Government of India
Ministry of Road Transport and Highways

PREPARATORY STUDY FOR ROAD NETWORK IMPROVEMENT IN NORTH-EAST STATES OF INDIA

FINAL REPORT

(Volume 1: Prioritization and Preliminary Design of NH54 & NH51)

June 2018

Japan International Cooperation Agency (JICA)

Study Team constituted by

NIPPON KOEI CO., LTD.

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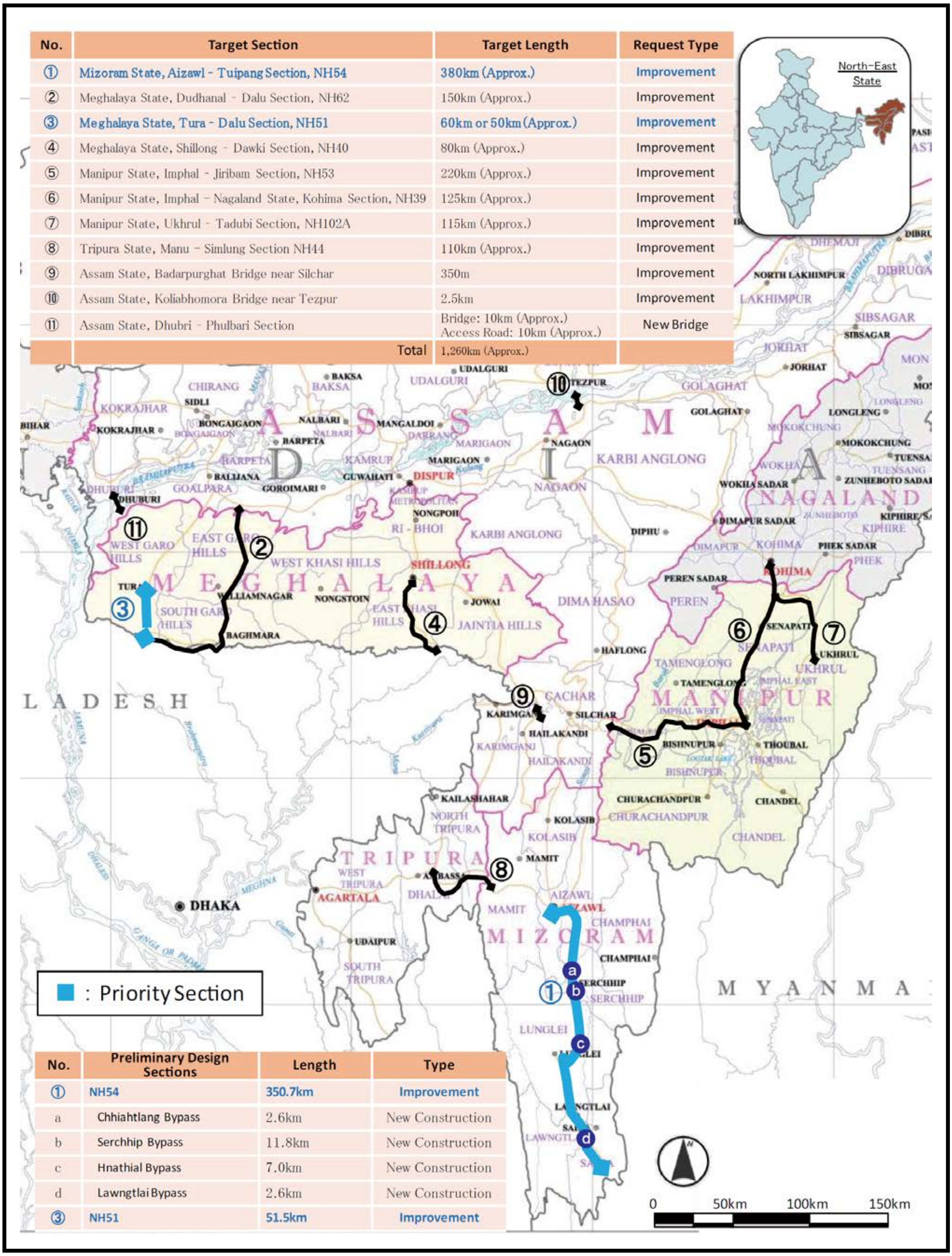

No.	Target Section	Target Length	Request Type
①	Mizoram State, Aizawl - Tuipang Section, NH54	380km (Approx.)	Improvement
②	Meghalaya State, Dudhanal - Dalu Section, NH62	150km (Approx.)	Improvement
③	Meghalaya State, Tura - Dalu Section, NH51	60km or 50km (Approx.)	Improvement
④	Meghalaya State, Shillong - Dawki Section, NH40	80km (Approx.)	Improvement
⑤	Manipur State, Imphal - Jiribam Section, NH53	220km (Approx.)	Improvement
⑥	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	125km (Approx.)	Improvement
⑦	Manipur State, Ukhrul - Tadubi Section, NH102A	115km (Approx.)	Improvement
⑧	Tripura State, Manu - Simlung Section NH44	110km (Approx.)	Improvement
⑨	Assam State, Badarpurghat Bridge near Silchar	350m	Improvement
⑩	Assam State, Koliabhomora Bridge near Tezpur	2.5km	Improvement
⑪	Assam State, Dhubri - Phulbari Section	Bridge: 10km (Approx.) Access Road: 10km (Approx.)	New Bridge
	Total	1,260km (Approx.)	

No.	Preliminary Design Sections	Length	Type
①	NH54	350.7km	Improvement
a	Chhiahtlang Bypass	2.6km	New Construction
b	Serchhip Bypass	11.8km	New Construction
c	Hnathial Bypass	7.0km	New Construction
d	Lawngtlai Bypass	2.6km	New Construction
③	NH51	51.5km	Improvement

Source: JICA Study Team

LOCATION MAP

PREPARATORY STUDY FOR ROAD NETWORK IMPROVEMENT IN NORTH-EAST STATES OF INDIA

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Abbreviations

AADT	- Average Annual Daily Traffic
AASHTO	- American Association of State Highway and Transportation Officials
AC	- Asphalt Concrete
ADB	- Asian Development Bank
ADT	- Average Daily Traffic
AH	- Asian Highway
AIDS	- Acquired Immunodeficiency Syndrome
BOD	- Biochemical Oxygen Demand
BOT	- Built Operation Transfer
BRDB	- Border Roads Development Board
BRO	- Border Roads Organization
CAGR	- The Compound Annual Growth Rate
CC	- Cement Concrete
CO	- Carbon Monoxide
COD	- Chemical Oxygen Demand
CPCB	- Central Pollution Control Board
CRORE	- 1 Crore = 100 Lakh = 10,000,000
CTCS	- Classified Traffic Count Survey
DB	- Double Bituminous Surface Dressing
DMS	- Detailed Measurement Survey
DOEF	- Department of Environment and Forests
DPR	- Detailed Project Report
EIA	- Environmental Impact Assessment
EIRR	- Economic Internal Rates of Return
EMMP	- Environmental Mitigation and Monitoring Plan
EPC	- Engineering, Procurement, and Construction
FDI	- Foreign Direct Investment
FIDIC	- The International Federation of Consulting Engineers
F/S	- Feasibility Study
GDP	- Gross Domestic Product
GHG	- Greenhouse Gas
GMS	- Grievance Redress Mechanism
GOI	- Government of India
GOJ	- Government of Japan
GRC	- Grievance Redress Committee
GS	- General Staff roads
GQ	- Golden Quadrilateral
HDM4	- Highway Development & Management 4
HIV	- Human Immunodeficiency Virus
HQ	- Headquarter
IEE	- Initial Environmental Examination
INR	- Indian Rupee
IRC	- Indian Road Congress
IRI	- International Roughness Index
IS	- Indian Standard
IUNC	- International Union for Conservation of Nature
IWAI	- Inland Waterway Authority of India
IWT	- Inland Water transport
JICA	- Japan International Cooperation Agency
JRSO	- Japan Road Structure Ordinance
KMMTTP	- Kaladan Multi-Modal Transit Transport Project
LAKH	- 1 Lakh = 100,000

LARR	- Land Acquisition, Rehabilitation and Resettlement Act
LCS	- Land Custom Station
LCV	- Light Commercial Vehicle
MDONER	- Ministry of Development of North Eastern Region
MEA	- Ministry of External Affairs of India
MOEF	- Ministry of Environment and Forests
MORTH	- Ministry of Road Transport and Highways
MSL	- Mean Sea Level
M-SPCB	- Mizoram State Pollution Control Board
MT	- Metric Ton
NE	- North East
NEC	- North Eastern Council
NER	- North Eastern Region
NGO	- Nongovernmental Organization
NH	- National Highway
NHAI	- National Highway Authority of India
NHDP	- National Highway Development Plan (NHDP)
NHIDCL	- National Highways and Infrastructure Development Corporation
NOx	- Oxides of Nitrogen
NP	- National Park
NPV	- Net Present Values
NRRP	- National Rehabilitation & Resettlement Policy
NSDP	- Net State Domestic Product
O-D	- Origin Destination
OFC	- Optical Fiber Cable
O&M	- Operation and Maintenance
PAP	- Project Affected Persons
PC	- Prestressed Concrete
PCI	- Per Capita Income
PCU	- Passenger Car Units
PHF	- Peak Hour Factor
PIU	- Project Implementation Unit
PM	- Penetration Macadam
PPP	- Public Private Partnership
PQ	- Pre-qualification
PWD	- Public Works Department
RAP	- Resettlement Assistance Program
RCC	- Reinforced Cement Concrete
RO	- Regional Offices
ROW	- Right of Way
RSI	- Roadside Origin-Destination Survey
SARDP-NE	- Special Accelerated Road Development Programme for North-East
SB	- Single Bituminous Surface Dressing
SC	- Supervision Consultant
SEZ	- Special Economic Zone
SH	- State Highway
SO2	- Sulphur Dioxide
SOR	- Schedule of Rates
SPCB	- State Pollution Control Board
SPM	- Suspended Particulate Matter
SPT	- Standard Penetration Test
SR	- State Road
SSI	- Small Scale Industrial
STD	- Sexually Transmitted Disease
STI	- Sexually Transmitted Infection

Strtg	- Strategic roads
SVF	- Seasonality Variation Factors
UN ESCAP	- United Nation Economic and Social Commission for Asia and the Pacific
TOR	- Terms of Reference
V/C	- Vehicle Capacity Ratio
VOC	- Vehicle Operating Cost
VOT	- Value of Time
WB	- World Bank
WGS	- World Geodetic System
WLS	- Wildlife Sanctuary
WWF	- The World Wildlife Fund
3D	- 3 Dimension

1. Introduction

In the North-Eastern States only 28.5% of the roads are paved (63.4% is the average in the whole country), and only 53% of national highways have more than two lanes; the lack of infrastructure is apparent. The GDP per capita of the target area is INR. 34,405 (2010-2011), only about 60% of the GDP per capita of the country which is INR. 59,606, and the development of the highway network that could be the foundation for economic acitivity is essential.

Government of India (hereinafter referred to as "GOI") raised the "Special Accelerated Road Development Programme for North East", which was committed in the "Twelfth Five Year Plan (from April, 2012 to March, 2017)", to cope with the abovementioned problems through the improvement of national highways connecting major cities within the North-Eastern States.

Based on such background, GOI requested the Government of Japan (hereinafter referred to as "GOJ") to provide loan assistance in carrying out the improvement of existing roads in eight sections, repair of two existing bridges, and construction of one new bridge within the six states of the North-Eastern States in India.

The major objectives of this study are:

- To analyze present conditions and prioritization of target roads under the Study;
- To analyze existing data/reports and review the existing Detailed Project Report (hereinafter referred to as "DPR"); and
- To examine procurement and construction method, implementation schedule, project organization, capability for operation and maintenance, social and environmental conditions, and evaluate project cost and feasibility of target sections.

The Study Area of this Project is the 11 roads located in six states of the North-Eastern States (including Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) as listed in Table 1-1.

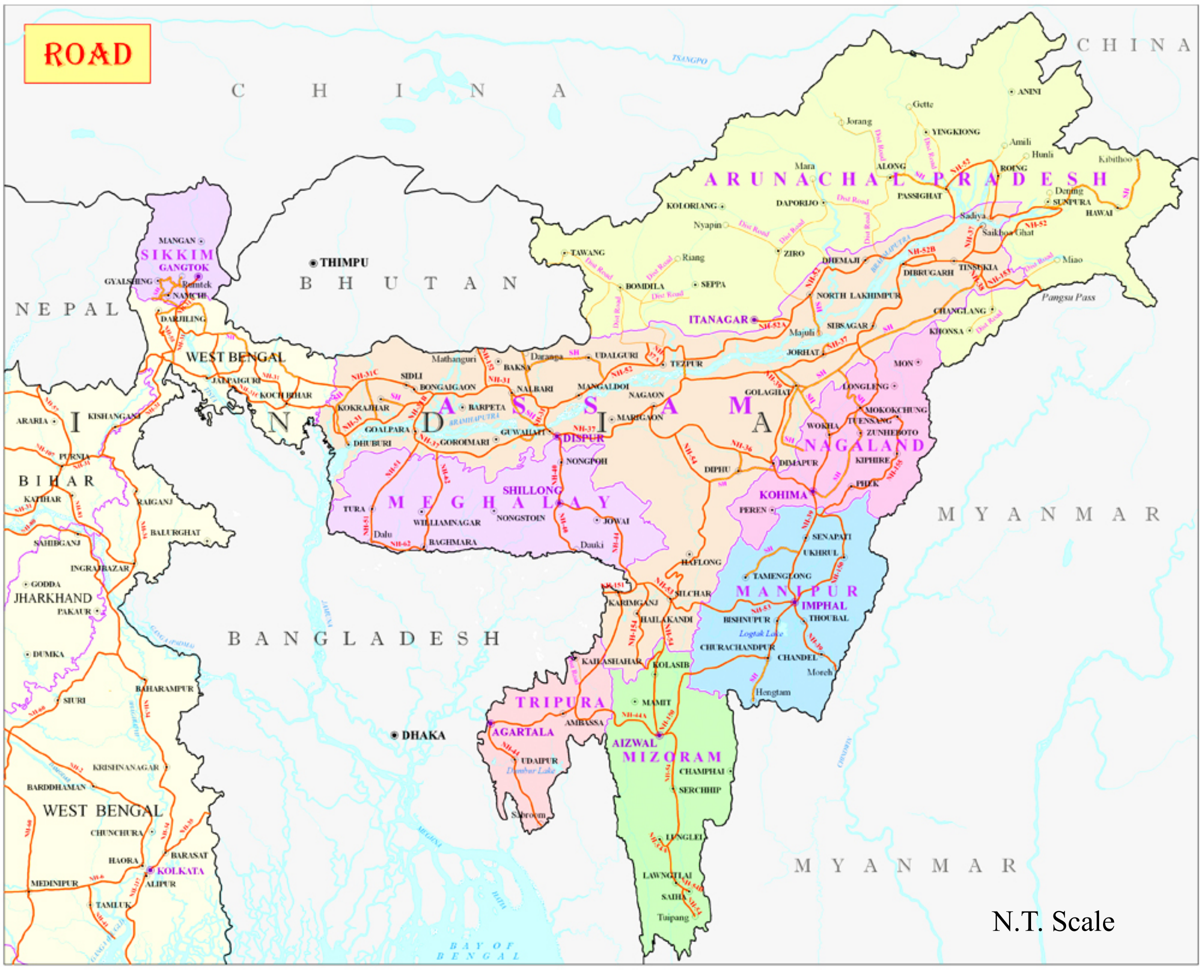
Table 1-1 Study Roads and Contents of Request

No.	Target Roads	Target Length	Request Type
①	Mizoram State, Aizawl – Tuipang Section, NH54	381 km (Approx.)	Improvement
②	Meghalaya State, Dudhanal – Dalu Section, NH62	183 km (Approx.)	Improvement
③	Meghalaya State, Tura – Dalu Section, NH51	54 km (Approx.)	Improvement
④	Meghalaya State, Shillong – Dawki Section, NH40	84 km (Approx.)	Improvement
⑤	Manipur State, Imphal – Jiribam Section, NH53	221 km (Approx.)	Improvement
⑥	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	138 km (Approx.)	Improvement
⑦	Manipur State, Ukhrul – Tadubi Section, NH102A	115 km (Approx.)	Improvement
⑧	Tripura State, Manu - Simlung Section NH44	110 km (Approx.)	New / Improvement
⑨	Assam State, Badarpurghat Bridge near Silchar	360 m	Improvement
⑩	Assam State, Koliabhomora Bridge near Tezpur	2.5 km	Improvement
⑪	Assam State, Dhubri – Phulbari Section	Bridge: 18 km (Approx.) Access Road: 21 km (Approx.)	New Bridge

Source: JICA Study Team

2. Present Condition of the Study Area

Highway network in the subject six states of the Study consists of approximately 391,000 km highways. The highways are classified into national highway, state highway, and other highway administrated by the state's Public Works Department (hereinafter referred to as "PWD"). Total length of the national highway network in the Study Area is 9,770 km as shown in Table 2-1 and the network mainly connects state capitals and major districts, as well as international cross border network as shown in Figure 2-1.



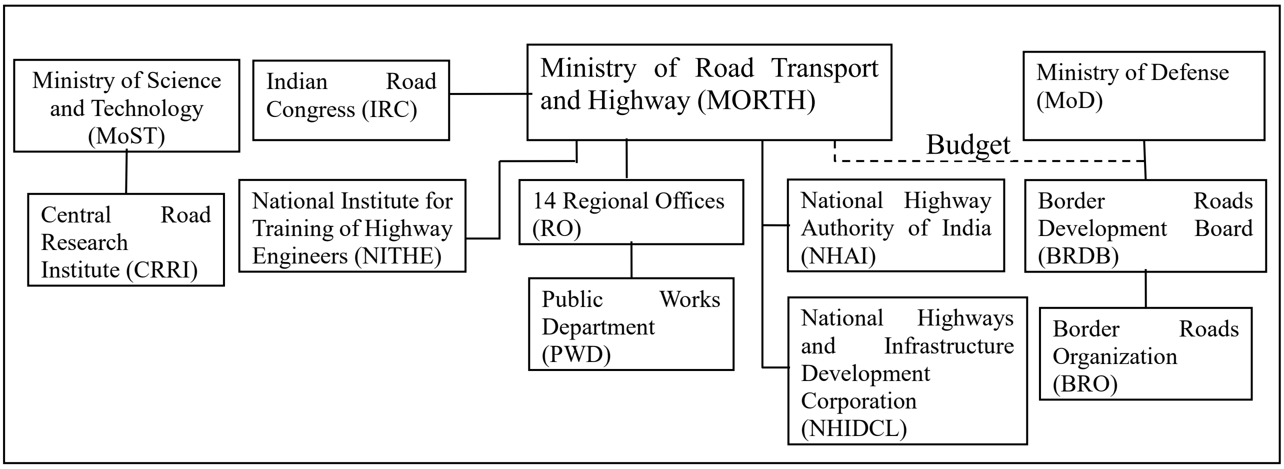
Source: Ministry of Development of North Eastern Region

Figure 2-1 National Highway Network in North Eastern Region

(1) National and Regional Highway Development Plans

1) Organizations Related to National Highway Development

National highways development has been promoted by the National Highway Authority of India (hereinafter referred to as "NHAI") and Regional Offices (hereinafter referred to as "RO") under the Ministry of Road Transport and Highway (hereinafter referred to as "MORTH"), and Border Roads Organization (hereinafter referred to as "BRO") under the Border Roads Development Board (hereinafter referred to as "BRDB"). The National Highways and Infrastructure Development Corporation (hereinafter referred to as "NHIDCL") was established for promoting the development of national highways in the North East and border areas of India, and started operation from January 1, 2015. Figure 2-2 shows the overall structure of organizations related to national highways development.



Source: Ministry of Road Transport and Highway (JICA Study Team modified)

Figure 2-2 Overall Structure of Organizations Related to National Highway Development

2) National Highway Development Plan (NHDP)

The National Highways Development Plan (hereinafter referred to as "NHDP") is a program to be executed in several phases to improve the road network in India. The program is overseen by NHAI. It involves the widening of roads and building of new links between all of India's major cities.

The first phase established the Golden Quadrilateral network, which linked India's four major cities of Delhi, Mumbai, Kolkata, and Chennai by 4-lane highways. The second phase focused on the North-South and East-West corridors while subsequent phases have seen the widening of 4-lane roads to six lanes.

In the Study Area, there is one section of the East-West corridor from Srirampur to Silchar in Assam which is 670 km in total as part of Phase II (4-lanes). Completed section is approximately 71% of the total section as of 2012 and target date of completion is December 2014. There is one section of Phase III road in Meghalaya and the section is NH44 from Jowai to Ratachhera, which is 102 km in total (2 lanes). Status of NHDP as of January 31, 2015 is shown in Table 2-1.

Table 2-1 Status of NHDP as on 31 January 2015

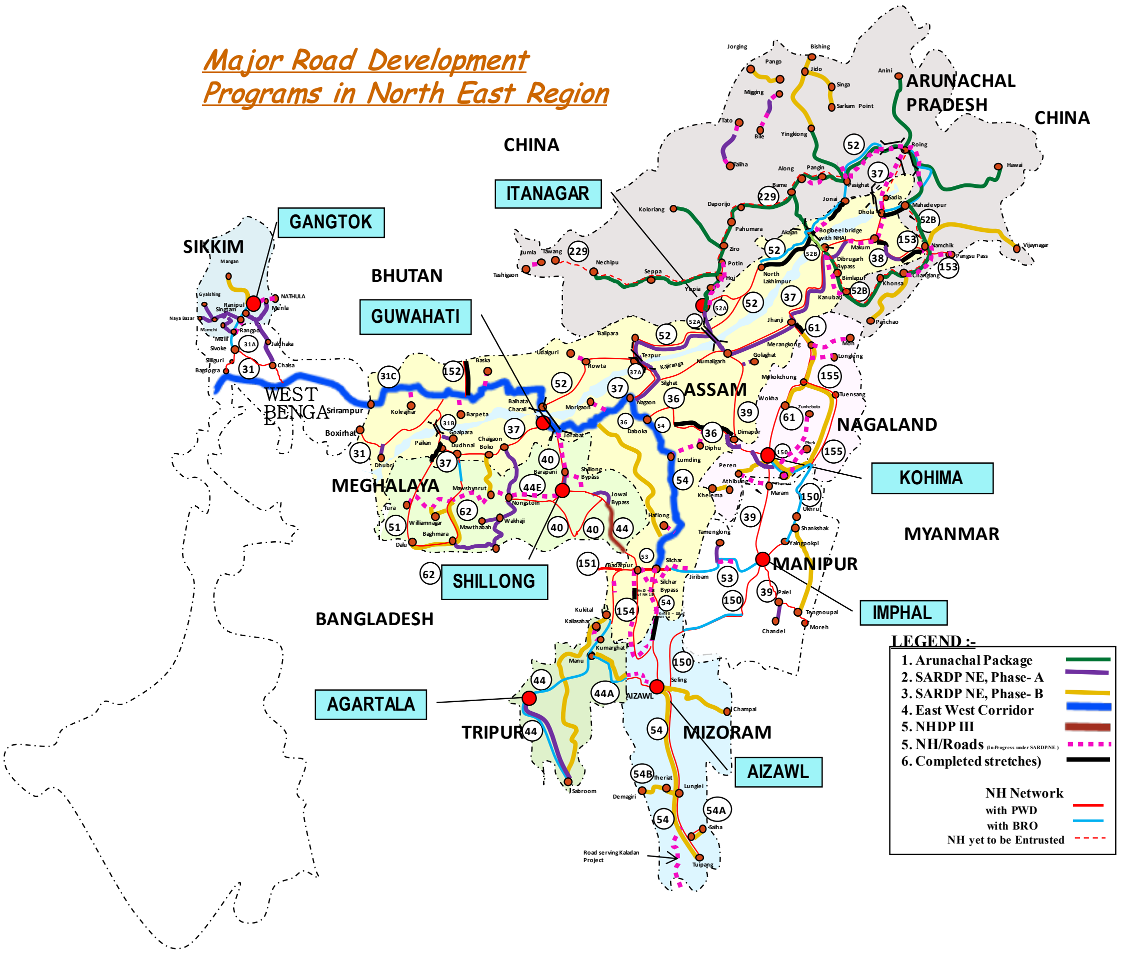
		Total Length (km.)	Already 4/6Laned (km.)	Under Implementation (km.)	Contracts Under Implementation (No.)	Balance length for award (km.)
NHDP	GQ	5,846	5,846 -100.00%	0	0	-
	NS - EW Ph. I & II	7,142	6,360	365	42	417
	Port Connectivity	380	379	1	1	0
	NHDP Phase III	12,109	6,393	4,373	89	1,343
	NHDP Phase IV	14,799	942	5,904	55	7,953
	NHDP Phase V	6,500	2,001	2,080	27	2,419
	NHDP Phase VI	1,000	-	-	-	1,000
	NHDP Phase VII	700	22	19	1	659
	NHDP Total	48,476	21,943	12,742	215	13,791
Others (Ph.-I, Ph.-II & Misc.)		1754	1428	326	10	-
SARDP -NE		388	99	12	1	277
Total by NHAI		50,618	23,470	13,080	226	14,068
*Total 20,000 km. was approved under NHDP Phase IV.Out of which 14,799 km. as assigned to NHAI remaining km. with MORTH.						

Source: NHAI Web Site

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

The Special Accelerated Road Development Programme for North-East (hereinafter referred to as SARDP-NE) was initiated by MORTH in 2005 with the following objectives:

- Upgrade national highways to 2/4 lanes;
- To provide connectivity to all 88 district headquarters by 2-lane roads;
- Connectivity to backward and remote areas of the North-Eastern Region;
- Improve roads of strategic importance; and
- Improve connectivity to neighboring countries.



Source: Ministry of Development of North Eastern Region

Figure 2-3 Major Road Development Programs in North East Region

Program of SARDP-NE is composed of Phase A, Phase B, and Arunnachal Pradesh Package. In Phase A, the major objective is improvement of road network connecting between national arterial roads and districts in the North-Eastern States and priority of implementation is given to the road project under Phase A. Road project under Phase B is intended to reinforce connectivity among districts in the North-Eastern States.

Table 2-2 Related SARDP-NE Project with the Study Roads

State & Package No.	Scope of work	Category of road & Implementing Agency	Length (km)
Phase A			
Meghalaya	Construction of new Shillong By-pass connecting NH-40 & NH-44 (2-lane)	NH – 40 / BOT(Annuity)	50
Nagaland	Four laning of Dimapur to Kohima Road including Dimapur/Kohima Bypass on NH-39	NH - 39/ BOT(Annuity)	81
Manipur,	Widening to double lane and strengthening of NH-53 from km 147.000 to 166.000 (Jiribam-Barak Section) in Manipur, formation width of 12 m corresponding to 2-lane NH in hilly terrain under Phase 'A' of SARDP-NE	NH – 53 / BRO	19
	Strengthening and widening of existing road from km.166.00 to 186.475 (Jiribam - Barak section)	NH – 53 / BRO	20.48
Meghalaya	Improvement of existing 2 lane Barapani - Shillong section of NH-40 and flyovers in Shillong city	NH – 40 / Meghalaya PWD	54
Phase B			
Meghalaya	2 laning from Assam/Meghalaya border to Dalu via Baghmara	NH- 62	161
Mizoram	2 laning from Aizawl to Tuipang section	NH- 54	380
Tripura	2 laning/ realignment from Manu to Tripura/Mizoram Border.	NH-44A	86

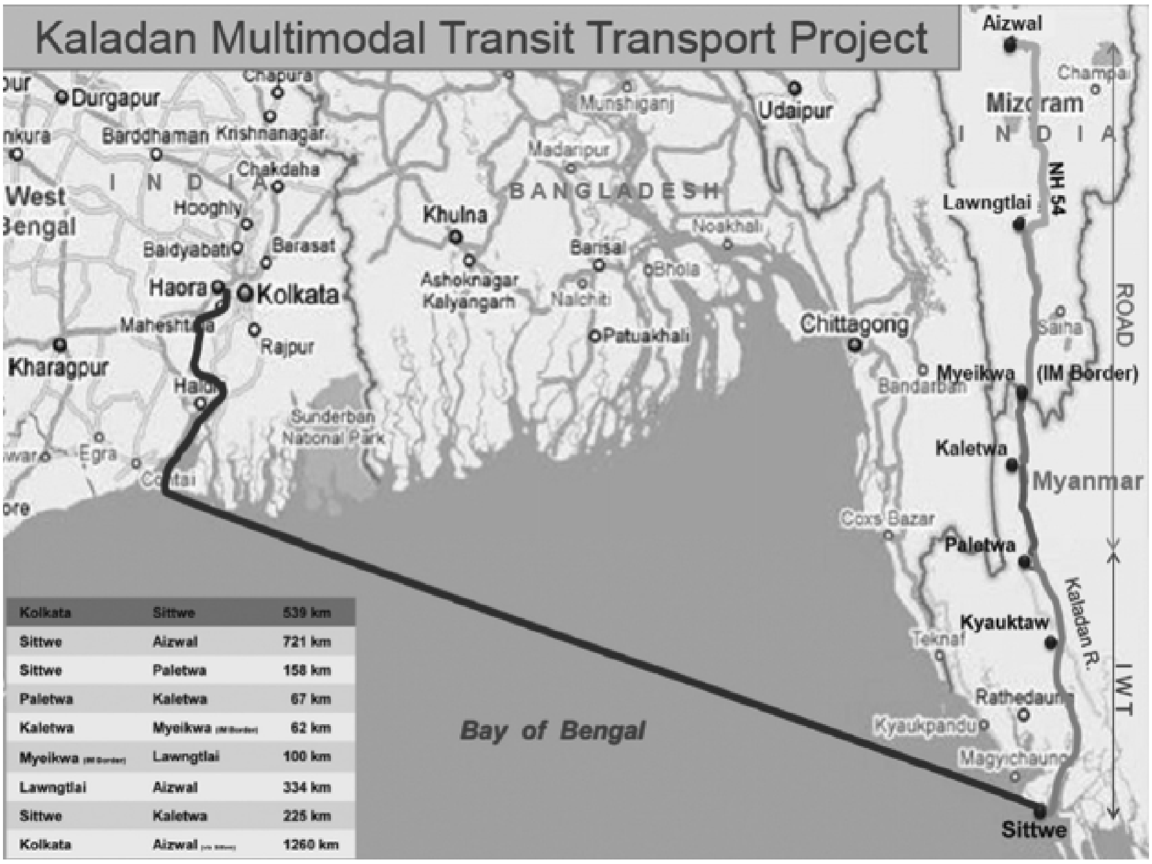
Source: Ministry of Development of North Eastern Region

4) Asian Highway

The Asian Highway network covers 32 countries in Asia and total length is approximately 142,000 km. Main objectives of the Asian Highway network are contribution to interregional and international socioeconomic development and promotion of trade and tourism through networking between Asia and Europe. HN40 in Meghalaya State and NH39 in Manipur State are part of Asian Highway Route No. 1.

5) Other Related Projects

Kaladan Multimodal Transport Project was proposed by the Ministry of External Affairs of India (hereinafter referred to as "MEA") to provide alternative connectivity from Mizoram to Haldia/Kolkata ports through NH54 and Kaladan River in Myanmar. MEA entered into a framework agreement with the Government of Myanmar in April 2008 to facilitate implementation of the project, and the work on the project has substantially been completed. The transit route envisaged between Kolkata (nearest Indian port/ commercial hub) and comprises of segments as shown in Figure 2-4.



Source: Twenty Five Year Plan (2012-2017)

Figure 2-4 Kaladan Multimodal Transit Transport Project

(2) On-going and Planned Road Projects Related to the Study Roads by International Cooperation

Several road projects related to the Study roads have been implemented through financing by international cooperation agencies as shown in Table 2-3.

Table 2-3 On-going and Planned Road Projects

International Donor	Project Name	Project Period	Project Cost (mil. USD)
World Bank	Assam State Roads Project (SH46)	2012.3-2018.3	400
World Bank	Mizoram State Road Project	2014.6-2020.10	107
Asian Development Bank (LN-2770-IND)	North Eastern State Roads Investment Program-Project-1 (Assam, Meghalaya and Sikkim)	2012.10-2016.12	109.5
Asian Development Bank	North Eastern State Roads Investment Program-Project-2 (Assam, Manipur, Mizoram and Tripura)	2014.5-2020.3	157.2
Asian Development Bank (LN-2445-IND)	Rural Roads Sector II Investment Program-Project-3 (Assam and West Bengal)	2009.1-2013.11	168.8
Asian Development Bank (LN-2535-IND)	Rural Roads Sector II Investment Program-Project-4 (Assam, Orissa and West Bengal)	2009.11-2013.4	185

Source: JICA Study Team, WB Web-site, ADB Web-site

(3) Socio Economic Conditions of the North-East States

1) Area and Social Framework

The area and population along with other social indicators are presented in Table 2-4. It is noted that the Study Area falls in the northeastern part of India, and geographically, the eastern part of India (consisting of five states – Bihar, West Bengal, Jharkhand, Odisha, and Chhattisgarh) is adjacent to the northeastern part, and therefore, a comparison of the social and other indicators of these two regions will be of interest for the present Study.

Table 2-4 Area, Population & Social Indicators of States

Items	Unit	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total	All India	Eastern Region
Area (2011)	Sq. km	78,438	22,327	22,429	21,081	16,579	10,486	171,340	3,287,263	553,530
Districts (2011)	Nos.	27	9	7	8	11	4	66	640	129
Population (2011)	(000)	31,169	2,722	2,964	1,091	1,981	3,671	43,598	1,210,193	295,606
Sex Ratio (2011)	Females per 1000 Males	958	992	989	976	931	960		940	919 to 991
Population Density (2011)	Person/ Sq. km	398	115	132	52	119	350	254	368	534
Literacy Rate (2011)	%	72.19	79.21	74.43	91.33	79.55	87.22		74.04	63.82% to 77.08%

Note: Eastern Region consists of Bihar, West Bengal, Jharkhand, Chhattisgarh, and Odisha
Source: North-East Council, Shillong

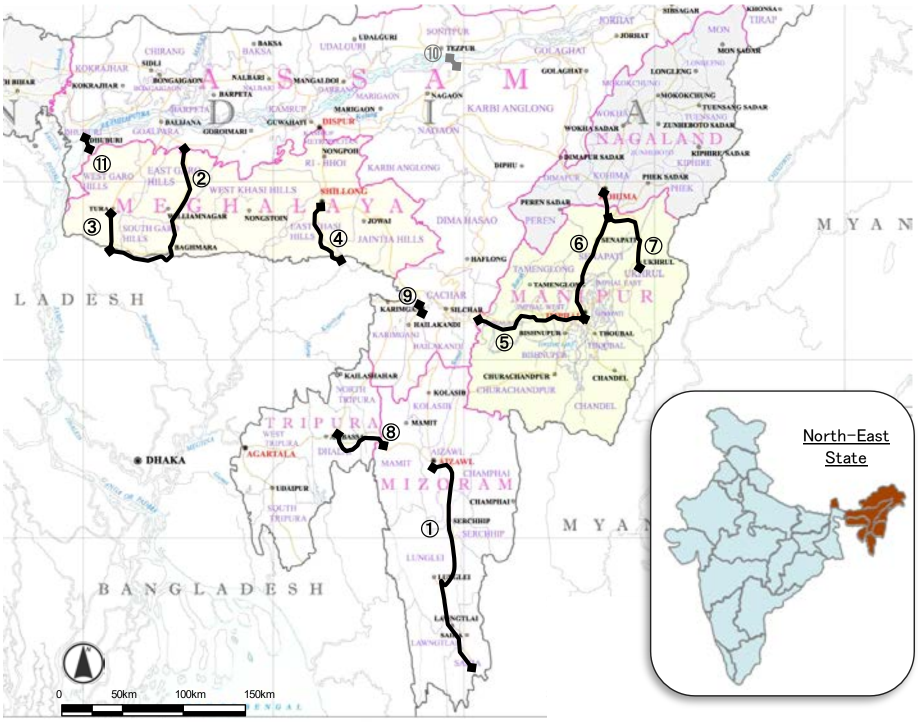
2) Regional Economy and Industrial Structure

The NSDP at current prices for the year 2013-14 for the Study Region stood at Rs.223,219 crore (14.98% of that of the Eastern Region), indicating a considerable difference in the economic output of the two regions. Also, the growth rate of NSDP in the 2004-05 to 2013-14 period for the Eastern Region was higher at 6.82% as compared to 6.13% observed during the same period for the Study Region.

In terms of the growth in PCI, the states in the Eastern Region performed better than the Study Region, as the growth rate of PCI during the 2004-05 to 2013-14 period for the states in the Eastern Region varied between 4.03% to 8.15%, while the rate for the states in the Study Region was 2.44% to 7.06%.

3. Present Condition and Major Issues of the Study Roads

Eleven Study roads in total are initially requested to be considered in the Study as shown in Figure 3-1 and Table 3-1. The construction of No.10 Koliabhomora Bridge Project has been started by GOI, thus Japan International Cooperation Agency (JICA) assistance for implementation of the project will not be required.



Source: JICA Study Team

Figure 3-1 Project Road for the Study

Table 3-1 The Study Roads for the Study

No.	Study Roads Section	Length	Request Type
①	Aizawl – Tuipang Section, NH54	381km	Improvement
②	Dudhanal – Dalu Section, NH62	196km	Improvement
③	Tura – Dalu Section, NH51	54km	Improvement
④	Shillong – Dawki Section, NH40	84km	Improvement
⑤	Imphal – Jiribam Section, NH53	221km	Improvement
⑥	Imphal - Kohima Section, NH39	138km	Improvement
⑦	Ukhrul – Tadubi Section, NH102A	115km	Improvement
⑧	Manu - Simlung Section NH44A	110 km	Improvement/New
⑨	Badarpurghat Bridge near Silchar	360m	Improvement/New
⑩	Koliabhomora Bridge near Tezpur	2.5km	Improvement
⑪	Dhubri – Phulbari Section	Bridge: 18km Access Road: 21km	New Bridge

Source: JICA Study Team

4. Traffic Survey, Analysis and Forecast

The following traffic surveys have been carried out on the Study road sections with a view to meet the requirements of the present Study.

- Classified Traffic Count Survey (CTCS)
- Roadside Origin-Destination Survey (RSI)

The traffic projections for 2020, 2025, 2030, and 2035 are set out in Table 4-1. The capacity requirement in terms of number of lanes is defined in the Indian Road Congress publication (IRC: 64-1990, Guidelines for Capacity of Roads in Rural Areas).

Table 4-1 Traffic Projections

Road ID	Road/Section & Terrain	Unit	2020	2025	2030	2035
RD-1	Aizawl - Tuipang (NH 54)					
RD-1.1	km 0 - km 55, Mountainous	Veh.	6131	8782	12216	16541
		PCU	6090	8611	11876	16010
		No. of Lanes	2	2	>2	>2
RD-1.2	km 55- km 125, Mountainous	Veh.	1905	2732	3802	5148
		PCU	1916	2716	3749	5057
		No. of Lanes	2	2	2	2
RD-1.3	km 125 - km 250, Mountainous	Veh.	1558	2237	3123	4242
		PCU	1598	2268	3142	4246
		No. of Lanes	2	2	2	2
RD-1.4	km 250 - km 381 Mountainous	Veh.	1882	2690	3741	5072
		PCU	1865	2646	3664	4957
		No. of Lanes	2	2	2	2
RD-2	Dudhanal - Dalu (NH 62)					
RD-2.1	km 0 -km30 Mountainous/ Level	Veh.	3246	5543	9490	13659
		PCU	2938	4699	7470	10585
		No. of Lanes	2	2	2	>2 (Mountainous part)
RD-2.2	km 30-km 87, Mountainous/ Rolling	Veh.	1151	2072	3658	5350
		PCU	1082	1760	2847	4077
		No. of Lanes	2	2	2	2
RD-2.3	km 87-km 91, Mountainous	Veh.	754	1429	2637	3866
		PCU	639	1090	1842	2646
		No. of Lanes	2	2	2	2
RD-2.4	km 91-km 183, Mountainous/ Rolling	Veh.	754	1429	2637	3866
		PCU	639	1090	1842	2646
		No. of Lanes	2	2	2	2
RD-3	Tura - Dalu (NH51)					
RD-3.1	km 0 -km 10, Rolling	Veh.	2524	4435	7653	11123
		PCU	2498	3999	6328	8996
		No. of Lanes	2	2	2	2
RD-3.2	km16 -km 60, Rolling	Veh.	5001	8420	14135	20251
		PCU	5482	8489	12997	18176
		No. of Lanes	2	2	2	2
RD-4	Shillong - Dawki (NH40)					
RD-4.1	km 0 -km 28, Mountainous/ Rolling	Veh.	9248	14286	21441	30671
		PCU	11616	17467	25443	35835
		No. of Lanes	>2	>2	>2	>2
RD-4.2	km 28 -km 43, Mountainous	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	2
RD-4.3	km 43 -km75, Mountainous/ Rolling	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	>2 (Mountainous part)
RD-4.4	km 75 -km 82 , Mountainous	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	2
RD-4.5	km 82 -km 84 , Mountainous	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208

Road ID	Road/Section & Terrain	Unit	2020	2025	2030	2035
		No. of Lanes	2	2	2	>2
RD-5	Imphal - Jiribam (NH53)					
RD-5.1	km 0 -km 3 , Level	Veh.	9801	14462	19977	26201
		PCU	10400	15032	20405	26456
		No. of Lanes	Already 4 L	Already 4 L	Already 4 L	Already 4 L
RD-5.2	km 3 -km 145 , Mountainous/ Level	Veh.	9224	13536	18717	24373
		PCU	12769	18281	26617	31818
		No. of Lanes	>2(Mountainous part)	>2	>2	>2
RD-5.3	km 145 -km 221 , Mountainous	Veh.	9224	13536	18617	24373
		PCU	12769	18281	26617	31818
		No. of Lanes	>2(Mountainous part)	>2	>2	>2
RD-6	Imphal - Kohima (NH39)					
RD-6.1	km 0 -km 8. Level	Veh.	12369	18256	25256	33199
		PCU	14923	21509	29156	37835
		No. of Lanes	Already 4 L	Already 4 L	Already 4 L	Already 4 L
RD-6.2	km 8 -km 107 , Mountainous/ Rolling	Veh.	8236	12280	17081	22488
		PCU	7764	11397	15651	20408
		No. of Lanes	2	>2(Mountainous part)	>2	>2
RD-6.3	km 107 -km 138 , Mountainous	Veh.	8236	12280	17081	22488
		PCU	7764	11397	15651	20408
		No. of Lanes	2	>2	>2	>2
RD-7	Ukhrul - Tadubi (NH102A)					
RD-7.1	km 0 -km 115 , Mountainous	Veh.	1534	2280	3164	4172
		PCU	1710	2476	3365	4379
		No. of Lanes	2	2	2	2
RD-8	Manu -Simlung (NH44A)					
RD-8.1	km 0 -km 16 Rolling/ Level	Veh.	1878	2780	3995	5618
		PCU	2066	2942	4106	5663
		No. of Lanes	2	2	2	2
RD-8.2	km 16 -km 67, Mountainous	Veh.	1090	1615	2319	3263
		PCU	1261	1798	2507	3456
		No. of Lanes	2	2	2	2
RD-8.3	km 67 -km 97 , Mountainous/ Rolling	Veh.	1090	1615	2319	3263
		PCU	1261	1798	2507	3456
		No. of Lanes	2	2	2	2
RD-8.4	km 97 -km 110, Mountainous/ Rolling	Veh.	1090	1615	2319	3263
		PCU	1261	1798	2507	3456
		No. of Lanes	2	2	2	2
RD-9	Badarpur Bridge (Near Silchar), Level	Veh.	7744	11703	17122	24278
		PCU	10952	16064	22877	31658
		No. of Lanes	2	2	>2	>2
RD-11	Dhubri-Phulbari Bridge, Assam , Level	Veh.	5867	8780	12727	17897
		PCU	9796	14200	19988	27357
		No. of Lanes	2	2	>2	>2

Source: JICA Study Team

5. Economic Analysis

In the present context, the HDM-4 model has been used to establish the economic viability of the proposed road improvement. The EIRR and net present values (NPVs) were estimated for the investment proposition for the road sections in the North-Eastern Region.

(1) Economic Analysis

Having applied the project options and completed the data input in the HDM-4, the economic analysis of the homogeneous road sections for each of the defined project options was performed. The results of the economic analysis are set out in Table 5-1.

Table 5-1 Results of Economic Analysis of Study Road Sections

Road ID	Road Section	EIRR (%)
1.0	Aizawl – Tuipang Section, NH54	15.1
2.0	Dudhanal – Dalu Section, NH62	7.3
3.0	Tura – Dalu Section, NH51	22.0
4.0	Shillong – Dawki Section, NH40	16.8
5.0	Imphal – Jiribam Section, NH53	22.6
6.0	Imphal - Nagaland, NH39	18.9
7.0	Ukhrul – Tadubi Section, NH102A	14.0
8.0	Manu - Simlung Section NH44	3.5
9.0	Badarpurghat Bridge near Silchar	(-) 0.2
11.0	Dhubri – Phulbari Section	18.7

Source: JICA Study Team

(2) Sensitivity Analysis

In order to know the economic strength of the Study roads and to identify its robustness, sensitivity analysis of the improvement option has been carried out under the adverse situation of cost and benefits. Through the sensitivity analysis, the changes in the project EIRR/NPV are estimated and compared to the minimum acceptable criteria (Table 5-2).

Case 1: Increase in Project Cost by 15%
Case 2: Decrease in Project Benefit by 15%
Case 3: Combined Impact of Case 1 and Case 2

Table 5-2 Results of Sensitivity Analysis of Study Road Sections

Road ID	Road Section	EIRR (%)			
		Base Case	Case 1	Case 2	Case 3
1.0	Aizawl – Tuipang Section, NH54	15.1	12.6	12.2	9.8
2.0	Dudhanal – Dalu Section, NH62	7.3	6.1	5.9	4.7
3.0	Tura – Dalu Section, NH51	22.0	18.0	17.4	13.9
4.0	Shillong – Dawki Section, NH40	16.8	15.2	14.9	13.2
5.0	Imphal – Jiribam Section, NH53	22.6	20.4	20.1	18.0
6.0	Imphal - Nagaland, NH39	18.7	17.1	16.8	15.2
7.0	Ukhrul – Tadubi Section, NH102A	14.0	10.7	11.5	9.4
8.0	Manu - Simlung Section NH44	3.5			
9.0	Badarpurghat Bridge near Silchar	(-) 0.2			
11.0	Dhubri – Phulbari Section	18.7	15.7	15.2	12.4

Source: JICA Study Team

6. Prioritization of Project Implementation and Selection of Project for JICA Loan Scheme

(1) Prioritization of Project Implementation

1) Evaluation Criteria

Evaluation criteria is selected to apply prioritization of project implementation for yen loan scheme based on the results of the study of present conditions and major issues, traffic demand forecast, and economic analysis in the foregoing sections. Proposed evaluation criteria are consistent with the above plan, project maturity, traffic demand, and EIRR. Table 6-1 shows the proposed evaluation criteria and weighting of scoring. The total length of the priority project will be around 450 km based on the annual budgetary quota for road sector project loan for India.

Table 6-1 Evaluation Criteria of Project Prioritization

Criteria		Evaluation Contents (Score)			Weighting (Average:10)
		High (10 - 8)	Middle (7-4)	Low (3-0)	
1	Consistency with upper plan	Listed in National Road Development Plan (e.g. SARDP-NE)	Listed in International Road Development Plan (e.g. Asia Highway)	Others	5
2	Project maturity	DPR、EIA、RAP are prepared	DPR、EIA、RAP are being prepared	DPR、EIA、RAP are not yet prepared	10
3	Traffic demand supply Gap (V/C)	Demand supply gap in year 2020 (V/C>0.75)	Demand supply gap in year 2020 (V/C 0.75-0.50)	Demand supply gap in year 2020 (V/C <0.50)	10
4	EIRR	EIRR>15%	EIRR 12% - 15%	EIRR<12%	25

Source: JICA Study Team

2) Results of Project Prioritization

Result of project prioritization based on the evaluation criteria is shown in Table 6-2.

Table 6-2 Results of Project Prioritization

Criteria		1				2			
		NH54: Aizawl-Tuipang				NH62: Dudhanai-Dalu			
		0-55	55-125	125-250	250-381	0-30	30-87	87-91	91-183
1	Consistency with upper plan	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B		*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B
		10	10	10	10		10	10	10
2	Project maturity	*DPR is being prepared	*DPR is being prepared	*DPR is mostly prepared	*DPR is mostly prepared	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		6	6	8	8	3	3	3	3
3	Traffic demand (V/C)	1.22	1.92	1.60	1.87	0.29	0.22	0.64	0.64
		10	10	10	10	3	2	6	6
4	EIRR	15.1				7.3			
		8				2			
Total Score		41	41	43	43	11	15	19	19
Combined Score (Cost Weight Base)		42				17			
Ranking		2				9			

Criteria		3		4				
		NH51: Tura-Dalu		NH40: Shillong-Dawki				
		0-10	16-60	0-28	28-43	43-75	75-82	82-84
1	Consistency with upper plan			*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1
				7	7	7	7	7
2	Project maturity	*DPR is mostly prepared	*DPR is mostly prepared	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		8	8	3	3	3	3	3

Criteria		3		4				
		NH51: Tura-Dalu		NH40: Shillong-Dawki				
		0-10	16-60	0-28	28-43	43-75	75-82	82-84
3	Traffic demand (V/C)	2.50	5.48	1.16	0.78	0.39	3.90	0.39
		10	10	10	7	4	10	4
4	EIRR	22.0		16.8				
		10		9				
Total Score		43	43	39	36	33	39	33
Combined Score (Cost Weight Base)		43		36				
Ranking		1		4				

Criteria		5			6			7
		NH53: Imphal-Jiribam			NH39: Imphal-Kohima			NH102A: Ukhrul-Tadubi
		0-3	3-145	145-221	0-8	8-107	107-138	0-115
1	Consistency with upper plan				*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1	
					7	7	7	
2	Project maturity	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		3	3	3	3	3	3	3
3	Traffic demand (V/C)	0.17	1.28	1.28	0.25	0.78	0.78	1.71
		2	10	10	2	7	7	10
4	EIRR	22.6			18.7			14.0
		10			9			4
Total Score		30	38	38	31	36	36	23
Combined Score (Cost Weight Base)		38			36			23
Ranking		3			4			7

Criteria		8				9	11	
		NH44A: Manu-Simlung				Badarpurg hat Bridge	NH127B: Dhubri-Phulbari Bridge	
		0-16	16-67	67-97	97-110	0-0.36	0-18	18-39
1	Consistency with upper plan	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B			
		10	10	10	10			
2	Project maturity	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		3	3	3	3	3	3	3
3	Traffic demand (V/C)	2.07	1.26	1.26	1.26	1.10	0.98	9.80
		10	10	10	10	10	9	10
4	EIRR	3.5				-0.2	18.7	
		2				0	9	
Total Score		23	23	23	23	18	35	36
Combined Score (Cost Weight Base)		23				13	35	
Ranking		7				10	6	

Source: JICA Study Team

(2) Conclusion of Project Priority for Yen Loan Scheme

The project road is categorized into three priority groups based on the project prioritization result. The remarks for project implementation are also mentioned in Table 6-3.

