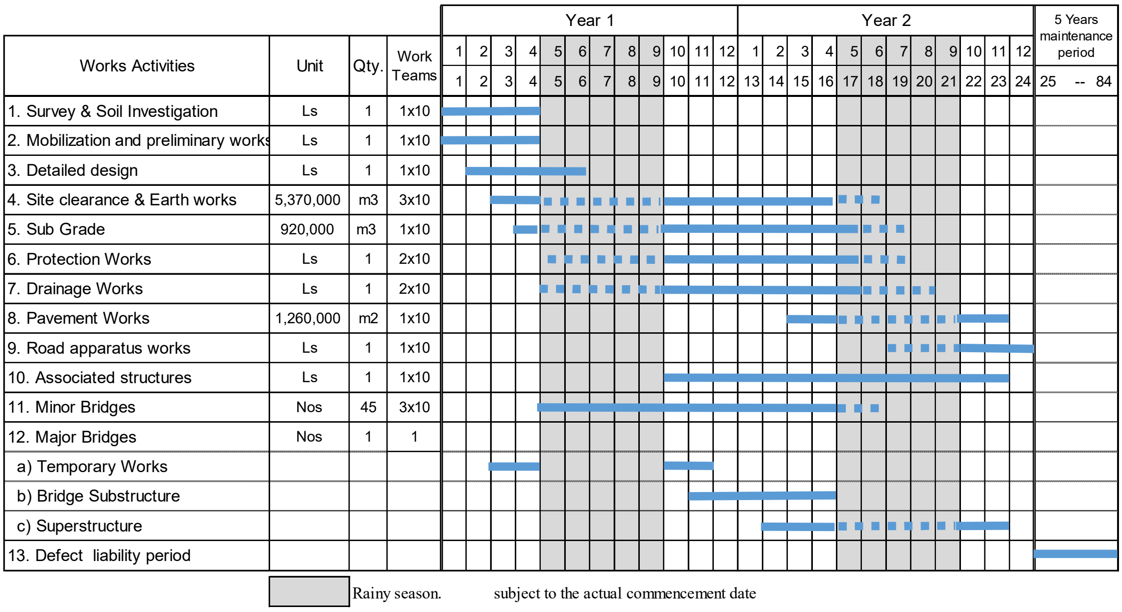
Table 6-4: Basic Consideration for Planning the Construction Schedule

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:	108.191
Construction period:	2 years
Maintenance period:	5 years
Nos. of Construction Package	10 Packages



Source: JICA Survey Team

Figure 6-2: Preliminary Construction Schedule for NH208 Tripura

As show on the schedule (Figure 6-2), JICA SurveyTeam consider that construction period for 24 months of NH208 (Tripura) is feasible.

6.1.7 Condition of Cost Estimates and Reference Documents

Project estimate has been prepared as per PWD National Highway- Schedule of Rates (SOR) Tripura (2020). Cost adjustment for escalation is therefore not required.
Quantities are measured from the final 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. GST (12%) is included in each SOR rates as prescribed in the above Circular.
<Note: Colored portion may be reviewed subject to the final DPR.>

6.1.8 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 15 % for contractor's profit and overheads 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

6.1.9 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.

6.1.10 Total Project Cost of NH208 Tripura

Priced B.O.Q is not prepared for each individual package in DPR. After confirmation with the DPR Consultant total project cost is as presented in Table 6-5 below. JST conclude that no cost adjustment is required to the cost indicated in Table 6-5.

<**Note**: Colored portion will be review subject to the final DPR>

Table 6-5: Project Cost Summary

<note: The underneath is subject to final DPR>

Cost summary Table

Source: DPR, Summarized by JICA Survey Team

6.1.11 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 6-6: Department Cost

Department Cost Table

Source: DPR, Summarized by JICA Survey Team

6.1.12 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 6-7A

: Unit Cost/km Comparison with Other Project

Source: DPR & JICA Survey Team

Table 0-7B: Analysis of Unit Cost/km difference with Other Project

Source：DPR & JICA Survey Team

Source: DPR & JICA Survey Team

A

Table 0-8: Analysis of Unit Cost/km difference with Other Project

Source：DPR & JICA Survey Team