Table 6-3 Conclusion of Project Priority for Yen Loan Scheme

Priority Group	Project	Remarks
A	NH54, Aizawl-Tuipang Section NH51, Tura-Dalu Section	i) Design review of two projects is being carried out by the JICA Study Team in October 2015
B	NH127B, Dhubri-Phulbari Section NH40, Shillong-Dawki Section NH53, Imphal-Jiribam Section NH39, Imphal-Kohima Section	i) Submission of the DPR and transferring administrative jurisdiction from BRO to MORTH are necessary ii) Security of the Study Team at Manipur State is essential
C	NH44, Badarpurghat Bridge NH44A, Manu-Simlung Section NH102A, Ukhrul-Tadubi Section NH62, Dudhanal-Dalu Section	

Source: JICA Study Team

(3) Selection of Projects for Preliminary Design

Project for the preliminary design are selected based on result of the project prioritization for Yen Loan Scheme and annual budgetary quota for road sector project loan for India. As a result, projects of NH54, Aizawl – Tuipang Section and NH51, Tura – Dalu Section are selected to be subjected to the preliminary design.

7. Preliminary Design of NH54 (AIzawl - Tuipang)

NH54 (Aizawl – Tuipang) project is prioritized as project in the Priority Group A as mentioned in Chapter 6 and this project is subjected to preliminary design to examine procurement and construction method, implementation schedule, project organization, capability of operation and maintenance, social and environmental conditions and evaluate project cost and feasibility.

(1) Natural Condition Surveys

1) Meteorological and Hydrological Surveys

For the application in the drainage design, the hydrological study based on meteorological and topographical condition at the project area was conducted.

2) Topographic Survey

No additional survey was done by the JICA Study Team for the road alignment, except for short sections where new bridge is proposed by the JICA Study Team in Section-1 at Chhingcchip and cross section survey at few locations with proposed representative landslide countermeasures.

i. 1:500 scale plan survey at Chhingcchip Bridge at 74+660, survey length of about 200 m

ii. Profile survey (cross section of road) at three locations of representative landslide countermeasures

(a) Issues from the Review

- The accuracy of the topographic survey data by all three DPR Consultants for the three sections was completely different from each other.
- Due to different coordinate systems applied for the survey, the three sections cannot be continuously interlinked.
- The elevation datum for Section-2 is only arbitrary and there is no continuation with Section-1 or Section-3.
- The concept of alignment design is different in all three sections. Therefore, the extent of topographic survey also differed across the three sections. For example, in Section-2, the

alignment was completely designed by cutting the hill side only. Virtually no survey data exists on the valley side beyond the existing road width.

- Section-2 has applied two sets of data, one for the existing road width and the other for the hill side slope. These two data largely differ from each other at many locations.
- The hill side slope data in Section-2 is found to be exceptionally steep at some interval of about 2-3 km, which was not observed in the site. This raised serious issues on the accuracy of the survey data of Section-2.
- The hill side slope data in Section-3 was available for limited width only. The slope grades at few locations were also found to be gentle than those observed in the site.

(b) Additional Data by the JICA Study Team

The alignment design approach of the JICA Study Team was to make a more balanced cut/fill design by shifting the alignment of DPR to the valley side. Since the topographic survey data was not available/very limited in the valley side, the slope inventory data conducted by the JICA Study Team was used to create the contour data in the valley side. However, the slope inventory was conducted at every 200-300 m interval only. Therefore, the accuracy of the valley side contour created through such data was very low.

3) Geological Survey

In order to clarify the geology and geological condition along NH54 and utilize the result for the road design, the JICA Study Team conducted geological survey including data collection, site reconnaissance, slope inventory survey, and boring survey.

Before starting the site survey, the JICA Study Team collected existing data and information on geological and topographical setting, earthquake occurrence, and landslide disaster in the study area. Although several organizations such as Mizoram Remote Sensing Application Centre and Geological Survey of India have established a landslide zonation map and a geological map, they did not identify landslide distribution and they have very large scale that the survey needed to clarify the exact location of the risk sites in detail for the design of the road and landslide countermeasures.

(2) Preliminary Design

1) Road Geometric Design

(a) Design Policy and Design Criteria

The major objectives of the Study are;

- To analyze the existing data/reports and review of existing Detailed Project Reports (DPR)
- To examine procurement and construction method, implementation schedule, project organization, capability of operation and maintenance, social and environmental conditions and evaluate project cost and feasibility of target sections.

However, after review of the DPR data, it was concluded that the accuracy of topographic survey data and design policies of each section of NH54 designed by separate DPR Consultants were not unified and varied largely from each other.

Therefore, although, redesign was not a part of the objectives of the Study, redesign to the extent possible from the available data was attempted to come up with some meaningful quantities and cost of the Project.

The following Design Policies are established;

- There were differences in design concept in each section of DPR with different road width, application of minimum design speed, minimum radius of horizontal curves and application of transition curves etc. Therefore, uniformity in the design criteria is required for all sections of NH54.

- Design of alignment shall be based on a policy with a balance between application of minimum design standard and the terrain condition, such that the improved alignment does not largely deviate from the existing road.
- Widening shall be done with a concept to minimize the earthwork imbalance and alignment shall be shifted to valley side to the extent not to increase the construction cost sharply.
- Especially at the landslide prone areas, identified by the JICA Study Team, widening side shall be decided based on the results of the study.
- Widening shall be done with a concept to minimize the relocation of houses along the existing road.
- As per the instruction by NHIDCL and IRC:37-1980, transition curves shall be designed for all horizontal curves. Exceptions maybe with the length of transition curves at difficult locations.

(b) Design Conditions

- As stated earlier, one of the major objectives of the Study was to analyze the existing data/reports and review of existing Detailed Project Reports (DPR).
- However, the alignment design by each DPR Consultant for each section was completely with different design policy and uniformity in design was required.
- Widening of existing road in DPR was exclusively by widening in the hill side only, due to which very big excavation volume was resulted, raising serious environmental concerns.
- Therefore, re-design of the entire project road was required by applying uniform design standards and making a more balanced cut/fill design by shifting the alignment to valley side wherever practicable.
- However, the topographic data on the valley side was not available in all DPR sections. The scope of the Study did not include topographic survey of the road and it was also not possible to be conducted during the short duration of the Study.
- The scope of the Study included slope inventory survey where the road side slopes were measured approximately by the use of Distance Meter at an interval of about 200-300m.
- The results from the slope inventory survey were used to create the digital terrain model of the valley side. However, since the data was available at an interval of every 200-300m only, the accuracy cannot be expected.
- Moreover, the hill side data of Section-2 showed exceptionally steep terrain at regular intervals of 2-3km which were not observed in the site. However, it was not possible to rectify it without conducting topographic survey. It was also not possible to combine the survey data of DPR with the results of the inventory in the hill side since mixing of data from two different sources with different accuracy levels will complicate the terrain model more.
- In the contrary, the hill side data of Section-3 showed gentler terrain at some locations than were observed in the site. The extent of data available was also to a narrow width only.
- The topographic data of Section-2 also largely lacks the details of existing features such as houses, structures etc.
- Therefore, the re-design of the alignment was done with the constraints mentioned above which would affect to the desired degree of accuracy.
- The Coordinate System used by each DPR Consultant was different and hence it was not possible to directly superimpose all sections in one system. Since Section Section-3 applied WGS-84 coordinate system, the Study Team approximately adjusted the

coordinate system of Section S1 and Section Section-2 based on the coordinate system of Section-3. However, there was some mismatch between the end of Section Section-1 and starting of Section Section-2. The natural features and the details were also different at this overlap section between Section-1 and Section-2, details of Section-1 being much closer to the existing conditions.

(c) Horizontal Alignment Design

The starting and ending chainages of each section in NH54 are given in Table 7-1.

Table 7-1 Start and End Chainages of Each Section in NH54

Section	Start Chainage	End Chainage	Remarks
1	km 8+000	km 116+710	km 116+710 (S1) is the revised design chainage which is set at the km post on the existing road and is the starting point for Section S2 with km 125+000 (S2)
2	km 125+000	km 243+330	km 243+330 (S2) is the revised design chainage which is at same location as km 431+100 (S3) on the existing road
3	km 431+100	km 554+410.287	The end point is at the roundabout in Tuipang

Source: JICA Study Team

The details of the revised alignment for each section of NH54 are given in Table 7-2, showing the percentage of radius less than the value required for minimum design speed of 30 km/h. These were applied only at the hairpin bends and IRC allows a minimum radius of 20 m at hairpin bends.

Table 7-2 Application Rates of Minimum Radius in Each Section of NH54

Section		R=20	20<R<25	R=25	25<R<30	R=30	Tot.R<30	Remarks
S1	No	10	0	4	0	495	14	R<30m mainly at hairpin curves
	(%)	0.8%	0%	0.3%	0%	40.2%	1.1%	
S2	No	11	0	0	0	605	11	
	(%)	0.7%	0%	0%	0%	40.8%	0.7%	
S3	No	10	0	10	0	317	20	
	(%)	0.7%	0%	0.7%	0%	21.2%	1.3%	

Source: JICA Study Team

The quantities of excavation and spoil volume for the revised alignments are also given for each section in Table 7.3-19 in comparison with the volume in DPR.

From the results, it may also be concluded that the terrain conditions of Section-1 and Section-2 may be steeper than for Section-3 where the application rate of minimum radius of 30 m is only 21.2%, compared with the above 40% for Section-1 and Section-2 and yet the excavation volume is almost the same. After the revision of the design from the original DPR, the excavation and spoil volumes for the revised design are given in Table 7-3 in comparison with the DPR volume.

Table 7-3 Excavation and Spoil Volume for the Revised Design by JICA Study Team

SN	Section	Revised Design		DPR	
		Excavation Volume (m^3)	Spoil Volume (m^3)	Excavation Volume (m^3)	Spoil Volume (m^3)
1	S1	3.44 million	2.40 million	Not reported	Not reported
2	S2	3.71 million	2.44 million	23.5 million	23.48 million
3	S3	3.55 million	2.46 million	7.1 million	7.01 million

Source: JICA Study Team

(d) Vertical Alignment Design

- Minimum gradient is designed as 0.5% at cut sections for drainage.
- The ruling gradient is designed as 6% as per the design standard given in Section 7.3.2 (1).
- The limiting gradient is 7% at difficult locations.

- The exceptional gradient is 8%, which is applied for unavoidable situations only and the maximum length is 100 m.

The length of the designed vertical profile grade range is given in Table 7-4 in percentage of the total length of each section.

Table 7-4 Length of Designed Vertical Profile Grade Range

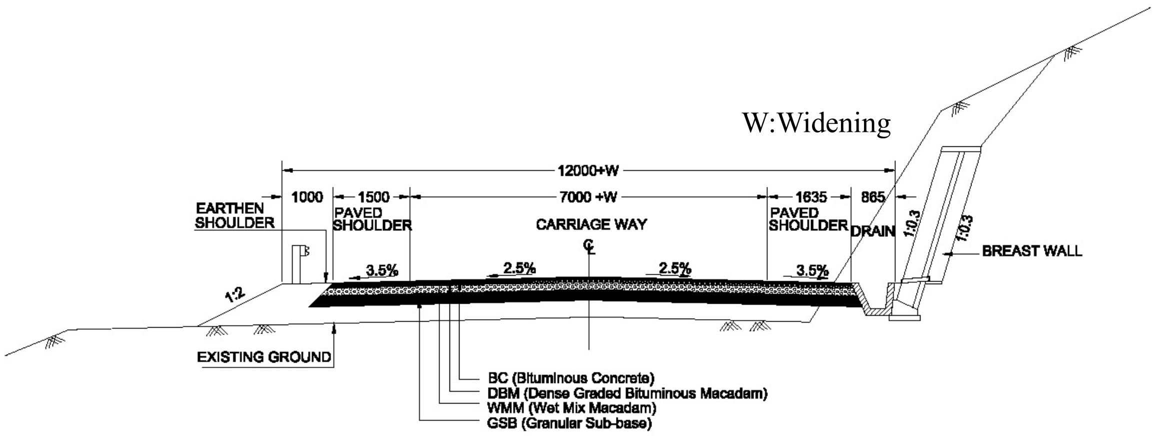
Section	Vertical Grade Range								
	0.5%	0.5%-1%	1%-2%	2%-3%	3%-4%	4%-5%	5%-6%	6%-7%	7%-8%
1	5.3%	2.5%	7.6%	11.6%	12.4%	26.9%	22.8%	10.6%	0.4%
2	3.3%	6.7%	9.1%	15.1%	21.7%	21.1%	14.4%	8.2%	0.3%
3	4.2%	4.3%	11.6%	21.5%	23.5%	15.9%	12.6%	6.2%	0.2%

Source: JICA Study Team

- The vertical grade higher than the ruling gradient of 6% but less than or equal to the limiting gradient of 7% was applied at a total percentage length of 10.6%, 8.2%, and 6.2% for Sections-1, 2, and 3, respectively.
- Exceptional gradient of 8% was applied at four locations (total of 400 m) each in Sections 1 and 2 and at two locations (200 m) in Section-3.

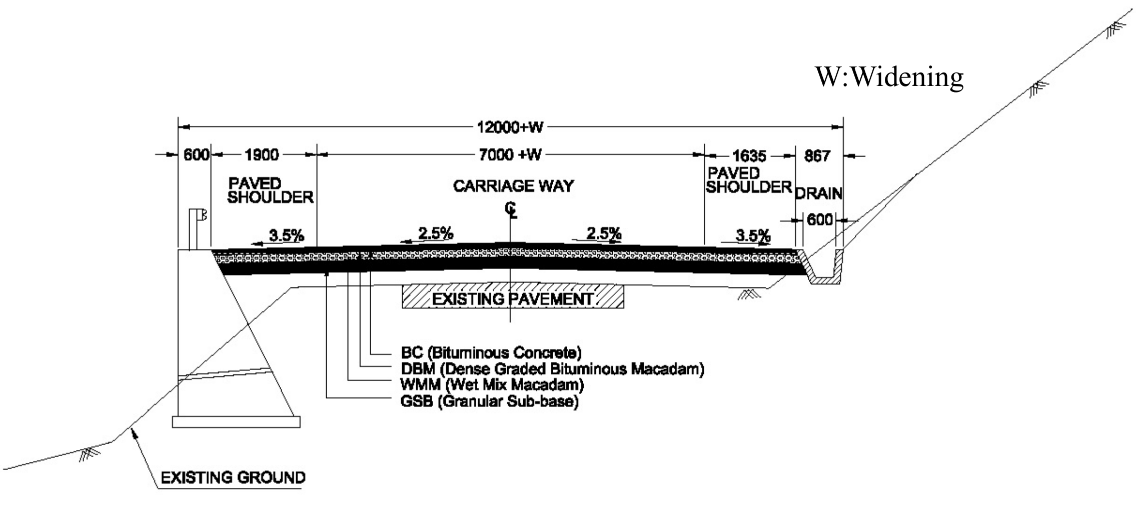
(e) Typical Cross Section

The typical cross section of the project is as given in Figure 7-1 for widening primarily to the hill side and Figure 7-2 for widening primarily to the valley side.



Source: JICA Study Team

Figure 7-1 Typical Cross Section for Widening Primarily to Hill Side



Source: JICA Study Team

Figure 7-2 Typical Cross Section for Widening Primarily to Valley Side

The minimum paved shoulder width is 1.5 m. However, the small width between the end of the paved shoulder and the side drain shall also be paved smooth surface drainage to the drain and also to avoid damaging this small unpaved area by the intrusion of water.

Similarly, when there is retaining wall in the valley side, the width between the end of the paved shoulder and the parapet of retaining wall shall also be paved for the same reason.

2) Bridges and Structures Design

(a) General

It is necessary for bridges on NH54 to provide functions adaptinged to the current nNational hHighway standards. If the existing bridge is adequate for based on the requirement of the current nNational hHighway, it can be retained with or without some repairing works. If the existing bridge is deemed to be inadequate, it should be replaced by ato new bridge. The necessity of bridge replacement should be carefully determined based onwith the following viewpoints:

(b) Existing Bridge Condition

According to IRC:5, the bridge is defined as a structure with span of more than 6m. On the road, several RC slab structures with masonry abutments whose span is approximately 5 m to 7 m are existing. In the study, such structure is classified as large slab culvert. This is explained in the chapter on cross drainage.

Hence, six existing bridges can be recognized in the target section of the Project.

Construction years are different across the bridges. For newly constructed bridges, road width and design load are in accordance with the national highway standard. Also, there are no issues in terms of soundness. On the other hand, old bridges provide only narrow width and light design load, and has deterioration. Hence, it can be proposed to replace the following three bridges with new bridges

a) 74+660 (Steel truss bridge in Chhing chip)

b) 190+190 (RC T-beam bridge in Maudarh)

c) 216+450 (RC slab bridge in Zobawk)

(c) New bridge planning

It is a new bridge plan located at valley point near Chhingchhip Town.

A bailey bridge is facilitated to pass over the valley at present. In the past, the route was positioned just on the slope with small radius curve. Due to the collapse of the slope on the previous route, the bridge is temporary provided to pass over the slope.

For the selection of bridge type, appropriate bridge type should be selected considering the condition of 130 m length and valley terrain at the site.

Steel arch type is frequently applied in valley terrain in the mountain area. It does not require pier construction at deep valley point through an arch rib built on rigid ground at both slopes. Manufacture of steel arch member in the factory enables comparably short construction period. The valley terrain and shape of arch rib are well harmonized and result in good landscape. As an alternative PC bridge, T-type rigid frame bridge, which is frequently used for similar scales, was compared. The steel arch type was superior based on the total evaluation; therefore proposed.

3) Earthworks / Slope Protection / Landslide Prevention Design

(a) Proposed Design Policy and Design Criteria

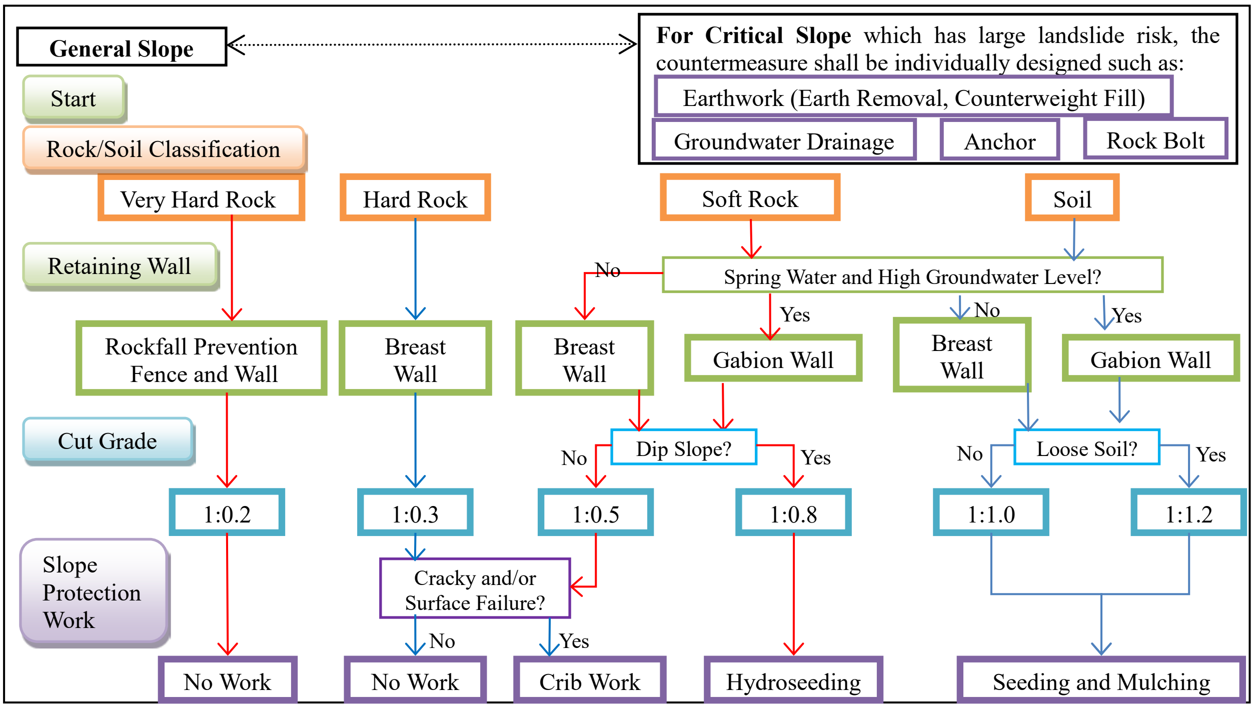
Against the general slopes, slope protection work, retaining wall, and grade of cut/embankment slope shall be planned based on natural condition including geology, geotechnics, and topography of each slope following the design criteria mentioned below. Especially, in order to prevent slope disaster, the design policies are established as below.

- Stable cut slope of soil and soft rock shall be covered with vegetation work.

- Unstable slope and unsuitable slope for vegetation shall adopt slope protection work.
- Height of one row of cut slope shall be 7 m at the maximum. In case exceeded, a berm with 1.5 m width shall be set between slopes.
- Total height of cut slope shall basically be 20 m at the maximum considering environment, construction workability, and disaster prevention.
- To prevent high cut slope, slope shall be cut steeper than stable grade and shall adopt slope protection work.
- Breast wall shall be built at the toe of slope on hill side to prevent small collapse and to maintain the side drain.
- Slope protection work shall be selected among common construction methods in India and Japan.
- Landslide site shall be avoided by road realignment as much as possible.
- If road cannot be planned not to pass the landslide area, landslide countermeasures such as groundwater drainage, counterweight fill, earth removal, and anchor work shall be examined for landslide stabilization.

Figure 7-3 summarizes the flowchart of selection of retaining wall type, cut grade, and slope protection works for cut slope on hill side. The critical slope which has large landslide with more than 1.0m depth and is expected to give huge damage to the road shall be individually surveyed and designed its countermeasures e.g. Earthworks including landslide removal and counterweight fill, groundwater drainage, anchor work, and rock-bolt work.

The JICA Study Team reviewed the existing manuals in India published by IRC (SP:48-1998, Hill Road Manual and Special Report, State of the Art: Landslide Correction Techniques, 1995), and started the design of the slope protection works. The criteria of earthworks such as cut and embankment based on the actual geotechnical condition at the site were improved. Because the manual is not enough for determination of dimension, specification of materials, and quantity of anchor work and reinforced earth wall, the JICA Study Team designed them utilizing the Japanese technical guideline for road works published by the Japan Road Association.

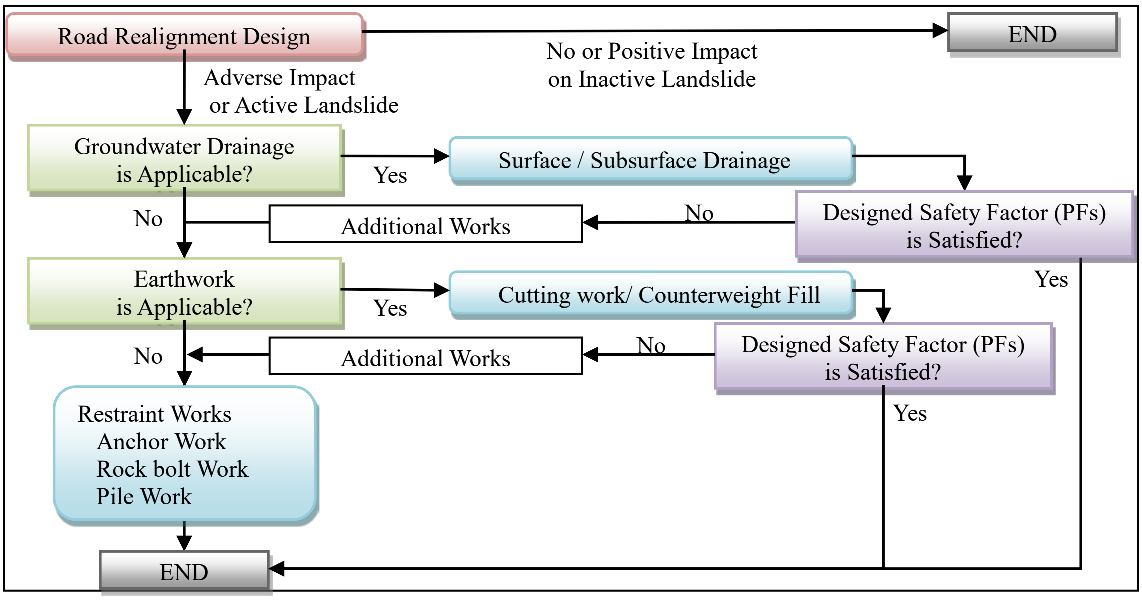


Source: JICA Study Team

Figure 7-3 Flowchart of Selection of Slope Protection Work for Cut Slope

(b) Landslide Prevention Design

Landslide prevention measure was planned and designed for the critical slopes identified in the slope inventory survey. Figure 7-4 shows the flowchart of selection of the landslide prevention measures.



Source: JICA Study Team

Figure 7-4 Flowchart of Landslide Prevention Measure

Table 7-5 Process of Safety Factor by Landslide Prevention Measures

Landslide Site	Groundwater Drainage		Earthwork		Restraint Work	
A	Not Applicable	0.980	Not Applicable	0.980	Anchor Work	1.100
B	Applicable	1.015	Not Applicable	-	Anchor Work	1.100
C	Applicable	1.023	Applicable	1.123	Not Necessary	-

Fs0=0.098, PFs=1.100

Source: JICA Study Team

4) Pavement Design

(a) Design Standards and Guidelines

Design guideline for flexible pavement is published by IRC as "Tentative Guidelines for the Design for Flexible Pavements (IRC37-2012).

(b) Pavement Design

Pavement design for NH54 is decided by NHIDCL in the meeting held on 14 August 2015 at NHIDCL as shown inTable 7-6.

Table 7-6 Pavement Conposition of NH54

Pavement Layer	Thickness (mm)
BC (Bituminous Concrete)	40
DBM (Dense Graded Bituminous Macadam)	100
WMM (Wet Mix Macadam)	250
GSB (Granular Sub-Base)	300
Total	690

Souce: JICA Study Team

5) Drainage Design

On the existing NH54, a large number of culverts exist that are crossing under the road. Because the road improvement includes road widening and alignment modification in most section, appropriate measures for culverts such as demolition/reconstruction or extension of existing culverts are considered to be undertaken in each location. However, it is considered that retention of existing culverts with extension measure is not practical under the situation. The reasons are explained below.

- Position shift due to road improvement: The culvert length needs to be extended due to road widening from existing 6-7 m to 12 m width. Also, the culvert position to be placed is changed because the road centerline is shifted by the alignment modification. Specially, it can be shifted to the valley side at every valley section where the curve radius is modified to be larger by alignment modification. Hence, the extension measure on existing culverts does not reduce the volumes compared with new construction. In addition, it makes the work more complicated.
- Condition of existing culvert: The existing structures constructed at the origin of the road are aging at nearly 50 years. It was confirmed by the investigation that these structures do not provide appropriate durability, structural features, and maintenance performance to be utilized in an improved national highway.

Moreover, it cannot be ensured that existing culverts are well durable for the next several decades. The replacement on one occasion of the road improvement would be much advantageous in terms of economy and serviceability of the road compared with frequent occasional replacement in the near future. Hence, it is general policy that existing culverts are demolished and new culverts are constructed.

The pipe culvert is proposed where the water discharge is comparably small. Box culvert is proposed where the water discharge is comparably large. The size is determined to satisfy the water discharge obtained by hydrological calculation.The quantity of each culvert for each section is summarized Table 7-7 below.

Table 7-7 Quantity for Each Culverts

	DPR Section-1	DPR Section-2	DPR Section-3	All NH54
Pipe culvert 1.2 m	693	724	675	2,092
(Type-A)	277	290	270	837
(Type-B)	416	434	405	1,255
Box culvert 2x2 m	8	22	69	99
Box culvert 3x3 m	2	9	11	22
Box culvert 4x4 m	0	2	7	9
Box culvert 4x6 m	0	3	2	5
Total	703	760	764	2,227

Source: JICA Study Team

6) Traffic Safety Facilities Plan

Traffic safety facilities are to be provided on roads or roadside to secure safety of all road users as well as nearby residents. In this study, considering road function of rural roads and usage situation of the target roads, the facilities listed in Table 7-8 are discussed for application to the project.

Table 7-8 Traffic Safety Facilities to be Applied for NH54

No.	Item	Remarks / Related Code
1	Traffic Sign	IRC67-2001, IRC7-1971, IRC-SP-31-1992
2	Road Marking	IRC35-1997, IRC-SP-31-1992, IRC2-1968
3	Road Delineator	IRC79-1981
4	Guardrail	
5	Street Furniture (Blinker, Road Stud/Cat's Eye)	MoRTH's Research Project R-63

Source: JICA Study Team

7) Road Appurtenances Plan

Road appurtenances are miscellaneous facilities for road users to take a rest and obtain road-related information as well as for road administrators to maintain their roads efficiently. In this study, considering road function of rural roads and usage situation of the target roads, the facilities listed in Table 7-9 are discussed for application to the project.

Table 7-9 Road Appurtenances to be Applied for NH54

No.	Item	Remarks / Related Code
1	Kilometer Stone	IRC8-1980, IRC26-1967
2	Boundary Stone	IRC25
3	Bus Bay	w/Bus Shed, IRC80-1981
4	Road Amenity	Public Toilet, Bazar Shed
5	View Spot	Parking space to be developed at locations with good view

Source: JICA Study Team

8) Preliminary Study of Bypass Route

The JICA Study Team has preliminarily designed NH54 lengthily stretching at about 380 km with widening to 12 m width in principle from its existing width of about 5 m. Because of its long stretch, the widening might trigger large impact to existing social environment especially in built-up areas along NH54. Therefore, the JICA Study Team has examined the applicability of bypass route for all the 48 built-up settlements identified along the target section of 380 km to mitigate its negative impact.

The result of the examination shows for all the target settlements in terms of the number of affected houses, population scale, and geometrical feasibility to mitigate the impact of these existing settlements along the designed alignment. The scores have been calculated to clarify the settlements where it is recommendable to construct the bypass route, without considering the set back option or any other options.

Based on the examination above, the four settlements below have scored high (more than 20 points) and are geometrically feasible. Therefore, it is recommendable to construct bypass route for avoiding densely populated area to mitigate the impact of resettlement as well as to secure smooth traffic coping with through traffic which have destinations to other settlements. Furthermore, in these four sections, the JICA Study Team recommended to apply an improvement of only 10 m road widening with black top pavement for the time being along the existing NH54 before completion of the bypass route. This recommendation can make few impacts to avoid resettlement or set-back of existing houses as much as possible.

1) Chhiahtlang
2) Serchhip
3) Hnathial
4) Lawngtlai

9) Preliminary Study of Spoil Bank

(a) General

Concerning the result of the preliminary design of NH54 of the JICA Study Team, the necessary volume of spoil bank has been calculated as shown in Table 7-10 where Sections 1, 2 and 3 at least require about 2.40, 2.44, and 2.47 million m^3 capacities, respectively.

Table 7-10 Required Volume for Spoil Bank

Highway No.	Sec.	Item	Unit	Volume of Generated Soil	Coefficient of Compation	Volume of Compacted Soil	Required Volume of Spoil Bank
				Cu.m		Cu.m	Cu.m
NH54	S1	Cut Soil	cu.m	3,442,909	0.9	3,098,618	2,400,495
		Fill Soil	cu.m			698,123	
	S2	Cut Soil	cu.m	3,710,629	0.9	3,339,566	2,437,522
		Fill Soil	cu.m			902,044	
	S3	Cut Soil	cu.m	3,560,596	0.9	3,204,536	2,465,129
		Fill Soil	cu.m			739,407	
	Total						7,303,146

Source: JICA Study Team

(b) Condition of Spoil Bank Selection

The JICA Study Team has examined and identified target locations which seem to have sufficient and required conditions for spoil bank construction. The following are assumed conditions for the suitable locations:

- To find out suitable place at every 5 km length along NH54 with following conditions:
  - Ground shape with concavity topography
  - Less ground gradient than 22 degrees which is assumed as average angle of spoil bank slope with necessary steps
  - No built-up area
  - No national sanctuary area
- To be able to construct the spoil bank with less than 30 m height

(c) Result of Examination for Spoil Bank Location

In accordance with the above assumed conditions, 115 locations in 381 km stretch of NH54 have been totally identified for spoil bank construction. There are 41, 32, and 42 numbers of spoil bank having about 2.43, 2.90, and 2.51 million m^3 capacities in Section-1, 2, and 3, respectively.

8. Preliminary Design of NH51 (Tura-Dalu)

NH51 (Tura – Dalu) project is prioritized as project in the Priority Group A as mentioned in Chapter 6 and this project is subjected to preliminary design to examine procurement and construction method, implementation schedule, project organization, capability of operation and maintenance, social and environmental conditions and evaluate project cost and feasibility.

(1) Natural Condition Surveys

1) Meteorological and Hydrological Surveys

For the application in the drainage design, the hydrological study based on meteorological and topographical conditions at the project area was conducted.

2) Topographic Survey

No additional survey was done by the JICA Study Team for the road alignment in NH51. The details of topographic survey data received by the JICA Study Team from the DPR Consultant are shown in Table 8-1.

Table 8-1 Details of Topographic Data Received from the DPR Consultant

SN	Items	Description
1	Applied coordinate system	Local Coordinate System, but the north direction seems to be correct
2	Existing road survey data	3D point data and 3D line connections for centerline and road edges for existing roads are available.
3	Topographic survey data	3D point data are available basically within the existing road width only and very limited beyond the road edges making it difficult to make representative digital terrain model for quantity calculations
4	Topographic data on hill side	No sufficient data is available for the hillside area
5	Topographic data on valley side	Data is available at few locations for limited width
6	Other features	Houses and other structures are not fully shown
7	Remarks	Data on hill slopes are limited.

Source: JICA Study Team

(a) Issues from the Review

- The coordinate system for the survey works is unknown.
- The topographic data in the hill and valley slopes are very limited

(b) Additional Data by the JICA Study Team

The alignment design approach of the JICA Study Team was to make a more balanced cut/fill design by shifting the alignment of DPR to the valley side. Since the topographic survey data was not available/very limited in the valley side, the slope inventory data conducted by the JICA Study Team was used to create the contour data in the hill slopes. However, the slope inventory was conducted at every 200 m-300 m interval only. Therefore, the accuracy of the contour created for the slopes through such data is very low.

3) Geological Survey

Similar to NH54, the JICA Study Team conducted slope inventory survey and road alignment soil survey for the design of slope protection work and pavement respectively in NH51.

(2) Preliminary Design

1) Road Geometric Design

(a) Design Policy and Design Criteria

The major objectives of the study are:

- To analyze the existing data/reports and review the existing detailed project reports (DPRs); and
- To examine procurement and construction method, implementation schedule, project organization, capability for operation and maintenance, social and environmental conditions and evaluate project cost and feasibility of target sections.

However, after review of the DPR data, it was concluded that the accuracy of topographic survey data and design standards were not properly applied.

Therefore, although not a part of the scopes of the study, redesign to the extent possible from the available data was attempted to come up with some meaningful quantities and cost of the project.

The following design policies are established:

- There were differences in the design concept with NH54 and with different road width, application of minimum design speed, minimum radius of horizontal curves, and application of transition curves. Therefore, uniformity in the design criteria is required for all roads in the project.
- Design of alignment shall be based on the policy of balance between application of minimum design standard and the terrain condition, such that the improved alignment does not largely deviate from the existing road.
- Widening shall be done with a concept to minimize the earthwork imbalance and alignment shall be shifted to the valley side up to the extent so as not to increase the construction cost sharply.
- At landslide-prone areas identified by the JICA Study Team, the widening side shall be decided based on the results of the study.
- Widening shall be done with a concept to minimize the relocation of houses along the existing road.
- As per the instruction of NHIDCL and IRC:37-1980, transition curves shall be designed for all horizontal curves. Exceptions maybe applied with the length of transition curves at difficult locations.

(b) Design Conditions

- As stated earlier, one of the major objectives of the study was to analyze the existing data/reports and review the existing DPRs.
- However, the alignment design by each DPR Consultant for each section and road was completely with different design policy, while uniformity in design was required.
- Widening of the existing road in DPR was exclusively designed for the hillside only, due to which very big excavation volume resulted, raising serious environmental concerns.
- Therefore, re-design of the entire project road was required by applying uniform design standards and making a more balanced cut/fill design by shifting the alignment to the valley side wherever practicable.
- However, the topographic data on the valley side was not available in DPR. The scope of the study did not include topographic survey of the road and it was also not possible to conduct the survey during the short duration of the study.
- The scope of the study included slope inventory survey where the roadside slopes were measured approximately by the use of a distance meter at an interval of about 200 m-300 m.
- The results from the slope inventory survey were used to create the digital terrain model of the valley side. However, since the data was available at an interval of every 200 m-300 m only, accuracy cannot be expected.
- Therefore, the re-design of the alignment was done with the constraints mentioned above which would affect to the desired degree of accuracy.

(c) Horizontal Alignment Design

The starting and ending chainages of each section in NH51 are given in Table 8-2.

Table 8-2 Start and End Chainages of Each Section in NH51

SN	Section	Start Chainage	End Chainage	Remarks
1	North	km 85+000	km 94+226.4	Revised design ends at same location as original km 95
2	South	km 101+000	km 143+289.9	The end point is recommended to extend until the intersection with NH62, which is 575 m south to the existing kilometer post

SN	Section	Start Chainage	End Chainage	Remarks
				of 145. According to PWD staff in Tura, DPR of this section towards the border of Bangladesh has already been completed under a separate contract from PWD. The data was requested to PWD but was not made available.

Source: JICA Study Team

The details of the revised alignment for NH51 are given in Table 8-3, showing the percentage of radius less than the value required for minimum design speed of 30 km/h. These were applied only at the residential area in the north section, which otherwise would require resettlement of large houses.

Table 8-3 Application Rates of Minimum Radius in Each Section of NH51

Section		R=20	20<R<25	R=25	25<R<30	R=30	Tot.R<30	Remarks
North	No	2	0	0	0	19	2	R=20 m at the residential area only
	(%)	2.1%	0%	0%	0%	20.2%	2.1%	
South	No	0	0	0	0	51	0	All horizontal curves satisfy minimum design speed of 30km/h
	(%)	0%	0%	0%	0%	11.9	0%	

Source: JICA Study Team

The quantities of excavation volume for the revised alignments are also given for each section in Table 8-4. The DPR design details were not made available.

Table 8-4 Excavation and Spoil Volume for the Revised Design by the JICA Study Team

SN	Section	Revised Design	
		Excavation Volume (m^3)	Spoil Volume (m^3)
1	All NH51	0.66 million	0.41 million

Source: JICA Study Team

(d) Vertical Alignment Design

- Minimum gradient is designed as 0.5% at cut sections for drainage.
- The ruling gradient is designed as 6% as per the design standard given in Section 7.2.3(1).
- The limiting gradient is 7% at difficult locations.
- The exceptional gradient is 8%, which is applied for unavoidable situations only and the maximum length is 100 m.

The length of the designed vertical profile grade range is given in Table 8-5 in percentage of the total length of each section is presented below.

Table 8-5 Length of Designed Vertical Profile Grade Range

SN	Section	Vertical Grade Range									
		≤0.5%	0.5%-1%	1%-2%	2%-3%	3%-4%	4%-5%	5%-6%	6%-7%	7%-8%	11%
1	North	5.8%	5.5%	5.0%	9.9%	5.7%	3.5%	6.0%	55.4%	2.2%	1.1%
2	South	7.5%	13.5%	18.2%	8.7%	14.2%	18.1%	13.8%	5.1%	1.0%	0%

Source: JICA Study Team

At the approach of the bridge from km 91+397 to km 91+497 in the north section, exceptional grade of 11% is applied for a length of 100 m due to unavoidable situations.

- The vertical grade higher than the ruling gradient of 6% but less than or equal to the limiting gradient of 7% was applied at a total percentage lengths of 10.6%, 8.2%, and 6.2% for Sections S1, S2, and S3, respectively.

- Exceptional gradient of 8% was applied at four locations (total of 400 m) each in Sections S1 and S2 and two locations (200 m) in Section S3.

(e) Typical Cross Section

The typical cross section of the project is basically the same as that for NH54.

2) Bridges and Structures Design

(a) Existing Bridge Condition

Fourteen existing bridges are identified in the project area of NH51. Construction years are different across the bridge. Carriageway width 7.5 m is roughly provided in all bridges. Aging deterioration is seen for all bridges except few new bridges. Hence, the proposal is for reconstruction of one bridge and replacement of superstructures for seven bridges as summarized below.

The bridge to be reconstructed ・・・1 location

(1) 140+690 (RC slab L=6.0 m)

The bridges' superstructure for replacement・・・6 locations

(2)90+077 (RC slab L=12.8 m)

(3) 91+385 (RC slab L=8.8 m)

(4) 103+240 (RC slab L=11.5 m)

(5) 137+825 (Side span of 3-span RC slab side span 2 nos x 9.0 m)

(6) 140+990 (3-span RC slab L: 3 x 9.7 m)

(7) 141+928 (RC slab L=7.5 m)

3) Earthworks / Slope Protection / Landslide Prevention Design

The JICA Study Team used the same design standards for earth works, slope protection, and landslide prevention measures for NH51 as NH54 mentioned in Clause 7.3.4 .

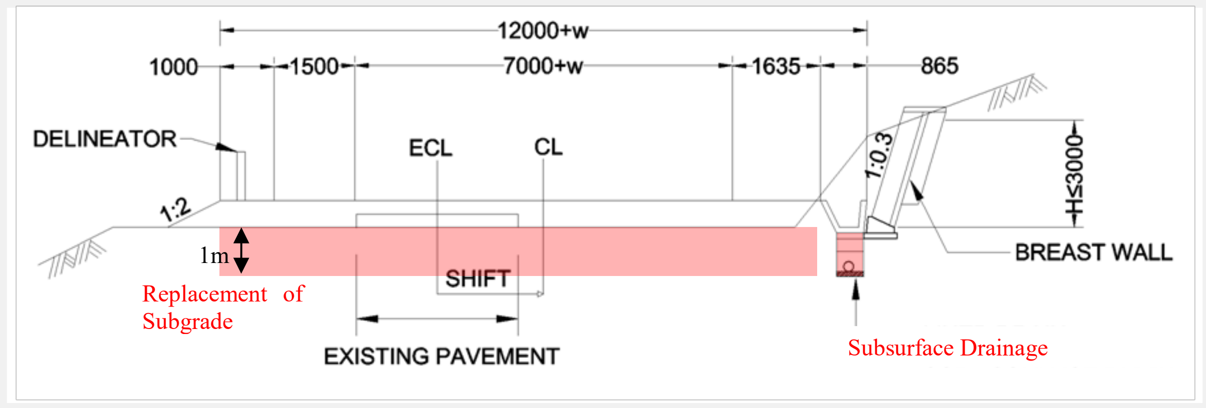
Slope along NH51 is covered by very loose quaternary alluvium. One concern is that slope failure and erosion have frequently occurred on cut slopes along NH51. Therefore, such loose soil slope shall be cut with 1:1.2 slope, which is gentler than IRC standard for landslide prevention as shown in Table 8-6. The cut slope shall be greened by seeding and mulching consisting of jute netting, including seeds which cover all over the slope and prevent erosion by rain water.

Table 8-6 Design Criteria of Cut Slope and Slope Protection Work

IRC Standard*		JICA Study Team Rock/Soil Classification		Cut Grade	Slope Protection Work
Classification	Cut Grade				
Ordinary Soil/ Heavy Soil	**1:1.0 ~ 1:0.5**	Soil	Dense Soil	**1:1.0**	Seeding and Mulching
			Loose Soil	**1:1.2**	Seeding and Mulching

*IRC: SP:48:1948 Clause 7.4
Source: JICA Study Team

The JICA Study Team identified a lot of road subsidence sites in the slope inventory survey, which was assumed to occur due to consolidation of loosened subsurface soil and high groundwater level except for embankment sliding. Therefore, replacement with 1.0 m thick subgrade and subsurface drainage are the planned countermeasures for sinking as shown in Figure 8-1.



Source: JICA Study Team

Figure 8-1 Typical Cross Section of Countermeasures for Sinking

4) Pavement Design

(a) Design Standards and Guidelines

Design guideline for flexible pavement is published by IRC as "Tentative Guidelines for the Design for Flexible Pavements (IRC37-2012).

(b) Pavement Design

Pavement design for NH51 is decided by NHIDCL in the meeting held on 14 August 2015 at NHIDCL as shown in Table 8-7.

Table 8-7 Pavement Conposition of NH51

Pavement Layer	Thickness (mm)
BC (Bituminous Concrete)	40
DBM (Dense Graded Bituminous Macadam)	70
WMM (Wet Mix Macadam)	250
GSB (Granular Sub-Base)	300
Total	660

Souce: JICA Study Team

5) Drainage Design

On the existing NH51, many culverts exist crossing under the road. Because road improvement includes road widening and alignment modification in most sections, appropriate measures for culverts such as demolition/reconstruction or extension of the existing ones are considered to be taken in each location. However, it is considered that retaining the existing culvert with extension measure is not practical for the situation. The reasons are explained below.

- Position shift due to road improvement : The culvert length needs to be extended due to road widening from existing 6-7 m to 12 m width. Also, the culvert position to be placed is changed because the road centerline is shifted by alignment modification. Specially, it can be shifted to the valley side at each section where the curve radius is modified to be larger by alignment modification. Hence, the extension measure on existing culverts does not reduce much the work volumes as compared with new construction. In addition, it makes the work more complicated.

- Condition of existing culvert : The existing original structures constructed at the beginning of the road are aged near to 50 years. It was confirmed by the investigation that these structures do not provide appropriate durability, structural features, and maintenance performance to be utilized in an improved national highway.

Moreover, it cannot be assured that existing culverts will be durable for next several decades. The replacement on this one occasion of road improvement would be of more advantage in terms of economy and serviceability of the road than frequent occasional replacements in the near future. Hence, it is the general policy that existing culverts are demolished and new ones are constructed.

Pipe culverts are proposed where the water discharge is comparably small, and box culvert is proposed where the water discharge is comparable large. The size is determined to accommodate the water discharge obtained by hydrological calculation. The quantity of each culvert for each section is summarized in Table 8-8.

Table 8-8 Quantity for Each Culvert

	Quantity for NH51
Pipe culvert 1.2 m	287
(Type-A)	115
(Type-B)	172
Box culvert 2x2 m	6
Box culvert 3x3 m	1
Box culvert 4x4 m	5
Box culvert 4x6 m	0
Total	299

Source: JICA Study Team

6) Traffic Safety Facilities Plan

Traffic safety facilities are to be provided on roads or roadsides to secure safety of all road users as well as nearby residents. In this study, considering the road function of rural roads and usage situation of the target roads, facilities listed in Table 8-9 are discussed for application to the project.

Table 8-9 Traffic Safety Facilities to be Applied for NH51

No.	Item	Remarks / Related Code
1	Traffic Sign	IRC67-2001, IRC7-1971, IRC-SP-31-1992
2	Road Marking	IRC35-1997, IRC-SP-31-1992, IRC2-1968
3	Road Delineator	IRC79-1981
4	Guardrail	
5	Street Furniture (Blinker, Road Stud/Cat's Eye)	MoRTH's Research Project R-63

Source: JICA Study Team

7) Road Appurtenances Plan

Road appurtenances are miscellaneous facilities for road users to take a rest and obtain road-related information as well as for road administrators to maintain their roads efficiently. In this study, considering the road function of rural roads and usage situation of the target roads, facilities listed in Table 8-10 are discussed for application to the project.

Table 8-10 Road Appurtenances to be Applied for NH51

No.	Item	Remarks / Related Code
1	Kilometer Stone	IRC8-1980, IRC26-1967
2	Boundary Stone	IRC25
3	Bus Bay	w/Bus Shed, IRC80-1981
4	Road Amenity	Public Toilet, Bazar Shed

Source: JICA Study Team

9. Preliminary Project Cost Estimate

(1) NH54

Unit costs set out based on the SOR 2014 were applied. Price escalation from 2014 up to the time of bidding was estimated to be 5% and was added to the construction cost.

(2) NH51

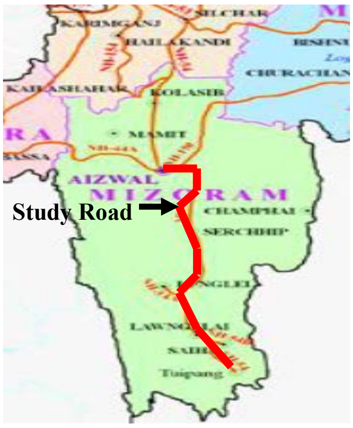
Unit costs set out based on the SOR 2014 were applied. Price escalation from 2014 up to the time of bidding was estimated to be 5% and was added to the construction cost.

10. Industrial Potential Analysis

(1) NH54

The Aizawl–Tuipang Road Section (approximately 381 km) is part of NH54, and is located in Mizoram State. Due to its location, the state assumes a prominent importance vis-à-vis the possibility of movement of goods, services, and trades with Southeast Asian countries. The integration of this road section under the construction of the Kaladan Project would open up a second major transport link to the North-East Region benefitting the southern part of the region.

The Study Corridor is considered as an area abutting the road section (NH54) under study where the influence of the road improvement can be felt by way of supporting the overall economic activities in the corridor. It may be observed (Figure 10-1) that the study road alignment runs almost through the entire state and traverses through or close to all the districts of Mizoram State.

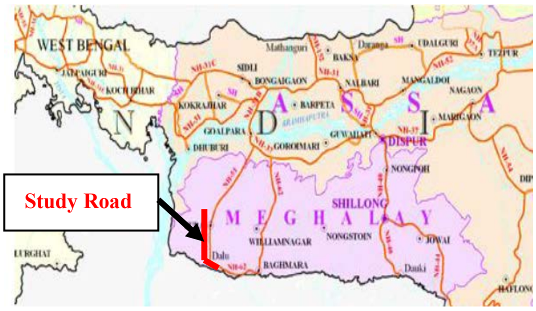


Source: JICA Study Team

Figure 10-1 Study Corridor – NH54

(2) NH51

The Tura–Tuipang Road section (approximately 54 km) is part of NH51 and is located in Meghalaya State. Due to its location, the state assumes a prominent importance vis-à-vis the possibility of movement of goods, services, and trades with Bangladesh and Assam State, and beyond the rest of India.



Source: JICA Study Team

Figure 10-2 Study Corridor – NH51

The Study Corridor is considered as an area abutting the road section (NH51), where the influence of the road improvement can be felt by way of supporting the overall economic activities in the corridor. It may be observed (Figure 10-2) that the road alignment runs almost through the southwest part of the state and traverses mainly through the South Garo Hills District and closes to the other two districts, viz., West Garo Hills and East Garo Hills in Meghalaya State.

11. Implementation Schedule

(1) Formulating Project Implementation Plan

JICA funded North – East Road States Network Improvement Project will be implemented by NHIDCL. JICA and NHIDCL schedule to sign Loan Agreement of NH-51 and NH-54 on March 2016. For examination of formulating the Project Implementation Schedule, the following control points need to consider;

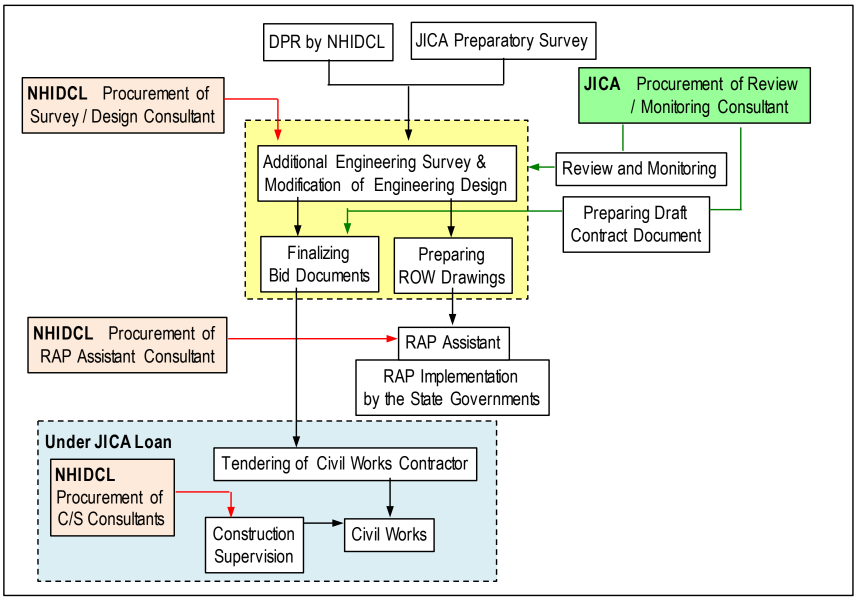
i). From the development policy of North – East States by GoI, NHIDC desires to commence the construction works of NH-51 and NH-54 at least until Year-2017.

ii). DPR designs as well as the preliminary design in this study are based on the topographic survey data conduced in the DPRs, of which coverage and accuracy are not sufficient to implement proper land acquisition and construction works.

iii). Therefore, before implementing tender of civil works and land acquisition, the additional topographic survey shall be required to update the road alignment design.

iv). In order to commence the civil works from Year-2017, NHIDCL should procure the Survey / Design Consultant for updating road alignment design and preparing ROW drawings for land acquisition as soon as possible.

v). For the updating road alignment design, JICA is recommended to procure the Review / Monitoring Consultant for the Survey / Design Consultant procured by NHIDCL, since the consultant industry in India has not sufficient capability in the engineering of slope design.



Source: the JICA Study Team

Figure 11-1 Conceptual Framework of Implementing Procedure for NH54 and NH51

Considering with the above points, the Study Team recommend the framework of implementing procedure of the Project as shown in Figure 11-1.

(2) Proposed Implementation Schedule

Considering with the above points, the Study Team examined construction and project implementation plan with commencement of construction from year 2017.

(3) Proposed Scope of Works for Survey/Design Consultant procured by NHIDCL

The JICA Study Team recommends the following engineering surveys shall be conducted to update the road alignment design and to finalize the bid documents for the civil works of NH-51 and NH-54;

A. Engineering Survey

i. Additional Topographic Survey

ii. Additional Geological / Geotechnical Survey

B. Modification of Engineering Design

Engineering design in DPR is principally pursued, and if necessary design modification resulted from the additional survey shall be incorporated into the engineer design in DPR.

JICA will procure a consultant to review and monitor entire process of the above survey and design. Survey/Design Consultant shall coordinate with JICA Consultant to accomplish the scope of works.

12. Environmental and Social Considerations

(1) Introduction

The environmental and social consideration in the preparatory study has been carried out in two-stages. In the first stage, the 10 study roads and bridges were screened from environmental and social point of view. Along with consideration from technical and economic points of view, the process informed the selection of two priority projects (NH54 and NH51). The screening was carried out through field visits and review of literatures. For study roads in Manipur and Nagaland (5, 6, 7 in the Table 12-1), however, the review was done only by a review of literature due to security concern in the area.

Table 12-1 List of Study Roads & Contents of Request

No.	Target Roads	Target Length	Request Type
①	Mizoram State, Aizawl – Tuipang Section, NH54	381km (Approx.)	Improvement
②	Meghalaya State, Dudhanal – Dalu Section, NH62	183km (Approx.)	Improvement
③	Meghalaya State, Tura – Dalu Section, NH51	54km (Approx.)	Improvement
④	Meghalaya State, Shillong – Dawki Section, NH40	84km (Approx.)	Improvement
⑤	Manipur State, Imphal – Jiribam Section, NH53	221km (Approx.)	Improvement
⑥	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	138km (Approx.)	Improvement
⑦	Manipur State, Ukhrul – Tadubi Section, NH102A	115km (Approx.)	Improvement
⑧	Tripura State, Manu - Simlung Section NH44	110 km (Approx.)	New / Improvement
⑨	Assam State, Badarpurghat Bridge near Silchar	360m	Improvement
⑩	Assam State, Dhubri – Phulbari Section	Bridge: 18km (Approx.) Access Road: 21km (Approx.)	New Bridge

Source: JICA Study Team

A meeting with selected officials and academia has been carried out to exchange opinions/concerns/suggestions.

Table 12-2 Summary of Stakeholder Consultations in the Screening Process

Date	People met	Relevant Road	Contents/Issues Discussed
02/03/15	Mr Liandawla, Chief Conservator of Forests, Chief Wildlife Warden Mizoram	NH54	Confirmed the location of National Park, wildlife sanctuary and other areas of ecological importance in the state and its distance from the study road Discussed recommended approach to protect natural environment in infrastructure project
16/05/15	Mr. A. K. Srivasata, I.F.S. PCCF, & Chairman, Meghalaya State Medicinal Plants Board	NH51, 62, 40	Collected the list of medicinal plants identified in Meghalaya and its use by local people

Date	People met	Relevant Road	Contents/Issues Discussed
12/04/15	Mr. Tanmay Samajdar, Senior Scientist, Krishi Vigyan Kendra, ICAR Research Complex for NE Hill Region.	All NE (with special attention to NH51, 62, and 40)	Collected information about traditional agricultural practices in Meghalaya and NE in general Current trend of Jhum in Meghalaya and NE in general
16/05/15	Prof. (Dr.) Saroj K. Barik, HOD, Dept. of Botany, North Eastern Hill University, Shillong	All NE (with special attention to NH51, 62, and 40)	Collected information about traditional agricultural practices in Meghalaya and NE in general Current trend of Jhum in Meghalaya and NE in general
10/04/15	Mr. R. K. Marak, DFO, Social Forestry Department, MFS	NH51, 62,	Collected information about community forest along the study roads in Garo Hills and how such forest is managed
16/05/15	Dr. M. Kit, HOD, Environmental Science, MLCU, Shillong	NH51, 62, 40	Collected information about environmental conditions in Meghalaya Collected information about elephant corridor (area earmarked as a crossing point of wild elephants) along NH62
10/04/15	Chief Wild Warden, Tura, Meghalaya, MFS, Tura	NH51, 62	Confirmed the location of National Park, wildlife sanctuary and other areas of ecological importance in Garo Hills and its distance from the study road Discussed recommended approach to protect natural environment in infrastructure project
03/07/15	Mr. N. Kalita, Executive Engineer, Water Resource Department, Dhubri	Dhubri	Collected information about migratory birds in the area and other information related to river ecosystem
03/07/15	Mr. Khandakar Mustafa, Secretary, Boat Association, Jogmaya Ghat, Dhubri	Dhubri	Collected information about local livelihood of boaters in Dhubri area and discussed how the new bridge might affect their livelihood
05/07/15	Mr. Pranjal Buragohain, Green Tech. Environmental Engineers & Consultants, Guwahati, Assam	Dhubri/ Badarpurghat	Discussed recommended practices in infrastructure project in general, with particular attention to bridge construction
06/07/15	Superintending Engineer, NH Division, Agartala	NH44	Discussed road condition of NH44 and surround environment

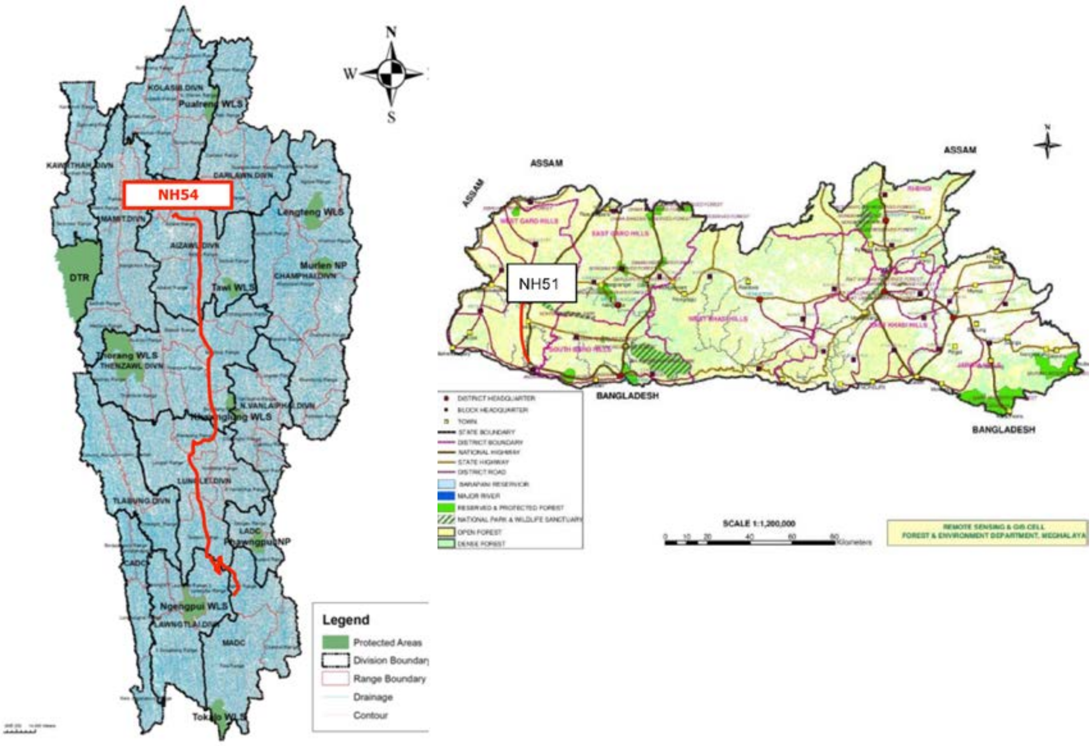
Source: JICA Study Team

The result of the screening selected NH54 in Mizoram and NH51 in Meghalaya as priority projects. The Project is classified as Category A under the JICA Guidelines for Environmental and Social Considerations. On the other hand, as per the EIA Notification dated 14.09.2006 (as amended in August 2013) by Ministry of Environment and Forest, EIA is not required for the expansion of NH54 and NH51. But as expansion of NH54 and NH51 shall cause large resettelement RAP is necessary. Following the screening, as the next stage for the environmental and social consideration study, the EIA and RAP studies have been carried out for both NH51 and NH54 based on their preliminary design. It should be noted that in the state of Mizoram, the tribal (Scheduled Tribe: ST) population constitutes about 95% of the total population and the overwhelming majority of the affected people. While they are considered indigenous to India, they are not considered a minority in the state of Mizoram. While they hold traditional culture, including shifting cultivation in forest called jhum, they freely interact with the non-ST and other tribal population within and outside community and not considered isolated. Therefore OP4.10 has been incorporated into the RAP study. The EIA and RAP reports were disclosed to the residents in local languages (NH54=Mizo, NH51=GAR) to gain better comprehension.

(2) EIA Study

For the screening mentioned above, the scoping matrix for mountain roads was used due to the length of the target route. The EIA study for NH54 and NH51 set this as a premise and prepared a scoping matrix to fit the social and environmental condtions investigated through field visits and review of literatures. Mitigation measures were studied based on the evalution of the scoping matrix. The air and water quality fulfill the indian standards as no polluntants were observed near the area. But at multiple survey locations such as school facilites around the area, noise pollutions exceeded the indian standard values and therefore confirmed the necessity of speed limits and noise barriers especialy around facilities such as schools and hospitals.

The region is susceptible to landslides due to the geology and weather conditions. Also as spills from spoil banks could risk damaging forest and farms, it is necessary to take special care of slope protection. The expansion of NH54 and NH51 does not directly affect any sanctuaries, national parks or forest preserves as shown in the figure below. Fauna assessment along NH54 found one “Vulnerable” species as per IUCN Red List, the Slow Loris and therefore proper care must be taken for conservation of the ecosystem. While the premise is to study an alignment that minimizes deforestation, construction of road extensions and spoil banks could cause deforestation along the route, plantation shall be discussed with forest departments of each state. To attain the most benefit out of the plantation and minimize the affect to the ecosystem, the location shall be selected carefully and local breeds shall be used. The affects of traffic shall also be monitored and additional plantation shall take place if necessary.



Source: Department of Environment and Forests, Mizoram State (Left), Forest and Environmental Department, Meghalaya State (Right)

Figure 12-1 Sanctuary, national parks, and forest preseves in Mizoram (Left) and Meghalaya (Right)

While NHIDCL is the implementing body for the improvement project for NH54 and NH51 due to the distance and different schedules and organization for implementation, different EMP and monitoring plans are to be prepared and implemented for each project.

(3) RAP Study

For the expansion of NH54, as per the preliminary ROW design, the project will affect 2,037 households (1,971 households whose houses will be affected and 66 households whose businesses will be affected). The total number of affected people is 8,230. Out of these, 1307 households (1,265 households whose houses will be affected and 42 households whose businesses will be affected) will have to be relocated. Based on the preliminary ROW design, remaining 730 households will be affected but relocation will not be necessary. For the expansion of NH51, as per the preliminary ROW design, 367 households (173 households whose houses will be affected and 194 households whose businesses will be affected) will be affected by the project. The total number of people is 1,820. Out of these, 319 households (161 households whose houses will be affected and 158 households whose businesses will be affected) will have to be relocated. The remaining 48 will be partially affected but relocation will not be necessary.

The percentage of people under the poverty line in Mizoram is 23% in the rural area and 7.9% in the urban area and in Meghalaya it is 12.5%, and 9.3% respectively. However, surveys found out that over 40% of respondents or 446 households considered themselves as BPL household which may reflect their real coping capacity against negative impacts. It also found that the main sources of income in the project influence area are agriculture and small business enterprises. The population has limited capacity to benefit from the livelihood opportunities created under the development projects or any government sponsored program. One of the key principles of the RAP is to ensure that the livelihood of PAPs will be improved, or at least restored compared with the pre-project level. The project will provide income restoration opportunities by way of skills development training and linkage with the ongoing government schemes for this purpose. The rehabilitation plan will therefore aim to support PAPs to regain their previous living standards by creating income generation opportunities as well as improving PAPs capacity to benefit from various economic opportunities developed by the project. The plan shall cater also to needs of households with women as the head of the household and shall ensure the participation of women during the implementation phase as many such households exist in both areas.

In Mizoram a road improvement project of similar scale, targeting the state highway in Lunglei and Lawngtali district, the Regional Transport Connectivity Project funded by the World Bank has prepared a RAP report in 2014. Similarly, in Meghalaya an ADB funded road improvement project has prepared an RAP report, satisfyin international standards. The resettlement policy and entitlement matrix proposed in the RAP of the expansion of NH54 and NH51 builds on a WB-funded project with revisions/updates based on changes/differences in socioeconomic conditions and new provisions laid out in LARR 2013. Implementation of RAP and the rehabilitation plan shall be internally monitored every 3 months and externally monitored every 6 months. An audit shall take place when implementation of RAP is completed and PAPs have either improved or regained their living standards.

Following the principles of the FPIC, stake holder meetings were held leading up the preparation of the RAP to better reflect the needs and concerns of the residents. Meetings were held in 5 areas for NH54 and was held twice in each area (second meeting was split into 2 at Lunglei where there were many affected PAP). In NH51 it was separated in 3 blocks and meetings were held twice in each block. Residence were notified through letters and phone calls beforehand and were asked to participate the meetings. Details of the Project and the anticipated impacts were explained. Furthermore, procedures for land acquisition and the rights of the residents were also discussed. Below are the pictuers taken during the meetings.

Source: JICA Study Team

Figure 12-2 Pictures of Stake Holder Meetings (Left: NH54, Right: NH51)

The improvement of the road network gained widespread support at both regions during the meetings as it was considered a high priority even among residents. The majority of residents opted for compensation through cash than land. As residents of villages with large scale relocation suggested the construction of bypass rather than expansion of the existing roads during the stakeholder meetings, bypasses have been considered for 4 locations (Refer to Vol.2).

13. Project Evaluation

(1) Project Evaluation of NH-54 Road Section (Mizoram)

(a) Targeted Outcome

Quantitative Effects

The quantitative effects of the improvement of NH54 road section has been evaluated in Table 13-1. The value for five performance parameters was estimated for the base year (2015) and the target year 2022, shortly after the completion of the improvement works.

Table 13-1 Targeted Outcome for Study Road Section of NH54

Performance Indicators	Baseline (2015) Value	Target Year (2022) - Value
Average Travel Speed (km/hour)	12	40
Average Annual Vehicle Operating Cost (INR/ Vehcle - km)	24	15
Traffic Volume (PCU / day)	835	3,103
Landslide beside Road (Time / year)	Year 2013: No data Year 2014: No data	-
Accidents (Fatality Rate per Traffic Volume)	Year 2013: 0.01268% Year 2014: 0.02052%	50% reduction in accidents
Economic Internal Rate of Return (%) - EIRR	12.43%	

Source: JICA Study Team

Qualitative Effects

1) The road widening shall be done within the ROW of the existing road corridor, with no or minor deviations. Thus the proposed improvement of road will not pose any environmental and social issues related to construction activities.
2) The improvement of road in terms of capacity and design will result in lowering the fuel consumption by vehicles and thereby reducing the adverse impact on the environment.
3) The above improvement measures shall also result in lowering noise pollution created by moving vehicles.

(2) Project Evaluation of NH-51 Road Section (Meghalaya)

(a) Targeted Outcome

Quantitative Effects

The quantitative effects of the improvement of NH51 road section have been evaluated in Table 13-2. The value for five performance parameters was estimated for the base year (2015/ 2017) and the target year 2022, shortly after the completion of the improvement works.

Table 13-2 Targeted Outcome for Study Road Section of NH51

Performance Indicators	Baseline (2015) Value	Target Year (2022) - Value
Average Travel Speed (km/hour)	15	40
Average Annual Vehicle Operating Cost (INR/ Vehicle - km)	30	15
Traffic Volume (PCU / day)	3,023	5,577
Landslide beside Road (Time / year)	Year 2013: 15 Year 2014: 53	90% reduction
Accidents (Fatality Rate per Traffic Volume)	Year 2013: 0.00041% Year 2014: 0.00010%	50% reduction in accidents
Economic Internal Rate of Return (%) - EIRR	14.38%	

Source: JICA Study Team

Qualitative Effects

1) The road widening shall be done within the ROW of the existing road corridor, with no or minor deviations. Thus, the proposed improvement of road will not pose any environmental and social issues related to construction activities.
2) The improvement of road in terms of capacity and design will result in lowering the fuel consumption by vehicles and thereby reducing the adverse impact on the environment
3) The above improvement measures shall also result in lowering noise pollution created by moving vehicles

14. Conclusions and Recommendations

(1) Effects of the Project on Development and Road Network in North Eastern States

1) The JICA Study Team examined the viability of NH51 and NH54 projects by reviewing the contents of DPR study as well as by linking it to the present traffic conditions, as of 2015. As a result, the JICA Study Team confirmed that the project properly met the SARDP-NE targets of development of the region through improvement of connectivity. The possibility of access from NH54 project to Kaladan Multimodal Transit Transport Project was confirmed. In this regard, NH54 project can be a prospective one to work with not only on road networks in the region but also with other transport systems.
2) According to the results of the traffic study, project costs and economic analysis of the project, EIRR of the base case of NH54 and NH51 projects are estimated at 12.43% and 13.64%, respectively.

(2) Confirmation of Appropriateness of the Project Components

1) The JICA Study Team reviewed the outcomes of DPR and environmental-related documents for the NH54 and NH51 projects and confirmed that some contents of the outcome had not been prepared in accordance with the JICA procurement guidelines.
2) After the JICA Study Team reviewed the preliminary design in DPR, it was confirmed that the design concept for alignment design does not well consider the environmental impact and natural disaster prevention. The JICA Study Team introduced the design concept for the environment and disaster prevention such as earth balanced alignment design and advanced

slope protection design as introduced in developed countries, as well as spoil bank to provide flat land for promotion of effective use of disposal soil.

3) After checking the number of design drawings, it was found that the area of topographic data is not sufficient on transverse direction and ground line is not accurate. Therefore, the JICA Study Team recommended to DPR Consultant to supplement and improve the topographic data. It was likewise recommended for DPR Consultant to revise DPR design based on the improved topographic data and the recommended design concept by the JICA Study Team. The DPR Consultant agreed to do so.

4) As a result of the review of the cost estimate prepared by DPR Consultant, some assumed the conditions such as material transportation, etc. are not unified. The JICA Study Team provides the cost data of advanced slope protection works which is introduced to the DPR Consultant for their cost estimate. The DPR Consultant corrected the estimates based on the comments made by the JICA Study Team.

5) The JICA Study Team examined the construction and implementation plans.

6) The JICA Study Team conducted surveys on NHIDCL's institutional structure, annual budget, and maintenance of the existing roads under their administration. As a result of the surveys, it was confirmed that NHIDCL has just started their organizational functions; and the maintenance system by NHIDCL is under consideration. Therefore, the JICA Study Team proposes an institutional structure for maintenance of the project road in consideration of importance of maintenance aiming to disaster prevention.

7) The JICA Study Team reviewed the EIA related activities on environment and social consideration, and confirmed the present condition of the environment (water quality, air, noise, vibration). In addition, the JICA Study Team carries out identification of PAPs based on the site survey with the use of design drawings, and social interview survey along the project road to prepare the draft RAP. The draft EIA and RAP are prepared in accordance with the JICA Environmental Guideline. To ensure smooth implementation of RAP works during project implementation, preparation of an accurate RAP drawing is essential.

(3) Recommendations

1) As a whole, the JICA Study Team confirmed the outcomes of the DPR design made by the DPR Consultant. It is desirable for NHIDCL to implement bid document preparation based on the improved topographic data through procurement of competent consultants that consist of qualified engineers having experiences in design and construction supervision on advanced slope protection, of which construction will be the first in India.

2) In relation to the revision of design for the bid documents based on improved topographic data, preparation of accurate RAP drawing is essential to ensure smooth implementation of RAP works during project implementation.

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The remarkable economic growth of India, located in South Asia, is widely known to the world today. Good progress of development of infrastructures in the transport sector, including strengthening of the connection between major cities, has made this economic growth possible. Especially, road is one of the most important modes to deal with mostly for domestic transportation activities along with railway, because road transportation constitutes 85% of total passengers while railway serves 60% of total freight. However, strengthening of traffic infrastructures in mountainous areas has not progressed smoothly due to financial and technical issues, while the reinforcement of the main highways in the plain areas has been undertaken with the acceleration of economic growth of India.

Particularly, only 28.5% (63.4% is the average in the whole country) of the roads in the North-Eastern States is paved and only 53% of national highways has more than two lanes. This is because the North-Eastern States are located far from the mainland of India as well as the access road to reach the borders with neighboring countries is undeveloped, considering that the Government of India (hereinafter referred to as "GOI") does not approve the agreement to make transportation with neighboring countries available except for particular countries to avoid security risk. Furthermore, the North-Eastern States area has severe natural conditions such as steep mountainous geography (most of the state is located in hilly area) and high rainfall area (more than 10,000 mm rainfall per year was recorded, particularly in Mizoram). Therefore, it is a key issue how to prevent or reduce road closure caused by natural disasters to achieve the economic growth in these states.

GOI raised the "Special Accelerated Road Development Programme for North East", which was committed in the "Twelfth Five Year Plan (from April, 2012 to March, 2017)", to cope with the abovementioned problems through the improvement of national highways connecting major cities within the North-Eastern States.

Based on such background, GOI requested the Government of Japan (hereinafter referred to as "GOJ") to provide loan assistance in carrying out the improvement of existing roads in eight sections, repair of two existing bridges, and construction of one new bridge within the six states of the North-Eastern States in India.

1.2 Objectives of the Study

The major objectives of this study are:

- To analyze present conditions and prioritization of target roads under the Study;
- To analyze existing data/reports and review the existing Detailed Project Report (hereinafter referred to as "DPR"); and
- To examine procurement and construction method, implementation schedule, project organization, capability for operation and maintenance, social and environmental conditions, and evaluate project cost and feasibility of target sections.

1.3 Study Roads and Contents of Request

The Study Area of this Project is the 11 roads located in six states of the North-Eastern States (including Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) as listed in Table 1.3-1.

Table 1.3-1 Study Roads and Contents of Request

No.	Target Roads	Target Length	Request Type
①	Mizoram State, Aizawl – Tuipang Section, NH54	381 km (Approx.)	Improvement
②	Meghalaya State, Dudhanal – Dalu Section, NH62	183 km (Approx.)	Improvement
③	Meghalaya State, Tura – Dalu Section, NH51	54 km (Approx.)	Improvement
④	Meghalaya State, Shillong – Dawki Section, NH40	84 km (Approx.)	Improvement
⑤	Manipur State, Imphal – Jiribam Section, NH53	221 km (Approx.)	Improvement
⑥	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	138 km (Approx.)	Improvement
⑦	Manipur State, Ukhrul – Tadubi Section, NH102A	115 km (Approx.)	Improvement
⑧	Tripura State, Manu - Simlung Section NH44	110 km (Approx.)	New / Improvement
⑨	Assam State, Badarpurghat Bridge near Silchar	360 m	Improvement
⑩	Assam State, Koliabhomora Bridge near Tezpur	2.5 km	Improvement
⑪	Assam State, Dhubri – Phulbari Section	Bridge: 18 km (Approx.) Access Road: 21 km (Approx.)	New Bridge

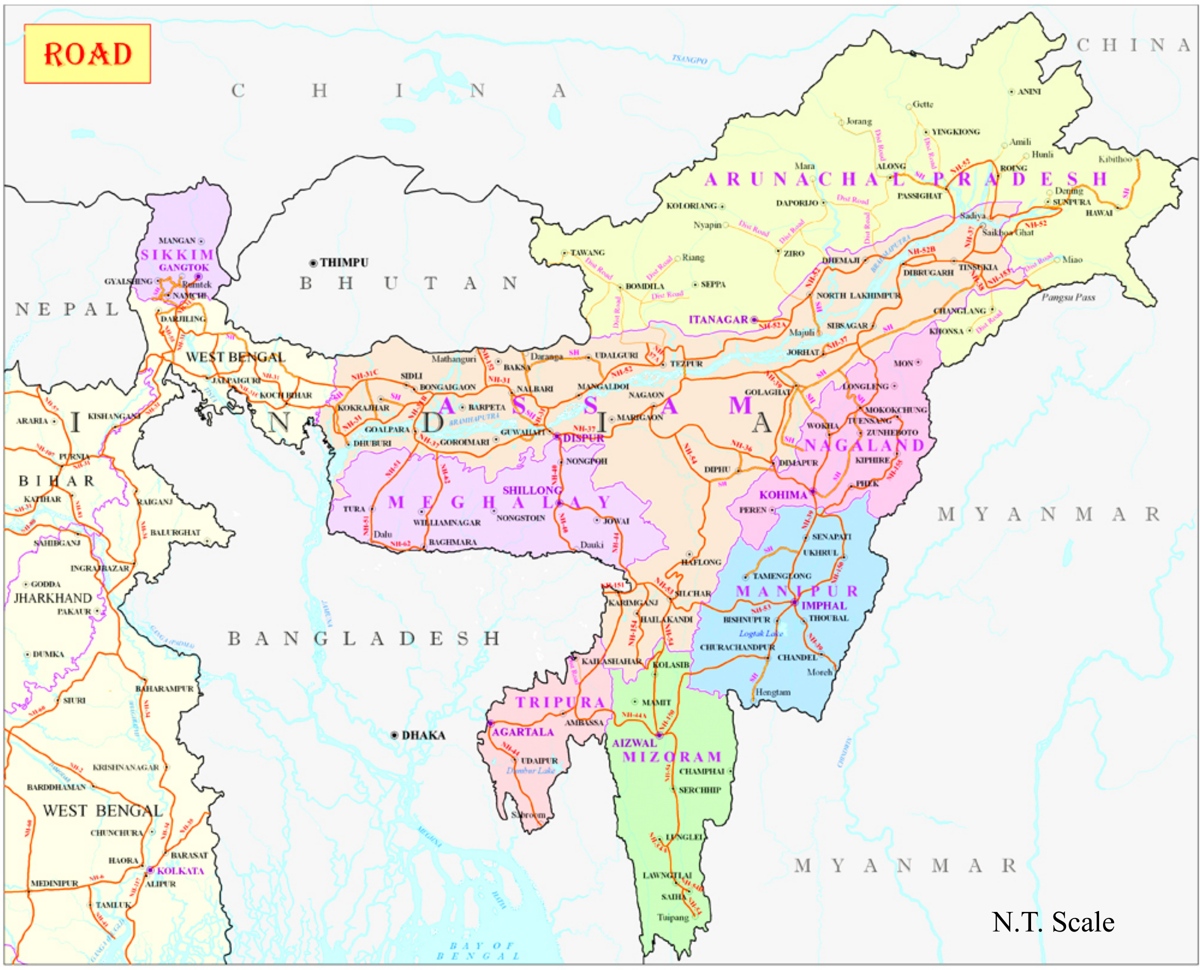
Source: JICA Study Team

CHAPTER 2 PRESENT CONDITION OF THE STUDY AREA

2.1 Present Status of Highway Network in the Study Area and Neighboring Countries

2.1.1 Highway Network in North-Eastern States

Highway network in the subject six states of the Study consists of approximately 391,000 km highways. The highways are classified into national highway, state highway, and other highway administrated by the state's Public Works Department (hereinafter referred to as "PWD"). Total length of the national highway network in the Study Area is 9,770 km as shown in Table 2.1.1 and the network mainly connects state capitals and major districts, as well as international cross border network as shown in Figure 2.1.1.



Source: Ministry of Development of North Eastern Region

Figure 2.1-1 National Highway Network in North Eastern Region

Table 2.1-1 Numbers and Lengths of National Highways in North Eastern States

States	National Highway Nos	Total Length (km)
Assam	31, 31B, 31C, 36, 37, 37A, 37E, 38, 39, 44, 51, 52, 52A, 52B, 53, 54, 61, 62, 117A, 127B, 127C, 127D, 127E, 151,152, 153, 154, 315A, 329, 427, 627, 702, 702C, 715A	3,783
Manipur	39, 53, 102A, 102B, 102C, 129A, 137, 137A, 150, 155, 702A	1,745
Meghalaya	40, 44, 51, 62, 127B	1,204
Mizoram	6, 44A, 54, 54A, 54B, 102B, 150, 154, 302, 306A, 502A	1,381
Nagaland	36, 39, 61, 129A, 150, 155, 702, 702A, 702B	1,080
Tripura	44, 44A, 108A, 208	577
Total		9,770

Source: Ministry of Road Transport and Highway

Table 2.1-2 Routes and Lengths of National Highways in North Eastern States

NH No.	Route	Length (km)
	Assam	
31	W.B. Border - Gouripur - North Salmara - Bijni - Nalbari - Rangia - Charali Amingaon (NH-37)	307.75
31B	North Salmara - Abhayapuri - Jogighopa (NH-37)	19.66
31C	W.B. Border - Kochugaon - Sidli - Bijni (NH-31)	93.00
36	Nagaon - Dabaka - Amlakhi - Nagaland Border	154.20
37	Goalpara (NH-31B) - Paikan - Boko - Guwahati - Dispur - Sonapur - Raha - Nagaon - Bokaghat - Numaligarh - Jorhat - Jhanzi - Sibdagar - Morahat - Dibrugarh - Tinsukia - Makum - Saikhoghat -Arunachal Pradesh Border	685.33
37A	Kuwari Tal (NH-37) – Tezpur (NH.-52)	23.10
38	Makum - Ledo - Likhapani	56.35
39	Numaligarh - Garampani - Naojan - Bokajan - Nagaland Border	106.78
44	Meghalaya Border - Badarpur - Karimganj - Patharkandi - Tripura Border	110.77
51	Paikan - Meghalaya Border	21.87
52	Baihata Charali - Mangaldai - Dhekiajuli - Tezpur - Gohpur-Bander Dewa - North Lakhimpur - Dhemaji - Kulajan - Arunachal Pradesh Border	540.76
	Arunachal Pradesh border - near Saikhoaghat (NH-31)	
52A	Gohpur - Arunachal Pradesh Border	9.23
	Arunachal Pradesh border - Bander Dewa	
52B	Kulajan - Dibrugarh - Arunachal Pradesh border	79.32
53	Badarpur (NH-44) - Silchar - Lakhipur - Manipur Border.	73.55
54	Dabaka - Lumding - Langting - Haflong - Silchar - Dwarband - Mizoram Border	321.37
61	Jhanzi - Amguri - Nagaland border	17.51
62	Damara - Meghalaya Border	8.60
151	Karimganj - Bangaladesh Border	14.06
152	Patacharkuchi - Hajua - Bhutan Border	38.00
153	Ledo - Likhapani - Arunachal Pradesh Border	23.70
154	Dhaleshwar (Badarpur) - Bhairabhi - Mizoram Border	88.23
315A (New)	Arunachal Pradesh Border - Nahorkatia - Tinsukia (NH-37)	64.22
127B (New)	Srimrampur – Dhuburi - Meghalaya border	74.00
127C New	Shyamthai - Hithijhar State PWD road statarting from NH- 27 in Chirang District, Assam and meeting at Galegphu in Bhutan.	40.00
127D New	Rangiya - Darrangamela State PWD road starting from NH- 27 in the district of Kamrup, Assam and meeting at Samdrupjunjkhar in Bhutan.	48.60
627 New	Nelle (Amsoi Gate)-NH-27 connecting Rajagaon, Doyangmukh, Umrangso, Khobak and terminating at NH-27 near Harangajao in the State of Assam	244.00
427 New	Howli on NH-27- Barpeta- Hajo- Jalukbari on NH 27	108.00
329 New	NH-29 near Manja connecting Diphu and terminating at its junction with new NH No. 27 near Lumding	54.60

NH No.	Route	Length (km)
117A	NH-17 near Bilasipara connecting Kokrajhar and terminating at its junction with New NH-27 near Garubhasa in the State of Assam	47.00
715A	NH-27 near Nakhola connecting Jagiroad, Marigaon, Kaupati, Rowta, Udalguri, Khoirabari and terminating at Indo/Bhutan border in the State of Assam	125.00
127E	NH-27 near Barama connecting Baska, Subankhata and terminating at Indo/Bhutan border in the State of Assam	65.00
702 New	Sonari -new NH No. 215 near Sapekhati in the State of Assam.	32.00
702C New	Sibasagar on NH-2 connecting Simalguri and terminating at its junction with new NH No. 702 at Sonari.	48.00
	Sub Total	3743.55
52B	Under Railway Dept.	13.65
37E	NH length taken up by MORTH on BOT	25.81
	Total km in ASSAM	3783.01
Manipur		
39	Nagaland Border - Maosongsang - Maram - Karong - Kangpokpi - Imphal - Thoubal - Wangling - Palel - Sibong - Moreh - Indo/Myanmar Border.	242.595
53	Assam Border - Oinamlong - Nungba - Imphal	221.14
150	Mizoram border - Parbung - Thanlon - Phaiphengmum - Churachandpur - Moirang - Bishnupur - Imphal - Humpum - Ukhrul - Kuiri - Nagaland Border	532
155	Jassami - Nagaland border	5
102A (New)	From Tadubi on N.H 2 connecting Paomata, Ukhrul, Finchcorner, Phungyar Kasom Khullen, Kampang and terminating at its junction with NH-102 near Thengnoupal	321
102B (New)	The highway starting from Churachandpur on N.H-2 connecting Singhat, Sinzawl, Tuivai Road and terminating at Mayanmar Road in the state of Manipur.	183
137	The highway starting from Rengpang on N.H-37, Khongsang and terminating at Tamenglong (Tenglong) in the state of Manipur.	65
129A New	Maram (NH-2) - Nagaland Border	108
702A New	Nagaland Border- Jessam (New NH No. 29)	2
102C New	Palel (new NH No. 102)- Chandel	20
137A New	From Khumbong (near new NH No. 37) connecting Nambol, Mayang, Imphal and terminating at its junction with new NH No. 102 near Kakching Lamkhai in the State of Manipur.	46
	Sub Total	1745.735
Meghalaya		
40	Assam border - Barni Hat - Nongpoh - Umsning - Barapani - Shillong - Indo/Bangladesh border - Dawki - Jowai	217.061
40 & 44	Bypass	48.76
44	Nongstoin - Shillong - Mawlyngkneng - Assam Border	255.725
51	Assam border - Bajengdoda - Rongram - Tura - Kherapara - Dalu	126.412
62	Damra - Dambu - Baghmara - Dalu	195.4
127B (New)	Assam border – Phulbari - Tura - Rongram - Ronjeng - Nongston.	361
	Sub Total	1204.358
Mizoram		
44A	Tripura Border - Tukkalh - Mamit - Sairang - Aizawl	130
54	Assam Border - Chhimlung - Kolasib - Bualpui - Mualvum - Alzawl - Zobawk - Serchhip - Pangzawl- Leite - Zobawk - Sairep - Saiha - Kaladan - Tuipang	522
54A	Lunglei - Theriat	9
54B	Venus Saddle - Saiha	27
150	Manipur Border - Thingsa - Ratn - Darlawn - Phaileng - Seling - Aizawl	140
154	Assam Border - Kanpui (NH 54)	58
502A (New)	Lawngtlai - Mayanmar Border (Kaladan road)	100
302 New	Theriat- Lunglei- Lungseni- Tuiehong - Demagiri	100
6 New	Kanpui- Aizawal- Selling- Lumtui- Khawthlir- Tuisen- Neihdawn - Champai	95
102B	Nagopa, Hliappui, Saichal and terminating at new NH No- 6 near Keifang	140

NH No.	Route	Length (km)
(New)		
306A New	Vairengte connecting Saiphai, Zonmun and terminating at its junction with NH-2 near New Vertek	60
	Sub Total	1381
Nagaland		
36	Assam Border - Dimapur	7.29
39	Dimapur - Cichuguard - Kohima - Viswema - Manipur border	107.3
61	Kohima - Tseminyu - Wokha - Mokokchung - Chantongia - MerangKong - Assam Border	240
150	Kohima - Chizami - Manipur Border	116
155	Mokokchung - Tuensang - Sampurre - Meluri - Manipur Border	326.5
129A New	Peren- Jaluki- Pimla Junction- Razaphe Junction- Dimapur	63
702 New	Chantongia - Longling- Lonhching- Mon- Lapa- Tizit - Assam Border	98
702A New	Mokokchung - Zunheboto- Phek - Manipur Border	88
702B New	Longling on new NH No.702 in Assam and terminating at its junction with new NH No. 202 at Tuensang in Nagaland.	34.00
	Sub Total	1080.09
Tripura		
44	Assam Border - Churai Bari - Manu - Ambasa - Agaratala - Visalgarh - Barjala - Udaipur - Sabrum.	335
44A	Mizoram Border - Sakhan - Manu	133
108A New	Jolaibari (new NH No. 8) - Belonia- Indo/Bangladesh border	15
208 New	Kumarghat - Kailashahar- Khowai -Teliamura	94
	Sub Total	577

Source: Ministry of Road Transport and Highway

Indicator of national highways in the Study Area shows higher rate compared with the rate of all India in terms of "Length of NH in km/1000 km^2" and "Length of NH in km/lakh population" as shown in Table 2.1.3. However, lane-wise length of national highways in the Study Area clearly shows the disparity between the Study Area and all of India as shown in Table 2.1.4 and Figure 2.1.2.

Table 2.1-3 National Highways Indicator in North Eastern States

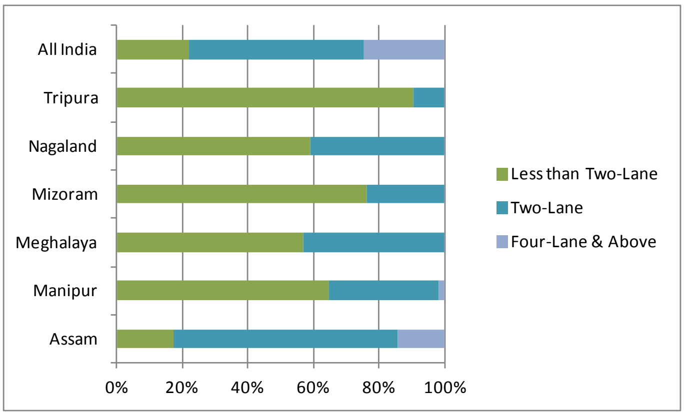
State	Total NH length (km)	Area (1000 km2)	Length of NH in km/1000 km2	Population in Lakhs as per 2011 census	Length of NH in km/ lakh population
Assam	3,783.23	78.438	48.2	311.69	12.1
Manipur	1,745.74	22.327	78.2	27.22	64.1
Meghalaya	1,204.36	22.429	53.7	29.64	40.6
Mizoram	1,381	21.081	65.5	10.91	126.6
Nagaland	1,080.09	16.579	65.1	19.81	54.5
Tripura	577	10.486	55	36.71	15.7
All India	96,260.72	3,292.564	29.2	12,086.69	8

Source: Ministry of Road Transport and Highway

Table 2.1-4 Lane-wise Length of National Highways in North Eastern States as of 31 March 2012

States	Total Length (km)	Less than Two-Lane		Two-Lane		Four-Lane & Above	
		(km)	%	(km)	%	(km)	%
Assam	2,940	505	17	2,007	68	428	15
Manipur	1,317	850	65	444	34	23	2
Meghalaya	1,171	665	57	506	43	0	0
Mizoram	1,027	784	76	243	24	0	0
Nagaland	494	291	59	203	41	0	0
Tripura	400	362	91	38	10	0	0
All India	76,818	16,998	22	40,720	53	19,100	25

Source: Ministry of Road Transport and Highway



Source: Ministry of Development of North Eastern Region

Figure 2.1-2 Share of Lane-wise Length of National Highways in North Eastern States as of 31 March 2012

Table 2.1.5 shows the road network indicator of the whole road network in the Study Area. Surfaced road ratios of Assam, Manipur, Nagaland, and Tripura are lower than that of all India.

Table 2.1-5 Road Network Indicator in North Eastern States as on 31 March 2012

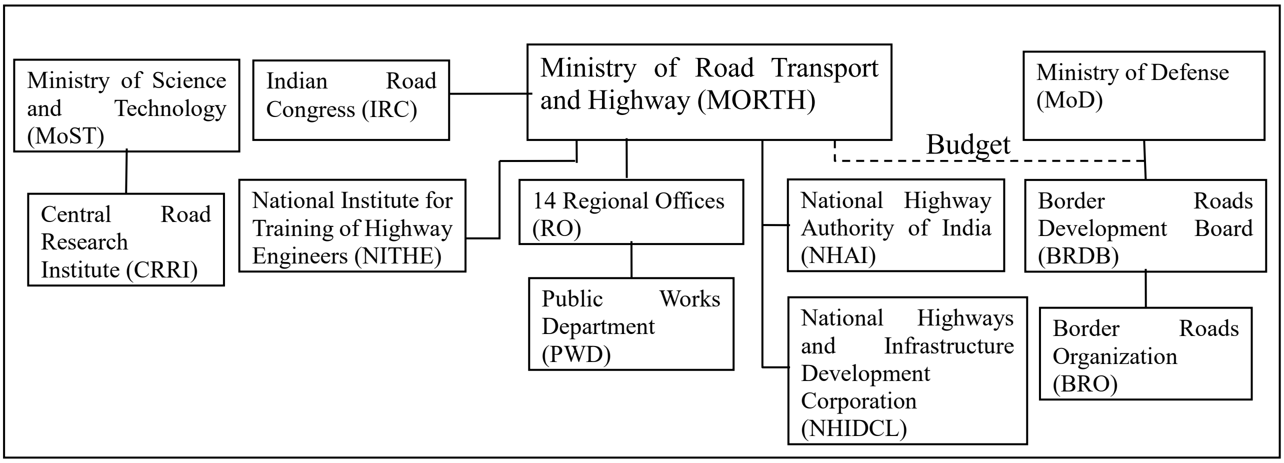
States	Total Road Length	Surfaced Road	Road Density	Road Density
	(km)	(%)	(per 1000 sq. km)	(per 1000 population)
Assam	284,232	18.83	3,623.65	9.19
Manipur	19,252	54.32	862.27	7.77
Meghalaya	12,103	65.45	539.61	4.57
Mizoram	11,293	71.72	535.70	11.12
Nagaland	35,189	47.84	2,122.50	15.47
Tripura	29,248	49.74	2,789.24	8
All India	3,965,394	63.43	1,206.29	3.28

Source: Ministry of Road Transport and Highway

2.2 National and Regional Highway Development Plans

2.2.1 Organizations Related to National Highway Development

National highways development has been promoted by the National Highway Authority of India (hereinafter referred to as "NHAI") and Regional Offices (hereinafter referred to as "RO") under the Ministry of Road Transport and Highway (hereinafter referred to as "MORTH"), and Border Roads Organization (hereinafter referred to as "BRO") under the Border Roads Development Board (hereinafter referred to as "BRDB"). The National Highways and Infrastructure Development Corporation (hereinafter referred to as "NHIDCL") was established for promoting the development of national highways in the North East and border areas of India, and started operation from January 1, 2015. Figure 2.2-1 shows the overall structure of organizations related to national highways development.



Source: Ministry of Road Transport and Highway (JICA Study Team modified)

Figure 2.2-1 Overall Structure of Organizations Related to National Highway Development

NHAI was set up by the National Highways Authority of India Act of 1988. It is the main nodal agency for developing, managing, and maintaining India's network of national highways. It became an autonomous body in 1995. The NHAI maintains 70,934 km of national highways and expressways across India.

NHIDCL started operation from January 1, 2015 and the development of the target roads in this study is being promoted under NHIDCL. The vision, mission, and description of NHIDCL are shown below, and its organizational structure is shown in Figure 2.2-2:

Vision

To be an instrument for creation and management of infrastructure of the highest standard in the country with focus on the North East and Border areas and contribute significantly towards nation building.

Mission

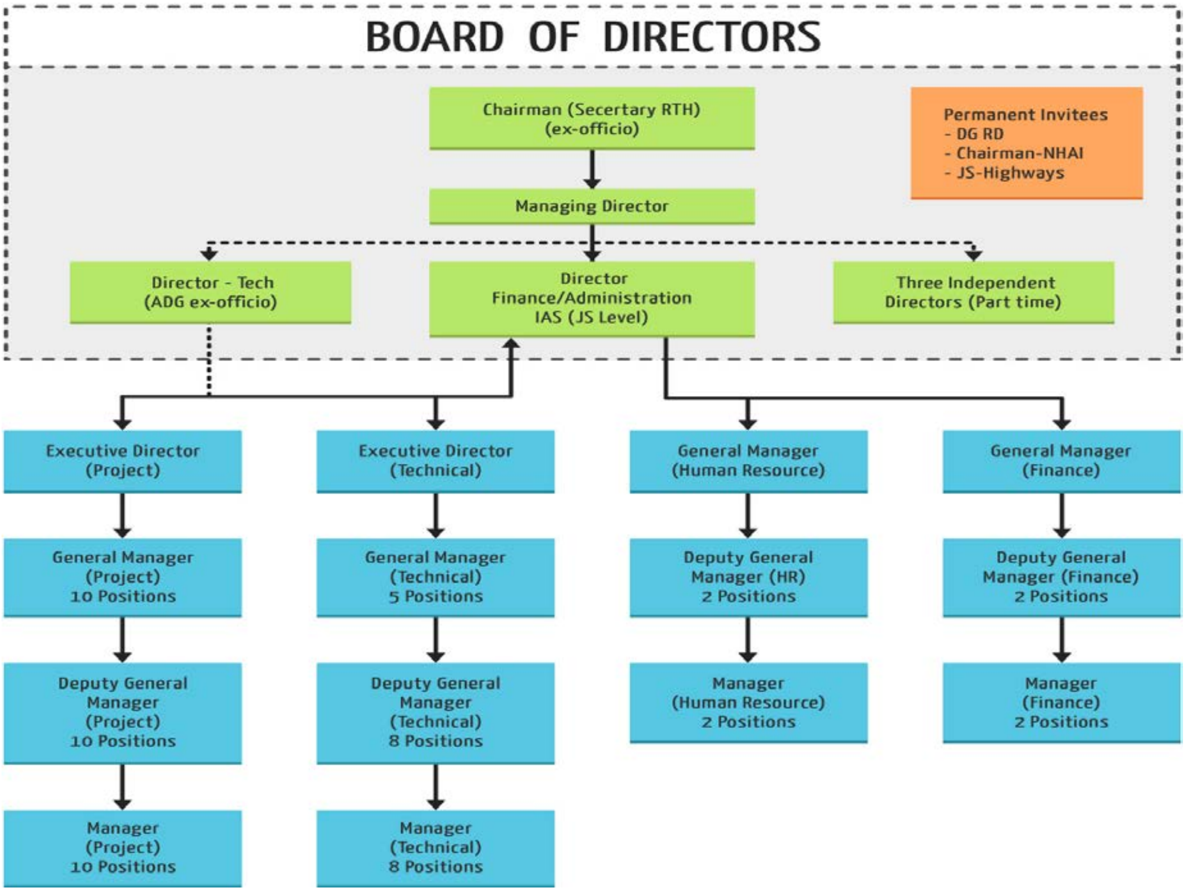
To be a professional company which works in most efficient and transparent manner and designs, develops, and delivers infrastructure projects in a time-bound basis for maximizing benefits to all stakeholders.

Description of NHIDCL

National Highways and Infrastructure Development Corporation (hereinafter referred to as "NHIDCL") is a fully owned company of the Ministry of Road Transport and Highways, Government of India. The company promotes, surveys, establishes, designs, builds, operates, maintains and upgrades national highways and strategic roads including interconnecting roads in parts of the country which share international boundaries with neighboring countries. The regional connectivity so enhanced would promote cross border trade and commerce and help safeguard India's international borders. This would lead to the formation of a more integrated and economically consolidated South and South-East Asia. In addition, there would be overall economic benefits for the local population and help integrate the peripheral areas with the mainstream in a more robust manner. An approximate aggregate length of 10,000 km has been identified to begin with for development through this company. The company envisages creating customized and specialized skills in terms of addressing issues like complexities of geographical terrains and addressing extensive coordination requirements with security agencies. The company would also endeavor to undertake infrastructure projects including but not restricted to urban infrastructure and urban or city transport and to act as an agency for development of all types of infrastructure. The company envisages working towards cross sharing of technical know-how and enhancing opportunities for business development with other nations and their agencies including the multilateral organizations and institutions.

The company also proposes to improve road connectivity and efficiency of the international trade corridor, by expanding about 500 km of roads in the North Bengal and the North-Eastern Region of India to enable efficient and safe transport regionally with other South Asia Sub-regional Economic Cooperation (SASEC) member countries. These projects are being funded by the Asian Development Bank (ADB).

Source: NHIDCL Home Page (http://www.nhidcl.com/)



Source: NHIDCL Home Page (http://www.nhidcl.com/)

Figure 2.2-2 Organization Structure of NHIDCL

2.2.2 National Highway Development Plan (NHDP)

The National Highways Development Plan (hereinafter referred to as "NHDP") is a program to be executed in several phases to improve the road network in India. The program is overseen by NHAI. It involves the widening of roads and building of new links between all of India's major cities.

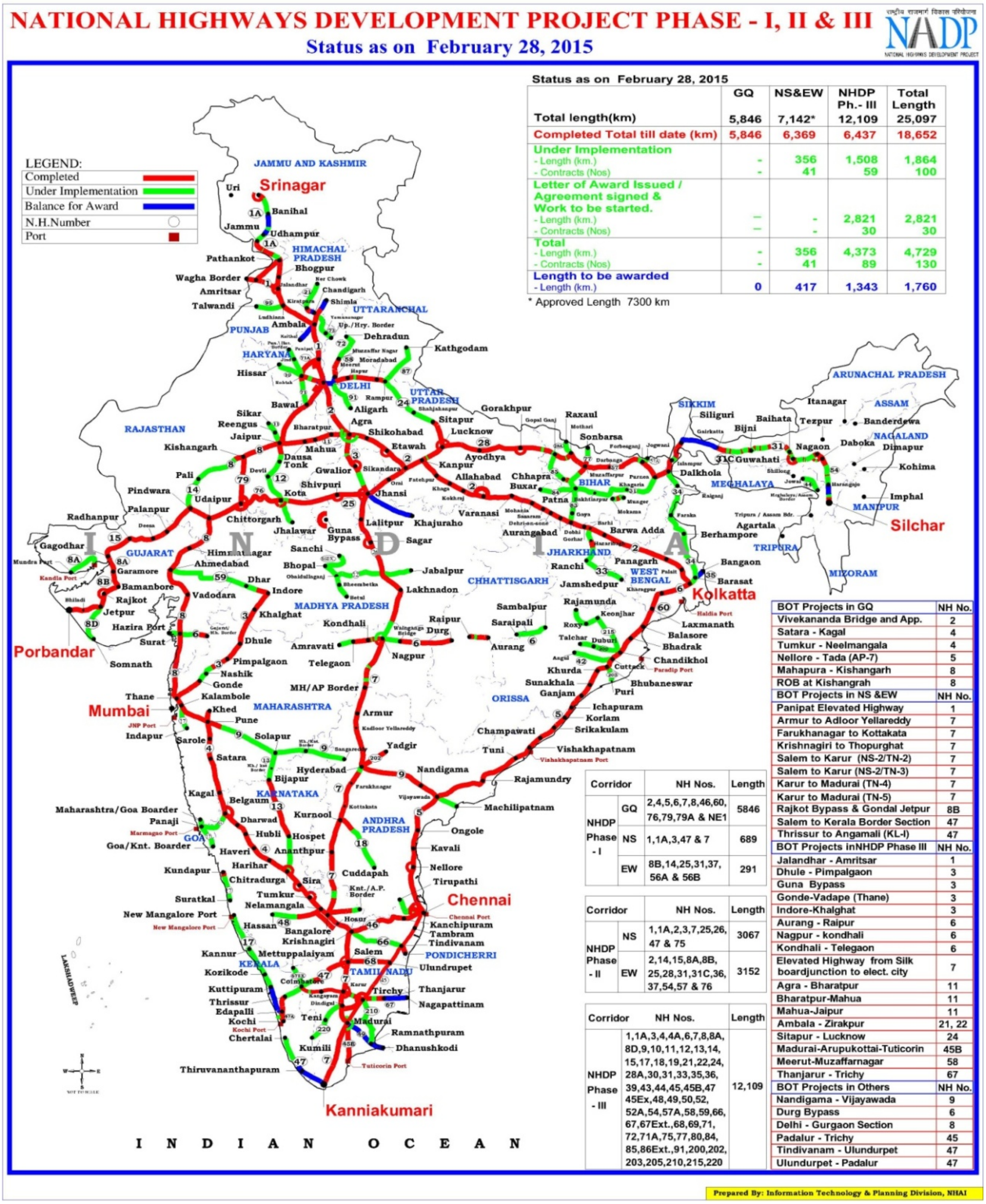
The first phase established the Golden Quadrilateral network, which linked India's four major cities of Delhi, Mumbai, Kolkata, and Chennai by 4-lane highways. The second phase focused on the North-South and East-West corridors while subsequent phases have seen the widening of 4-lane roads to six lanes.

In the Study Area, there is one section of the East-West corridor from Srirampur to Silchar in Assam which is 670 km in total as part of Phase II (4-lanes). Completed section is approximately 71% of the total section as of 2012 and target date of completion is December 2014. There is one section of Phase III road in Meghalaya and the section is NH44 from Jowai to Ratachhera, which is 102 km in total (2 lanes). Status of NHDP as of January 31, 2015 is shown in Table 2.2-1 and Figure 2.2-3 shows the implementation status as of February 28, 2015. There are incomplete sections on Phase II and Phase III sections in the Study Area according to Figure 2.2-3.

Table 2.2-1 Status of NHDP as on 31 January 2015

		Total Length (km.)	Already 4/6Laned (km.)	Under Implementation (km.)	Contracts Under Implementation (No.)	Balance length for award (km.)
NHDP	GQ	5,846	5,846 -100.00%	0	0	-
	NS - EW Ph. I & II	7,142	6,360	365	42	417
	Port Connectivity	380	379	1	1	0
	NHDP Phase III	12,109	6,393	4,373	89	1,343
	NHDP Phase IV	14,799	942	5,904	55	7,953
	NHDP Phase V	6,500	2,001	2,080	27	2,419
	NHDP Phase VI	1,000	-	-	-	1,000
	NHDP Phase VII	700	22	19	1	659
	NHDP Total	48,476	21,943	12,742	215	13,791
Others (Ph.-I, Ph.-II & Misc.)		1754	1428	326	10	-
SARDP -NE		388	99	12	1	277
Total by NHAI		50,618	23,470	13,080	226	14,068
*Total 20,000 km. was approved under NHDP Phase IV.Out of which 14,799 km. as assigned to NHAI remaining km. with MORTH.						

Source: NHAI Web Site



Status as on February 28, 2015

	GQ	NS&EW	NHDP Ph.- III	Total Length
Total length(km)	5,846	7,142*	12,109	25,097
Completed Total till date (km)	5,846	6,369	6,437	18,652
Under Implementation				
- Length (km.)	-	356	1,508	1,864
- Contracts (Nos)	-	41	59	100
Letter of Award Issued / Agreement signed & Work to be started.				
- Length (km.)	–	-	2,821	2,821
- Contracts (Nos)	–	-	30	30
Total				
- Length (km.)	-	356	4,373	4,729
- Contracts (Nos)	-	41	89	130
Length to be awarded				
- Length (km.)	0	417	1,343	1,760

* Approved Length 7300 km

Corridor		NH Nos.	Length
NHDP Phase - I	GQ	2,4,5,6,7,8,46,60, 76,79,79A & NE1	5846
	NS	1,1A,3,47 & 7	689
	EW	8B,14,25,31,37, 56A & 56B	291

Corridor		NH Nos.	Length
NHDP Phase - II	NS	1,1A,2,3,7,25,26, 47 & 75	3067
	EW	2,14,15,8A,8B, 25,28,31,31C,36, 37,54,57 & 76	3152

Corridor	NH Nos.	Length
NHDP Phase - III	1,1A,3,4,4A,6,7,8,8A, 8D,9,10,11,12,13,14, 15,17,18,19,21,22,24, 28A,30,31,33,35,36, 39,43,44,45,45B,47 45Ex,48,49,50,52, 52A,54,57A,58,59,66, 67,67Ext.,68,69,71, 72,71A,75,77,80,84, 85,86Ext.,91,200,202, 203,205,210,215,220	12,109

BOT Projects in GQ	NH No.
Vivekananda Bridge and App.	2
Satara - Kagal	4
Tumkur - Neelmangala	4
Nellore - Tada (AP-7)	5
Mahapura - Kishangarh	8
ROB at Kishangrah	8
BOT Projects in NS &EW	**NH No.**
Panipat Elevated Highway	1
Armur to Adloor Yellareddy	7
Farukhanagar to Kottakata	7
Krishnagiri to Thopurghat	7
Salem to Karur (NS-2/TN-2)	7
Salem to Karur (NS-2/TN-3)	7
Karur to Madurai (TN-4)	7
Karur to Madurai (TN-5)	7
Rajkot Bypass & Gondal Jetpur	8B
Salem to Kerala Border Section	47
Thrissur to Angamali (KL-I)	47
BOT Projects inNHDP Phase III	**NH No.**
Jalandhar - Amritsar	1
Dhule - Pimpalgaon	3
Guna Bypass	3
Gonde-Vadape (Thane)	3
Indore-Khalghat	3
Aurang - Raipur	6
Nagpur - kondhali	6
Kondhali - Telegaon	6
Elevated Highway from Silk boardjunction to elect. city	7
Agra - Bharatpur	11
Bharatpur-Mahua	11
Mahua-Jaipur	11
Ambala - Zirakpur	21, 22
Sitapur - Lucknow	24
Madurai-Arupukottai-Tuticorin	45B
Meerut-Muzaffarnagar	58
Thanjarur - Trichy	67
BOT Projects in Others	**NH No.**
Nandigama - Vijayawada	9
Durg Bypass	6
Delhi - Gurgaon Section	8
Padalur - Trichy	45
Tindivanam - Ulundurpet	47
Ulundurpet - Padalur	47

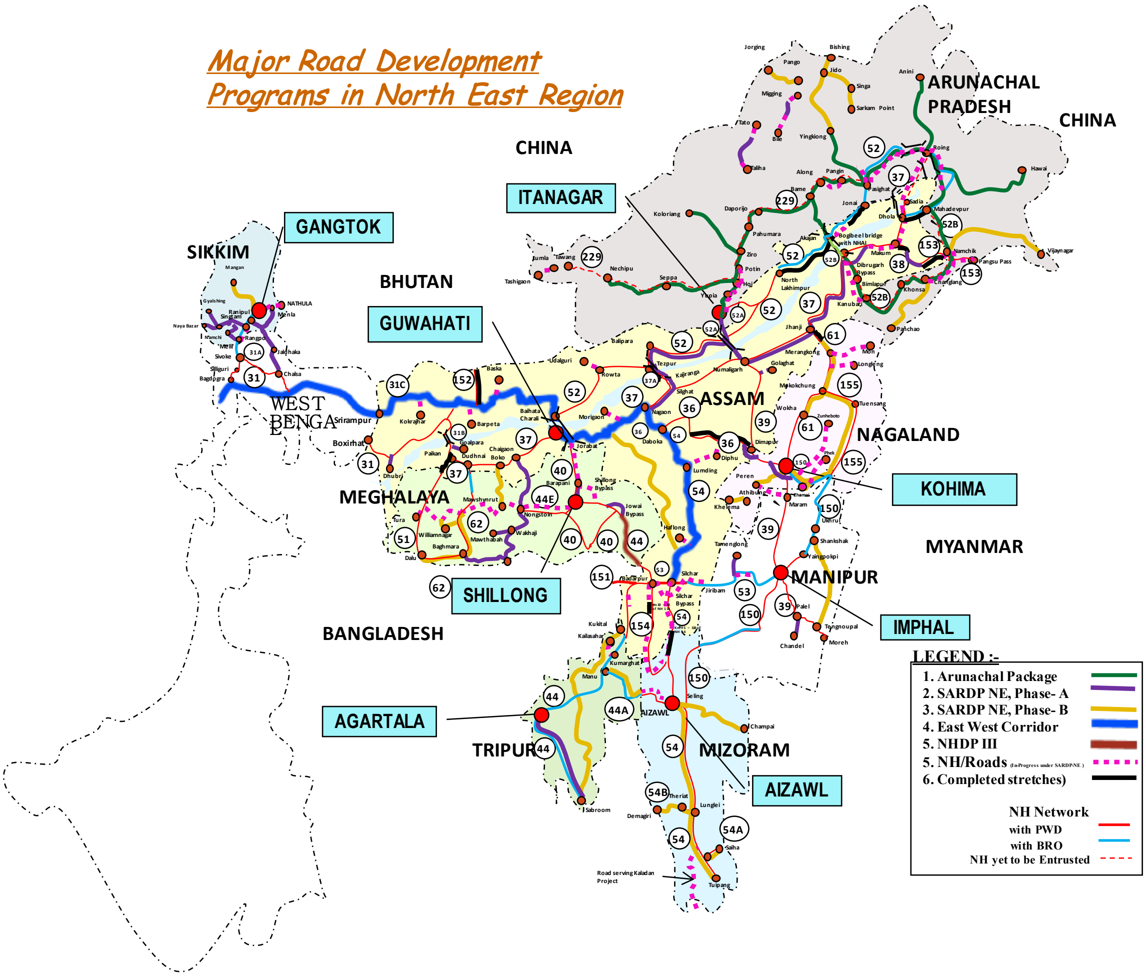
Source: National Highways Authority of India

Figure 2.2-3 Status of NHDP as on 28 February 2015

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

The Special Accelerated Road Development Programme for North-East (hereinafter referred to as SARDP-NE) was initiated by MORTH in 2005 with the following objectives:

- Upgrade national highways to 2/4 lanes;
- To provide connectivity to all 88 district headquarters by 2-lane roads;
- Connectivity to backward and remote areas of the North-Eastern Region;
- Improve roads of strategic importance; and
- Improve connectivity to neighboring countries.



Source: Ministry of Development of North Eastern Region

Figure 2.2-4 Major Road Development Programs in North East Region

Program of SARDP-NE is composed of Phase A, Phase B, and Arunnachal Pradesh Package. In Phase A, the major objective is improvement of road network connecting between national arterial roads and districts in the North-Eastern States and priority of implementation is given to the road project under Phase A. Road project under Phase B is intended to reinforce connectivity among districts in the North-Eastern States. Table 2.2-2 and Table 2.2-3 show the details of SARDP-NE, and the related SARDP-NE projects with the Study roads are shown in Table 2.2-4.

Table 2.2-2 Length and Budget of SARDP-NE

Packages		Total Length (km)	Budget (INR Crore)	Budget per km (INR Crore)
Phase A	Approved for execution	3,213	12,821	4.0
	Approved In-Principle	886	8,948	10.0
	Total	4,099	21,767	5.3
Arunnachal Pradesh Package		2,319	11,919	5.14
Phase B		3,723	64 (for DPR only)	-
Total		10,141	33,752	-
*NH 4,798km (47%), SR 5,343km (53%)				

Source: Ministry of Development of North Eastern Region

Table 2.2-3 State-wise Status of SARDP-NE (2013)

STATE	SARDP-NE Phase 'A' (km)			Arunachal Pradesh Package of Roads and Highways (km)			SARDP-NE Phase 'B' (km)			Grand Total (km)		
	NHs	SR/GS	Total	NH	SR/GS/ Strtg	Total	NH	SR/GS/ Strtg	Total	NH	SR/GS/ Strtg	Total
Assam	1179	177	1356	126	12	138	0	285	285	1305	474	1779
Manipur	39	166	205	0	0	0	0	202	202	39	368	407
Meghalaya	259	526	785	0	0	0	161	201	362	420	727	1147
Mizoram	221	100	321	0	0	0	416	272	688	637	372	1009
Nagaland	81	350	431	0	0	0	622	169	791	703	519	1222
Tripura	130	22	152	0	0	0	86	310	396	216	332	548

Note: SR: State Road; GS: General Staff roads & Strtg: Strategic roads
Source: Ministry of Development of North Eastern Region

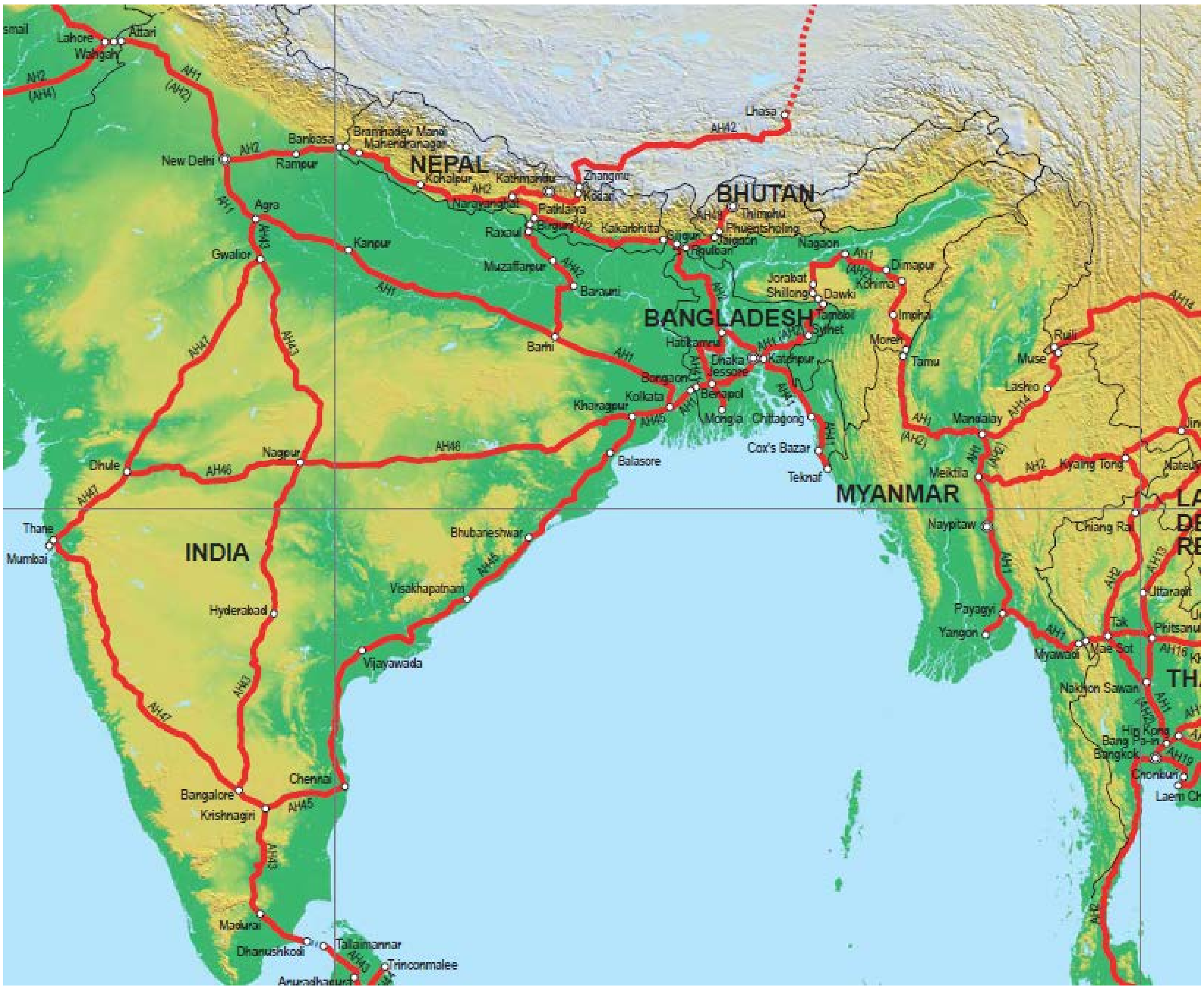
Table 2.2-4 Related SARDP-NE Project with the Study Roads

State & Package No.	Scope of work	Category of road & Implementing Agency	Length (km)
Phase A			
Meghalaya	Construction of new Shillong By-pass connecting NH-40 & NH-44 (2-lane)	NH – 40 / BOT(Annuity)	50
Nagaland	Four laning of Dimapur to Kohima Road including Dimapur/Kohima Bypass on NH-39	NH - 39/ BOT (Annuity)	81
Manipur,	Widening to double lane and strengthening of NH-53 from km 147.000 to 166.000 (Jiribam-Barak Section) in Manipur, formation width of 12 m corresponding to 2-lane NH in hilly terrain under Phase 'A' of SARDP-NE	NH – 53 / BRO	19
	Strengthening and widening of existing road from km.166.00 to 186.475 (Jiribam - Barak section)	NH – 53 / BRO	20.48
Meghalaya	Improvement of existing 2 lane Barapani - Shillong section of NH-40 and flyovers in Shillong city	NH – 40 / Meghalaya PWD	54
Phase B			
Meghalaya	2 laning from Assam/Meghalaya border to Dalu via Baghmara	NH- 62	161
Mizoram	2 laning from Aizawl to Tuipang section	NH- 54	380
Tripura	2 laning/ realignment from Manu to Tripura/Mizoram Border.	NH-44A	86

Source: Ministry of Development of North Eastern Region

2.2.4 Asian Highway

The Asian Highway network covers 32 countries in Asia and total length is approximately 142,000 km. Main objectives of the Asian Highway network are contribution to interregional and international socioeconomic development and promotion of trade and tourism through networking between Asia and Europe. The Asian Highway network connects North-Eastern States and the neighboring countries of Myanmar, Bangladesh, and Bhutan as shown in Figure 2.2-5.



Source: UN ESCAP

Figure 2.2-5 Asian Highway Network

The Asian Highway network is classified into four road categories and design standards are proposed as shown in Table 2.2-5.

Table 2.2-5 Classification and Design Standards of Asian Highway

Highway classification		Primary (4 or more lanes)				Class I (4 or more lanes)			
Terrain classification		L	R	M	S	L	R	M	S
Design speed (km/h)		120	100	80	60	100	80	50	
Width (m)	Right of way	(50)				(40)			
	Lane	3.50				3.50			
	Shoulder	3.00		2.50		3.00		2.50	
	Median strip	4.00		3.00		3.00		2.50	
Min. radii of horizontal curve (m)		520	350	210	115	350	210	80	
Pavement slope (%)		2				2			
Shoulder slope (%)		3 – 6				3 – 6			
Type of pavement		Asphalt/cement concrete				Asphalt/cement concrete			
Max. superelevation (%)		10				10			
Max. vertical grade (%)		4	5	6	7	4	5	6	7
Structure loading (minimum)		HS20-44				HS20-44			

Highway classification		Class II (2 lanes)				Class III (2 lanes)			
Terrain classification		L	R	M	S	L	R	M	S
Design speed (km/h)		80	60	50	40	60	50	40	30
Width (m)	Right of way	(40)				(30)			
	Lane	3.50				3.00 (3.25)			
	Shoulder	2.50		2.00		1.5 (2.0)		0.75 (1.5)	
	Median strip	N/A		N/A		N/A		N/A	
Min. radii of horizontal curve(m)		210	115	80	50	115	80	50	30
Pavement slope (%)		2				2 - 5			
Shoulder slope (%)		3 – 6				3 - 6			
Type of pavement		Asphalt/cement concrete				Dbl. bituminous treatment			
Max. superelevation (%)		10				10			
Max. vertical grade (%)		4	5	6	7	4	5	6	7
Structure loading (minimum)		HS20-44				HS20-44			

Notes: Figures in parentheses are desirable values.
Source: UN ESCAP

Minimum radii of horizontal curve should be determined in conjunction with superelevation. The recommended width of the median can be reduced with the proper type of guard fence. The Parties should apply their national standards when constructing structures such as bridges, culverts and tunnels along the Asian Highway.

Table 2.2-6 to Table 2.2-9 show the status of Asian Highway network development in India and surrounding countries. HN40 in Meghalaya State and NH39 in Manipur State are part of Asian Highway Route No. 1.

Table 2.2-6 Status of Asian Highway Development in India

AH Route No.	Own Route No./ Road Name	Road Category	AH Design Standard	City/Town Name at Start and end Point	Section Length (km)	Number of Lanes (km)				
					Existing Road	1	2	4	6	8
1	NH39, NH37, NH36, NH40, NH35, NH34, NH2, NH1	National	I, II, III, Below III	Moreh (Border of Myanmar)- Attari (Border of Pakistan)	2,870	80	1,809	936	37	8
2	SH, NH31, NH87, NH74, NH125, NH24	National, State	I, II, III, Below III	Border of Bangladesh (Phulbani)- New Delhi	377	27	290	56	0	4
42	NH28A, NH28, NH31	National	III	Raxaul (Border of Nepal)- Barhi	457	0	457	0	0	0
43	NH3, NH75, NH26, NH7, NH49	National	I, II, III, Below III	Agra- Dhanushkod i	2,433	10	2,115	300	8	0
45	NH5, NH4, NH46	National	I, II, III	Kolkata- Krishnagiri	1,945	0	165	1,780	0	0
46	NH6	National	I, III	Kharagpur- Dhule	1,508	0	1,470	38	0	0
47	NH3, SH, NH4, Expressway	National, State, State Expressway	I, II, III, Primary	Shajapur- Bangalore	2,060	0	1,068	878	114	0
48	NH31	National		Phulbari- Jaigaon (Border of Bhutan)	160	0	0	0	0	0

AH Route No.	Surface Type (km)				Surface Condition (km)			Carriageway Width (km)				
	AC	CC	PM/DB /SB	CG/M a/Me	Good	Fair	Bad	<=4.5m	4.5- 6m	6-7m	7-14m	>=14 m
1	1,796	157	917	0	1,839	950	81	33	54	155	2,620	8
2	149	0	226	2	318	57	2	8	38	233	94	4
42	0	0	457	0	0	457	0	0	0	427	30	0
43	389	0	2,044	0	1,086	1,335	12	40	9	1,212	1,034	138
45	454	59	1,432	0	1,847	98	0	0	0	165	1,749	31
46	0	0	1,508	0	1,118	270	120	0	0	1,470	38	0
47	1,525	109	426	0	1,883	62	115	0	0	1,068	878	114
48	0	0	0	0	0	0	0	0	0	0	0	0

Source: UN ESCAP

AH1 connects Myanmar and the North-Eastern States at Moreh in the Indian side and Tamu in Myanmar side.

Table 2.2-7 Status of Asian Highway Development in Myanmar

AH Route No.	Own Route No./ Road Name	Road Category	AH Design Standard	City/Town Name at Start and end Point	Section Length (km)	Number of Lanes (km)			
					Existing Road	1	2	4	6
1	Thaton-Paan-Kawkaerik-Myawadi Road, Yangon-Mawlamyne-Dawe-Myeik-Kawthaung Road, Yangon-Toungoo-Mandalay Road, Mandalay-Sagain-Ondaw-Moniwa Road, MoniwAH-Pale-Gangaw Road, Kalemyo-Kyigon-Tamu RoadGangaw-Kan-Kalemyo Road	Union	I, III, Below III	Myawadi (Border of Thailand)-Tamu (Border of India)	1,691	292	1,064	159	53
2	MTKT Road	Union	III, Below III	Tachilek (Border of Thailand)-Meiktila	804	356	351	0	96
3	Kyaing Tong-Mongla Road	Union	III	Mongla (Border of China)-Kyaing Tong	90	0	90	0	0
14	MBLM Road	Union	I, III	Muse (Border of China)-Mandalay	460	15	0	393	68
111	n.a.	Union	III	Thibaw-Loilem	240	240	0	0	0
112	n.a.	Union	Below III	Thaton-Kauthaung	1,059	15	823	224	4
123	n.a.	Union	I	Dawei (Deep Sea Port)	150	0	150	0	0

AH Route No.	Surface Type (km)		Surface Condition (km)			Carriageway Width (km)				
	AC	PM/DB/SD	Good	Fair	Bad	<=4.5m	4.5-6m	6-7m	7-14m	>=14m
1	131	1,435	1,221	292	31	359	151	32	939	80
2	2	802	681	91	30	367	0	325	115	0
3	0	90	90	0	0	0	93	0	0	0
14	0	460	0	460	0	0	0	386	67	0
111	0	240	0	240	0	n.a.	n.a.	n.a.	n.a.	n.a.
112	0	1,059	418	337	304	n.a.	n.a.	n.a.	n.a.	n.a.
123	0	150	0	150	0	n.a.	n.a.	n.a.	n.a.	n.a.

Source: UN ESCAP

AH1 and AH2 connect Bangladesh and the North-Eastern States. AH1 connects Bangladesh and the North-Eastern States at Dawki in Indian side and Tamabil in Bangladesh side. AH2 connects Bangladesh and the North-Eastern States at Phulbari in Indian side and Banglabandha in Bangladesh side.

Table 2.2-8 Status of Asian Highway Development in Bangladesh

AH Route No.	Own Route No./ Road Name	Road Category	AH Design Standard	City/Town Name at Start and end Point	Section Length (km)		Number of Lanes (km)				
					Existing Road	River Ferry	1	2	4	6	8
AH1	N2, N1, N8, N805, N806, Z7503, R750, N706	National, Zila, Regional	II, Below III, III	Tamabil (Border of India)- Benapol (Border of India)	479	5.3	12	445	20	1	0
AH2	N3, N4, N405, N5	Urban Road, National	I, II, III, Below III	Dhaka (South)- Panchagarh	514	0	10	457	6	25	14
AH41	N1, N507, N6, N704, N7	National	II	Teknaf- Khulna	744	0	6	705	31	1	0.5

AH Route No.	Surface Type (km)	Surface Condition (km)				Carriageway Width (km)					
	AC	Good	Fair	Bad	Unknown	Unknown	<=4.5m	4.5-6m	6-7m	7-14m	>=14m
AH1	479	262	125	63	28	0	6	21	32	479	0
AH2	514	271	206	38	0	0	11	14	135	514	33
AH41	744	160	341	244	0	0	0	90	249	630	0

Source: UN ESCAP

AH48 connects Bhutan and the North-Eastern States at Jaigaon in Indian side and Phuentsholing in Bhutan side.

Table 2.2-9 Status of Asian Highway Development in Bhutan

AH Route No.	Own Route No./ Road Name	Road Category	AH Design Standard	City/Town Name at Start and end Point	Section Length (km)	Number of Lanes (km)				
					Existing Road	1	2	4	6	8
AH48	2	National Highway	I, II, Below III	Phuentsholing (Border of India)- Thimphu	170	42	121	7	0	0

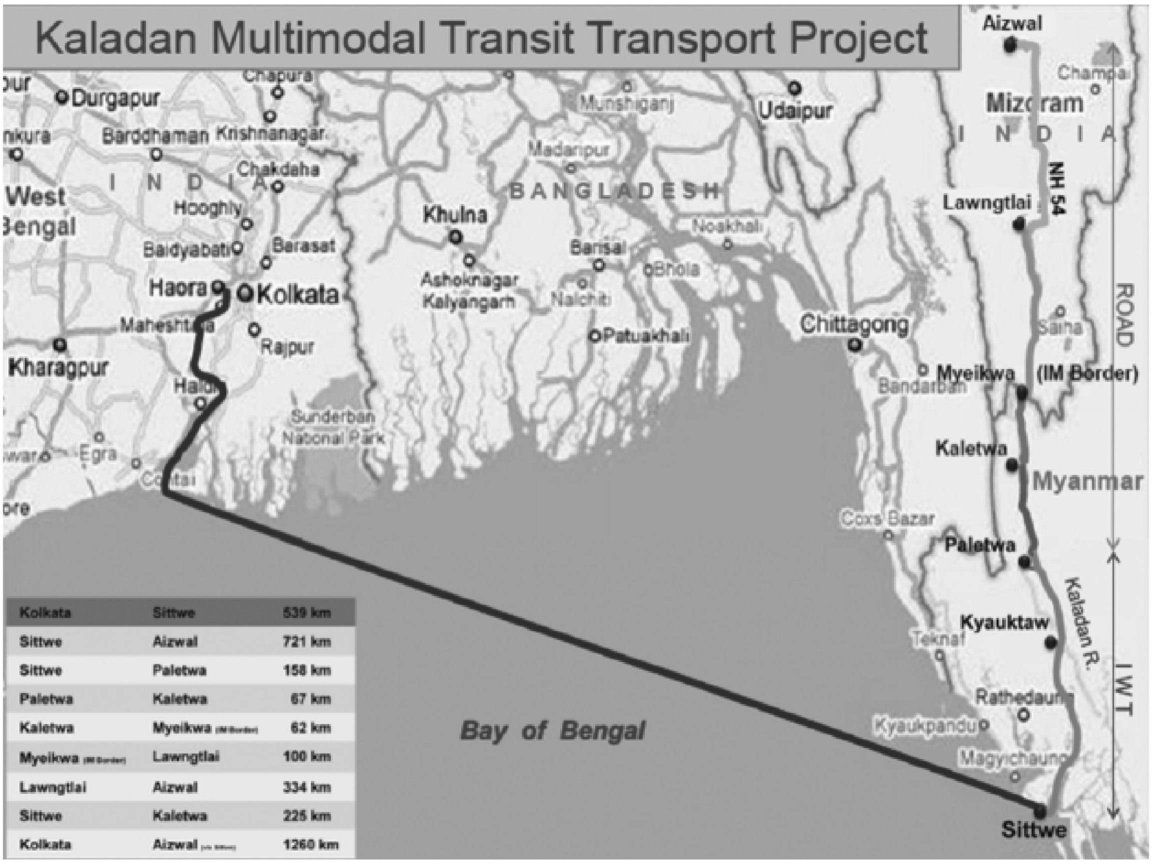
AH Route No.	Surface Type (km)		Surface Condition (km)			Carriageway Width (km)				
	AC	PM/DB/SD	Good	Fair	Bad	<=4.5m	4.5-6m	6-7m	7-14m	>=14m
AH48	128	42	170	0	0	42	0	0	128	0

Source: UN ESCAP

2.2.5 Other Related Projects

(1) Kaladan Multimodal Transport Project

Kaladan Multimodal Transport Project was proposed by the Ministry of External Affairs of India (hereinafter referred to as "MEA") to provide alternative connectivity from Mizoram to Haldia/Kolkata ports through NH54 and Kaladan River in Myanmar. MEA entered into a framework agreement with the Government of Myanmar in April 2008 to facilitate implementation of the project, and the work on the project has substantially been completed. The transit route envisaged between Kolkata (nearest Indian port/ commercial hub) and comprises of segments as shown in Figure 2.2-6.



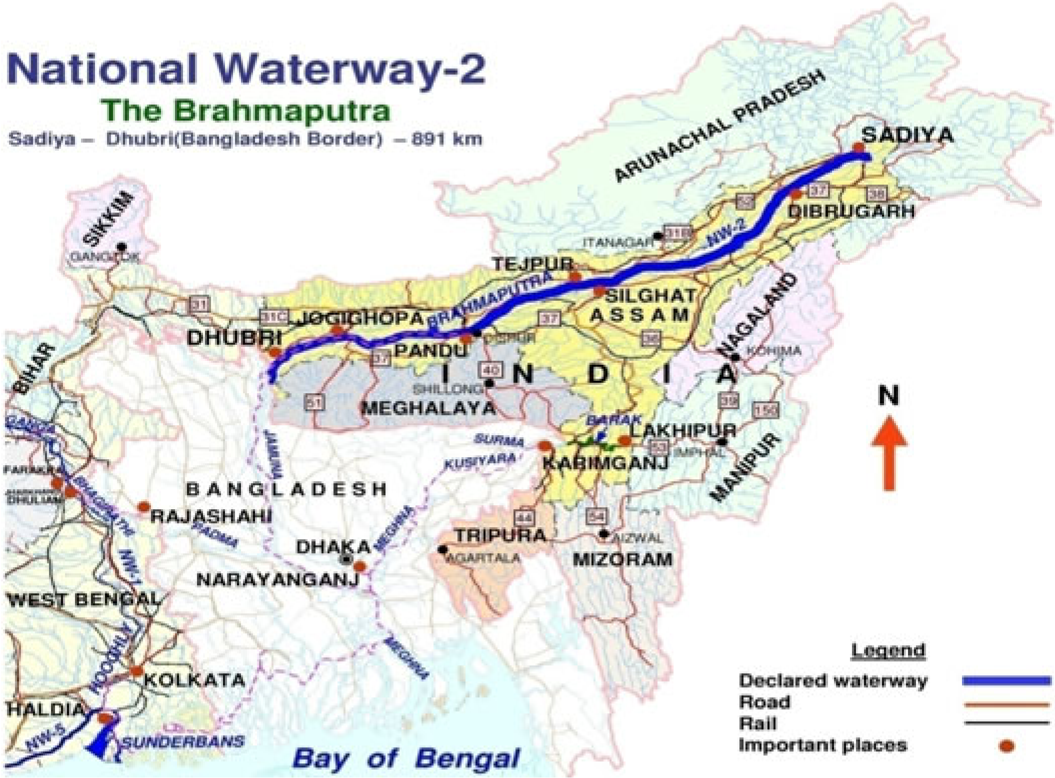
Kolkata	Sittwe	539 km
Sittwe	Aizwal	721 km
Sittwe	Paletwa	158 km
Paletwa	Kaletwa	67 km
Kaletwa	Myeikwa (IM Border)	62 km
Myeikwa (IM Border)	Lawngtlai	100 km
Lawngtlai	Aizwal	334 km
Sittwe	Kaletwa	225 km
Kolkata	Aizwal	1260 km

Source: Twenty Five Year Plan (2012-2017)

Figure 2.2-6 Kaladan Multimodal Transit Transport Project

(2) National Waterway-2: Brahmaputra-Barak Route

National Waterway-2 Brahmaputra was declared in 1988 to connect from Dhubri to Sadia with total distance of 891 km as shown in Figure 2.2-7. This all-weather waterway helps to avoid the congested West Bengal–Sikkim narrow corridor and shorten the distance from Tripura, Mizoram, and Southern Assam to Bangladesh for cargo transport. Inland Waterways Authority of India (hereinafter referred to as “IWAI”) maintains navigational channel of minimum 45 m width and 2.5 m depth in National Waterway-2 between Dhubri – Neamati, and terminal facilities for loading and unloading of cargo is being maintained by IWAI at strategic locations like Dhubri, Jogighopa, Pandu, Silghat, Neamati, and Dibrugarh. Pandu (Guwahati) is being developed as a multimodal transport hub which can serve the entire North-Eastern Region. A permanent terminal at Dhubri, Assam is under construction with all facilities at an approximate cost of Rs.46.68 crore. Dhubri is the first important terminal on the Brahmaputra. The existing temporary inland water transport terminal at Jogighopa is proposed to be upgraded to a bulk cargo-handling terminal for products like Meghalaya coal, with rail connectivity up to the terminal. (Source: Inland Water Transport (IWT) Master Plan for North-East/ Inland Waterways Authority of India (IWAI))



Source: Inland water Transport (IWT) Master Plan for NE/ Inland Waterways Authority of India (IWAI)

Figure 2.2-7 National Waterway-2 Brahmaputra Project

2.3 On-going and Planned Road Projects Related to the Study Roads by International Cooperation

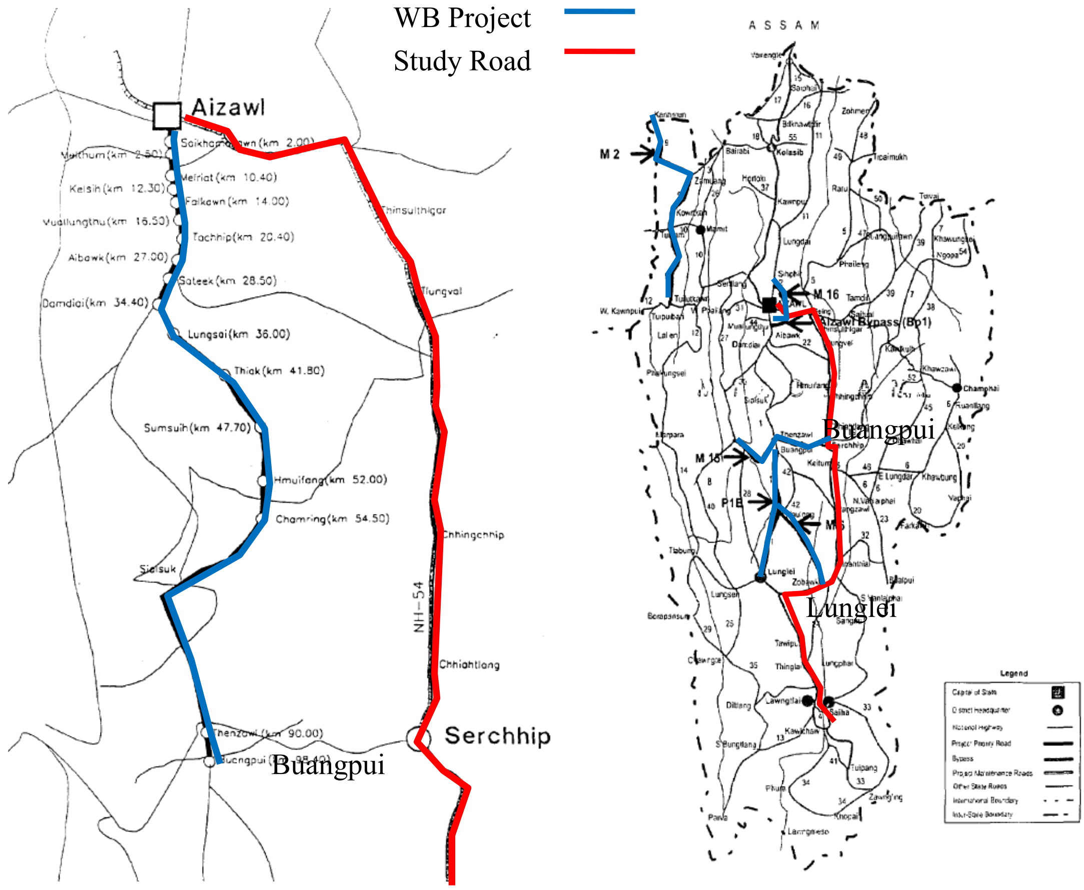
Several road projects related to the Study roads have been implemented through financing by international cooperation agencies as shown in Table 2.3-1.

Table 2.3-1 On-going and Planned Road Projects

International Donor	Project Name	Project Period	Project Cost (mil. USD)
World Bank	Assam State Roads Project (SH46)	2012.3-2018.3	400
World Bank	Mizoram State Road Project	2014.6-2020.10	107
Asian Development Bank (LN-2770-IND)	North Eastern State Roads Investment Program-Project-1 (Assam, Meghalaya and Sikkim)	2012.10-2016.12	109.5
Asian Development Bank	North Eastern State Roads Investment Program-Project-2 (Assam, Manipur, Mizoram and Tripura)	2014.5-2020.3	157.2
Asian Development Bank (LN-2445-IND)	Rural Roads Sector II Investment Program-Project-3 (Assam and West Bengal)	2009.1-2013.11	168.8
Asian Development Bank (LN-2535-IND)	Rural Roads Sector II Investment Program-Project-4 (Assam, Orissa and West Bengal)	2009.11-2013.4	185

Source: JICA Study Team, WB Web-site, ADB Web-site

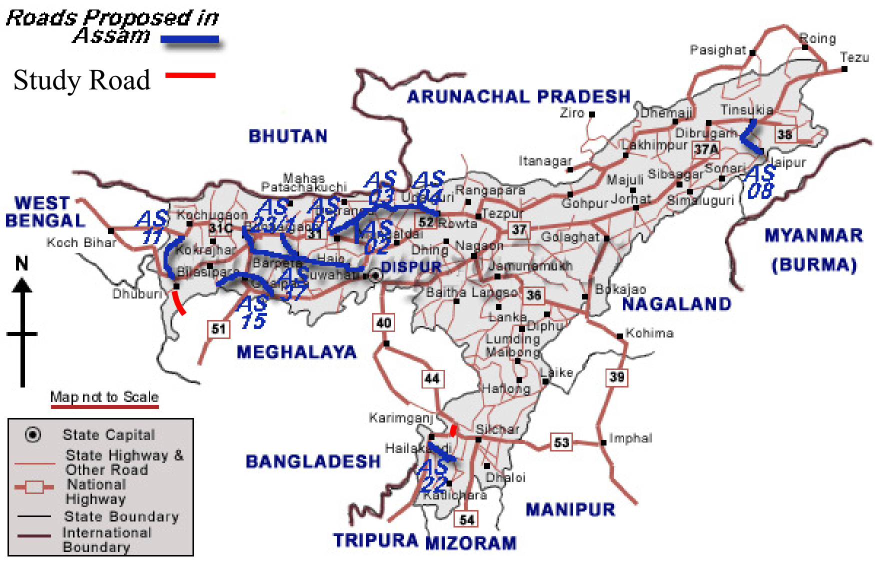
The Mizoram State Road Project financed by the World Bank (hereinafter referred to as "WB") has been carried out to connect districts along the west side of NH54 corridor as shown in Figure 2.3-1. The project roads are connecting to NH54 at Lunglei and state highway design standard is applied to the project roads.



Source: Mizoram State Road Project Phase I & II, EIA Report

Figure 2.3-1 WB-Mizoram Road Infrastructure Development Project (Left: Phase I, Right: Phase II)

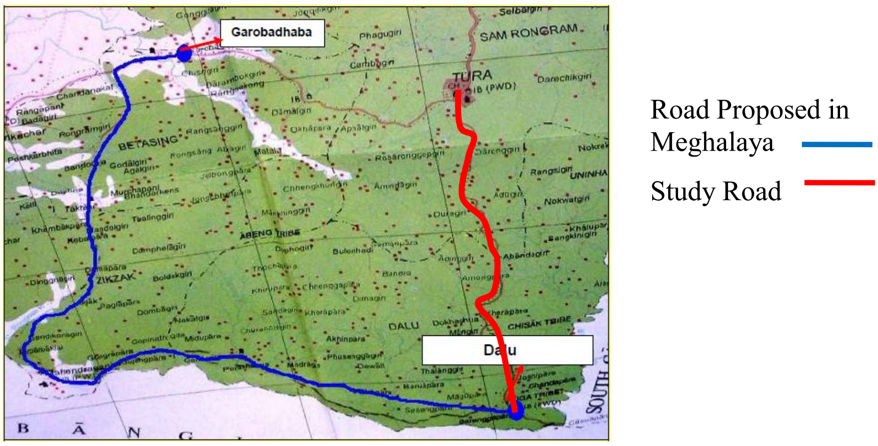
The North-Eastern State Roads Investment Program is a large-scale road development program for the North-Eastern States financed by the Asian Development Bank (hereinafter referred to as "ADB"), and second phase of the program has been contracted with the states in the North-Eastern Region. Figure 2.3-2 shows the proposed roads by the program and AS 02, 03, 11, 37 roads are included in the second phase.



Source: North Eastern State Roads Investment Program, EIA Report

Figure 2.3-2 ADB-North Eastern State Roads Investment Program (Assam) No. 02, 03, 11, 37

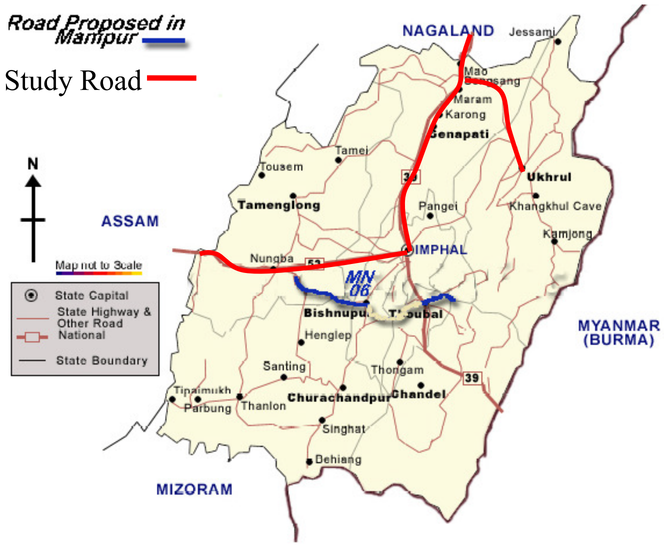
In Meghalaya State, the Dalu to Garobadhaba section connecting to NH51 from Tura to Dalu section has been implemented as second phase road as shown in Figure 2.3-3.



Source: North Eastern State Roads Investment Program, EIA Report

Figure 2.3-3 ADB-North Eastern State Roads Investment Program (Meghalaya)

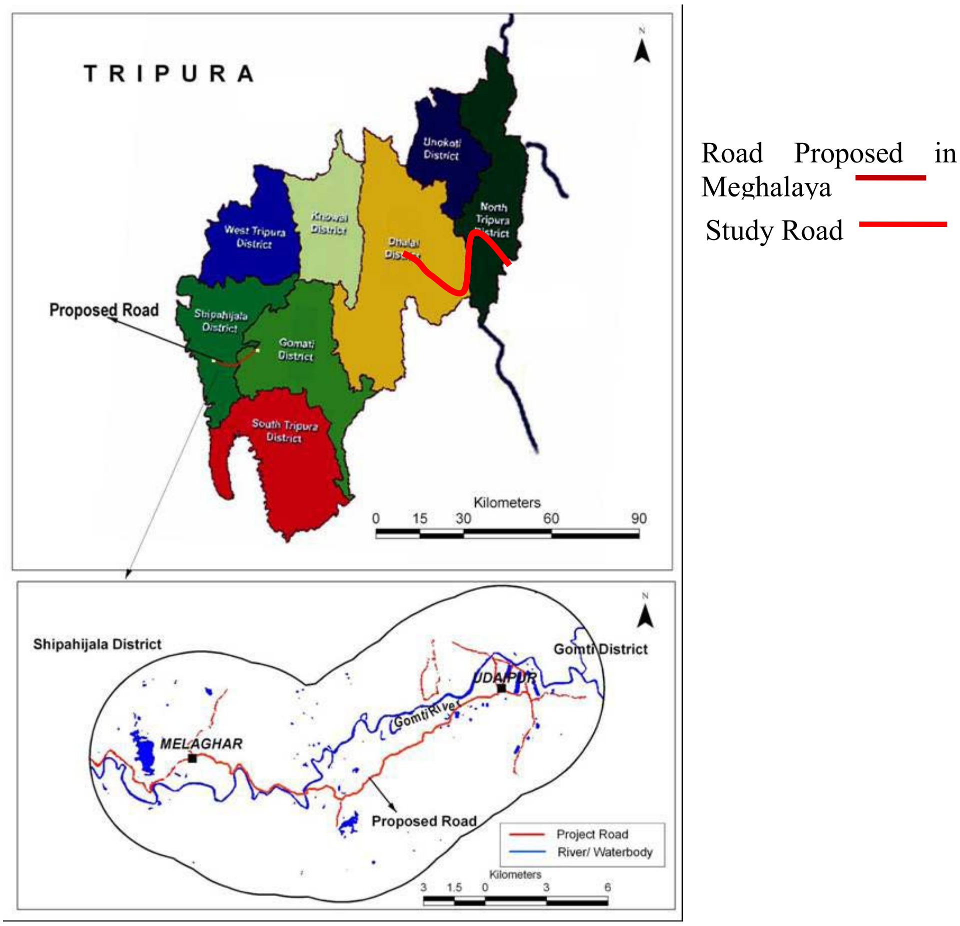
In Manipur State, the Tupul to Kasom Khullen section connecting to NH53 has been implemented as second phase road as shown in Figure 2.3-4.



Source: North Eastern State Roads Investment Program, EIA Report

Figure 2.3-4 ADB-North Eastern State Roads Investment Program (Manipur) No.06

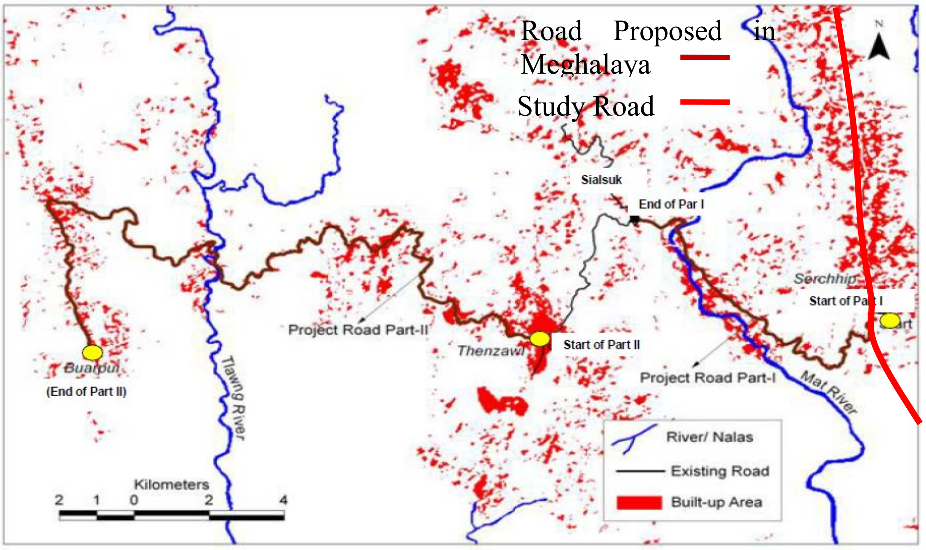
In Tripura State, the Udaipur to Melaghar section has been implemented as second phase road as shown in Figure 2.3-5.



Source: North Eastern State Roads Investment Program, EIA Report

Figure 2.3-5 ADB-North Eastern State Roads Investment Program (Tripura)

In Mizoram State, the Serchip to Buarpui section near NH54 has been implemented as second phase road as shown in Figure 2.3-6.



Source: North Eastern State Roads Investment Program, EIA Report

Figure 2.3-6 ADB-North Eastern State Roads Investment Program (Mizoram)

2.4 Socio Economic Conditions of the North-East States

The North-East States of India constitute eight states, viz., Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. For the present Study, the states of Arunachal Pradesh and Sikkim are not included. The road network/ sections included in the present Study are spread over six states.

2.4.1 Area and Social Framework

The area and population along with other social indicators are presented in Table 2.4-1. The figures on population, sex ratio, and literacy are based on actual census (2011 Census), which is conducted every ten years. The Study Area, with a total area of 171,340 km (about 65% of the area of the North-Eastern Region), contains a population of about 44 million (about 96% of the total North-Eastern Region population). Almost half (about 46%) of the area of the Study Area is under Assam State, and the population of the state is about 71% of that of the Study Area population, indicating higher concentration of population in Assam.

Within the states, the population density in Assam and Tripura states is more than three times of the other four states (about 7.5 times that in Mizoram). It can be observed that despite the almost equal geographical area of Manipur, Meghalaya, and Mizoram, the population density in Mizoram is almost 40% less than that in the other two states.

The literacy rate in all the six states is above 70% (literacy at India level is 74.04%). Mizoram has the highest literacy rate at 91.33% and Assam the lowest at 72.19%. The sex ratio ranges between 931 (Nagaland), which is below the national figure of 940, to 992 (Manipur).

A comparison of the Study Area (constituting the six states) reveals that the total geographical area covered by the Study is about 5.2% of the national area, whereas the population is about 3.6%, indicating lower population density of the Study Area vis-a-vis the national figure.

The Study Area falls in the northeastern part of India, and geographically, the eastern part of India (consisting of five states – Bihar, West Bengal, Jharkhand, Odisha, and Chhattisgarh) is adjacent to the northeastern part, and therefore, a comparison of the social and other indicators of these two regions will be of interest for the present Study.

The population of the Eastern Region is 6.78 times that of the Study Region and the area is 3.29 times, resulting in much higher population density (534 persons/km^2) in the Eastern Region as compared to the Study Region. In terms of sex ratio and literacy rates, the two regions are almost comparable, with not much difference in the figures.

Table 2.4-1 Area, Population & Social Indicators of States

Items	Unit	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total	All India	Eastern Region
Area (2011)	Sq. km	78,438	22,327	22,429	21,081	16,579	10,486	171,340	3,287,263	553,530
Districts (2011)	Nos.	27	9	7	8	11	4	66	640	129
Population (2011)	(000)	31,169	2,722	2,964	1,091	1,981	3,671	43,598	1,210,193	295,606
Sex Ratio (2011)	Females per 1000 Males	958	992	989	976	931	960		940	919 to 991
Population Density (2011)	Person/ Sq. km	398	115	132	52	119	350	254	368	534
Literacy Rate (2011)	%	72.19	79.21	74.43	91.33	79.55	87.22		74.04	63.82% to 77.08%

Note: Eastern Region consists of Bihar, West Bengal, Jharkhand, Chhattisgarh, and Odisha
Source: North-East Council, Shillong

2.4.2 Regional Economy and Industrial Structure

(1) Net State Domestic Product (NSDP) and Per Capita Income (PCI)

The NSDP and PCI at constant 2004 prices for all the six states, as well as for individual states, for the 2004-05 to 2013-14 period, are presented in Table 2.4-2 It can be observed that during the 2004-05 to 2013-14 period, the annual growth of the region (constituting the six states) was 6.41%. In the same period, the primary sector (agriculture and allied activities) grew at 4.11%, the secondary sector (industry – includes manufacturing, mining, quarrying, and construction) grew at 3.99%, and the tertiary sector (transport, communications, hotels, real estate, services, and banking) grew at 8.47%.

While the economy of the region grew at 6.41%, a change in the economic structure of the region is well evident over the years. The contribution of the primary sector to the regional economy (NSDP) was 27% in the year 2004-05, and it declined to 22% by 2013-14. Similarly, the share of the secondary sector has declined from 24% to 20%. It may be emphasized that the decline in the share of the primary sector was higher at 18.52% than the share of the secondary sector, which declined by 16.67%.

Contrary to the share of the primary and secondary sector, the regional share of the tertiary sector during the 2004-05 to 2013-24 period increased from 49% to 58%, depicting an increase of 18.37% over the period.

In terms of PCI, the compound annual growth rate (CAGR) for the region as a whole was observed at 4.93% during the period.

The NSDP at current prices for the year 2013-14 for the Study Region stood at Rs.223,219 crore (14.98% of that of the Eastern Region), indicating a considerable difference in the economic output of the two regions. Also, the growth rate of NSDP in the 2004-05 to 2013-14 period for the Eastern Region was higher at 6.82% as compared to 6.13% observed during the same period for the Study Region.

In terms of the growth in PCI, the states in the Eastern Region performed better than the Study Region, as the growth rate of PCI during the 2004-05 to 2013-14 period for the states in the Eastern Region varied between 4.03% to 8.15%, while the rate for the states in the Study Region was 2.44% to 7.06%.

Table 2.4-2 State-wise NSDP & PCI Series

(Million INR)

Sector	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	CAGR (%)
Assam											
Agriculture & Allied (P)	126280	128314	130213	134716	139425	148677	152262	159558	166068	173205	3.70
Share to NSDP (%)	27%	26%	26%	25%	25%	24%	23%	23%	23%	22%	
Industry (S)	119581	113511	113181	110972	119117	131640	131747	134948	137812	146397	2.83
Share to NSDP (%)	25%	23%	22%	21%	21%	21%	20%	20%	19%	19%	
Services (T)	225947	244192	264571	283991	302687	332622	373251	395842	426933	454158	7.95
Share to NSDP (%)	48%	50%	52%	54%	54%	54%	57%	57%	58%	59%	
NSDP	471807	486016	507965	529680	561230	612939	657260	690348	730813	773760	5.80
Population (in 000)	28114	28506	28896	29282	29660	30037	30413	30791	31167	31540	1.27
PCI (INR)	16782	17050	17579	18089	18922	20406	21611	22420	23448	24533	4.53
Manipur											
Agriculture & Allied (P)	11548	11657	11549	12773	14123	16130	12931	13188	13288		2.32
Share to NSDP (%)	25%	24%	23%	24%	25%	27%	22%	21%	20%		
Industry (S)	16970	18300	18700	19073	19460	20825	17265	17722	17994		0.11
Share to NSDP (%)	37%	37%	37%	36%	34%	34%	29%	28%	27%		
Services (T)	17516	19112	19671	20815	22838	23440	28423	33291	34920		8.80
Share to NSDP (%)	38%	39%	39%	40%	40%	39%	48%	52%	53%		
NSDP	46033	49070	49920	52661	56421	60395	58619	64201	66202		4.53
Population`(in 000)	2470	2519	2569	2619	2670	2721	2772	2823	2956		2.09
PCI (INR)	18640	19478	19430	20104	21131	22197	21147	22739	22395		2.44
Meghalaya											
Agriculture & Allied (P)	14296	15000	15156	14946	15519	15814	15948	16696	16954	17739	2.12
Share to NSDP (%)	24%	24%	22%	21%	20%	19%	17%	16%	16%	15%	
Industry (S)	14465	15737	17949	18671	22071	23300	25667	31951	31438	34978	10.11
Share to NSDP (%)	25%	25%	26%	27%	28%	28%	28%	31%	30%	30%	
Services (T)	29696	32290	34672	36293	41303	44850	50646	54341	56510	65664	8.72
Share to NSDP (%)	51%	51%	51%	52%	52%	53%	55%	53%	54%	55%	
NSDP	58457	63028	67777	69909	78893	83964	92261	102988	104902	118381	7.82
Population`(in 000)	2427	2458	2488	2518	2548	2578	2609	3010	3085	3162	3.06
PCI (INR)	24086	25642	27242	27764	30963	32569	35363	34217	34004	37439	4.76

Sector	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	CAGR (%)
Mizoram											
Agriculture & Allied (P)	5891	5970	5957	6867	7809	8512	9914	9583	9541		7.64
Share to NSDP (%)	25%	23%	22%	23%	23%	22%	22%	22%	20%		
Industry (S)	3647	4825	4832	5430	6600	6732	7023	7081	6996		7.87
Share to NSDP (%)	15%	19%	18%	18%	19%	18%	15%	16%	15%		
Services (T)	14459	14977	16139	17587	19962	23076	28452	27388	30346		10.30
Share to NSDP (%)	60%	58%	60%	59%	58%	60%	63%	62%	65%		
NSDP	23996	25773	26927	29885	34370	38320	45389	44053	46883		9.30
Population`(in 000)	973	998	1024	1050	1077	1104	1133	1162	1192		2.53
PCI (INR)	24662	25826	26308	28467	31921	34699	40072	37921	39347		6.77
Nagaland											
Agriculture & Allied (P)	19425	19957	20176	20299	22066	22652	24545	25856	26872	27892	4.35
Share to NSDP (%)	36%	33%	31%	29%	30%	29%	29%	28%	27%	27%	
Industry (S)	6721	7921	9111	10069	11560	12145	10159	11586	12603	13709	6.63
Share to NSDP (%)	12%	13%	14%	14%	16%	15%	12%	12%	13%	13%	
Services (T)	28069	31983	35250	39416	40592	43623	51167	55471	59394	63622	8.98
Share to NSDP (%)	52%	53%	55%	56%	55%	56%	60%	60%	60%	60%	
NSDP	54215	59861	64537	69784	74217	78420	85872	92912	98869	105222	7.26
Population`(in 000)	1781	1810	1840	1870	1901	1932	1952	2005	2055	2106	1.80
PCI (INR)	30441	33072	35074	37317	39041	40590	43992	46340	48111	49963	5.46
Tripura											
Agriculture & Allied (P)	21304	21917	23629	27827	29796	31005	33874	35947	37092		7.55
Share to NSDP (%)	26%	25%	25%	28%	27%	25%	26%	25%	24%		
Industry (S)	18536	21097	23552	23512	25784	29006	29927	30424	31342		6.48
Share to NSDP (%)	23%	24%	25%	23%	23%	24%	23%	21%	20%		
Services (T)	41857	44068	47399	49483	55883	62862	68348	77018	87413		9.32
Share to NSDP (%)	51%	51%	50%	49%	50%	51%	52%	54%	56%		
NSDP	81697	87082	94580	100822	111463	122873	132149	143389	155847		8.24
Population`(in 000)	3349	3390	3432	3474	3515	3557	3599	3641	3683		1.19
PCI (INR)	24394	25688	27558	29022	31711	34544	36718	39382	42315		7.06
Total											
Agriculture & Allied (P)	198743	202816	206679	217427	228738	242789	249474	260828	269813		4.11
Share to NSDP (%)	27%	26%	25%	25%	25%	24%	23%	23%	22%		
Industry (S)	179919	181392	187325	187728	204592	223649	221788	233712	238186		3.99
Share to NSDP (%)	24%	24%	23%	22%	22%	22%	21%	21%	20%		
Services (T)	357542	386621	417702	447585	483264	530472	600288	643351	695516		8.47

Sector	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	CAGR (%)
Share to NSDP (%)	49%	50%	51%	52%	53%	53%	56%	57%	58%		
NSDP	736205	770829	811706	852740	916594	996910	1071550	1137891	1203515		6.41
Population`(in 000)	39114	39681	40249	40813	41371	41929	42478	43432	44138		1.48
PCI (INR)	18822	19426	20167	20894	22156	23776	25226	26199	27267		4.93

Note: P = Primary Sector; S = Secondary Sector, T = Tertiary Sector CAGR = Compound Annual Growth Rate
Source: Ministry of Statistics & Programme Implementation, Government of India

(2) Industries

As per the Annual Report 2011-12 of the Ministry of Micro, Small and Medium Enterprises, the total number of working enterprises in the year 2009-10 was 46,863, and the corresponding employment was 441,495 persons, depicting an employment intensity of 9.42 persons per unit (Table 2.4-3).

The annual growth of enterprises (small and medium) during 2006-07 to 2010-11 for the Study Region (six states) was observed at 11.79%. Assam with a share of around 53% (in terms of number) indicated a growth of 7.48% during the same period. Nagaland, with a share of 11.95%, grew at an impressive rate of 48.66%. While Manipur, with a share of 10.16%, was able to grow annually at only 2.15%.

Table 2.4-3 Small & Medium Industries in the Study Region

Variables	States / Year	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total 6 States
Working Enterprises	2006-07	19864	4492	3010	3715	1332	1343	33756
	2007-08	21618	4530	3416	3941	2110	1499	37114
	2008-09	23249	4670	3826	4419	4631	1711	42506
	2009-10	24927	4759	4725	4919	5602	1931	46863
	2010-11*	26887	4881	5497	5403	9315	2180	54163
	CAGR (%)	7.48%	2.15%	15.29%	9.71%	48.66%	12.22%	11.79%
Employment (Persons)	2006-07	210507	19960	12700	26032	16281	23166	308646
	2007-08	229095	20129	14413	27616	25790	25857	342900
	2008-09	246379	20751	16143	30965	56605	29514	400357
	2009-10	264162	21146	19936	34469	68473	33309	441495
	2010-11*	284933	21689	23193	37860	113857	37604	519136
Production (Rs.in Crore)	2006-07	9389	200	447	310	1396	608	12351
	2007-08	10218	201	508	329	2211	679	14147
	2008-09	10989	208	569	369	4854	775	17763
	2009-10	11782	212	702	410	5871	875	19853
	2010-11*	12709	217	817	451	9763	987	24944

Note: 2010-11 figures are projections
Source: Annual Report 2011-12, Ministry of Micro, Small and Medium Enterprises

(3) Potential Industries of the Region

The areas with good industrial potential are mainly horticulture, tourism, and pharmaceutical. The main strength of the region lies in its ecology, which needs to be exploited. The summarized industrial potential of the region is presented in Table 2.4-4.

Table 2.4-4 Summary of Industrial Potential of the Study Region

Area/ Activity	Potential
Power	The power industry is developing but still has no surplus for export. There is a potential of 60,000 MW of hydropower in the region and some 4,000 MW is under construction. To solve the bottlenecks which mar the development of large hydropower plants, more people's participation coupled with taking up smaller run-of-the-river projects should be promoted. Development of inland water transport will be an excellent mode of transport facilitating movement of construction materials, machinery, equipment, raw materials, and manpower for power projects (including hydropower) located close to the river front.
Horticulture	The development of rubber plantation, fruit cultivation, spices, tea, and cinchona has shown an improvement but the enabling atmosphere for export in the form of cold storages, processing, packaging, and marketing strategies is yet to be developed. Moreover, the production levels and quality standards need to match the export requirements. There is a need to develop skills in this regard in the region. A cluster-based approach to develop these products with local level participation and providing the logistics support will instill confidence in the local community and generate required growth in the region. The only special economic zone (SEZ) in the region is Dimapur and the SEZs are planned at Moreh

Area/ Activity	Potential
	and Thoubal and are under development. A variety of horticulture products are produced that introduce scope for vertical integration and specialization of post-harvest activities. Activities such as extraction of juice and slicing of fruits can be done close to the fruit growing areas, and further processing, bottling, and packaging can be carried out at industrial hub. This is expected to significantly reduce transportation cost for which adequate road facilities shall be needed. Also, for transportation of agricultural products, the quality of rural roads needs to be improved to avoid damages and pilferages.
Handlooms and Handicrafts	The development of sericulture, handlooms, and handicrafts is a major strength of the region and things are happening in the region. However, there is a need to increase awareness, advertisement, and the cluster-wise development that will boost the production, packaging, and marketing of the products.
Petroleum	The oil refining sector has a potential surplus with regard to its refining capabilities but the fuel produced is not export competitive owing to the high grade of the output produced which is still not required in the adjoining nations. Thus, importing of crude and exporting the refined surplus by sea route via a pipeline to Sittwe Port can be possible. Development of inland water transport, wherever possible, for movement of petroleum products will be quite economical vis-à-vis other modes of transport. Strengthening and improving the movement of petroleum products by rail transport should be considered.
Medical Tourism	There is a good potential for development of medical tourism which is being operated in other parts of the country. Development of air link will provide much needed impetus to the promotion of medical tourism. It should be supported by rail link to facilitate movement of patients who otherwise would avoid travel by air.
Tourism	The tourism master plan has been developed and the circuits have to be developed by the states with the support of the industry. The development of tourism in Sikkim is a case in point where the hospitality and the friendly atmosphere have given the required impetus to domestic and international tourism. Each tourism circuit needs to be equipped with good quality road network. Promotion of tourism shall also require providing adequate rail and air linkages suitable to different income groups, and these are to be adequately linked with the road transport network to reach the tourist destinations.
Other Industries	There is a potential for the development of automobile spare parts industry and bicycle in the region as these have a great potential of not only for consumption in the region but for export as well. Raw hides are being exported from the region; however, efforts to promote the tanning industry in the region will have to be considered. With the gas potential, gas-based industries can be developed, mainly in Tripura. Nature provides the best potential for developing the pharmaceutical industry. The cluster-based approach for promotion of industry has been lacking due to the need for good intra- and inter-state road connectivity. Similarly, promotion of vertical integration of industrial production between the hills and plains shall require improvement of road infrastructure. Roads are very much needed for the backward integration of Land Custom Stations (LCSs) and Integrated Check Posts (ICPs), in particular for the following LCSs: a) Moreh (Manipur) b) Dawki (Mehglaya) c) Agartala (Tripura) d) Sutarkandi (Assam) **e)** Khwarpuchia (Mizoram)

Source: Taken from various available documents on the North-Eastern Region

(4) Export-Import

The exports and imports of the Study Region for the 2008-09 to 2012-13 period are set out in Table 2.4-5. It can be observed that exports and imports grew during the period at an annual rate (CAGR) of 19.49%.

Table 2.4-5 Export and Imports in Rs. Mill. – Project Area

Area	2008-09	2009-10	2010-11	2011-12	2012-13	CAGR (%)
Shillong	3,094	3,511	2,906	4,767	6,389	17.56%
Dhubri	1,082	1,453	1,554	2,415	3,507	28.86%
Guwahati	3,323	4,669	3,951	5,046	6,145	13.07%
Karimganj	651	804	703	892	1,240	13.95%
Imphal	24	105	41	29	261	35.04%
Aizawl	0	0	0	1	0	-
Total	8,173	10,542	9,154	13,151	17,542	19.49%

Source: North-East Council, Shillong

CHAPTER 3 PRESENT CONDITION AND MAJOR ISSUES OF THE STUDY ROADS

3.1 General

3.1.1 Methodology of the Survey

(1) Present Road Conditions

Site investigations and secondary data collection to collect and analyze present road conditions of the Study roads were carried out. Result of the investigations and secondary data collection are summarized in Table 3.1-1 and some data items are used for the economic analysis.

The Study road is basically divided into sections by number of lanes, and the data are summarized by sections. Data of road dimensions and pavement conditions are summarized based on results of sampling visual observation method. To be subjected to economic analysis, provisional improvement project cost of the Study roads is estimated based on the unit prices which are set based on similar road projects in the North-Eastern States.

Table 3.1-1 Survey Items based on Road Investigation and Secondary Data Collection

No.	Data Items	Type / Unit
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m), New (0)
2	Carriageway Width	m
3	Shoulder Width	Average in section / m
4	Shoulder Type	Paved or Unpaved
5	Average Altitude	m
6	Average Roughness	IRI
7	Total Area of Crack	%
8	Ravelled Area	%
9	No. of Pot Holes	per km
10	Edge Break Area	m2/km
11	Road Side Friction	%
12	Average Travel Speed	km/h
13	Road Capacity	PCU – IRC73-1980

No.	Data Items	Type	Unit Cost (INR crore/km)
14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2 + Shoulder 2.5m x 2)	Mountainous (INR crore/km)	9.0
		Rolling (INR crore/km)	5.5
		Level (INR crore/km)	4.0
		Long Bridge (INR crore/km)	12.0
		Total (INR crore)	

Source: JICA Study Team

(2) Identification of Limitation and Issue for Project Implementation

In parallel with the site investigations and secondary data collection, the following surveys were carried out to identify the limitations and issues of project implementation:

i) Conservation area (sanctuaries, reserved forest)

ii) Situation of entrance restrictions of foreigner

Entrance restrictions for foreigners including Japanese are prescribed by "The Foreigners (Protected Areas) Order 1958 ". In the state in which the target section is located, application for permission to enter the area is necessary for the following:

Table 3.1-2 Situation of Entrance Restriction in the Target Area

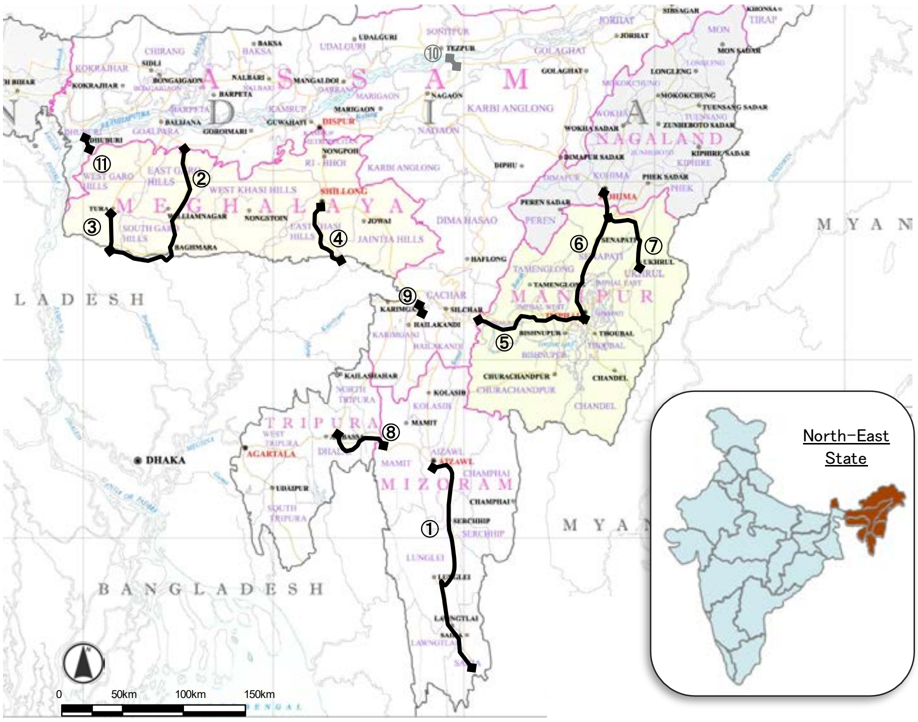
State	Prohibited/limited area	Organization in charge of the authorization
Manipur	Lohtak Lake, Imphal, Moirang INA Memorial, Keibul Deer Sanctuary and Waithe Lake Kongjam War Memorial	All Indian Missions abroad, All FRROs & MHA, State Government of Manipur
Mizoram	Vairangte, Thingdawl and Aizawl	All Indian Missions abroad, All FRROs, State Government of Mizoram
Nagaland	Dimapur District: Dimapur Town, Chumudima Sethikima and all places on the NH39 enroute to Kohima Town Kohima District: Kohima Town, Khonoma Dzulakie Kigwema, Jakhama Viswema, Khuzama, Japhfu, Dzuku Valley Mokochong District: Mokochong Town, Lungkhum, Ungma, Impur Mopungohukit, Chuchlyimlang, Tuli, Chani Wokha District: Wokha Town, Doyang, Vankhosand, Tsunki, Governor's Camp and Mount Tlyi	All Indian Missions abroad, All FRROs, State Government of Nagaland

Source: JICA Study Team

iii) Obtaining topographical maps
iv) Administrative jurisdiction
v) Related road plan
vi) Competing road development plan
vii) Others

3.1.2 The Study Roads

Eleven Study roads in total are initially requested to be considered in the Study as shown in Figure 3.1-1 and Table 3.1-3. The construction of No.10 Koliabhomora Bridge Project has been started by GOI, thus Japan International Cooperation Agency (JICA) assistance for implementation of the project will not be required.



Source: JICA Study Team

Figure 3.1-1 Project Road for the Study

Table 3.1-3 The Study Roads for the Study

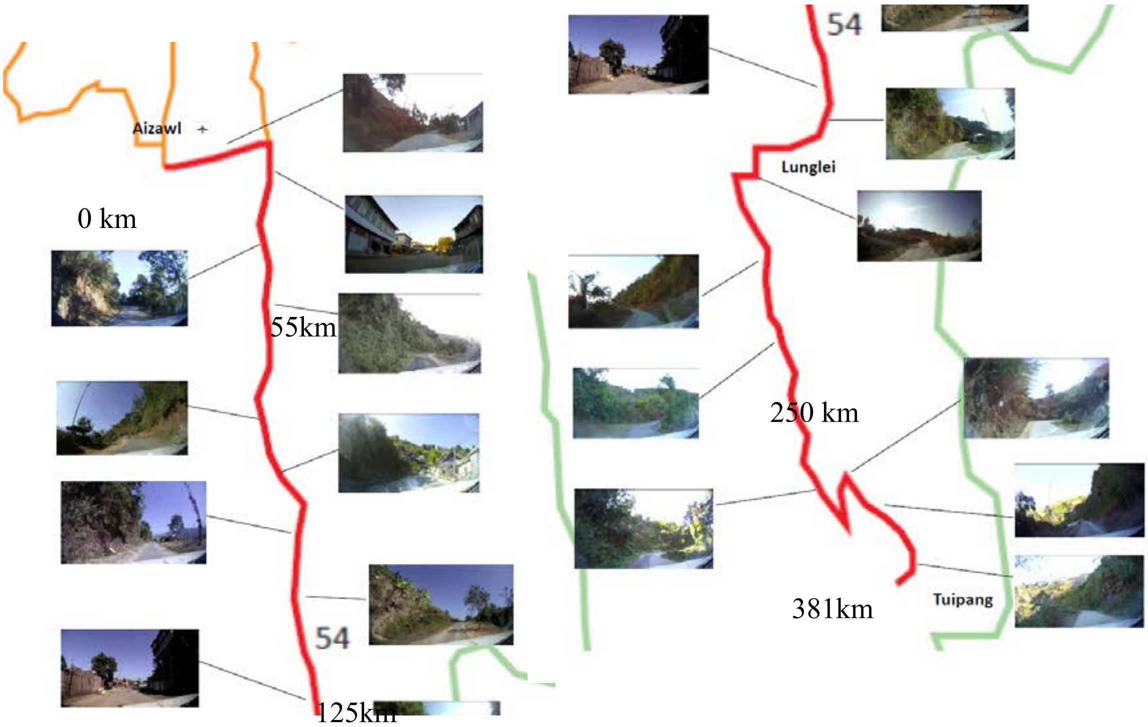
No.	Study Roads Section	Length	Request Type
①	Aizawl – Tuipang Section, NH54	381km	Improvement
②	Dudhanal – Dalu Section, NH62	196km	Improvement
③	Tura – Dalu Section, NH51	54km	Improvement
④	Shillong – Dawki Section, NH40	84km	Improvement
⑤	Imphal – Jiribam Section, NH53	221km	Improvement
⑥	Imphal - Kohima Section, NH39	138km	Improvement
⑦	Ukhrul – Tadubi Section, NH102A	115km	Improvement
⑧	Manu - Simlung Section NH44A	110 km	Improvement/New
⑨	Badarpurghat Bridge near Silchar	360m	Improvement/New
⑩	Koliabhomora Bridge near Tezpur	2.5km	Improvement
⑪	Dhubri – Phulbari Section	Bridge: 18km Access Road: 21km	New Bridge

Source: JICA Study Team

3.2 Present Conditions and Major Issues of the Project Roads

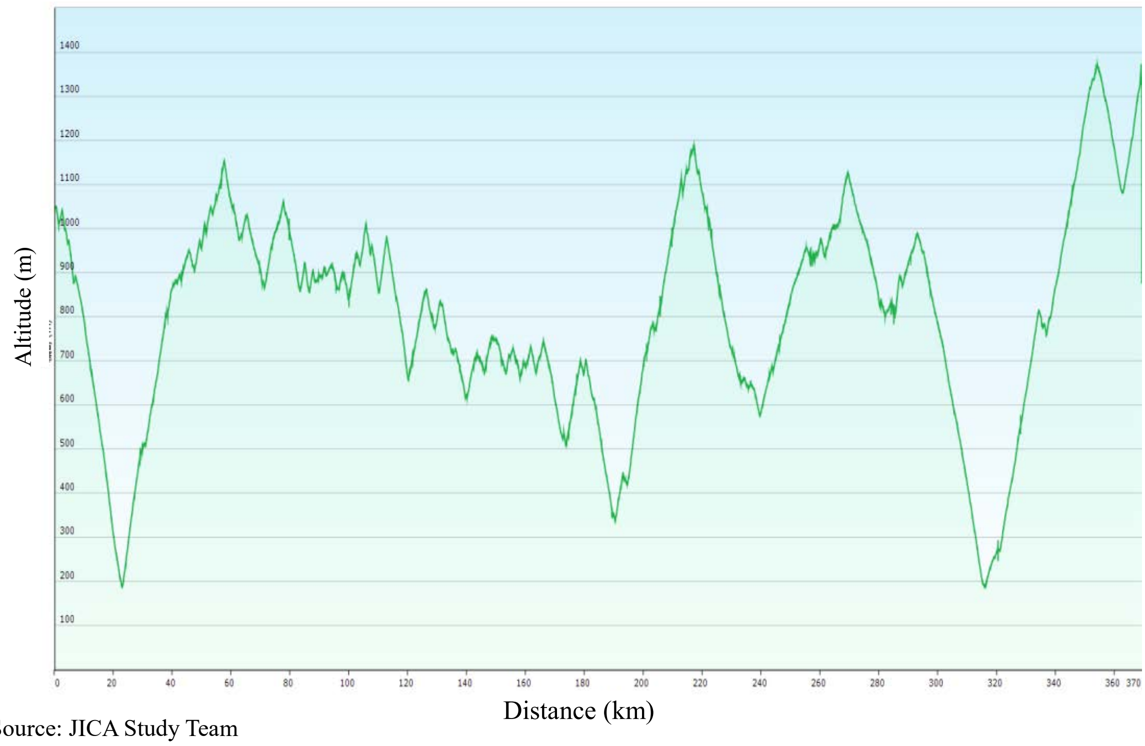
3.2.1 NH54 (Aizawl-Tuipang)

The Study road of NH54 starts from Aizawl in Mizoram State to Tuipang with total length of approximately 381 km. The road mainly passes on the brow of variegated mountains and the alignment consists of many small horizontal and vertical curves as shown in Figure 3.2-1 and Figure 3.2-2. Number of lanes is 1.5 lanes for the section near Aizawl and one lane for the other sections. Pavement condition between Aizawl to Lunglei is fair, while the section between Lunglei and Tuipang is deteriorated due to inadequate road maintenance.



Source: JICA Study Team

Figure 3.2-1 Road Alignment and Present Road Condition of NH54



Source: JICA Study Team

Figure 3.2-2 Existing Road Profile of NH54

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-1. Average travel speeds are 30 km/hour to 21 km/hour and this low travel speed is evidence of steep mountainous terrain and poor pavement surface condition.

Table 3.2-1 Present Conditions and Provisional Improvement Cost of NH54

<table>
<tr><th rowspan="4">No.</th><th rowspan="4">Data Items</th><th rowspan="4" colspan="2">Type / Unit</th><th colspan="8">Road</th></tr>
<tr><th colspan="8">NH54 (Upper: KM distance from Aizawl, Lower: KP)</th></tr>
<tr><th colspan="2">0-55</th><th colspan="2">55-125</th><th colspan="2">125-250</th><th colspan="2">250-381</th></tr>
<tr><th colspan="2">181-236</th><th colspan="2">236-306</th><th colspan="2">306-431</th><th colspan="2">431-562</th></tr>
<tr><td>1</td><td>Number of Lanes</td><td colspan="2">Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m)
New (0)</td><td colspan="2">1.5</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">1</td></tr>
<tr><td>2</td><td>Carriageway Width</td><td colspan="2">m</td><td colspan="2">5.5</td><td colspan="2">3.75</td><td colspan="2">3.75</td><td colspan="2">3.75</td></tr>
<tr><td>3</td><td>Shoulder Width</td><td colspan="2">Average in section / m</td><td colspan="2">0.4</td><td colspan="2">0.5</td><td colspan="2">0.4</td><td colspan="2">0.45</td></tr>
<tr><td>4</td><td>Shoulder Type</td><td colspan="2">Paved or Unpaved</td><td colspan="2">Unpaved</td><td colspan="2">Unpaved</td><td colspan="2">Unpaved</td><td colspan="2">Unpaved</td></tr>
<tr><td>5</td><td>Average Altitude</td><td colspan="2">m</td><td colspan="2">714</td><td colspan="2">860</td><td colspan="2">724</td><td colspan="2">853</td></tr>
<tr><td>6</td><td>Average Roughness</td><td colspan="2">IRI</td><td colspan="2">4.5</td><td colspan="2">5</td><td colspan="2">6.2</td><td colspan="2">9.1</td></tr>
<tr><td>7</td><td>Total Area of Crack</td><td colspan="2">%</td><td colspan="2">6.3</td><td colspan="2">7.5</td><td colspan="2">25</td><td colspan="2">62</td></tr>
<tr><td>8</td><td>Ravelled Area</td><td colspan="2">%</td><td colspan="2">6.3</td><td colspan="2">10</td><td colspan="2">5</td><td colspan="2">4</td></tr>
<tr><td>9</td><td>No. of Pot Holes</td><td colspan="2">per km</td><td colspan="2">5</td><td colspan="2">5</td><td colspan="2">21</td><td colspan="2">7</td></tr>
<tr><td>10</td><td>Edge Break Area</td><td colspan="2">m2/km</td><td colspan="2">50</td><td colspan="2">100</td><td colspan="2">50</td><td colspan="2">20</td></tr>
<tr><td>11</td><td>Road Side Friction</td><td colspan="2">%</td><td colspan="2">50</td><td colspan="2">15</td><td colspan="2">10</td><td colspan="2">5</td></tr>
<tr><td>12</td><td>Average Travel Speed</td><td colspan="2">km/h</td><td colspan="2">30</td><td colspan="2">26</td><td colspan="2">23</td><td colspan="2">21</td></tr>
<tr><td>13</td><td>Road Capacity</td><td colspan="2">PCU – IRC73-1980</td><td colspan="2">5,000</td><td colspan="2">1,000</td><td colspan="2">1,000</td><td colspan="2">1,000</td></tr>
<tr><td rowspan="5">14</td><td rowspan="5">Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 2.5m x 2)</td><td>Mountainous (INR crore/km)</td><td>9</td><td>55</td><td>495</td><td>70</td><td>630</td><td>125</td><td>1125</td><td>131</td><td>1179</td></tr>
<tr><td>Rolling (INR crore/km)</td><td>5.5</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Level (INR crore/km)</td><td>4</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Long Bridge (INR crore/km)</td><td>120</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">Total (INR crore)</td><td colspan="2">495</td><td colspan="2">630</td><td colspan="2">1125</td><td colspan="2">1179</td></tr>
</table>

Source: JICA Study Team

There is no critical limitation and issue on improvement of NH54 based on interview survey with road administrators and secondary data collection.

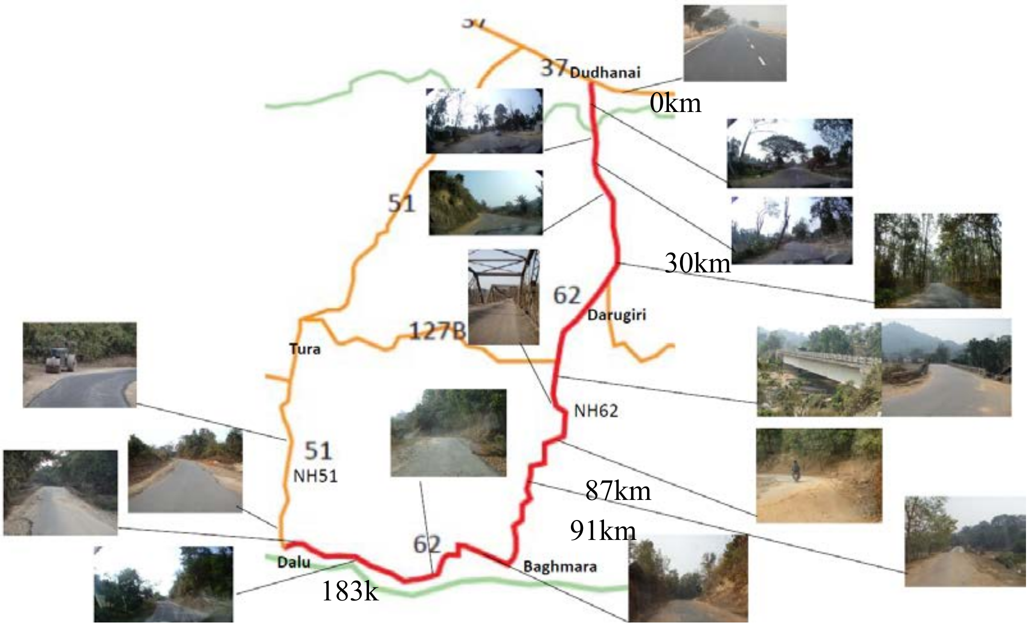
Table 3.2-2 Findings and Issues of NH54

Items	Findings	Issues
Conservation area	No finding	No issue
Restrictions of foreigner	Need Registration	No issue
Obtaining a topographical map	Possible	No issue
Administrative Jurisdiction	MORTH	No issue
Bypass Plan	No large-scale plan	No issue
Competing plan	No finding	No issue
Others	No finding	No issue

Source: JICA Study Team

3.2.2 NH62 (Dudhanai-Dalu)

The Study road of NH62 starts from Dudhanai in Assam State to Dalu in Meghalaya State with total length of approximately 183 km. The road passes on flat land section near Dudhanai, and rolling and mountainous terrain in succeeding sections. Alignment of the road consists of combination of small and medium horizontal and vertical curves as shown in Figure 3.2-3 and Figure 3.2-4. Numbers of lanes are two lanes for the section near Dudhanai, 1.5 lanes for KM30-KM87, and one lane for the succeeding section. Pavement condition between Dudhanai to KM87 is fair, while section after KM87 is partially deteriorated due to inadequate road maintenance.



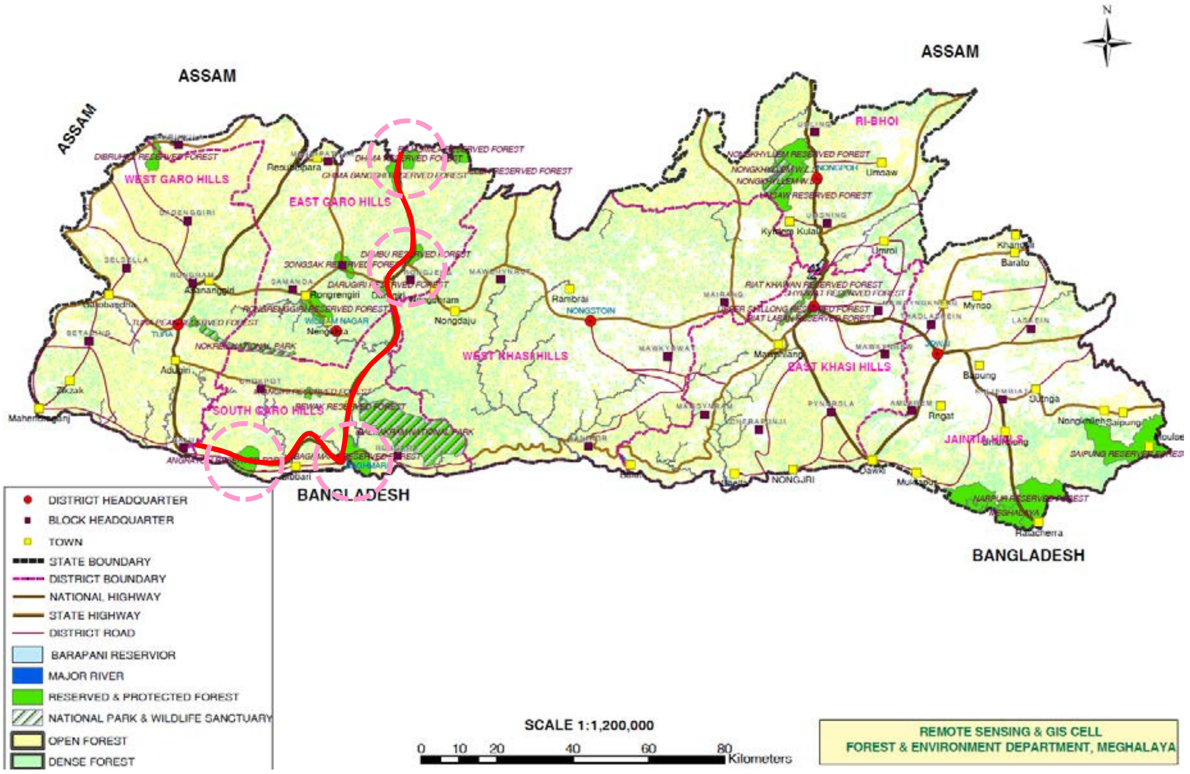
Source: JICA Study Team

Figure 3.2-3 Road Alignment and Present Road Condition of NH62

Source: JICA Study Team

Figure 3.2-4 Existing Road Profile of NH62

There are four reserved forests along NH62 according to the forest map of Meghalaya State as shown in Figure 3.2-5. Necessary process for road improvement is needed to be confirmed.



Source: Forest & Environment Department, Meghalaya State

Figure 3.2-5 Reserved Forest along NH62

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-3. Average travel speeds on the section from Dudhanai to KM87 and the section from KM91 to KM183 are high, ranging from 52 km/hour to 36 km/hour. Meanwhile, the average travel speed on the section from KM87 to KM91 is 28 km/hour and this low travel speed is evidence of the steep mountainous terrain and poor pavement surface condition.

Table 3.2-3 Present Conditions and Provisional Improvement Cost of NH62

No.	Data Items	Type / Unit	Road			
			NH62 (Upper: KM distance from Dudhanai, Lower: KP)			
			0-30	30-87	87-91	91-183
			-	-	-	-
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m) New (0)	2	1.5	1	1
2	Carriageway Width	m	7	5.5	3.75	3.75
3	Shoulder Width	Average in section / m	0.3(20%)/1.0(80%)	1	1	1
4	Shoulder Type	Paved or Unpaved	Paved/ Unpaved	Unpaved	Unpaved	Unpaved
5	Average Altitude	m	133	287	440	175
6	Average Roughness	IRI	4.1	4.5	8	7.2
7	Total Area of Crack	%	5	5	80	43
8	Ravelled Area	%	5	5	10	8

No.	Data Items	Type / Unit	Road: NH62 (Upper: KM distance from Dudhanai, Lower: KP) 0-30	30-87	87-91	91-183
			-	-	-	-
9	No. of Pot Holes	per km	5	5	50	42
10	Edge Break Area	m2/km	50	50	50	220
11	Road Side Friction	%	8	12	15	5
12	Average Travel Speed	km/h	52	39	28	36
13	Road Capacity	PCU – IRC73-1980	10,000	5,000	1,000	1,000

14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 2.5m x 2)	Mountainous (INR crore/km)	9	10	90	52	468	4	36	62	558
		Rolling (INR crore/km)	5.5	0	0	5	27.5	0	0	30	165
		Level (INR crore/km)	4	20	80	0	0	0	0	0	0
		Long Bridge (INR crore/km)	120	0	0	0	0	0	0	0	0
		Total (INR crore)			170		495.5		36		723

Source: JICA Study Team

Reserved forest is found as mentioned above along NH62 and there is some security risk surrounding the project area according to security information.

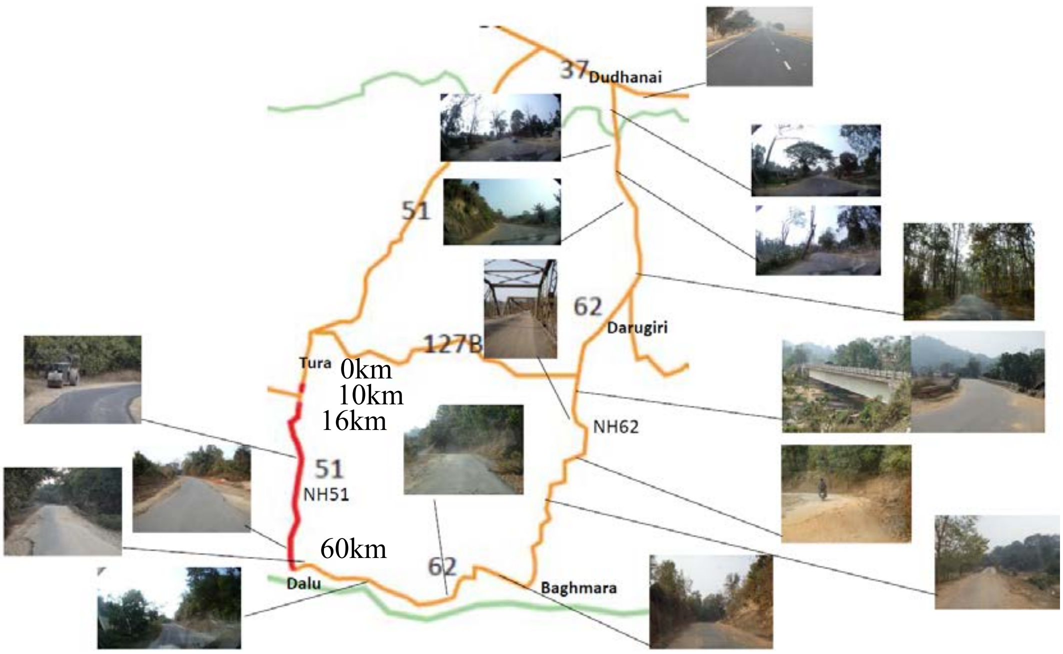
Table 3.2-4 Findings and Issues of NH62

Items	Findings	Issues
Conservation area	Reserved Forest	Need Confirmation
Restrictions of foreigner	No finding	No issue
Obtaining a topographical map	Possible	No issue
Administrative Jurisdiction	MORTH	No issue
Bypass Plan	No finding	No issue
Competing plan	No finding	No issue
Others	Security	Need Confirmation

Source: JICA Study Team

3.2.3 NH51 (Tura-Dalu)

The Study road of NH51 starts from Tura to Dalu in Meghalaya State with total length of approximately 54 km. The road passes mostly on rolling terrain, and the alignment consists of a combination of medium horizontal and vertical curves as shown in Figure 3.2-6 and Figure 3.2-7. The whole section consists of one lane. Pavement condition is rather deteriorated on the whole section due to inadequate road maintenance.



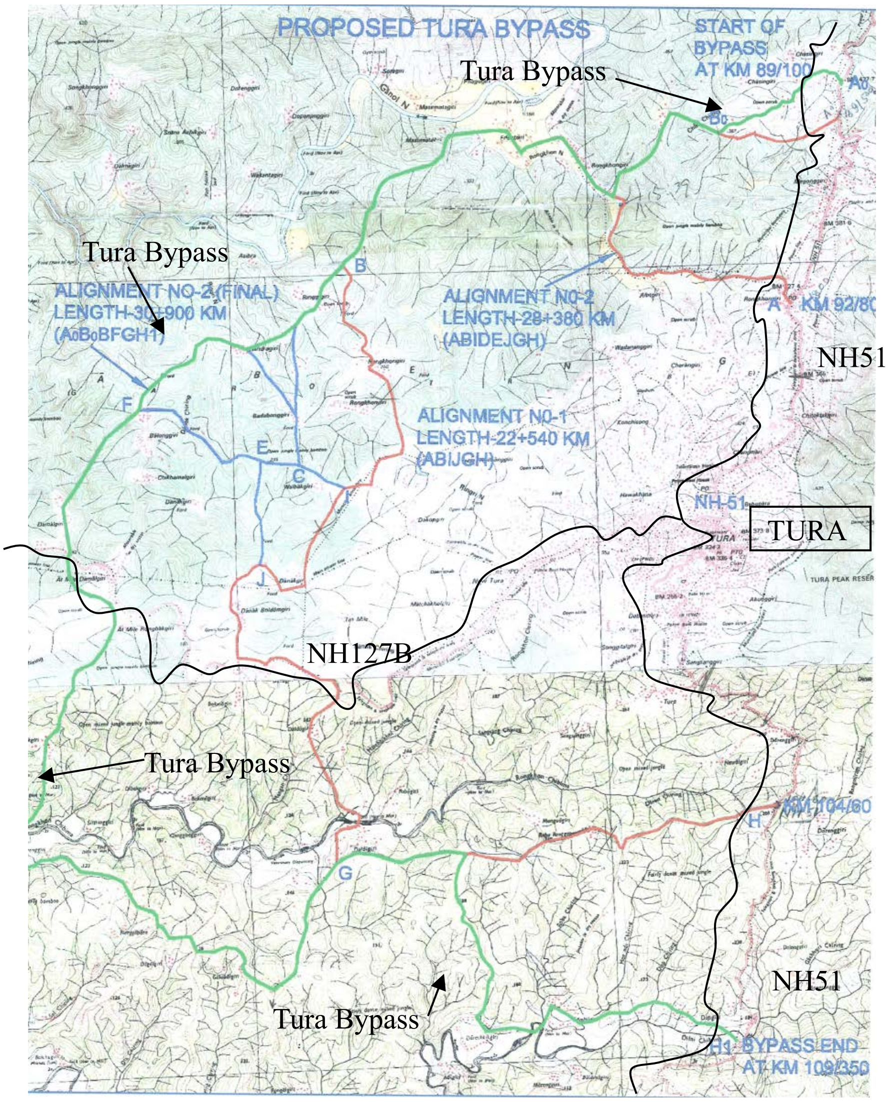
Source: JICA Study Team

Figure 3.2-6 Road Alignment and Present Road Condition of NH51

Source: JICA Study Team

Figure 3.2-7 Existing Road Profile of NH51

Bypass route at Tura City is proposed and draft DPR for the bypass, named Tura Bypass, was prepared. The total length of Tura Bypass is 30.9 km as shown in Figure 3.2-8 and 12 m road width (7.0 m carriageway + 1.5 m hard shoulder x 2 + 1.0 m earthen shoulder x 2) is given. There is only few existing earthen roads under the proposed alignment of Tura Bypass according to site investigation.



Source: PWD Meghalaya

Figure 3.2-8 Proposed Tura Bypass

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-5. Average travel speed on the section from Tura to KM10 is 21 km/hour due to deteriorated pavement condition and steep road profile. Meanwhile, the average travel speed on the succeeding section is 36 km/hour.

Table 3.2-5 Present Conditions and Provisional Improvement Cost of NH51

No.	Data Items	Type / Unit		Road			
				NH51 (Upper: KM distance from Tura, Lower: KP)			
				0-10		16-60	
				85-95		101-145	
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m) New (0)		1		1	
2	Carriageway Width	m		3.75		3.75	
3	Shoulder Width	Average in section / m		1		1	
4	Shoulder Type	Paved or Unpaved		Unpaved		Unpaved	
5	Average Altitude	m		258		110	
6	Average Roughness	IRI		5.2		6.5	
7	Total Area of Crack	%		25		32	
8	Ravelled Area	%		1.5		2	
9	No. of Pot Holes	per km		30		24	
10	Edge Break Area	m2/km		162		162	
11	Road Side Friction	%		40		27	
12	Average Travel Speed	km/h		21		36	
13	Road Capacity	PCU – IRC73-1980		1,000		1,000	
14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 2.5m x 2)	Mountainous (INR crore/km)	9	0	0	0	0
		Rolling (INR crore/km)	5.5	10	55	44	242
		Level (INR crore/km)	4	0	0	0	0
		Long Bridge (INR crore/km)	120	0	0	0	0
		Total (INR crore)			55		242

Source: JICA Study Team

Since Tura bypass is almost green field project, implementation schedule need to be carefully considered in consideration of environmental related process, if Tura Bypass is incorporated into the study scope. There is some security risk surrounding of the project area according to security information.

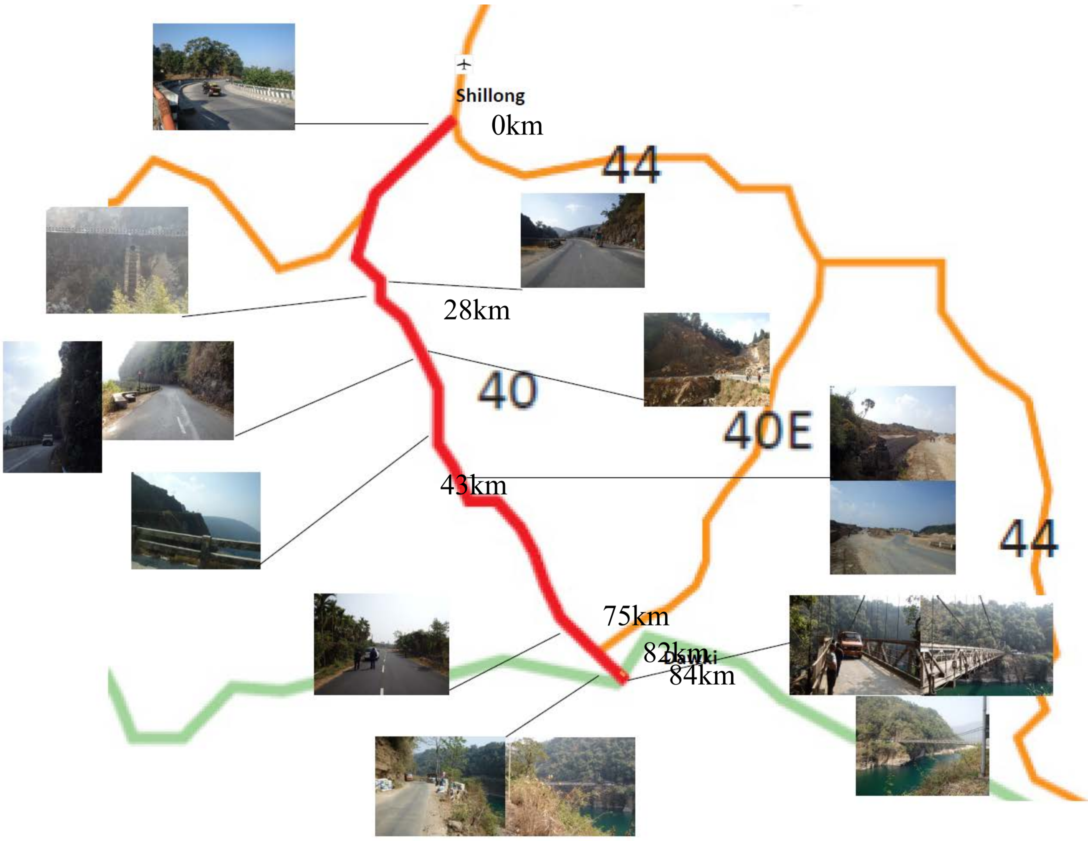
Table 3.2-6 Findings and Issues of NH51

Items	Findings	Issues
Conservation area	No finding	No Issue
Restrictions of foreigner	No finding	No Issue
Obtaining topographical maps	Possible	No Issue
Administrative Jurisdiction	MORTH	No Issue
Bypass Plan	Tura Bypass	Need Confirmation
Competing plan	No finding	No Issue
Others	Security	Need Confirmation

Source: JICA Study Team

3.2.4 NH40 (Shillong-Dawki)

The Study road of NH40 starts from Shillong to Dawki in Meghalaya State, with total length of approximately 84 km. Vertical interval of the study road is very high starting from approximately 1,700 m to approximately 50 m at the ending point. Alignment of the study road consists of combination of medium horizontal and vertical curves as shown in Figure 3.2-9 and Figure 3.2-10. Numbers of lanes are variable from two lanes to one lane for the whole section, and there are few narrow sections located between deep valleys and overhanging rocky slopes. There is an old steel suspension bridge (L=135 m) near the end of the Study road and this bridge is a bottleneck due to its one-lane bridge width. Pavement condition is rather deteriorated on the whole section except the section from KM0 to KM28 due to inadequate road maintenance.



Source: JICA Study Team

Figure 3.2-9 Road Alignment and Present Road Condition of NH40

Source: JICA Study Team

Figure 3.2-10 Existing Road Profile of NH40

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-7. Average travel speeds on the section from Shillong to KM75 are high, ranging from 40 km/hour to 43 km/hour while average travel speeds on the succeeding section are from 15 km/hour to 18k m/hour. This low travel speed is evidence of steep mountainous terrain and poor pavement surface condition.

Table 3.2-7 Present Conditions and Provisional Improvement Cost of NH40

No.	Data Items	Type / Unit	Road				
			NH40 (Upper: KM distance from Sillong, Lower: KP)				
			0-28	28-43	43-75	75-82	82-84
			80-108	108-123	123-155	155-162	162-164
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m), New (0)	2	1.5	2	1	2
2	Carriageway Width	m	7	5	7	3.75	7
3	Shoulder Width	Average in section / m	0.5	0.5	0.4	0.5	0.5
4	Shoulder Type	Paved or Unpaved	Unpaved	Unpaved	Unpaved	Unpaved	Unpaved
5	Average Altitude	m	1710	1552	813	47	30
6	Average Roughness	IRI	3.6	5.5	5	7	5.5
7	Total Area of Crack	%	3.5	20	16	40	30
8	Ravelled Area	%	2	30	10	10	30
9	No. of Pot Holes	per km	2	10	22	50	50
10	Edge Break Area	m2/km	45	50	80	150	150
11	Road Side Friction	%	65	5	12	5	30
12	Average Travel Speed	km/h	43	40	43	18	15
13	Road Capacity	PCU – IRC73-1980	10,000	5,000	10,000	1,000	10,000

14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 2.5m x 2)	Mountainous (INR crore/km)	9	22	198	15	135	19	171	7	63	1.85	16.65
		Rolling (INR crore/km)	5.5	6	33	0	0	13	71.5	0	0	0	0
		Level (INR crore/km)	4	0	0	0	0	0	0	0	0	0	0
		Long Bridge (INR crore/km)	120	0	0	0	0	0	0	0	0	0.15	18
		Total (INR crore)			231		135		242.5		63		34.65

Source: JICA Study Team

Two alternative routes to avoid the present bottleneck of the existing steel suspension bridge are being studied by PWD Meghalaya. One is new bridge construction at about 200 m downstream of the existing steel suspension bridge and PWD Meghalaya carried out detailed design of the new bridge. Another is a bypass route starting near KM75 of NH40 to near the ending point through NH40E, with total length of approximately 13 km. Since the bypass route includes a green field section, the implementation schedule needs to be carefully considered with respect to environmental-related process, in case the bypass will be adopted.

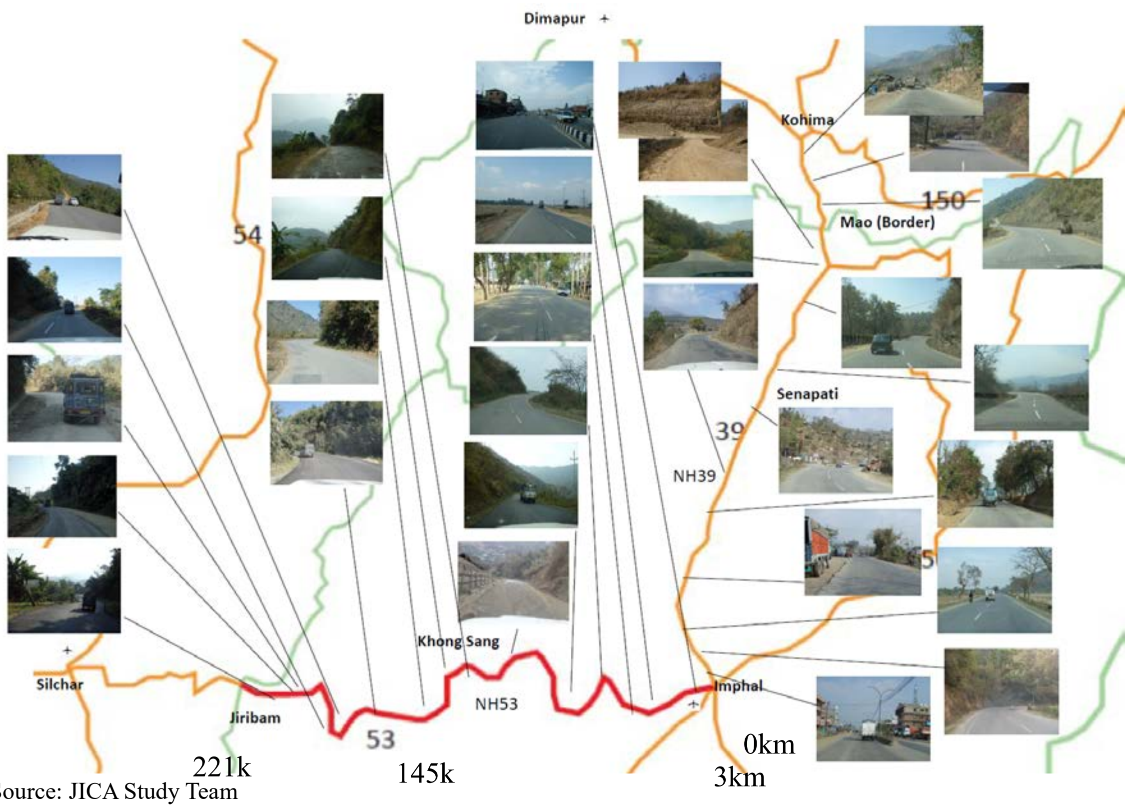
Table 3.2-8 Findings and Issues of NH40

Items	Findings	Issues
Conservation area	No finding	No Issue
Restrictions of foreigner	No finding	No Issue
Obtaining a topographical map	Possible	No Issue
Administrative Jurisdiction	MORTH	No Issue
Bypass Plan	Dawki Bypass	Need Confirmation
Competing plan	No finding	No Issue
Others	No finding	No Issue

Source: JICA Study Team

3.2.5 NH53 (Imphal-Jiribam)

The Study road of NH53 starts from Imphal to Jiribam in Manipur State with total length of approximately 221 km. The Study road passes three mountains at KM30, KM120, and KM160 and existing profile shows steep grade around the three mountains as shown in Figure 3.2-12. Alignment of the study road consists of combination of small and medium horizontal and vertical curves as shown in Figure 3.2-11 and Figure 3.2-12. Number of lanes from near Imphal is four lanes and succeeding section is two lanes. Pavement condition between Imphal to Khong Sang is rather fair while the pavement condition of succeeding sections are variable.



Source: JICA Study Team

Figure 3.2-11 Road Alignment and Present Road Condition of NH53

Source: JICA Study Team

Figure 3.2-12 Existing Road Profile of NH53

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-9. Average travel speeds are stable, ranging from 35 km/hour to 40 km/hour.

Table 3.2-9 Present Conditions and Provisional Improvement Cost of NH53

No.	Data Items	Type / Unit	Road		
			NH53 (Upper: KM distance from Imphal, Lower: KP)		
			0-3	3-145	145-221
			-	-	-
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m), New (0)	4	2	2
2	Carriageway Width	m	14	7	7
3	Shoulder Width	Average in section / m	0.3	0.4	0.5
4	Shoulder Type	Paved or Unpaved	Paved	unpaved	unpaved
5	Average Altitude	m	786	587	370
6	Average Roughness	IRI	4	5	5.5
7	Total Area of Crack	%	5	31.5	31
8	Ravelled Area	%	5	13.5	6
9	No. of Pot Holes	per km	5	65	78
10	Edge Break Area	m2/km	50	110	100
11	Road Side Friction	%	100	5	12
12	Average Travel Speed	km/h	39.6	35	37
13	Road Capacity	PCU – IRC73-1980	60,000	10,000	10,000

14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 2.5m x 2)	Mountainous (INR crore/km)	9	0	0	130	1170	62	558
		Rolling (INR crore/km)	5.5	0	0	0	0	14	77
		Level (INR crore/km)	4	3	12	12	48	0	0
		Long Bridge (INR crore/km)	120	0	0	0	0	0	0
		Total (INR crore)			12		1218		635

Source: JICA Study Team

Border Roads Organization (hereinafter referred to as "BRO") currently administrates the maintenance and rehabilitation works. There is some security risk surrounding the project area according to security information.

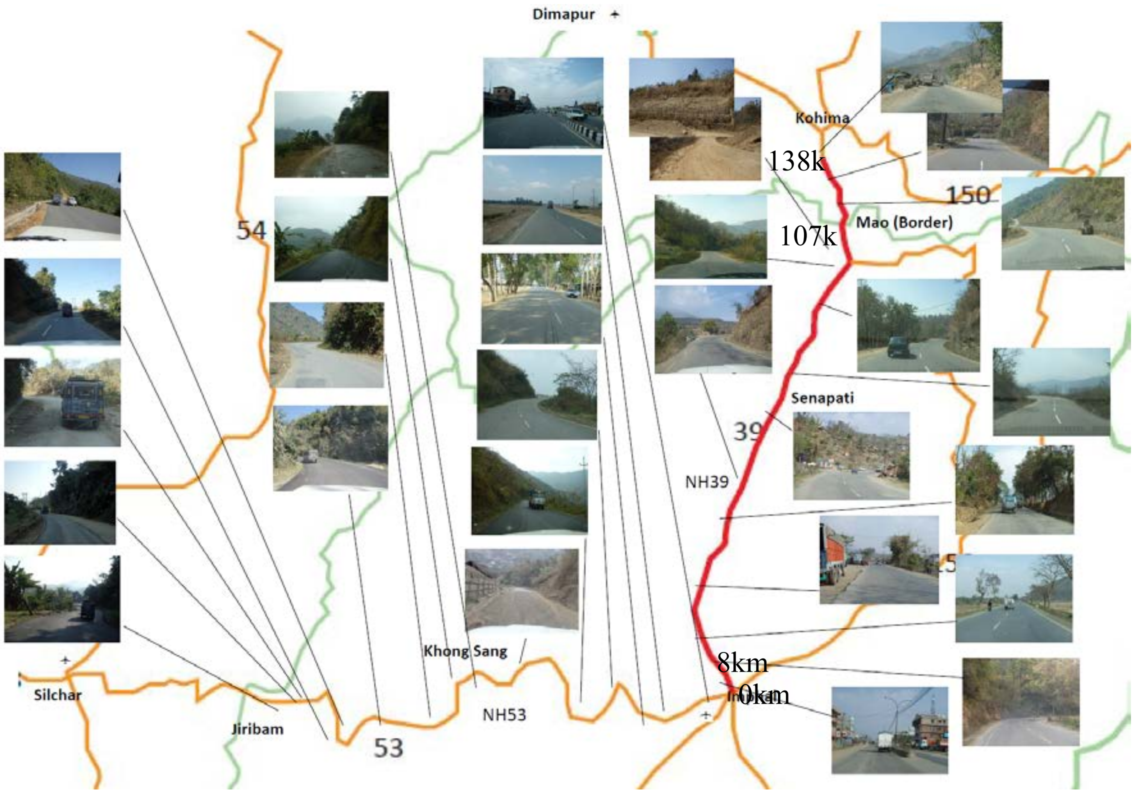
Table 3.2-10 Findings and Issues of NH53

Items	Findings	Issues
Conservation area	No finding	No issue
Restrictions of foreigner	Need registration	No issue
Obtaining topographical maps	Army facilities	Need Confirmation
Administrative Jurisdiction	BRO	Need Confirmation
Bypass Plan	No finding	No issue
Competing plan	No finding	No issue
Others	Security	Need Confirmation

Source: JICA Study Team

3.2.6 NH39 (Imphal – Kohima)

The Study road of NH39 starts from Imphal in Manipur State to Kohima in Nagaland State with total length of approximately 138 km. Vertical interval of the Study road is high, starting from approximately 800 m to approximately 1,700 m at the ending point. Alignment of the road consists of a combination of medium horizontal and vertical curves as shown in Figure 3.2-13 and Figure 3.2-14. Number of lanes from near Imphal is four lanes and succeeding section is two lanes. Pavement condition is rather fair for the whole section.



Source: JICA Study Team

Figure 3.2-13 Road Alignment and Present Road Condition of NH39

Source: JICA Study Team

Figure 3.2-14 Existing Road Profile of NH39

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-11. Average travel speeds are stable, ranging from 37 km/hour to 45 km/hour.

Table 3.2-11 Present Conditions and Provisional Improvement Cost of NH39

No.	Data Items	Type / Unit	Road		
			NH39 (Upper: KM distance from Imphal, Lower: KP)		
			0-8	8-107	107-138
			181-212	212-311	311-319
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m), New (0)	4	2	2
2	Carriageway Width	m	14	7	7
3	Shoulder Width	Average in section / m	0.5	0.5	0.5
4	Shoulder Type	Paved or Unpaved	paved	unpaved	unpaved
5	Average Altitude	m	790	1148	1618
6	Average Roughness	IRI	4.5	5	5.5
7	Total Area of Crack	%	10	17.5	12.5
8	Ravelled Area	%	15	15	15
9	No. of Pot Holes	per km	50	40	27.5
10	Edge Break Area	m2/km	50	75	125
11	Road Side Friction	%	100	12	12
12	Average Travel Speed	km/h	45	45	36.6
13	Road Capacity	PCU – IRC73-1980	60,000	10,000	10,000

14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 2.5m x 2)	Mountainous (INR crore/km)	9	0	0	74	666	31	279
		Rolling (INR crore/km)	5.5	0	0	25	137.5	0	0
		Level (INR crore/km)	4	8	32	0	0	0	0
		Long Bridge (INR crore/km)	120	0	0	0	0	0	0
		Total (INR crore)			32		803.5		279

Source: JICA Study Team

BRO currently administrates the maintenance and rehabilitation works for the section in Nagaland State. Alternative routes for Kohima Bypass are being studied to divert through traffic in Kohima City. There is some security risk surrounding the project area according to security information.

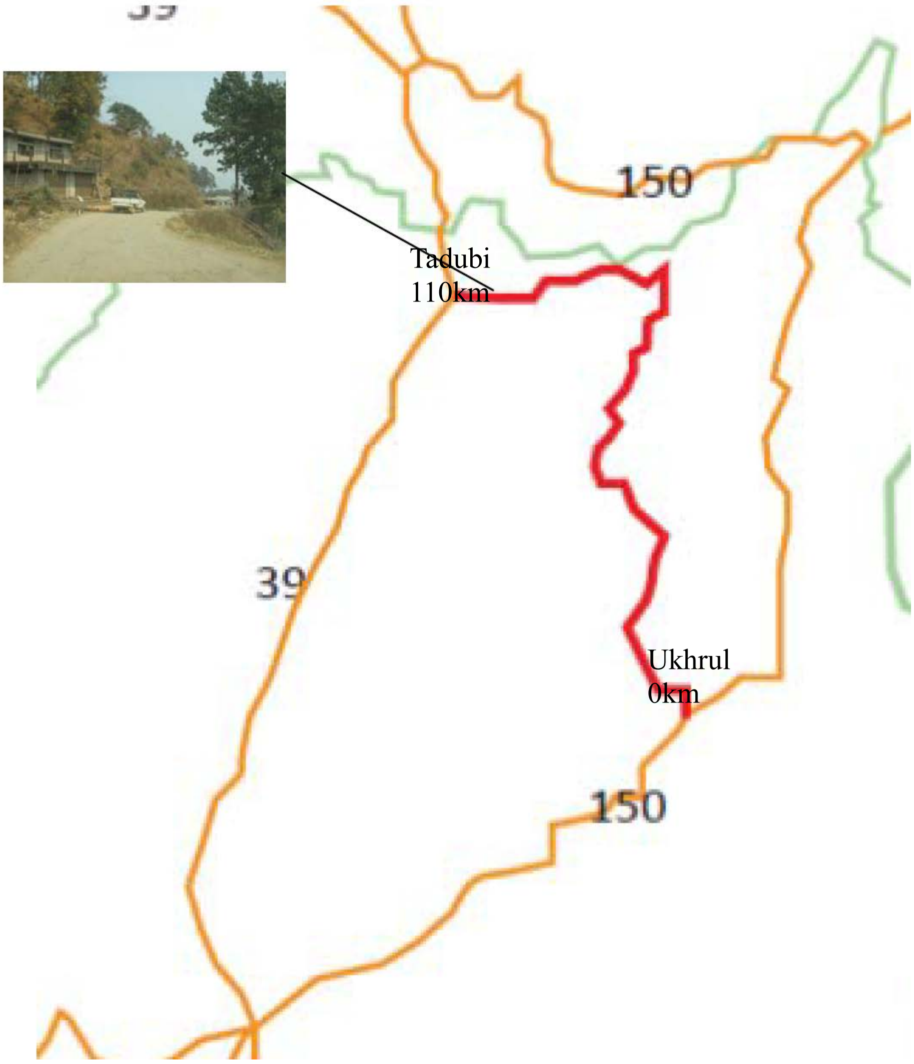
Table 3.2-12 Findings and Issues of NH39

Items	Findings	Issues
Conservation area	No finding	No Issue
Restrictions of foreigner	Need registration	No Issue
Obtaining a topographical map	Army facilities	Need Confirmation
Administrative Jurisdiction	BRO (Nagaland section)	Need Confirmation
Bypass Plan	Kohima Bypass	Need Confirmation
Competing plan	No finding	No Issue
Others	Security	Need Confirmation

Source: JICA Study Team

3.2.7 NH102A (Ukhrul-Tadubi)

The Study road of NH102A starts from Ukhrul to Tadubi in Manipur State with total length of approximately 110 km. Site investigation was carried out only at the ending point of Tadubi due to security reason.



Source: JICA Study Team

Figure 3.2-15 Road Alignment and Present Road Condition of NH102A

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-13.

Table 3.2-13 Present Conditions and Provisional Improvement Cost of NH102A

No.	Data Items	Type / Unit		Road NH102A (KM distance from Ukhrul) 0-115 -
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m) New (0)		1
2	Carriageway Width	m		3.5
3	Shoulder Width	Average in section / m		0.5
4	Shoulder Type	Paved or Unpaved		Unpaved
5	Average Altitude	m		-
6	Average Roughness	IRI		-
7	Total Area of Crack	%		-
8	Ravelled Area	%		-
9	No. of Pot Holes	per km		-
10	Edge Break Area	m2/km		-
11	Road Side Friction	%		-
12	Average Travel Speed	km/h		-
13	Road Capacity	PCU – IRC73-1980		1,000
14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 3.5m x 2)	Mountainous (INR crore/km)	9	115 1035
		Rolling (INR crore/km)	5.5	0 0
		Level (INR crore/km)	4	0 0
		Long Bridge (INR crore/km)	120	0 0
		Total (INR crore)		1035

Source: JICA Study Team

BRO currently administrates the maintenance and rehabilitation works. There is some security risk surrounding the project area according to security information.

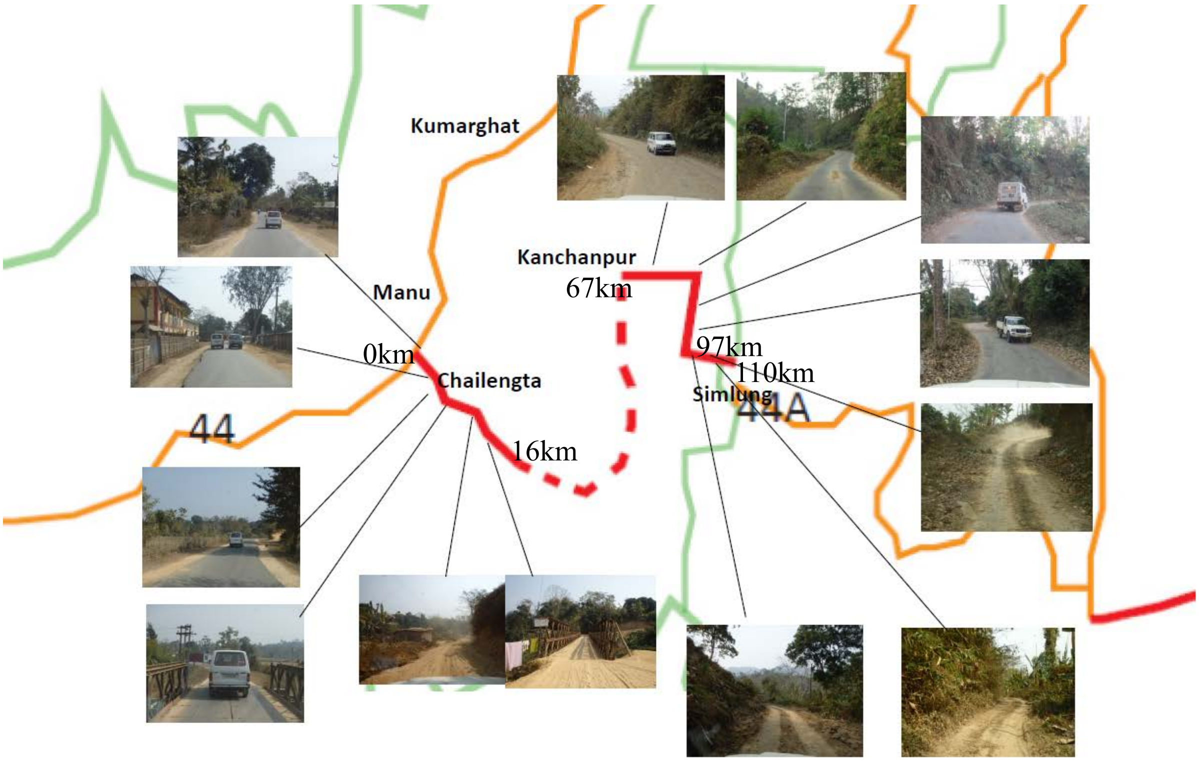
Table 3.2-14 Findings and Issues of NH102A

Items	Findings	Issues
Conservation area	No finding	No issue
Restrictions of foreigner	Need registration	No issue
Obtaining topographical maps	Army facilities	Need Confirmation
Administrative Jurisdiction	BRO	Need Confirmation
Bypass Plan	No finding	No issue
Competing plan	No finding	No issue
Others	Security	Need Confirmation

Source: JICA Study Team

3.2.8 NH44A (Manu-Simlung)

The Study road of NH44A starts from Manu to Simlung in Tripura State with total length of approximately 110 km. The Study road includes approximately 50 km of new construction section, and cross over on about five mountain ranges as shown in Figure 3.2-17 and Figure 3.2-18. Alignment of the road consists of a combination of small and medium horizontal and vertical curves, and profile is steep around the cross over sections on mountains. Number of lane is one lane for the whole section. Pavement condition of Manu side is fair while pavement condition of Simlung side is rather deteriorated.



Source: JICA Study Team

Figure 3.2-16 Road Alignment and Present Road Condition of NH44A

Source: JICA Study Team

Figure 3.2-17 Existing Road Profile of NH44A (Manu Side)

Source: JICA Study Team

Figure 3.2-18 Existing Road Profile of NH44A (Simlung Side)

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-15. Average travel speed of Manu side is high, ranging from 42 km/hour, while that of Simlung side ranges from 13 km/hour to 29 km/hour and this low travel speed is evidence of steep mountainous terrain and poor pavement surface condition.

Table 3.2-15 Present Conditions and Provisional Improvement Cost of NH44A

No.	Data Items	Type / Unit	Road			
			NH44A (KM distance from Manu)			
			0-16	16-67	67-97	97-110
			-	-	-	-
1	Number of Lanes	Four (4): Carriageway Width (7 m + 7 m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m) New (0)	1	0: New section	1	1: Unpaved section
2	Carriageway Width	m	3.5		3.5	3.5
3	Shoulder Width	Average in section / m	0.5		0.5	
4	Shoulder Type	Paved or Unpaved	Unpaved		Unpaved	
5	Average Altitude	m	90		350	167
6	Average Roughness	IRI	6		5.8	20
7	Total Area of Crack	%	25		20	
8	Ravelled Area	%	5		5	
9	No. of Pot Holes	per km	20		52	
10	Edge Break Area	m2/km	50		100	
11	Road Side Friction	%	5		3	3
12	Average Travel Speed	km/h	42		29	13
13	Road Capacity	PCU – IRC73-1980	1,000	1,000	1,000	1,000

No.	Data Items	Type / Unit		Road							
				NH44A (KM distance from Manu)							
				0-16		16-67		67-97		97-110	
				-		-		-		-	
14	Improvement Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 3.5m x 2)	Mountainous (INR crore/km)	9	0	0	51	459	22	198	8	72
		Rolling (INR crore/km)	5.5	9	49.5	0	0	8	44	5	27.5
		Level (INR crore/km)	4	7	28	0	0	0	0	0	0
		Long Bridge (INR crore/km)	120	0	0	0	0	0	0	0	0
		Total (INR crore)			77.5		459		242		99.5

Source: JICA Study Team

There is no critical limitation and issue on the improvement of NH44A based on secondary data collection and interview survey with road administrators.

Table 3.2-16 Findings and Issues of NH44A

Items	Findings	Issues
Conservation area	No finding	No Issue
Restrictions of foreigner	No finding	No Issue
Obtainingtopographical maps	No finding	No Issue
Administrative Jurisdiction	No finding	No Issue
Bypass Plan	No finding	No Issue
Competing plan	No finding	No Issue
Others	No finding	No Issue

Source: JICA Study Team

3.2.9 NH44 Badarpurghat Bridge

Badarpurghat Bridge is located on NH44 near Silchar in Assam State. The bridge was constructed in 1974 as reinforced concrete box girder bridge and total length is 359.44 m consisting of five cantilever spans (56.20 m x 2 + 108.50 m x 2 + 30.04 m x 1). Carriageway width of the bridge is 12 m and footpath is installed on both sides of the carriageway with 1.5 m width.

Some defects have been observed and repair works for the defects have been implemented as follows:

A) 20 cm level difference between the cantilever tips in 2002

B) Replacement of all gap slab in 2002

C) Replacement of all the 8 pairs of bearings in 2002

D) Fitting and fixing of 8 nos. of expansion joint in 2003

E) Cantilever end between pier 1 and pier 2 of the north side (damage of pedestal, saddle plate, steel girder) in 2012

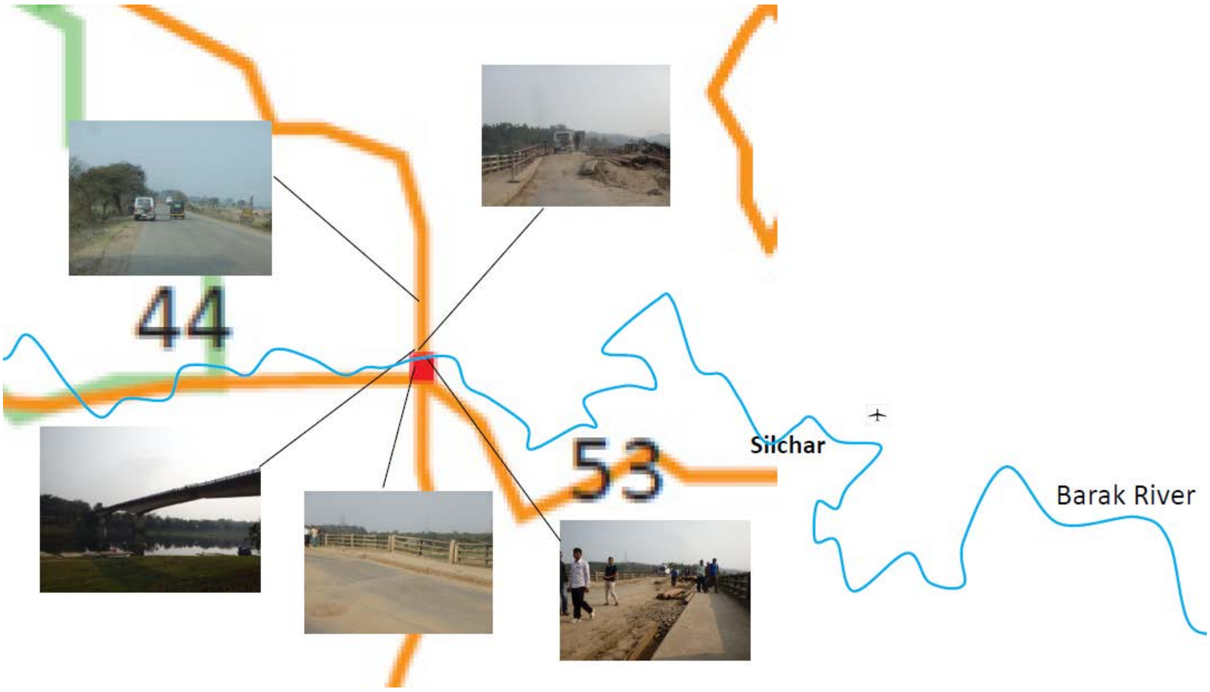
F) Displacement bearing in 2012

G) Gap developed between saddle plate and bearing in 2012

H) Cantilever end between pier 2 and pier 3 of the north side (damage of pedestal, saddle plate) in 2012

I) Pier 4 from the north side (roller bearing corrugated) in 2012

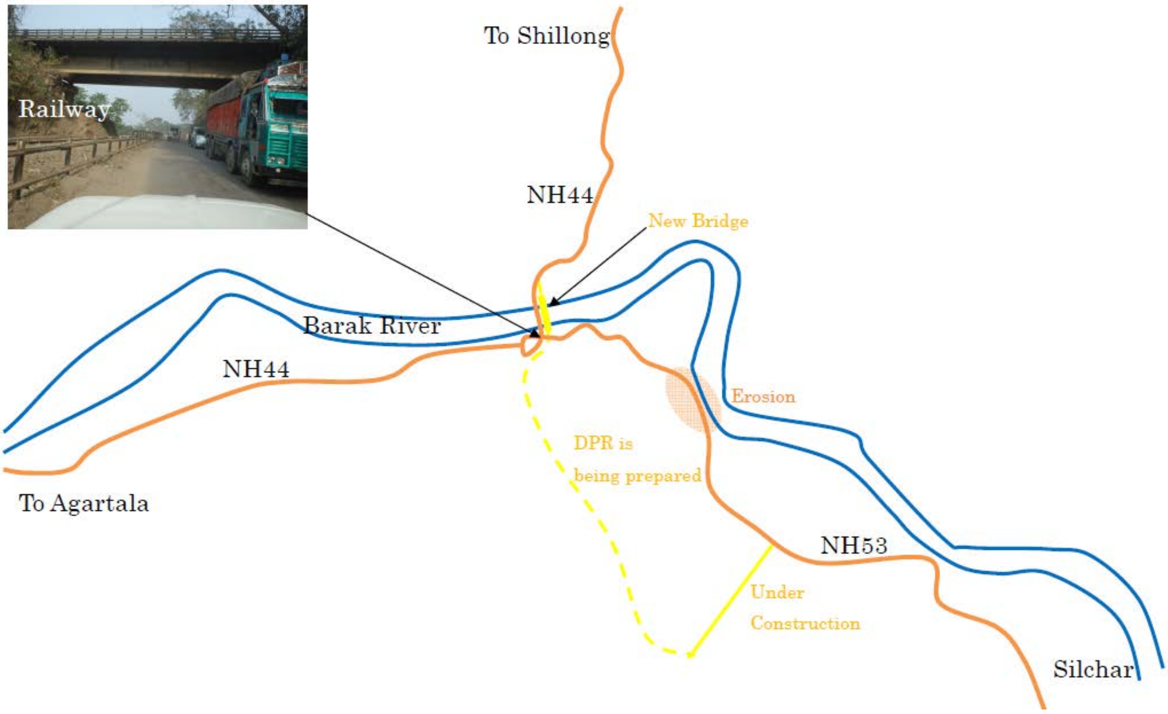
Remedial measures for G, H, and I above were proposed in 2012, but implementation has not been done. For traffic to pass temporarily, a steel bridge is constructed over the gap slab between pier 2 and pier 3 of the north side.



Source: JICA Study Team

Figure 3.2-19 Present Condition of NH44 Badarpurghat Bridge

A new bridge plan with bypass route has been implemented as shown in Figure 3.2-20. Bypass route is planned to avoid the eroded section on NH53 by the Barak River.



Source: JICA Study Team

Figure 3.2-20 Bypass Plan of NH44 Badarpurghat Bridge

Since examination of detailed remedial measure and costing of the existing bridge are difficult and the new bridge plan has been implemented, preliminary project cost is estimated based on new bridge construction as shown in Table 3.2-17.

Table 3.2-17 Present Conditions and Provisional Improvement Cost of NH44 Badarpurghat Bridge

No.	Data Items	Type / Unit		Bridge	
				NH44 Badarpurghat Bridge	
				0-0.36	
				-	
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m) New (0)		0: New Bridge	
2	Carriageway Width	m			
3	Shoulder Width	Average in section / m			
4	Shoulder Type	Paved or Unpaved			
5	Average Altitude	m			
6	Average Roughness	IRI			
7	Total Area of Crack	%			
8	Ravelled Area	%			
9	No. of Pot Holes	per km			
10	Edge Break Area	m2/km			
11	Road Side Friction	%			
12	Average Travel Speed	km/h			
13	Road Capacity	PCU – IRC73-1980			10,000
14	New Construction Project Cost (Bridge: W=12m, Carriageway 3.5m x 2+ Safety Strip 3.5m x 2)	Mountainous (INR crore/km)	9	0	0
		Rolling (INR crore/km)	5.5	0	0
		Level (INR crore/km)	4	0	0
		New Long Bridge (INR crore/km)	120	0.36	43.2
		Total (INR crore)			43.2

Source: JICA Study Team

Rehabilitation of the existing bridge needs to be made urgently through prompt budgetary scheme.

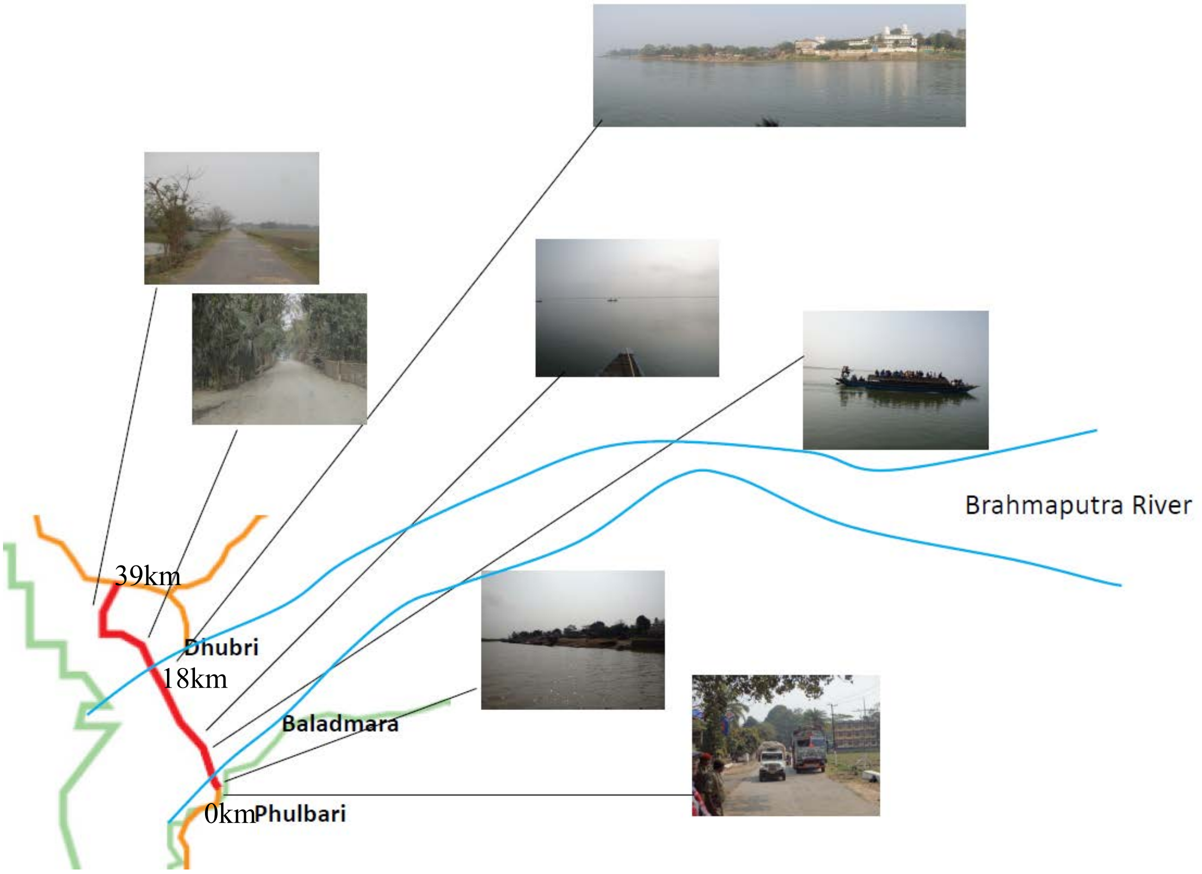
Table 3.2-18 Findings and Issues of NH44 Badarpurghat Bridge

Items	Findings	Issues
Conservation area	No finding	No issue
Restrictions of foreigner	No finding	No issue
Obtaining a topographical map	No finding	No issue
Administrative Jurisdiction	No finding	No issue
Bypass Plan	New bridge with bypass plan	Need confirmation
Competing plan	No finding	No issue
Others	Urgent rehabilitation of existing bridge is necessary	Need confirmation

Source: JICA Study Team

3.2.10 NH127B Dhubri – Phulbari Bridge

Dhubri-Phulbari Bridge is planned to be located on NH127B near Dhubri in Assam State. The bridge has been studied with an approach road, and 18 km new bridge construction and 21 km approach road in Dhubri side are proposed in the previous study. Phulbari is proposed as the bridge approach point due to its stable river bank.



Source: JICA Study Team

Figure 3.2-21 Present Condition of NH127B Dhubri-Phulbari Bridge

Data collected by site investigation and secondary data collection and preliminary project cost are tabulated in Table 3.2-19. Average travel speed on the approach road is 25km/hour due to deteriorated pavement condition.

Table 3.2-19 Present Conditions and Provisional Improvement Cost of NH127B Dhubri-Phulbari Bridge

No.	Data Items	Type / Unit	Bridge & Approach Road	
			NH127B Dhubri - Phulbari Bridge & Approach Road	
			0-18	18-39
			-	-
1	Number of Lanes	Four (4): Carriageway Width (7m+7m), Double (2): Carriageway Width (7m/10m), Intermediate (1.5): Carriageway Width (5m/5.5m), Single (1): Carriageway Width (3.5m/3.75m), New (0)	0: New Bridge	1
2	Carriageway Width	m		3.5
3	Shoulder Width	Average in section / m		0.5
4	Shoulder Type	Paved or Unpaved		unpaved
5	Average Altitude	m		31

No.	Data Items	Type / Unit	Bridge & Approach Road NH127B Dhubri - Phulbari Bridge & Approach Road 0-18	 18-39
			-	-
6	Average Roughness	IRI		6.5
7	Total Area of Crack	%		50
8	Ravelled Area	%		5
9	No. of Pot Holes	per km		50
10	Edge Break Area	m2/km		100
11	Road Side Friction	%		35
12	Average Travel Speed	km/h		25
13	Road Capacity	PCU – IRC73-1980	10,000	1,000

14	Improvement and New Construction Project Cost (W=12m: Carriageway 3.5m x 2+ Shoulder 3.5m x 2) (Bridge: W=12m, Carriageway 3.5m x 2+ Safety Strip 3.5m x 2)	Mountainous (INR crore/km)	9	0	0	0	0
		Rolling (INR crore/km)	5.5	0	0	0	0
		Level (INR crore/km)	4	0	0	21	84
		New Long Bridge (INR crore/km)	120	18	2160	0	0
		Total (INR crore)			2160		84

Source: JICA Study Team

There is no critical limitation and issue on the improvement of NH127B Dhubri-Phulbari Bridge based on interview survey with road administrators and secondary data collection.

Table 3.2-20 Findings and Issues of NH127B Dhubri-Phulbari Bridge

Items	Findings	Issues
Conservation area	No finding	No issue
Restrictions of foreigner	No finding	No issue
Obtaining topographical maps	No finding	No issue
Administrative Jurisdiction	No finding	No issue
Bypass Plan	No finding	No issue
Competing plan	No finding	No issue
Others	No finding	No issue

Source: JICA Study Team

CHAPTER 4 TRAFFIC SURVEY, ANALYSIS AND FORECAST

4.1 General

Traffic surveys have been carried out on the Study road sections with a view to meet the requirements of the present Study. The traffic surveys were performed by following the standard practices in effect in India and elsewhere in other countries to determine the present traffic volumes (classified according to the type of vehicles) as well as the pattern of traffic flows in the Study Area.

The present chapter covers the following sections:

- Study Road Network/Sections
- Traffic Survey and Forecast Methodology
- Past Traffic Data
- Traffic Surveys
  - ➢ Classified Traffic Count Survey (CTCS)
  - ➢ Roadside Origin-Destination Survey (RSI)
- Traffic Forecast

4.2 Study Road Network/ Sections

The road network/sections included in the present Study are set out in Table 4.2-1. There are ten road and bridge projects in total, adding up to 1,325.36 km, and spread over six states. The traffic survey, analysis, and projects are done for these ten roads.

Table 4.2-1 Study Road Network/ Sections

Road ID	Road Section	Target Length (km)	Type for Intervention
1.0	Mizoram State, Aizawl – Tuipang Section, NH54	381	Improvement
2.0	Meghalaya State, Dudhanal – Dalu Section, NH62	183	Improvement
3.0	Meghalaya State, Tura – Dalu Section, NH51	54	Improvement
4.0	Meghalaya State, Shillong – Dawki Section, NH40	84	Improvement
5.0	Manipur State, Imphal – Jiribam Section, NH53	221	Improvement
6.0	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	138	Improvement
7.0	Manipur State, Ukhrul – Tadubi Section, NH102A	115	Improvement
8.0	Tripura State, Manu - Simlung Section NH44	110	Improvement/New
9.0	Assam State, Badarpurghat Bridge near Silchar	0.36	Improvement/New
11.0	Assam State, Dhubri – Phulbari Section, New Bridge (Main Bridge)	18	New Bridge
	Assam State, Dhubri – Phulbari Section, New Bridge (Access Road)	21	
Total			1325.36

Source: JICA Study Team

4.3 Traffic Survey Methodology

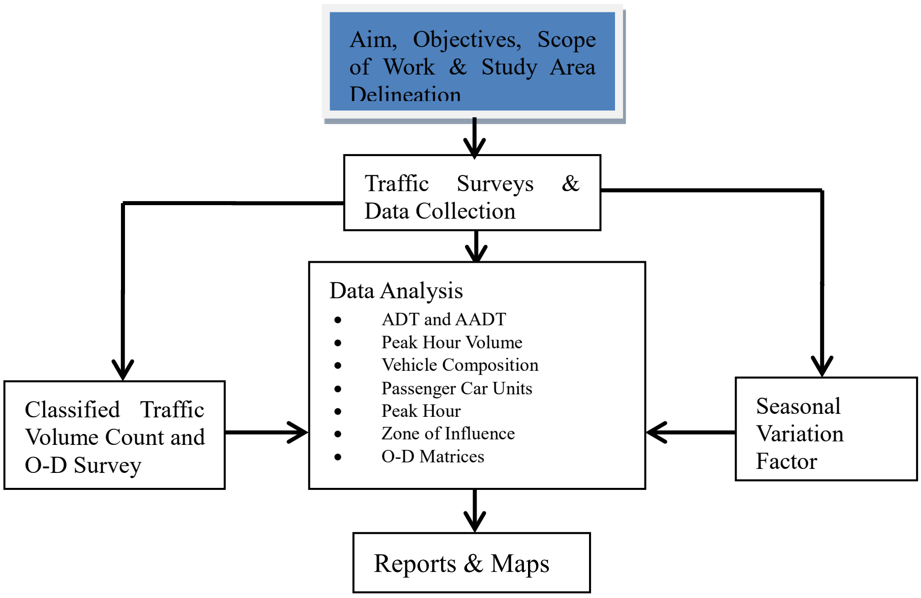
The objectives of the traffic surveys are listed below:

- To obtain the latest information or data on road transport situation around the North-Eastern States,

- To identify the zone of influence for the project stretch and extent of influence based on O-D survey,
- To determine characteristics of traffic movement around the zones of influence,
- To determine the travel pattern of goods and passenger vehicles,
- To analyze transport characteristics through interview with road users, and
- To provide basic data for traffic demand forecast.

The O-D survey was conducted on normal working day through road side interview (RSI) method for 24 continuous hours in two shifts on random sample basis. A sample of well above 20% was targeted for RSIs, to obtain a fairly representative data.

In order to capture the entire traffic along the Project roads, classified volume count surveys were carried out at locations after detailed investigations of each road sections. The survey data collected were analyzed for calculating the Average Daily Traffic (ADT), by taking simple average for the 7-day traffic figures. The Average Annual Daily Traffic (AADT) was calculated after applying seasonal correction factors (to capture the seasonality in traffic movement on the project road sections). RSI was conducted at specified traffic count survey locations for 24 hours for one normal day (excluding holidays and weekends). Vehicles were stopped with the help of local police on a random basis. Trained enumerators were engaged for collecting information as per questionnaire and compiling the same. A schematic diagram showing the traffic survey methodology is presented in Figure 4.3-1.



Source: JICA Study Team

Figure 4.3-1 Traffic Survey Methodology

4.4 Past Traffic Data

The Study Team collected past traffic count data (Source: MORTH) available in the website. Also, traffic data were available in the DPRs for NH54 and NH51, prepared by the consultants engaged by MORTH. It was observed that the traffic count locations and period of traffic surveys mentioned in these data sources were different than the ones taken by the Study Team.

Since the traffic count data was not available for all the road network/sections being considered under the present Study, the Consultant carried out their own independent traffic surveys at representative locations, identified by them, on each of the ten road sections/bridges that are part of the road network considered in the present Study.

The past traffic count data, apart from being not available for the entire road sections considered in the present Study, was not available for sufficient number of years to be used for regression analysis for forecasting the traffic for future years. Therefore, in the absence of traffic data series, the past data on registered vehicles (state-wise) were used for the purpose of estimating future traffic.

The past traffic data (vehicle-wise) collected by the Consultant is presented in Appendix-1.

4.5 Traffic Survey

Following the methodology described above, the Study Team studied the road network in the Project area and conducted a reconnaissance survey to identify the exact survey locations. The traffic count survey was to be conducted, round the clock, continuously for seven days. However, due to the prevailing security concerns in the Project area, the survey locations, days, and period (time) of survey at some target roads were revised, in consultation with JICA. The list indicating the survey locations at each Study road, number of survey days and daily survey hours is set out in Table 4.5-1.

Table 4.5-1 Classified Traffic Count & O-D Survey - Locations & Schedule

Road ID	Road Section	Survey Location	Traffic Count Survey		Origin - Destination Survey	
			Start Date	End Date	Date	Day
1	Mizoram State, Aizawl – Tuipang Section, NH54	1. -Khualazin Tawangtaina Village	23-02-2015	02-03-2015	24-02-2015	Tuesday
		2.Serchhip	23-02-2015	02-03-2015	25-02-2015	Wednesday
		3.Hirakundi	23-02-2015	02-03-2015	26-02-2015	Thursday
		4.Tuipang Police Post	23-02-2015	02-03-2015	27-02-2015	Friday
2	Meghalaya State, Dudhanal – Dalu Section, NH62	1. Nengkhar	15-02-2015	22-02-2015	17-02-2015	Tuesday
		2. Rongra	15-02-2015	22-02-2015	18-02-2015	Wednesday
		3.Dudhnoi	15-02-2015	22-02-2015	19-02-2015	Thursday
3	Meghalaya State, Tura – Dalu Section, NH51	1. Danakgre	15-02-2015	22-02-2015	17-02-2015	Tuesday
		2 .Karoggre Village	15-02-2015	22-02-2015	18-02-2015	Wednesday
4	Meghalaya State, Shillong – Dawki Section, NH40	1. Mylliem Nagar	19-02-2015	26-02-2015	23-02-2015	Monday
		2.Dawki Bridge	19-02-2015	26-02-2015	24-02-2015	Tuesday
5	Manipur State, Imphal – Jiribam Section, NH53	1. Potsoi	22-03-2015	24-03-2015	23-03-2015& 24-03-2015	Monday & Tuesday
		2. Jirighat	19-03-2015	21-03-2015	19-03-2015& 20-03-2015	Thursday & Friday
6	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	1. Awang Sekmai	22-03-2015	24-03-2015	23-03-2015& 24-03-2015	Monday & Tuesday
		2. P.R Hills Near Zakhama	19-03-2015	21-03-2015	19-03-2015 & 20-03-2015	Thursday & Friday
7	Manipur State, Ukhrul – Tadubi Section, NH102A	Shajouba	19-03-2015	21-03-2015	19-03-2015& 20-03-2015	Thursday & Friday
8	Tripura State, Manu - Simlung Section NH44	1.Manu Police Check Post	19-02-2015	26-02-2015	23-02-2015	Monday
		2. Chailengta Village	19-02-2015	26-02-2015	24-02-2015	Tuesday
9	Assam State, Badarpur Bridge	Badarpur Ghat	04-03-15	11-03-2015	09-03-2015	Monday
11	Assam, New Bridge at Dhubri	Existing Goalpara Bridge	04-03-15	11-03-2015	06-03-2015	Friday

Source: JICA Study Team

4.5.1 Classified Traffic Count Survey (CTCS)

The vehicle classification system was followed as per IRC:SP-19:2001 with minor modifications representing the local aspects. Classified manual traffic counts were recorded in 15-minute intervals using tally marks on pre-prepared standard format. The survey data was analyzed to bring out the following traffic characteristics:

- Daily variation of traffic volume
- Average hourly variation of traffic volume
- Average composition of traffic
- Average Daily Traffic (ADT)
- Passenger Car Units (PCU)
- Annual Average Daily Traffic (AADT)
- Directional distribution of traffic

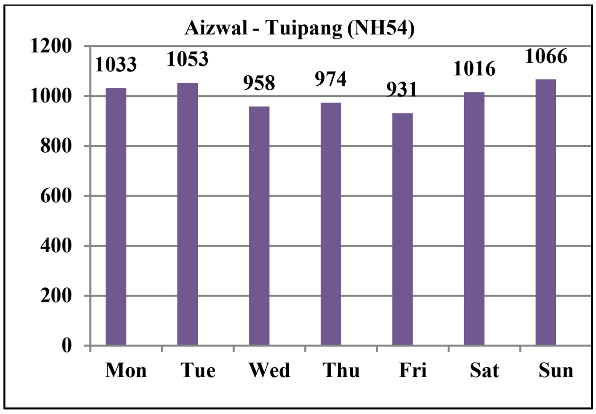
It may be noted that the traffic count survey for the three road sections (NH53, NH39, and NH102A) in Manipur was carried out for only three days and for limited hours (6:30 AM to 4:30 PM), due to security concerns.

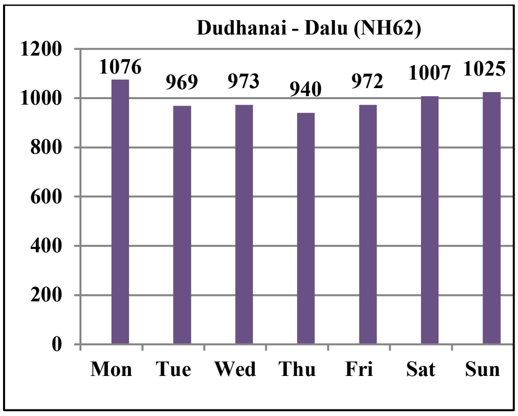
(1) Daily Variation of Traffic Volume

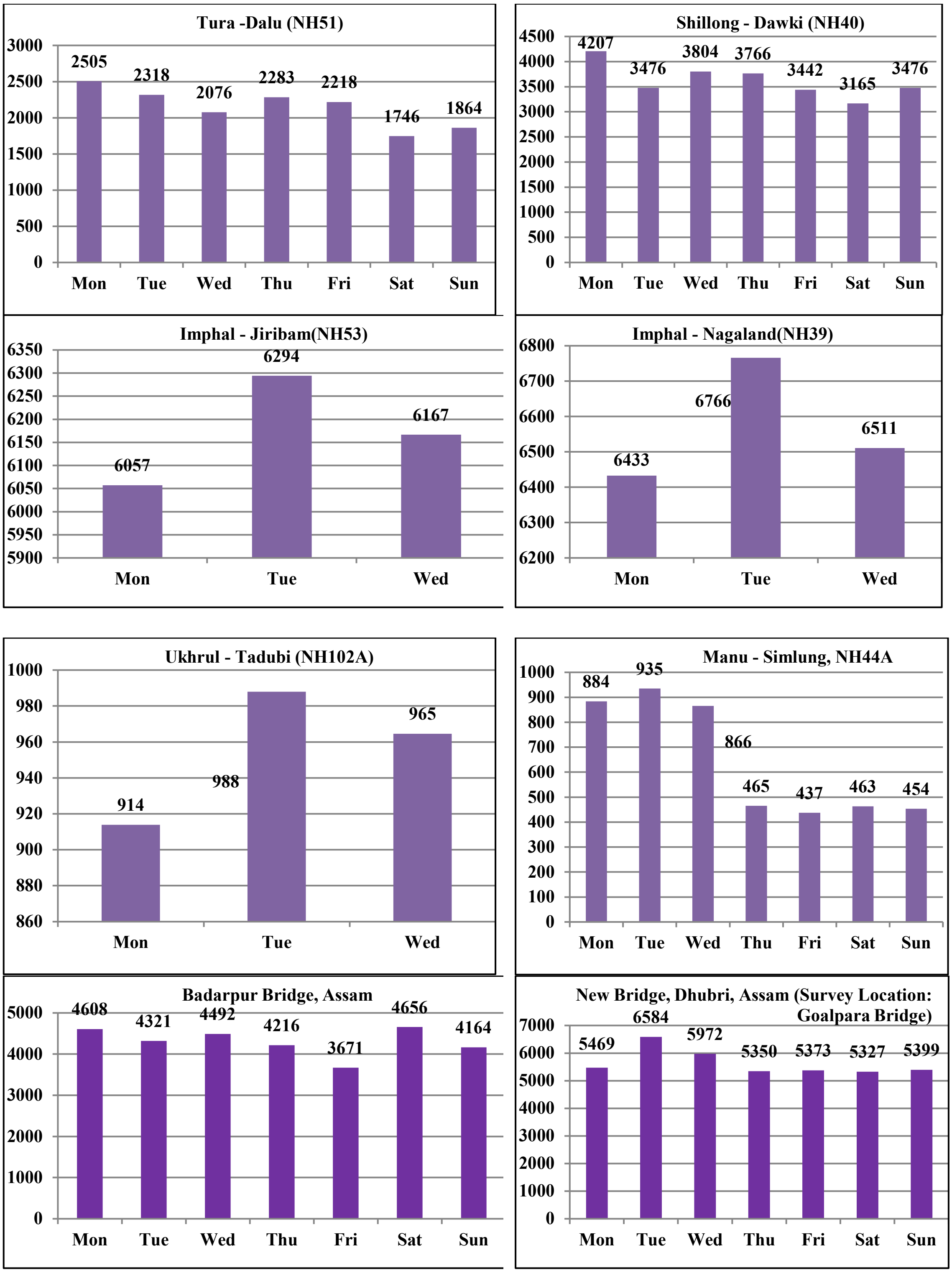
The day wise average traffic volume count index (with respect to the day for which the traffic volume is the highest) for the ten road sections is given in Figure 4.5-1.

It is observed that for the roads where 7-day traffic count was conducted, the highest volume of traffic is on Monday/Tuesday, except on Aizawl-Tuipang Road (NH54) section, where the highest traffic volume is observed on Sunday. Broadly, a general traffic movement pattern followed on the project road sections is that traffic volume is high at the onset of the week. This pattern is also observed on the three roads in Manipur where the traffic count survey was done for only three days. The traffic volume on weekends is not low as is normally expected.

Except for Manu-Simlung Road (NH44A) section, the variation in daily traffic volumes is not found to be significant. Therefore, the ADT (and AADT for that matter), which is based on the average of the 7-day traffic volumes, significantly represents the traffic volumes on the project road sections.





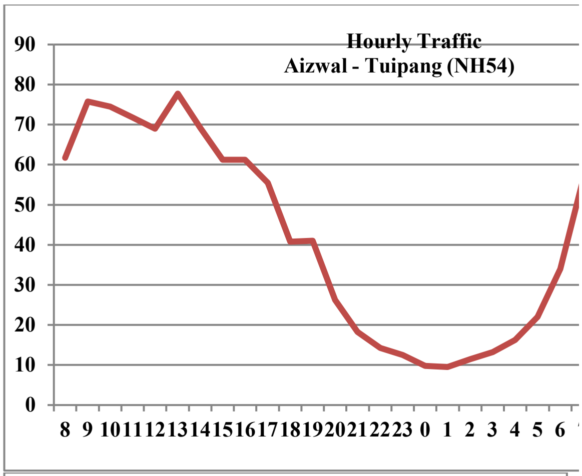


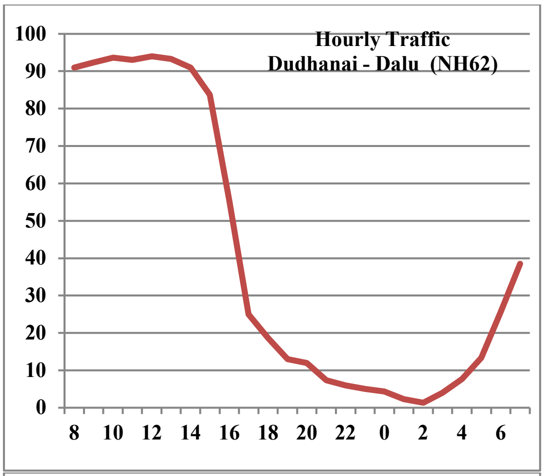
Source: JICA Study Team

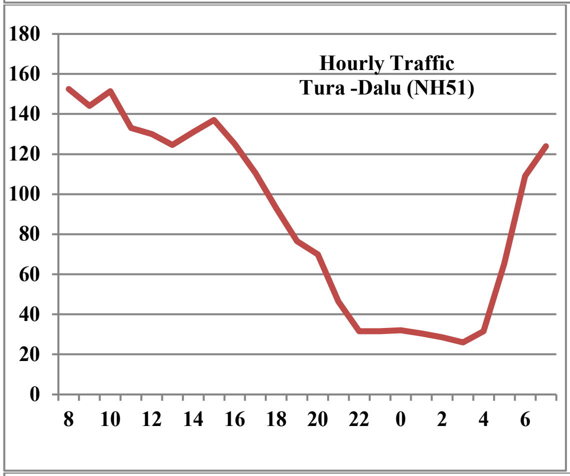
Figure 4.5-1 Daily Variation of Traffic Volume on Ten Study Road Sections

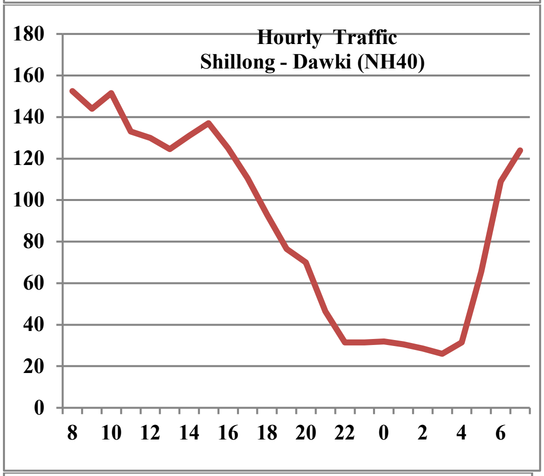
(2) Average Hourly Variation of Traffic

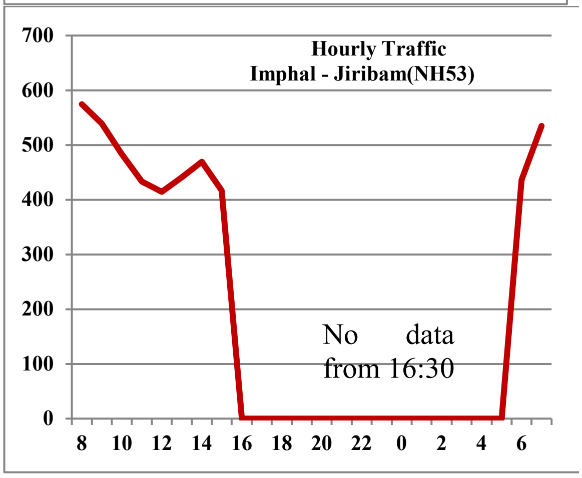
The hourly flow pattern of passenger and goods vehicles on the ten study road sections is depicted in the charts shown in Figure 4.5-2. As normally expected, the traffic volume is high during forenoon, and after that it starts falling untill mid night and picks up from early morning.

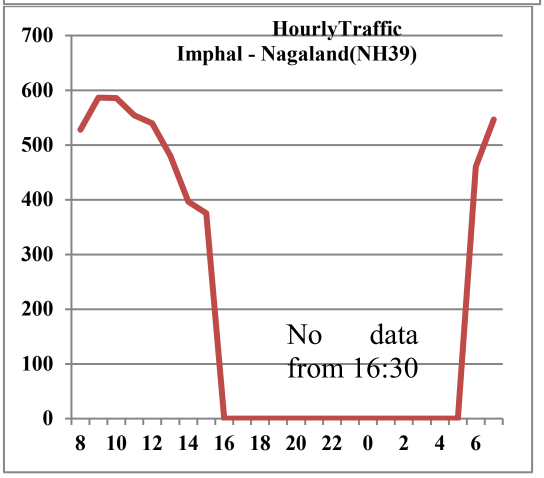

Hourly Traffic
Aizwal - Tuipang (NH54)
0 10 20 30 40 50 60 70 80 90
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2 3 4 5 6

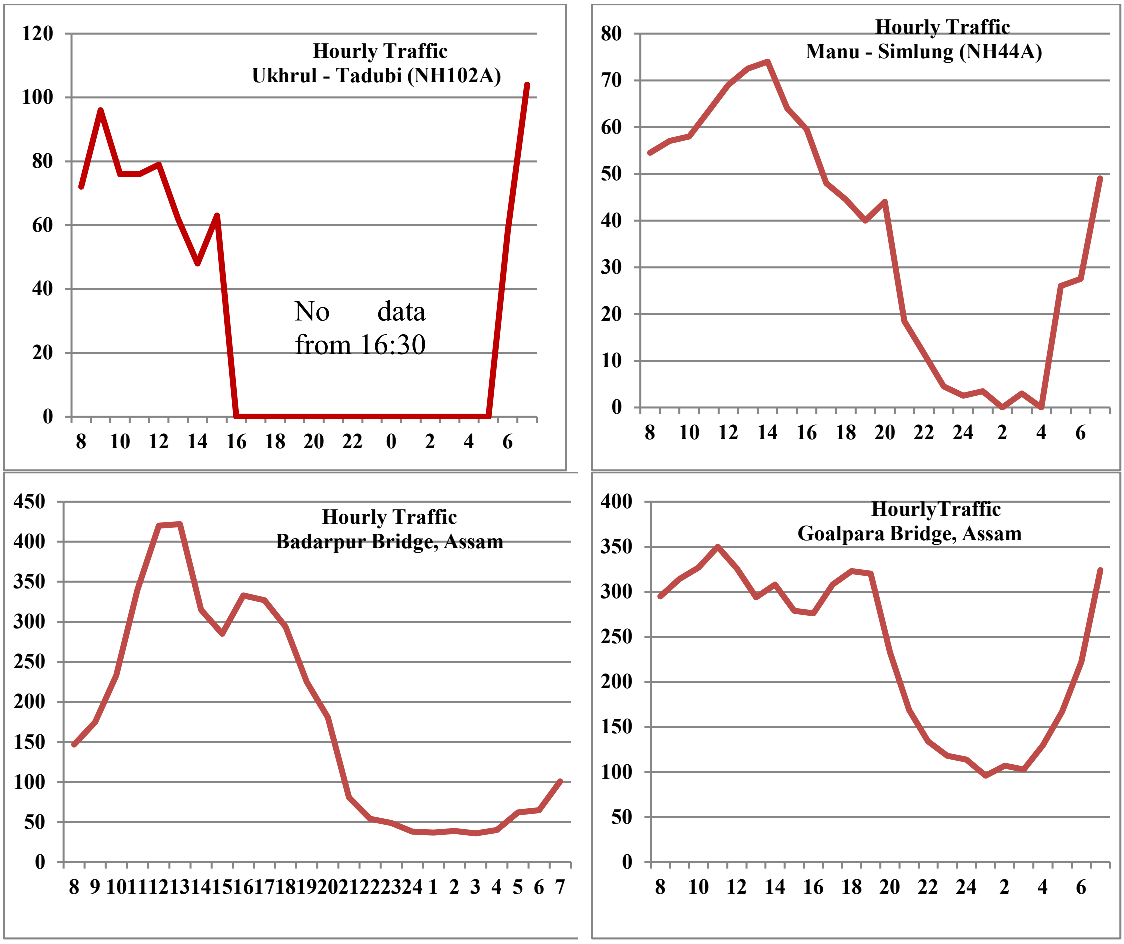

Hourly Traffic
Dudhanai - Dalu (NH62)
0 10 20 30 40 50 60 70 80 90 100
8 10 12 14 16 18 20 22 0 2 4 6


Hourly Traffic
Tura -Dalu (NH51)
0 20 40 60 80 100 120 140 160 180
8 10 12 14 16 18 20 22 0 2 4 6


Hourly Traffic
Shillong - Dawki (NH40)
0 20 40 60 80 100 120 140 160 180
8 10 12 14 16 18 20 22 0 2 4 6


Hourly Traffic
Imphal - Jiribam(NH53)
0 100 200 300 400 500 600 700
No data from 16:30
8 10 12 14 16 18 20 22 0 2 4 6


HourlyTraffic
Imphal - Nagaland(NH39)
0 100 200 300 400 500 600 700
No data from 16:30
8 10 12 14 16 18 20 22 0 2 4 6



Source: JICA Study Team

Figure 4.5-2 Hourly Variation of Traffic Volume on Ten Study Road Sections

Table 4.5-2 presents the peak period hourly flow of traffic in terms of percentage traffic flow (hourly) to total traffic flow during the day. The percentage of traffic flow (hourly) defined as peak hour factor (PHF) varies from 6.21% (near the existing bridge at Goalpara, Assam) to as high as 14.17% at Ukhrul-Tadubi Section (NH102A, Manipur State). While a PHF in the range of 6% to 8% is normally expected on national highways, high values (of PHF) for some of the project road sections indicate skewed traffic flow pattern, possibly due to security situation prevailing in the area of influence of these roads.

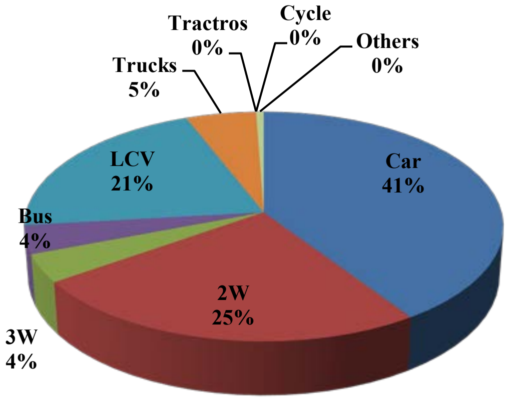
Table 4.5-2 Peak Hour Factor (%) for Ten Study Road Sections

Road ID	Study Road Sections	Peak - Hr	Peak-Hr Factor
1.0	Mizoram State, Aizawl – Tuipang Section, NH54	12 :00 – 13:00 Hrs	7.75%
2.0	Meghalaya State, Dudhanal – Dalu Section, NH62	11 :00 – 12:00 Hrs	9.68%
3.0	Meghalaya State, Tura – Dalu Section, NH51	08 :00 – 09:00 Hrs	7.14%
4.0	Meghalaya State, Shillong – Dawki Section, NH40	09 :00 – 10:00 Hrs	7.88%
5.0	Manipur State, Imphal – Jiribam Section, NH53	08 :30 – 09:30 Hrs	12.11%
6.0	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	10 :30 – 11:30 Hrs	11.59%
7.0	Manipur State, Ukhrul – Tadubi Section, NH102A	07 :30 – 08:30 Hrs	14.17%
8.0	Tripura State, Manu - Simlung Section NH44 A	14 :00 – 15:00 Hrs	8.27%
9.0	Assam State, Badarpurghat Bridge near Silchar	12 :00 – 13:00 Hrs	9.82%
11.0	Assam State, Goalpara Bridge	11 :00 – 12:00 Hrs	6.21%

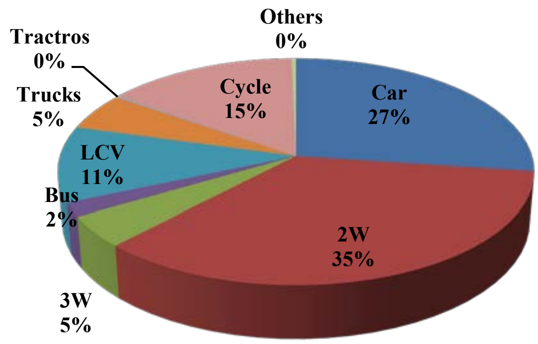
Source: JICA Study Team

(3) Composition of Traffic

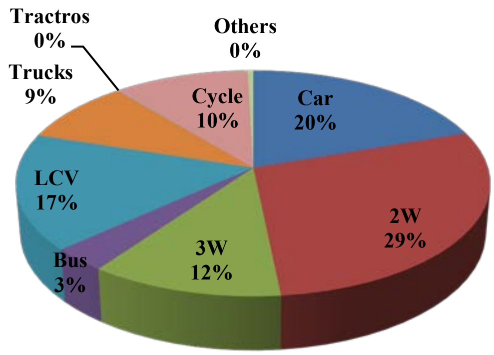
The average percentage composition of classified vehicles is depicted in Figure 4.5-3. It can be observed that for all the ten Study road sections that the percentage of cars/jeeps/taxis and two-wheelers is high. On Shillong-Dawki Road (NH40) section, the percentage of cars/jeeps/taxis is 75%. The highest percentage (23%) of trucks to the average daily traffic is observed at the survey location at the existing bridge at Goalpara (Assam). The traffic count survey at Goalpara Bridge is for estimating the potential divergence of traffic to the proposed new bridge at Dhubri, which is located west of Goalpara Bridge.



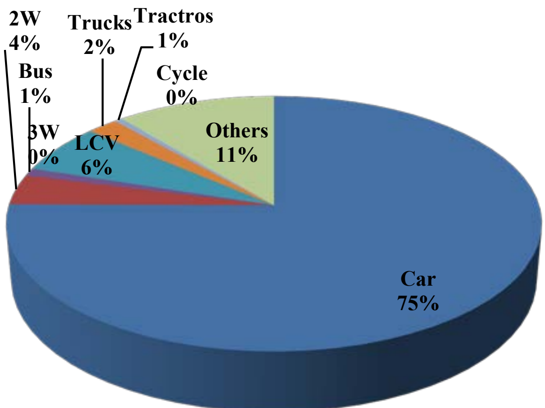
Traffic Composition
Aizwal - Tuipang (NH54)



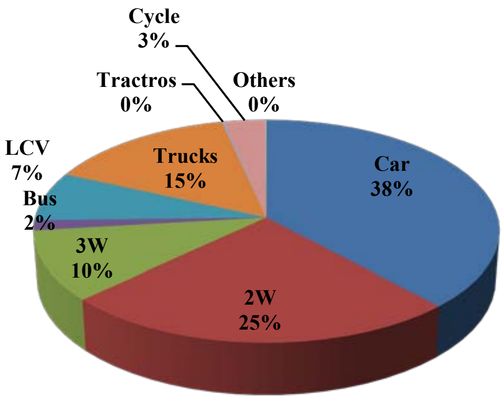
Traffic Composition
Dudhanai - Dalu (NH62)



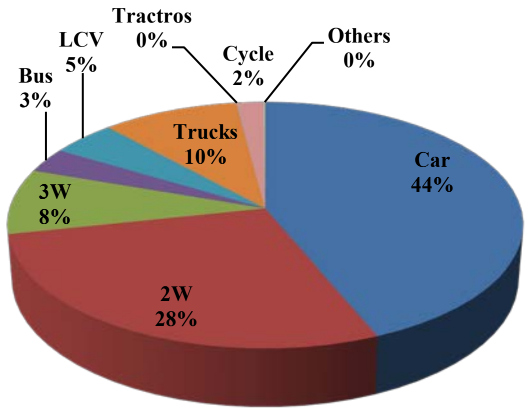
Traffic Composition
Tura -Dalu (NH51)



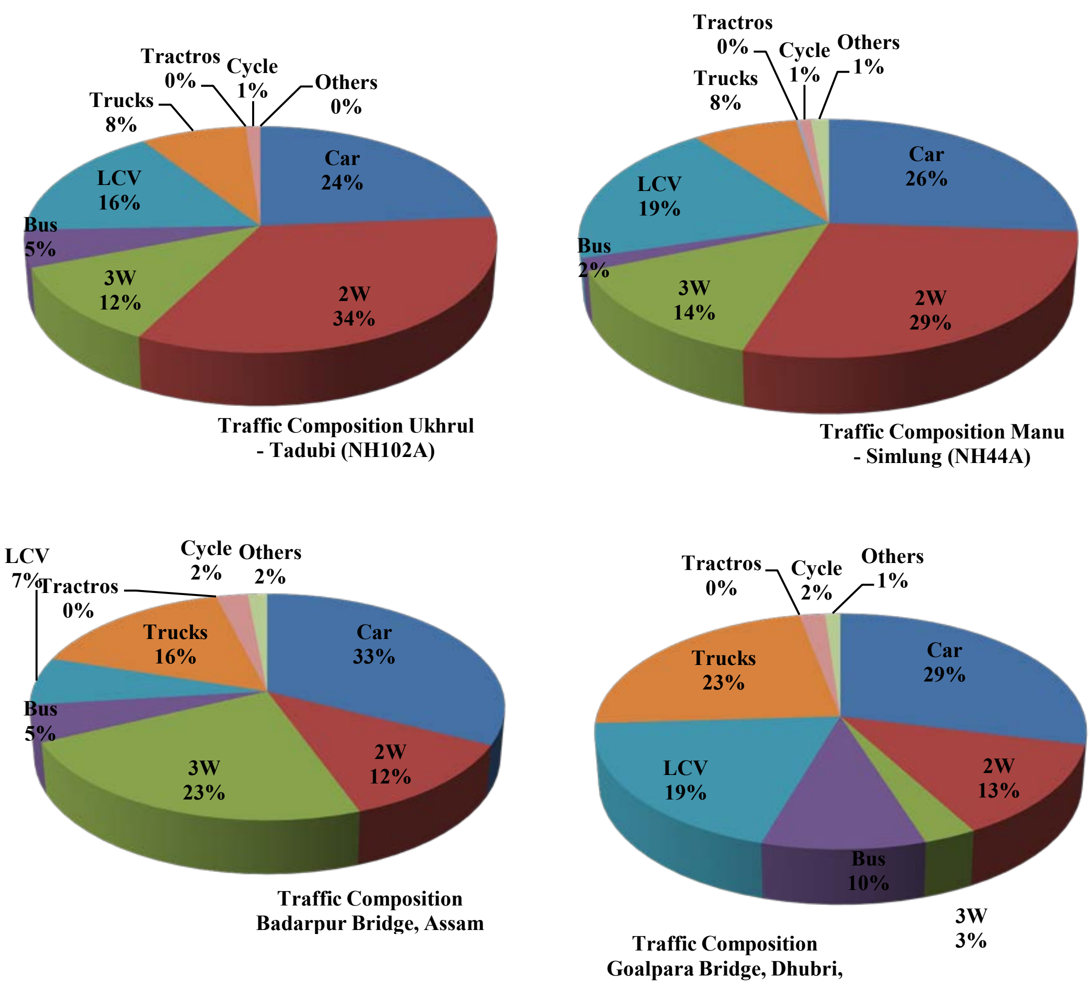
Traffic Composition
Shillong - Dawki (NH40)



Traffic Composition
Imphal - Jiribam(NH53)



Traffic Composition
Imphal - Nagaland(NH39)



Source: JICA Study Team

Figure 4.5-3 Composition of Traffic Volume on Ten Study Road Sections

(4) Average Daily Traffic (ADT) and Average Annual Daily Traffic (AADT)

The ADT for all the ten road sections was worked out both in terms of "number of vehicles" as well as in "Passenger Car Units" (PCU). The PCU values have been adopted as given in IRC 64-1990, and are presented in Table 4.5-3.

Table 4.5-3 Equivalent Passenger Car Units (PCU) Adopted

Vehicle	PCU Value	Vehicle	PCU Value
Car	1.0	Standard Bus	3.0
Mini Bus	1.5	2 -Wheeler	0.5
3- Wheeler	1.0	Light Commercial Vehicles	1.5
2-Axle Truck	3.0	3 -Axle Truck	4.5
Multi Axle Truck	4.5	Tractor	1.5
Tractor Trailer	4.5	Cycle	0.5
Cycle Rickshaw	2.0	Animal Drawn	8.0
Hand Drawn	3.0		

Source: IRC 64 – 1990

To arrive at ADT, an arithmetic mean of seven days count was considered (in case of road sections in Manipur State, three days were considered). The ADT traffic figures were converted to AADT by applying seasonality variation factors (SVF) given in Table 4.5-4.

Base year (2015) AADT is computed by multiplying ADT with respective seasonal factor. Seasonal factor has been arrived based on the fuel sales data along the Study road section. The traffic survey along the corridor was carried out in February and March 2015. The computed seasonal factors for petrol and diesel using vehicles for February and March were estimated and applied to the ADT traffic to arrive at the AADT.

Table 4.5-4 Seasonality Variation Factors (SVF) Adopted

Road ID	Road Section	Fuel station location	Petrol (SVF)	Diesel (SVF)	TVC Location	Petrol (SVF) adopted	Diesel (SVF) adopted
1	Mizoram State, Aizawl – Tuipang Section, NH54	Singson filling station	0.96	0.99	1. Khualazin Tawangtaina Village	0.96	0.99
		Lalzuithanga filling station	1.03	1.06	2.Serchhip	1.03	1.06
		ADC filling station	0.98	1.02	3.Hirakundi	0.98	1.02
		Near Theiri	0.97	1.05	4.Tuipang Police Post	0.97	1.05
2	Meghalaya State, Dudhanal – Dalu Section, NH62	Nengkhar service station	1.05	0.97	1. Nengkhar	1.05	0.97
		Near Baghmara	0.97	1.01	2. Rongra	0.97	1.01
		Near Wagiasi	0.97	0.96	3.Dudhnoi	0.97	0.96
3	Meghalaya State, Tura – Dalu Section, NH51	Near Debasipara	1.04	0.98	1. Daronggre	1.04	0.98
		Police reserve petrol pump	0.97	1.04	2 .Karoggre Village	0.97	1.04
4	Meghalaya, Shillong – Dawki Section, NH40	Myllium service station	0.99	1.02	1. Mylliem Nagar	0.99	1.02
					2.Dawki Bridge	0.99	1.02
5	Manipur State, Imphal – Jiribam Section, NH53	Indian oil pamp Near taxi Stand in imphal	0.98	0.96	Sagolband on NH-53	0.98	0.96
6	Manipur State, Imphal - Nagaland State, Kohima Section, NH39	Tendongyan petrol station	0.97	0.97	Awang Sekhmai	0.97	0.97
	Manipur State, Imphal – Jiribam Section, NH53	Maa Durga Filling Station near Jiribam	0.99	1.00	Jirighat	0.99	1.00
7	Manipur State, Ukhrul – Tadubi Section, NH102A	Tadubi Petrol pump	1.04	0.98	Shajouba	1.04	0.98
8	Tripura State, Manu - Simlung Section NH44	Akhil chandra gosh petrol station	1.02	0.98	1.Manu Police Check Post	1.02	0.98
		Lalthanzua filling station	1.06	0.97	2. Chailengta Village	1.06	0.97
9	Assam State, Badarpurghat Bridge near Silchar	Petrol pump in Tezpur	1.03	0.99	1. Tez Pur Bridge	1.03	0.99
		Joghigopa service station	0.98	0.98	2. Goal Para Bridge	0.98	0.98
		Mazumdar filling station	0.99	1.01	3. Badarpur Ghat	0.99	1.01
10	Kohima section NH-39	Petrol pump near P. R. Hills	1.02	1.03	P.R HILLS Near Zakhama	1.02	1.03

Source: JICA Study Team

The AADT figures for all the project road sections are set out in Table 4.5-5.

Table 4.5-5 Average Daily Traffic for Ten Road Sections

Road ID	Road/Section	Unit	2 W	3 W	Car	Bus	Mini Bus	Truck (2-Axle)	Truck (3-Axle)	Truck (4 to 6-Axle)	Truck (7 & more Axle)	LCV	Bicycle	Animal Vehicle	Agri. Tractors	Others	Total
RD-1	Aizawl - Tuipang (NH 54)																
RD-1.1	km 0 - km 55	Veh.	598	42	1193	71	55	149	50	0	0	577	0	0	0	23	2760
		PCU	299	42	1193	214	83	448	227	0	0	866	0	0	0	69	3441
RD-1.2	km 55- km 125	Veh.	164	20	168	12	21	0	0	0	0	89	0	0	0	0	474
		PCU	82	20	168	35	32	0	0	0	0	134	0	0	0	0	471
RD-1.3	km 125 - km 250	Veh.	97	0	125	0	0	13	0	0	0	53	0	0	0	0	288
		PCU	49	0	125	0	0	40	0	0	0	80	0	0	0	0	294
RD-1.4	km 250 - km 381	Veh.	119	96	130	0	0	0	0	0	0	110	0	0	0	0	455
		PCU	60	96	130	0	0	0	0	0	0	165	0	0	0	0	451
RD-2	Dudhanal - Dalu (NH 62)																
RD-2.1	km 0 -km30	Veh.	586	89	473	12	17	115	0	0	0	201	416	0	0	0	1909
		PCU	293	89	473	35	26	346	0	0	0	301	208	0	0	0	1771
RD-2.2	km 30-km 87	Veh.	233	28	244	3	16	26	0	0	0	57	4	1	6	6	625
		PCU	117	28	244	9	25	79	0	0	0	86	2	8	27	18	643
RD-2.3	km 87-km 91	Veh.	207	12	78	4	5	16	0	0	0	60	13	0	0	4	399
		PCU	103	12	78	12	8	48	0	0	0	89	7	0	0	12	369
RD-2.4	km 91-km 183	Veh.	207	12	78	4	5	16	0	0	0	60	13	0	0	4	399
		PCU	103	12	78	12	8	48	0	0	0	89	7	0	0	12	369
RD-3	Tura - Dalu (NH51)																
RD-3.1	km 0 -km 10	Veh.	441	232	351	9	79	41	6	2	0	209	0	0	1	18	1390
		PCU	220	232	351	26	119	123	26	9	0	313	0	0	5	54	1478
RD-3.2	km16 -km 60	Veh.	794	266	499	11	45	343	0	0	0	509	450	9	4	1	2932
		PCU	397	266	499	34	67	1030	0	0	0	763	225	72	18	3	3374
RD-4	Shillong - Dawki (NH40)																
RD-4.1	km 0 -km 28	Veh.	180	0	3829	30	36	608	0	0	0	737	0	0	0	16	5436
		PCU	90	0	3829	89	54	1824	0	0	0	1106	0	0	0	48	7040
RD-4.2	km 28-km 43	Veh.	78	0	1213	0	0	146	0	0	0	423	0	0	0	2	1862
		PCU	39	0	1213	0	0	438	0	0	0	635	0	0	0	6	2331
RD-4.3	km 43-km75	Veh.	78	0	1213	0	0	146	0	0	0	423	0	0	0	2	1862
		PCU	39	0	1213	0	0	438	0	0	0	635	0	0	0	6	2331
RD-4.4	km 75 -km 82	Veh.	78	0	1213	0	0	146	0	0	0	423	0	0	0	2	1862
		PCU	39	0	1213	0	0	438	0	0	0	635	0	0	0	6	2331
RD-4.5	km 82 -km 84	Veh.	78	0	1213	0	0	146	0	0	0	423	0	0	0	2	1862
		PCU	39	0	1213	0	0	438	0	0	0	635	0	0	0	6	2331
RD-5	Imphal - Jiribam (NH53)																
RD-5.1	km 0 -km 3	Veh.	1767	880	2122	50	46	379	90	22	0	461	344	10	19	5	6196
		PCU	883	880	2122	150	69	1138	406	99	0	691	172	80	86	15	6791
RD-5.2	km 3 -km 145	Veh.	1251	352	2501	41	40	1018	234	48	0	408	46	0	1	5	5946
		PCU	626	352	2501	123	60	3054	1053	216	0	612	23	0	5	15	8640
RD-5.3	km 145 -km 221	Veh.	1251	352	2501	41	40	1018	234	48	0	408	46	0	1	5	5946
		PCU	626	352	2501	123	60	3054	1053	216	0	612	23	0	5	15	8640
RD-6	Imphal - Kohima (NH39)																
RD-6.1	km 0 -km 8	Veh.	2159	458	3332	138	275	817	157	130	0	263	167	0	8	5	7909
		PCU	1080	458	3332	413	413	2450	707	585	0	394	84	0	36	15	9967
RD-6.2	km 8 -km 107	Veh.	1482	664	2359	5	9	138	26	4	0	340	80	0	0	6	5113
		PCU	741	664	2359	15	14	414	116	19	0	510	40	0	0	18	4910
RD-6.3	km 107 -km 138	Veh.	1482	664	2359	5	9	138	26	4	0	340	80	0	0	6	5113
		PCU	741	664	2359	15	14	414	116	19	0	510	40	0	0	18	4910
RD-7	Ukhrul - Tadubi (NH102A)																
RD-7.1	km 0 -km 115	Veh.	327	111	228	24	27	64	15	0	0	157	11	0	0	0	963
		PCU	163	111	228	71	41	191	66	0	0	235	6	0	0	0	1112
RD-8	Manu -Simlung (NH44A)																
RD-8.1	km 0 -km 16	Veh.	332	144	305	7	6	74	5	1	0	242	5	0	1	20	1142
		PCU	166	144	305	21	9	223	22	4	0	363	3	0	5	60	1325
RD-8.2	km 16 -km 67	Veh.	191	104	166	10	9	44	15	2	0	111	10	0	3	4	667
		PCU	95	104	166	29	13	131	65	9	0	166	5	0	14	12	809
RD-8.3	km67-km 97	Veh.	191	104	166	10	9	44	15	2	0	111	10	0	3	4	667
		PCU	95	104	166	29	13	131	65	9	0	166	5	0	14	12	809

Road ID	Road/Section	Unit	2 W	3 W	Car	Bus	Mini Bus	Truck (2-Axle)	Truck (3-Axle)	Truck (4 to 6-Axle)	Truck (7 & more Axle)	LCV	Bicycle	Animal Vehicle	Agri. Tractors	Others	Total
RD-8.4	km97-km 110	Veh.	191	104	166	10	9	44	15	2	0	111	10	0	3	4	667
		PCU	95	104	166	29	13	131	65	9	0	166	5	0	14	12	809
RD-9	Badarpur Bridge, Assam	Veh.	514	1012	1405	94	131	382	202	111	0	296	107	0	0	65	4320
		PCU	257	1012	1405	282	197	1145	909	500	0	444	54	0	0	195	6400
RD-11	Goalpara Bridge, Assam	Veh.	725	170	1594	250	279	781	398	87	0	1077	105	0	0	63	5531
		PCU	363	171	1594	750	419	2343	1790	392	0	1616	53	0	0	189	9680

Source: JICA Study Team

4.5.2 RSI (Origin and Destination Data Analysis)

In order to understand the travel demand pattern in the region, origin and destination (O-D) survey was carried out at the locations mentioned in Table 4.5-1. Police assistance was arranged to ensure successful completion of the survey. Both passenger and commercial vehicles plying on the project road were stopped on a random sampling basis and interviewed. The travel characteristics obtained through the O-D survey facilitate the identification of traffic flows and possibility of diversion.

Trained enumerators under the supervision of transport planners collected the trip characteristics using survey forms designed for this purpose. The O-D survey elicited characteristics like origin, destination, frequency, and commodity distribution of trip for commercial vehicles. The information pertaining to origin and destination of trips collected during roadside interviews was analyzed to obtain the trip distribution based on a zoning system presented in Appendix-2.

Table 4.5-6 provides the trip distribution for main vehicle categories at Goalpara survey location. This analysis was used to work out the potential diversion of traffic from Goalpara Bridge to the proposed new bridge at Dhubri.

Table 4.5-6 Trip Distribution of Vehicles at Goalpara (Assam) Bridge Location

Vehicle Type	Total vehicles	Intra District (Goalpara)	Inter District (Goalpara)	Intra State (Assam)	Inter State (Assam)	Intra - NE region	Inter NE and rest of Indian states
Car	366	0%	63%	90%	8%	98%	2%
Bus	59	0%	68%	95%	5%	100%	0%
Mini Bus	73	0%	77%	96%	4%	100%	0%
2W	162	0%	83%	83%	17%	100%	0%
LCV	257	0%	59%	92%	8%	100%	0%
Truck	247	0%	53%	74%	7%	81%	19%
MAV	27	0%	44%	67%	0%	67%	33%

Source: JICA Study Team

4.6 Traffic Projections

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

The exercise on normal traffic growth rate estimation has been carried out by the Study Team using the elasticity approach. The total traffic that is likely to patronize the improved road facility will comprise three distinct streams, viz: i) normal traffic, ii) generated (or induced) traffic, and iii) diverted traffic.

4.6.1 Traffic Type

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

Generated/Induced Traffic: connotes the stream of traffic which will get generated on account of the improved service (e.g., reduction in transport cost, reduced transit time, safe and comfortable travel) attributed to the proposed improvements on the Study road. As the Study road passes through the industrial zone and several villages and towns, with the widening/improvement of roads, the trip frequencies are expected to increase, thus a minimum of 5% of normal traffic is considered as generated/induced traffic in the Study road where there is sufficient road capacity for at least five years after the improvement of roads.

Diverted Traffic: denotes the stream of traffic which will get diverted from other routes/modes of transport to the Study road because of the improved transport services traceable to the proposed improvements. The Study corridor is the only major road in the Study Region and there are no competing roads. As such, diverted traffic is not anticipated for the project road. However, with the construction of new bridge at Dhubri, a lot of savings in distance is expected for the traffic, at present, using Goalpara Bridge. Based on the analysis of O-D survey, it is expected that two streams of traffic shall benefit considerably due to savings in distance, by diverting to the new bridge proposed at Dhubri. It is estimated that about 40% of the traffic intercepted at the traffic station at Goalpara, shall be saving about 118 km and another 20% shall be saving about 26 km.

Kaladan Multimodal Transit Transport Project

Apart from the above, it is expected that due to taking up of already planned/earmarked major projects, traffic volumes may increase on some of the Study roads. In this respect, the impact of Kaladhan Project, which will increase the traffic volume on NH54, is expected and studied.

The Ministry of External Affairs (MEA), Government of India entered into a framework agreement with the Government of Myanmar in April 2008 to facilitate the implementation of the project. The framework agreement is for development of the multimodal transit transport system to the North-Eastern States through Myanmar. The transit route is envisaged between Kolkata (nearest Indian port/commercial hub) and comprises of the following segments.

Table 4.6-1 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 work on the project has substantially been completed, and it shall function shortly. The traffic due to this project is expected to increase considerably on NH54 and from there on to other roads in the North-Eastern Region. It is assumed that on this account, the traffic on NH54 will increase by 30% by 2017, and thereby, increase at a rate of 7% per annum.

4.6.2 Traffic Projection Methodology

The traffic projections have been carried out using the elasticity approach. The elasticity method relates traffic growth to changes in the related economic parameters.

Step1: Determining Vehicle-wise Elasticity

Step 2: Estimating Vehicle Growth Rates

The exercise on normal traffic growth rate estimation has been carried out by the Study Team using the vehicle registration method and elasticity approach mentioned in the IRC: 108-1996, using the following form:

Table 4.6-2 Step of Traffic Projection

Item	Function	Parameters
Step 1		
Elasticity	Log e (P) = A0 + A1 Log e (EI)	• P = Traffic volume (of any vehicle type) • EI = Economic Indicator (GDP/NSDP/Population/PCI) • A0 = Regression constant; • A1 = Regression co-efficient (Elasticity Index)
Step2		
Passenger Vehicles	Grp = [(1+Rp) (1+ rpci x Em) – 1]	• Grp- Growth Rate Passenger Vehicle • Rp= Population Growth • Rpci= Per capita Income Growth • Em= Elasticity
Goods Vehicles	Grg = Em * R(nsdp)	• Grg- Growth Rate Goods Vehicle • Em= Elasticity Value • R(nsdp) = NSDP Growth Rate

Source: Derived from IRC: 108-1996

4.6.3 Registered Vehicles

Following the forecast methodology stated above, the data on traffic volume was collected. In the absence of the traffic count figures series for the project road sections, the series (year 2005 to 2012) was used as a surrogate for traffic volume. The state-level registered vehicle data is presented in Table 4.6-3 for the six North-Eastern States considered in the Study.

Table 4.6-3 Registered Vehicles in 6 Study Area States

State	Two Wheeler	Autos Rickshaw	Cars / Jeep Taxi	Bus	Truck	LCV
Assam						
2005	476378	32386	150523	10776	87118	16852
2006	541275	34906	172780	11378	91801	19371
2007	610529	37691	194828	13091	97790	22587
2008	667788	41267	215817	13732	105565	25451
2009	740420	45266	240811	14460	114485	29703
2010	830836	51185	277376	15084	124132	32473
2011	958935	59742	318627	15984	136090	35788
2012	1101265	67921	366884	17035	144183	47296
CAGR (%)	11.61%	10.57%	12.46%	6.41%	7.49%	13.73%
Manipur						
2005	80557	2630	18170	3150	6314	1490
2006	86931	2721	20178	3371	6746	1854
2007	93595	3787	20819	3549	7078	2005
2008	105465	4071	21635	3977	7216	2245
2009	105465	4071	21635	3977	7216	2245
2010	139650	7266	28180	4293	7639	2871
2011	145286	9954	30816	4376	8249	3207
2012	148942	11854	32107	4473	8599	4054
CAGR (%)	9.61%	22.59%	8.35%	5.15%	4.04%	12.89%
Meghalaya						
2005	27237	3001	36856	3285	15819	1907
2006	31008	3569	42083	3497	17060	2565
2007	36112	4081	47076	3639	17937	3222
2008	40953	4433	51637	3779	18572	3781
2009	45747	4842	57999	3905	19747	4425
2010	51709	5348	64916	4008	21372	4955
2011	56790	6000	73419	4117	23064	6058

State	Two Wheeler	Autos Rickshaw	Cars / Jeep Taxi	Bus	Truck	LCV
2012	65712	6744	81615	4326	25451	7210
CAGR (%)	12.36%	10.91%	11.22%	3.65%	6.46%	17.92%
Mizoram						
2005	21816	1336	13457	672	4061	0
2006	24737	1534	14986	704	4475	5
2007	27776	1758	20870	907	3000	2566
2008	30062	1931	22367	954	3167	2981
2009	32267	2105	23551	1003	3343	3397
2010	39902	2219	25660	1036	3507	4003
2011	47978	2477	28040	1088	3844	4862
2012	60278	2955	31233	1141	4285	6194
CAGR (%)	13.79%	10.40%	11.55%	7.54%	0.16%	17.25%
Nagaland						
2005	39989	9100	61586	4079	44002	10733
2006	42851	9548	64998	4410	47089	11804
2007	45961	10408	69192	4683	51466	13319
2008	48976	12939	72997	4896	55974	14043
2009	52119	13143	76681	5172	60684	15068
2010	55208	13403	80300	5538	65729	16345
2011	61085	14284	83278	6074	77968	25158
2012	61546	14429	87127	6047	84008	17799
CAGR (%)	6.43%	7.16%	4.96%	5.85%	9.36%	9.53%
Tripura						
2005	34450	11881	11299	1877	7664	1872
2006	61968	13237	12330	1974	8138	2535
2007	69830	14544	13653	2097	8593	3336
2008	76952	15829	14942	2200	9000	4037
2009	85455	16968	16323	2241	9524	4819
2010	97895	15749	25634	2212	10432	6199
2011	117486	18074	29126	2313	10934	7568
2012	129343	19203	31462	2330	11166	8452
CAGR (%)	16.16%	6.22%	16.01%	2.96%	5.65%	21.50%

Source: NEC, Shillong

4.6.4 Economic Indicators

NSDP at constant prices is presented in Table 4.6-4. It was used as independent variable for estimating the elasticity of the goods vehicles such as trucks and LCVs.

Table 4.6-4 NSDP at Constant Prices

(in INR Million)

Year	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
2004-05	471807	46033	58457	23996	54215	81697
05-06	486016	49070	63028	25773	59861	87082
06-07	507965	49920	67777	26927	64537	94580
07-08	529680	52661	69909	29885	69784	100822
08-09	561230	56421	78893	34370	74217	111463
09-10	612939	60395	83964	38320	78420	122873
10-11	657260	58619	92261	45389	85872	132149
11-12	690348	64201	102988	44053	92912	143389

Source: Ministry of Statistics & Programme Implementation, Government of India

The per capita income data used as independent variables for estimating elasticity for passenger vehicles, such as cars, buses, and two-wheelers, is presented in Table 4.6-5.

Table 4.6-5 Per Capita Income (in INR)

Year	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
2004-05	16782	18640	24086	24662	30441	24394
05-06	17050	19478	25642	25826	33072	25688
06-07	17579	19430	27242	26308	35074	27558
07-08	18089	20104	27764	28467	37317	29022
08-09	18922	21131	30963	31921	39041	31711
09-10	20406	22197	32569	34699	40590	34544
10-11	21611	21147	35363	40072	43992	36718
11-12	22420	22739	34217	37921	46340	39382

Source: Ministry of Statistics & Programme Implementation, Government of India

4.6.5 Elasticity

The projected elasticity values established for the vehicles categories and for the six states are given in Table 4.6-6.

Table 4.6-6 Vehicle-wise Elasticity Values

Assam						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
NSDP Growth Rate (%)	5.80%	6.09%	6.40%	6.08%	5.78%	5.49%
Population Growth Rate (%)	1.27%	1.21%	1.15%	1.15%	1.09%	1.04%
PCI Growth Rate (%)	4.53%	4.92%	5.29%	4.97%	4.72%	4.49%
Elasticity w.r.t PCI						
Two Wheeler, ($y=2.551x-11.65$, $R^2 = 0.969$)	2.55	2.30	1.84	1.65	1.57	1.49
Autos Rickshaw, ($y = 2.363x - 12.57$, $R^2 = 0.989$)	2.36	2.12	1.70	1.53	1.45	1.38
Cars / Jeep Taxi, ($y = 2.740x - 14.64$, $R^2 = 0.972$)	2.74	2.33	1.86	1.68	1.59	1.51
Bus, ($y = 1.368x - 3.950$, $R^2 = 0.894$)	1.37	1.23	1.17	1.05	1.00	0.95
Elasticity w.r.t NSDP						
Truck, ($y = 1.296x - 5.547$, $R^2 = 0.992$)	1.30	1.24	1.17	1.11	1.06	1.01
LCV, ($y = 2.347x - 20.86$, $R^2 = 0.957$)	2.35	2.00	1.60	1.44	1.37	1.30
Manipur						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
NSDP Growth Rate (%)	4.53%	5.44%	5.98%	6.58%	5.92%	5.33%
Population Growth Rate (%)	2.09%	1.88%	1.69%	1.52%	1.37%	1.23%
PCI Growth Rate (%)	2.44%	3.56%	4.30%	5.08%	4.58%	4.13%
Elasticity w.r.t PCI						
Two Wheeler, ($y = 3.220x - 20.37$, $R^2 = 0.858$)	3.22	2.25	1.80	1.53	1.38	1.24
Autos Rickshaw, ($y = 7.266x - 63.64$, $R^2 = 0.774$)	7.27	2.91	2.04	1.42	1.14	0.97
Cars / Jeep Taxi, ($y = 2.748x - 17.21$, $R^2 = 0.795$)	2.75	1.93	1.44	1.23	1.10	0.99
Bus, ($y = 1.736x - 8.982$, $R^2 = 0.868$)	1.74	1.22	1.10	1.04	0.99	0.94
Elasticity w.r.t NSDP						
Truck, ($y = 0.824x - 0.085$, $R^2 = 0.870$)	0.82	0.90	0.99	1.04	0.94	0.94
LCV, ($y = 2.695x - 21.60$, $R^2 = 0.923$)	2.69	1.61	1.21	1.03	0.98	0.93
Meghalaya						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
NSDP Growth Rate (%)	7.82%	7.82%	7.04%	6.69%	6.35%	6.03%
Population Growth Rate (%)	3.06%	2.60%	2.21%	1.88%	1.59%	1.36%

PCI Growth Rate (%)	4.76%	5.19%	4.82%	4.82%	4.78%	4.71%
Elasticity w.r.t PCI						
Two Wheeler, ($y = 2.103x - 10.98$, $R^2 = 0.948$)	2.10	1.79	1.70	1.61	1.53	1.45
Autos Rickshaw, ($y = 1.860x - 10.70$, $R^2 = 0.944$)	1.86	1.58	1.50	1.43	1.36	1.29
Cars / Jeep Taxi, ($y = 1.922x - 8.862$, $R^2 = 0.961$)	1.92	1.63	1.55	1.47	1.40	1.33
Bus, ($y = 0.619x + 1.871$, $R^2 = 0.93$)	0.62	0.68	0.75	0.83	0.78	0.74
Elasticity w.r.t NSDP						
Truck, ($y = 0.817x + 0.703$, $R^2 = 0.994$)	0.82	0.90	0.99	1.04	0.94	0.94
LCV, ($y = 2.229x - 16.78$, $R^2 = 0.963$)	2.23	1.56	1.25	1.19	1.13	1.07
Mizoram						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
NSDP Growth Rate (%)	9.30%	7.91%	7.11%	6.40%	6.08%	5.78%
Population Growth Rate (%)	2.53%	2.03%	1.62%	1.46%	1.31%	1.25%
PCI Growth Rate (%)	6.77%	5.88%	5.51%	4.97%	4.80%	4.57%
Elasticity w.r.t PCI						
Two Wheeler, ($y = 1.766x - 7.831$, $R^2 = 0.902$)	1.77	1.59	1.43	1.29	1.16	1.05
Autos Rickshaw, ($y = 1.299x - 5.834$, $R^2 = 0.875$)	1.30	1.24	1.17	1.11	1.11	1.11
Cars / Jeep Taxi, ($y = 1.425x - 4.741$, $R^2 = 0.809$)	1.42	1.35	1.28	1.22	1.22	1.22
Bus $y = 0.929x - 2.774$, ($y = 0.929x - 2.774$, $R^2 = 0.772$)	0.93	0.93	0.93	0.93	0.93	0.93
Elasticity w.r.t NSDP						
Truck. ($y = 0.584x + 2.031$, $R^2 = 0.875$)	0.58	0.73	0.83	0.96	0.96	0.96
LCV, ($y = 1.475x - 7.219$, $R^2 = 0.904$)	1.47	1.32	1.19	1.07	1.02	0.97
Nagaland						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
NSDP Growth Rate (%)	7.26%	6.53%	6.21%	5.90%	5.60%	5.32%
Population Growth Rate (%)	1.80%	1.71%	1.54%	1.39%	1.25%	1.12%
PCI Growth Rate (%)	5.46%	4.84%	4.69%	4.54%	4.39%	4.24%
Elasticity w.r.t PCI						
Two Wheeler, ($y = 1.109x - 0.866$, $R^2 = 0.989$)	1.11	1.11	1.11	1.11	1.11	1.11
Autos Rickshaw, ($y = 1.240x - 3.683$, $R^2 = 0.905$)	1.24	1.18	1.18	1.12	1.06	1.01
Cars / Jeep Taxi, ($y = 0.853x + 2.211$, $R^2 = 0.990$)	0.85	0.98	1.12	1.12	1.12	1.12
Bus, ($y = 1.009x - 2.109$, $R^2 = 0.983$)	1.01	0.91	0.91	0.91	1.00	1.10
Elasticity w.r.t NSDP						
Truck, ($y = 1.258x - 3.077$, $R^2 = 0.983$)	1.26	1.01	0.96	0.91	0.91	0.91
LCV, ($y = 1.282x - 4.713$, $R^2 = 0.773$)	1.28	1.15	1.15	1.04	1.04	1.04
Tripura						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
NSDP Growth Rate (%)	8.24%	7.42%	7.05%	6.70%	6.36%	6.04%
Population Growth Rate (%)	1.19%	1.07%	0.96%	0.87%	0.78%	0.70%
PCI Growth Rate (%)	7.06%	6.41%	6.15%	5.90%	5.65%	5.41%
Elasticity w.r.t PCI						
Two Wheeler, ($y = 2.257x - 12.05$, $R^2 = 0.873$)	2.26	1.81	1.63	1.46	1.32	1.19
Autos Rickshaw, ($y = 0.866x + 0.697$, $R^2 = 0.878$)	0.87	0.96	1.05	1.16	1.27	1.40
Cars / Jeep Taxi, ($y = 2.295x - 13.92$, $R^2 = 0.956$)	2.29	1.60	1.28	1.28	1.28	1.28
Bus, ($y = 0.410x + 3.428$, $R^2 = 0.853$)	0.41	0.62	0.74	0.81	0.89	0.89
Elasticity w.r.t NSDP						

Truck, ($y = 0.687x + 1.183$, $R^2 = 0.991$)	0.69	0.90	0.90	0.90	0.90	0.90
LCV, ($y = 2.598x - 21.73$, $R^2 = 0.980$)	2.60	1.30	1.17	1.05	0.95	0.95

Source: JICA Study Team

4.6.6 Traffic Projections

Traffic projections for the project road have been made on the basis of the growth rates given in Table 4.6-7. It can be observed that the growth rates are given state-wise. Depending on which state the project road section is located, the growth rate of that state has been applied to project the traffic on the road section.

Table 4.6-7 Growth Rates Adopted for Traffic Projections

Assam						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
Two Wheeler	12.97%	12.64%	10.98%	9.46%	8.59%	7.80%
Autos Rickshaw	12.10%	11.79%	10.25%	8.84%	8.03%	7.30%
Cars / Jeep Taxi	13.84%	12.81%	11.13%	9.58%	8.70%	7.90%
Bus	7.56%	7.35%	7.42%	6.45%	5.88%	5.36%
Mini Bus	7.56%	7.35%	7.42%	6.45%	5.88%	5.36%
Truck (2-Axle)	7.55%	7.53%	7.51%	6.78%	6.12%	5.52%
Truck (3-Axle)	7.55%	7.53%	7.51%	6.78%	6.12%	5.52%
Truck (4 to 6-Axle)	7.55%	7.53%	7.51%	6.78%	6.12%	5.52%
Truck (7 & more Axle)	7.55%	7.53%	7.51%	6.78%	6.12%	5.52%
LCV	13.64%	12.17%	10.23%	8.74%	7.89%	7.12%
Bicycle	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Animal Drawn Vehicle	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Agricultural Tractors	2.00%	2.00%	2.00%	1.00%	1.00%	1.00%
Others	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Manipur						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
Two Wheeler	10.12%	10.06%	9.58%	9.43%	7.77%	6.42%
Autos Rickshaw	20.23%	12.43%	10.60%	8.87%	6.66%	5.28%
Cars / Jeep Taxi	8.95%	8.87%	8.01%	7.85%	6.50%	5.38%
Bus	6.43%	6.30%	6.49%	6.89%	5.96%	5.16%
Mini Bus	6.43%	6.30%	6.49%	6.89%	5.96%	5.16%
Truck (2-Axle)	3.71%	4.90%	5.93%	6.85%	5.55%	5.00%
Truck (3-Axle)	3.71%	4.90%	5.93%	6.85%	5.55%	5.00%
Truck (4 to 6-Axle)	3.71%	4.90%	5.93%	6.85%	5.55%	5.00%
Truck (7 & more Axle)	3.71%	4.90%	5.93%	6.85%	5.55%	5.00%
LCV	12.19%	8.77%	7.24%	6.77%	5.79%	4.95%
Bicycle	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Animal Drawn Vehicle	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Agricultural Tractors	2.00%	2.00%	2.00%	1.00%	1.00%	1.00%
Others	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Meghalaya						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
Two Wheeler	13.37%	14.70%	16.17%	16.98%	15.28%	8.29%
Autos Rickshaw	12.19%	11.02%	9.61%	8.88%	8.17%	7.50%
Cars / Jeep Taxi	12.48%	11.29%	9.85%	9.10%	8.38%	7.70%
Bus	6.10%	6.23%	5.90%	5.92%	5.40%	4.91%
Mini Bus	6.10%	6.23%	5.90%	5.92%	5.40%	4.91%
Truck (2-Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%
Truck (3-Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%
Truck (4 to 6-Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%
Truck (7 & more Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%

LCV	17.44%	12.21%	8.79%	7.93%	7.16%	6.46%
Mizoram						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
Two Wheeler	14.81%	11.58%	9.65%	7.97%	6.96%	6.08%
Autos Rickshaw	11.55%	9.43%	8.20%	7.08%	6.74%	6.40%
Cars / Jeep Taxi	12.39%	10.12%	8.80%	7.60%	7.24%	6.87%
Bus	8.99%	7.60%	6.83%	6.15%	5.84%	5.55%
Mini Bus	8.99%	7.60%	6.83%	6.15%	5.84%	5.55%
Truck (2-Axle)	5.39%	5.73%	5.93%	6.14%	5.83%	5.54%
Truck (3-Axle)	5.39%	5.73%	5.93%	6.14%	5.83%	5.54%
Truck (4 to 6-Axle)	5.39%	5.73%	5.93%	6.14%	5.83%	5.54%
Truck (7 & more Axle)	5.39%	5.73%	5.93%	6.14%	5.83%	5.54%
LCV	13.67%	15.72%	18.08%	6.86%	6.19%	5.59%
Nagaland						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
Two Wheeler	7.97%	7.17%	6.82%	6.49%	6.18%	5.88%
Autos Rickshaw	8.69%	7.51%	7.15%	6.54%	5.97%	5.45%
Cars / Jeep Taxi	6.53%	6.52%	6.89%	6.56%	6.24%	5.94%
Bus	7.41%	6.18%	5.87%	5.57%	5.69%	5.83%
Min Bus	7.41%	6.18%	5.87%	5.57%	5.69%	5.83%
Truck (2-Axle)	9.15%	6.59%	5.94%	5.37%	5.10%	4.84%
Truck (3-Axle)	9.15%	6.59%	5.94%	5.37%	5.10%	4.84%
Truck (4 to 6-Axle)	9.15%	6.59%	5.94%	5.37%	5.10%	4.84%
Truck (7 & more Axle)	9.15%	6.59%	5.94%	5.37%	5.10%	4.84%
LCV	9.29%	7.53%	7.15%	6.11%	5.81%	5.52%
Tripura						
Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	Beyond 2030
Two Wheeler	17.32%	12.78%	11.06%	9.57%	8.28%	7.16%
Autos Rickshaw	7.40%	7.27%	7.50%	7.75%	8.03%	8.34%
Cars / Jeep Taxi	17.54%	11.45%	8.92%	8.49%	8.08%	7.69%
Bus	4.12%	5.05%	5.54%	5.69%	5.86%	5.57%
Min Bus	4.12%	5.05%	5.54%	5.69%	5.86%	5.57%
Truck (2-Axle)	5.69%	6.66%	6.32%	6.01%	5.71%	5.42%
Truck (3-Axle)	5.69%	6.66%	6.32%	6.01%	5.71%	5.42%
Truck (4 to 6-Axle)	5.69%	6.66%	6.32%	6.01%	5.71%	5.42%
Truck (7 & more Axle)	5.69%	6.66%	6.32%	6.01%	5.71%	5.42%
LCV	21.43%	9.65%	8.25%	7.05%	6.03%	5.73%

Source: JICA Study Team

The traffic projections for 2020, 2025, 2030, and 2035 are set out in Table 4.6-8. The capacity requirement in terms of number of lanes is defined in the Indian Road Congress publication (IRC: 64-1990, Guidelines for Capacity of Roads in Rural Areas). The existing road sections are a mix of single lane, intermediate lane, and 2-lane (with a negligible length with 4-lane) roads. These study roads are expected to be improved to two lanes (7 m carriageway) with 1.5 m paved shoulder on each side, and 1.0 m unpaved area beyond the shoulders. Thus, the capacity of the improved 2-lane roads will be higher than the normal 2-lane road with earthen shoulders.

As per the IRC guidelines, the capacity of a road with 7 m carriageway, and good earthen shoulder (peak hour traffic in the range of 8% to 10% and Level of Service B) is as under:

Terrain	Design Service Volume (PCU/ day)
Plain/ Level	: 12,500 to 15,000
Rolling	: 10,000 to 11,000
Hilly/ Mountainous	: 5,000 to 7,000

The above capacity can increase by 15% if the shoulders are at least 1.5 m wide, and are paved and surfaced. Thus, with the proposed improvement under the present Study, the following PCU values for design service volume for the Study roads have been considered. These values form the basis for deciding the number of lane requirements for the Study road sections, as presented in Table 4.6-8.

Terrain	Design Service Volume (PCU/ day)
Plain/ Level	: 17,250
Rolling	: 12,650
Hilly/ Mountainous	: 8,050

Table 4.6-8 Traffic Projections

Road ID	Road/Section & Terrain	Unit	2020	2025	2030	2035
RD-1	Aizawl - Tuipang (NH 54)					
RD-1.1	km 0 - km 55, Mountainous	Veh.	6131	8782	12216	16541
		PCU	6090	8611	11876	16010
		No. of Lanes	2	2	>2	>2
RD-1.2	km 55- km 125, Mountainous	Veh.	1905	2732	3802	5148
		PCU	1916	2716	3749	5057
		No. of Lanes	2	2	2	2
RD-1.3	km 125 - km 250, Mountainous	Veh.	1558	2237	3123	4242
		PCU	1598	2268	3142	4246
		No. of Lanes	2	2	2	2
RD-1.4	km 250 - km 381 Mountainous	Veh.	1882	2690	3741	5072
		PCU	1865	2646	3664	4957
		No. of Lanes	2	2	2	2
RD-2	Dudhanal - Dalu (NH 62)					
RD-2.1	km 0 -km30 Mountainous/ Level	Veh.	3246	5543	9490	13659
		PCU	2938	4699	7470	10585
		No. of Lanes	2	2	2	>2 (Mountainous part)
RD-2.2	km 30-km 87 , Mountainous/ Rolling	Veh.	1151	2072	3658	5350
		PCU	1082	1760	2847	4077
		No. of Lanes	2	2	2	2
RD-2.3	km 87-km 91 , Mountainous	Veh.	754	1429	2637	3866
		PCU	639	1090	1842	2646
		No. of Lanes	2	2	2	2
RD-2.4	km 91-km 183 , Mountainous/ Rolling	Veh.	754	1429	2637	3866
		PCU	639	1090	1842	2646
		No. of Lanes	2	2	2	2
RD-3	Tura - Dalu (NH51)					
RD-3.1	km 0 -km 10, Rolling	Veh.	2524	4435	7653	11123
		PCU	2498	3999	6328	8996
		No. of Lanes	2	2	2	2
RD-3.2	km16 -km 60 , Rolling	Veh.	5001	8420	14135	20251
		PCU	5482	8489	12997	18176
		No. of Lanes	2	2	2	2
RD-4	Shillong - Dawki (NH40)					
RD-4.1	km 0 -km 28, Mountainous/ Rolling	Veh.	9248	14286	21441	30671
		PCU	11616	17467	25443	35835

Road ID	Road/Section & Terrain	Unit	2020	2025	2030	2035
		No. of Lanes	>2	>2	>2	>2
RD-4.2	km 28 -km 43, Mountainous	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	2
RD-4.3	km 43 -km75, Mountainous/ Rolling	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	>2 (Mountainous part)
RD-4.4	km 75 -km 82, Mountainous	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	2
RD-4.5	km 82 -km 84 , Mountainous	Veh.	3195	4956	7477	10694
		PCU	3904	5901	8648	12208
		No. of Lanes	2	2	2	>2
RD-5	Imphal - Jiribam (NH53)					
RD-5.1	km 0 -km 3, Level	Veh.	9801	14462	19977	26201
		PCU	10400	15032	20405	26456
		No. of Lanes	Already 4 L	Already 4 L	Already 4 L	Already 4 L
RD-5.2	km 3 -km 145, Mountainous/ Level	Veh.	9224	13536	18717	24373
		PCU	12769	18281	26617	31818
		No. of Lanes	>2(Mountainous part)	>2	>2	>2
RD-5.3	km 145 -km 221, Mountainous	Veh.	9224	13536	18617	24373
		PCU	12769	18281	26617	31818
		No. of Lanes	>2(Mountainous part)	>2	>2	>2
RD-6	Imphal - Kohima (NH39)					
RD-6.1	km 0 -km 8. Level	Veh.	12369	18256	25256	33199
		PCU	14923	21509	29156	37835
		No. of Lanes	Already 4 L	Already 4 L	Already 4 L	Already 4 L
RD-6.2	km 8 -km 107, Mountainous/ Rolling	Veh.	8236	12280	17081	22488
		PCU	7764	11397	15651	20408
		No. of Lanes	2	>2(Mountainous part)	>2	>2
RD-6.3	km 107 -km 138, Mountainous	Veh.	8236	12280	17081	22488
		PCU	7764	11397	15651	20408
		No. of Lanes	2	>2	>2	>2
RD-7	Ukhrul - Tadubi (NH102A)					
RD-7.1	km 0 -km 115 , Mountainous	Veh.	1534	2280	3164	4172
		PCU	1710	2476	3365	4379
		No. of Lanes	2	2	2	2
RD-8	Manu -Simlung (NH44A)					
RD-8.1	km 0 -km 16 Rolling/ Level	Veh.	1878	2780	3995	5618
		PCU	2066	2942	4106	5663
		No. of Lanes	2	2	2	2
RD-8.2	km 16 -km 67, Mountainous	Veh.	1090	1615	2319	3263
		PCU	1261	1798	2507	3456
		No. of Lanes	2	2	2	2
RD-8.3	km 67 -km 97 , Mountainous/ Rolling	Veh.	1090	1615	2319	3263
		PCU	1261	1798	2507	3456
		No. of Lanes	2	2	2	2
RD-8.4	km 97 -km 110, Mountainous/ Rolling	Veh.	1090	1615	2319	3263
		PCU	1261	1798	2507	3456

Road ID	Road/Section & Terrain	Unit	2020	2025	2030	2035
		No. of Lanes	2	2	2	2
RD-9	Badarpur Bridge (Near Silchar), Level	Veh.	7744	11703	17122	24278
		PCU	10952	16064	22877	31658
		No. of Lanes	2	2	>2	>2
RD-11	Dhubri-Phulbari Bridge, Assam , Level	Veh.	5867	8780	12727	17897
		PCU	9796	14200	19988	27357
		No. of Lanes	2	2	>2	>2

Source: JICA Study Team

CHAPTER 5 ECONOMIC ANALYSIS

5.1 General

The proposed project aims at the improvement of the defined road network in the six states of the North-Eastern Region. These roads are existing roads that warrant improvements in terms of design, slopes, deteriorated conditions, and congested stretches, among others. The goals of these improvements are to encourage socioeconomic development, trade and tourism in the North-Eastern Region, as well as to increase external trade with neighboring countries and beyond.

The economic evaluation methodology considers the magnitude of the impact of the project road improvements as compared to their existing situation. The improvement of road sections will result in savings to road users in the form of reduced 'vehicle operating cost' (VOC) and reduction in travel time for passengers and freight traffic, expressed in 'value of time' (VOT) terms. These savings/reduced costs, calculated over the project life, are compared with construction costs for road improvement option. The results are expressed in terms of the economic internal rates of return (EIRRs).

In the present context, the HDM-4 model has been used to establish the economic viability of the proposed road improvement. This has enabled the Study Team to estimate the EIRR and net present values (NPVs) of the investment proposition for the road sections in the North-Eastern Region.

5.2 Methodology for Economic Analysis

The various steps considered for economic analysis are summarized as follows:

- Preparing Homogeneous Road Sections (HRS)
- Preparing Inputs for HDM 4 Analysis and Calibration
- Defining Improvement (Investment) Option
- Assigning Works Standards and Costs
- Assigning Maintenance Standards and Costs
- Incorporating Exogenous Cost and Benefits (if considered)
- Carrying out Economic Analysis using HDM 4
- Establishing Economic Feasibility (EIRR) and Conducting Sensitivity Analysis

The economic analysis framework follow the 'with' (i.e., project alternatives) and 'without' (i.e., base case or do minimum/nothing) project approach, whereby the cost to the economy for moving a specified and projected volume of traffic on the road sections would be estimated in both the 'with' and 'without' the project situations, and compare these costs to obtain the net benefit to the economy. The framework adopted for economic analysis is presented in Table 5.2-1.

Table 5.2-1 Framework for Economic Analysis

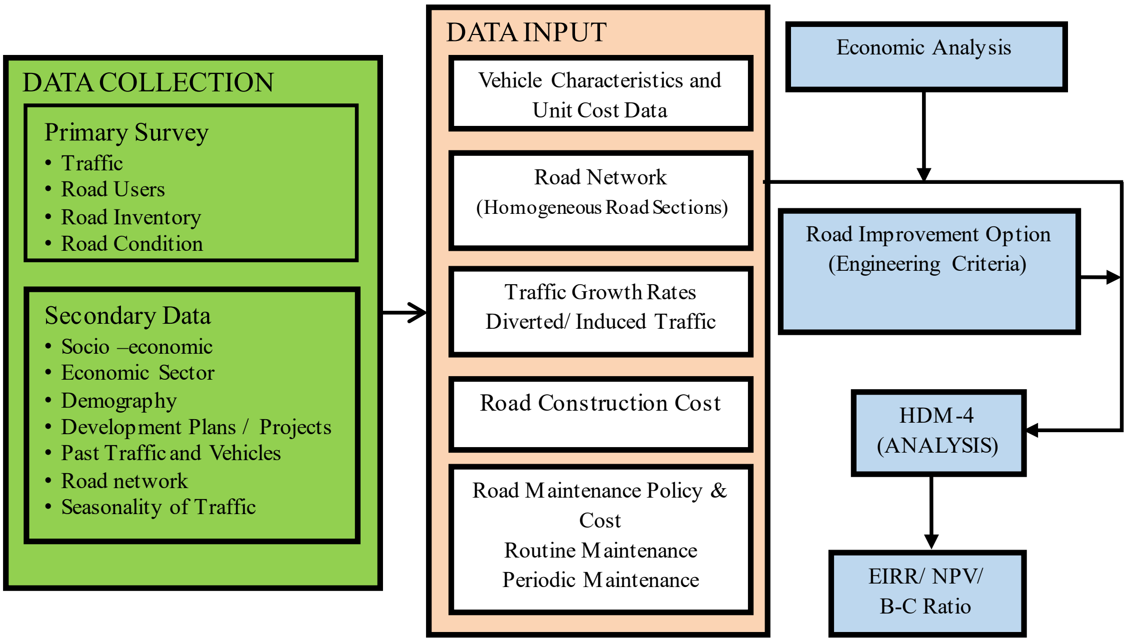
Cost to Economy	'Without' the Project Case (Project Benefit)	'With' the Project Case (Project Cost)
Capital Cost		Construction cost of improvement/ upgrading/ strengthening of the road
Maintenance Cost	Exiting maintenance cost (annual and periodic)	Considered by the Study Team for the desired maintenance of the new/ improved road assets created and the future level of performance expected from these assets
Vehicle Operating Cost (VOC)	Operating cost of the different vehicle types captured in the Classified Traffic Count Survey (and projected for future years) under the prevailing operating condition on the project road (estimated by using HDM 4)	Operating cost of the different vehicle types captured in the Classified Traffic Count Survey (and projected for future years) under the improved operating condition on the target roads; operating cost of 'diverted' and 'induced' traffic, if applicable (estimated by using HDM 4)
Value of Time (VOT)	Estimates of the time value of the projected passengers and goods traffic in transit under the prevailing road condition and the resulting speed of the vehicles (estimated by using HDM 4)	Estimates of the time value of the projected passengers and goods traffic in transit under the improved road condition and the resulting speed of the vehicles (estimated by using HDM 4)

Source: JICA Study Team

The project cost and benefits have been estimated for the project analysis period of 25 years, including 3 years construction period. At the terminal year of the analysis period, a salvage value of 10% has been considered. The social discount rate for the purpose of working out the NPV is taken at 12%. This is the rate considered for similar kinds of projects in developing countries, and also reflecting the premium on 'decision to invest today' vis-à-vis 'saving it for future consumption'.

Constant base year (2015) prices are used for the economic evaluation. Since the project costs such as capital, vehicle, and consumables are based on market prices, these costs have been converted into economic costs by applying appropriate factors established for resource costs. For this, all the cost items (under 'with' and 'without' project cases) estimated at base year prices are adjusted for transfer of payments such as taxes, duties, and subsidies on materials and equipment. Standard conversion factor (SCF) of 0.80 for road construction and for road maintenance has been used for converting the cost estimates at market prices to economic prices. The project capital cost comprises the costs relating to physical works implemented under the project.

The details on economic analysis have been provided in the subsequent sections of this chapter. The methodological frame has been illustrated in Figure 5.2-1.



Source: JICA Study Team

Figure 5.2-1 Methodology for Economic Analysis of Target Roads in NER

5.3 Homogeneous Road Sections

The traffic, engineering, and cost data are major inputs for the economic analysis of the roads sections. It is observed that a particular road section may not have uniform characteristics such as pavement width, traffic volume, and roughness due to which data input in HDM-4 may become tedious and impractical. To overcome this situation, the concept of Homogeneous Road Section (HRS) is applied while performing data input and economic analysis. The project roads are divided into homogeneous sections, mainly on the basis of parameters – traffic, lane configuration, terrain and road condition (roughness of the road defined by IRI), whereby, each road is divided into homogeneous road sections on the basis of these parameters. The framework for combining is set out in Table 5.3-1. It also presents the HRS for each of the roads.

Table 5.3-1 Homogeneous Road Sections

Road ID	Road/Section	Length (km)	Traffic (AADT)	Traffic (AADT)-PCU	Lane Configuration	Shoulder Width (Mt)	Adopted Lane Configuration	Terrain	Wt. Avg. IRI
MIZORAM STATE									
RD-1	Aizawl - Tuipang (NH 54)	381							
RD-1.1	km 0 - km 55 (Ref: Aizawl)	55	2760	3320	5.5 (IL)	0.4 (UP)	IL	Mountainous	4.50
RD-1.2	km 55- km125 (Ref: Aizawl)	70	474	471	3.75 (SL)	0.5 (UP)	SL	Mountainous	5.00
RD-1.3	km 125 - km 250 (Ref: Aizawl)	125	288	293	3.75 (SL)	0.4 (UP)	SL	Mountainous	6.20
RD-1.4	km 250 - km 381 (Ref: Aizawl)	131	455	451	3.75 (SL)	0.45 (UP)	SL	Mountainous	9.10
MEGHALAYA STATE									
RD-2	Dudhanal - Dalu (NH 62)	183							
RD-2.1 L	km 0 -km 20 (Ref: Dudhanai)	20	1909	1770	7.0 (DL)	0.85 (UP)	DL	Level	4.10
RD-2.1M	km 20 -km 30 (Ref: Dudhanai)	10	1909	1770	7.0 (DL)	0.85 (UP)	DL	Mountainous	4.10
RD-2.2 M	km 30-km 82 (Ref: Dudhanai)	52	625	610	5.5 (IL)	1.0 (UP)	IL	Mountainous	4.50
RD-2.2 R	km 82-km 87 (Ref: Dudhanai)	5	625	610	5.5 (IL)	1.0 (UP)	IL	Rolling	4.50
RD-2.3	km 87-km 91 (Ref: Dudhanai)	4	399	362	3.75 (SL)	1.0 (UP)	SL	Mountainous	8.00
RD-2.4 M	km 91-km 153 (Ref: Dudhanai)	62	399	362	3.75 (SL)	1.0 (UP)	SL	Mountainous	7.20
RD-2.4 R	km 153-km 183 (Ref: Dudhanai)	30	399	362	3.75 (SL)	1.0 (UP)	SL	Rolling	7.20
RD-3	Tura - Dalu (NH51)	54							

Road ID	Road/Section	Length (km)	Traffic (AADT)	Traffic (AADT)-PCU	Lane Configuration	Shoulder Width (Mt)	Adopted Lane Configuration	Terrain	Wt. Avg. IRI
RD-3.1	km 0 -km 10 (Ref: Tura)	10	1390	1432	3.75 (SL)	1.0 (UP)	SL	Rolling	5.20
RD-3.2	km16 -km 60 (Ref: Tura)	44	2932	3343	3.75 (SL)	1.0 (UP)	SL	Rolling	6.50
RD-4	Shillong - Dawki (NH40)	84							
RD-4.1 R	km 0 -km 6 (Ref: Shillong)	6	5240	6901	7.0 (DL)	0.5 (UP)	DL	Rolling	3.60
RD-4.1 M	km 6 -km 28 (Ref: Shillong)	22	5240	6901	7.0 (DL)	0.5 (UP)	DL	Mountainous	3.60
RD-4.2	km 28 -km 43 (Ref: Shillong)	15	1862	2327	5.5 (IL)	0.5 (UP)	IL	Mountainous	5.50
RD-4.3 M	kmv43 -km 62 (Ref: Shillong)	19	1862	2327	7.0 (DL)	0.4 (UP)	DL	Mountainous	5.00
RD-4.3 R	kmv 62 -km 75 (Ref: Shillong)	13	1862	2327	7.0 (DL)	0.4 (UP)	DL	Rolling	5.00
RD-4.4	km 75 -km 82 (Ref: Shillong)	7	1862	2327	3.75 (SL)	0.5 (UP)	SL	Mountainous	7.00
RD-4.5	km 82 -km 84 (Ref: Shillong)	2	1862	2327	7.0 (DL)	0.5 (UP)	DL	Mountainous	5.50
MANIPUR STATE									
RD-5	Imphal - Jiribam (NH53)	221							
RD-5.1	km 0 -km 3 (Ref: Imphal)	3	6196	6569	14.0 (4L)	0.4 (UP)	4 L	Level	4.00
RD-5.2 L	km 3 -km 15 (Ref: Imphal)	12	5946	8640	7.0 (DL)	0.4 (UP)	DL	Level	5.00
RD-5.2 M	km 15 -km 145 (Ref: Imphal)	130	5946	8640	7.0 (DL)	0.4 (UP)	DL	Mountainous	5.00
RD-5.3 M	km 145 -km 207 (Ref: Imphal)	62	6196	6569	7.0 (DL)	0.5 (UP)	DL	Mountainous	5.50
RD-5.3 R	km 207 -km 221 (Ref: Imphal)	14	5946	8640	7.0 (DL)	0.5 (UP)	DL	Rolling	5.50
RD-6	Imphal - Kohima (NH39)	138							
RD-6.1	km 0 -km 8 (Ref: Imphal)	8	7909	9697	14.0 (4L)	0.5 (UP)	4 L	Level	4.50
RD-6.2 R	km 8 -km 33 (Ref: Imphal)	25	5113	4859	7.0 (DL)	0.5 (UP)	DL	Rolling	5.00
RD-6.2 M	km 33 -km 107 (Ref: Imphal)	74	5113	4859	7.0 (DL)	0.5 (UP)	DL	Mountainous	5.00
RD-6.3	km 107 -km 138 (Ref: Imphal)	31	5113	4859	7.0 (DL)	0.5 (UP)	DL	Mountainous	5.50
RD-7	Ukhrul - Tadubi (NH102A)	115							
RD-7.1	km 0 -km 115 (Ref: Ukhrul)	115	963	1112	3.5 (SL)	0.5 (UP)	SL	Mountainous	5.00
TRIPURA STATE									
RD-8	Manu -Simlung (NH44A)	110							
RD-8.1 L	km 0 -km 7 (Ref: Manu)	7	1142	1274	3.5 (SL)	0.5 (UP)	SL	Level	6.00
RD-8.1 R	km 7 -km 16 (Ref: Manu)	9	1142	1274	3.5 (SL)	0.5 (UP)	SL	Rolling	6.00
RD-8.2	km 16 -km 67 (Ref: Manu)	51	667	771	New Section			Mountainous	10.0
RD-8.3 R	km 67 -km 75 (Ref: Manu)	8	667	771	3.5 (SL)	0.5 (UP)	SL	Rolling	5.80
RD-8.3 M	km 75 -km 97 (Ref: Manu)	22	667	771	3.5 (SL)	0.5 (UP)	SL	Mountainous	5.80
RD-8.4 M	km 97 -km 105 (Ref: Manu)	8	667	771	3.5 (SL)	0.5 (UP)	SL	Mountainous	20.00
RD-8.4 R	km 105 -km 110 (Ref: Manu)	5	667	771	3.5 (SL)	0.5 (UP)	SL	Rolling	20.00
ASSAM STATE									
RD-9	Badarpur Bridge (Near Silchar)	0.36	4320	6400	Realignment of Existing Bridge 0.36 km				
RD-11	Dhubri (Dhubri - Phulbari Section)*	39	5531	9680	18 km New Bridge + 21 km Access Road (DL)				
	Grand Total	1325.36 km							

Source: JICA Study Team

It can be observed from the above table that the road network included in the present Study consists of eight roads (RD-1 to RD-8) that are part of different national highways and add up to a length of 1,286 km. These eight roads are further divided into 37 homogenous sections. Road No. 9 (RD-9) is the existing bridge of 0.36 km length at Badarpur (near Silchar, Assam) and Road No. 11 is a new bridge of 18 km with 21 km of approach/ access road on River Brahmaputra at Dhubri (Dhubri-Phulbari Section, Assam). The economic analysis has been conducted for the eight roads as well as the two bridges.

5.4 Application of Improvement Option

The Study Team has formulated improvement options after having detailed interaction on the engineering and local aspects concerning the Study roads and bridges. The identified improvement options are presented in Table 5.4-1.

Table 5.4-1 Project Roads and Bridges Improvement Options

Project Road/ Bridge	Project Option	Description
RD-1 to RD-8	Base Case (Without the Project Case)	'No-construction/improvement' (do-nothing or do-minimum) situation, wherein the current practices that are adopted by the PWD for the routine and periodic maintenance of the roads form the part of the works, without any new investments on the project roads
	Improvement Option (With the Project Case)	Improvement to 2-lane (wide) road with carriageway width of 7 m (adjusted to lower width in urban areas) and 2.5 m x 2 shoulder (unpaved)
RD-9 (Badarpur Bridge)	Base Case (Without the Project Case)	'no-construction/improvement' (do-nothing or do-minimum) situation, wherein the current practices that are adopted by the PWD for the routine and periodic maintenance of the bridge form part of the works, without any new investments on the project bridge
	Improvement Option (With the Project Case)	Construction of new 2-lane bridge adjacent to the existing bridge
RD-11 (New Bridge at Dhubri)	Base Case (Without the Project Case)	'no-construction/improvement' (do-nothing or do-minimum) situation, wherein the current practices that are adopted by the PWD for the routine and periodic maintenance of existing road from where the traffic will divert to the new bridge location, without any new investments on the roads
	Improvement Option (With the Project Case)	Construction of new 2-lane bridge of 18 km with 21 km of 2-lane approach/ access road

Source: JICA Study Team

The improvement option indicated above has been applied to each of the homogeneous road sections. As observed in the chapter on traffic analysis, the traffic volumes in some of the Study roads shall reach capacity limits (V/C ratio close to 1) within the project analysis period (2017 to 2041), warranting further widening; otherwise, the intended benefits shall not occur due to congestion on the improved roads after the capacity limits have been reached. Since no investments on capacity augmentation for such cases are envisaged in the present Study for the purpose of economic analysis, the increase in traffic has been frozen for the roads, after the year when the V/C ratio is close to 1.

5.5 HDM 4 Data Inputs

HDM-4 requires data input in a structured manner. The data requirements relate to road network, vehicle, and traffic details. These data were obtained by different means such as road survey of the network; collecting vehicle characteristics, costs, vehicle performance; traffic surveys for estimating traffic composition and forecasting growth rates. These data are combined into structured input files for running the programme. It may be mentioned that the Project Analysis utility available in HDM-4 was used for carrying out the economic analysis as it has facility to include diverted traffic in the economic analysis.

5.5.1 Project Road Network

As specified earlier, the road network consists of the 37 homogeneous sections representing eight project roads and two bridges (one bridge along with the approach road) totaling to 1,325.36 km. A summary of the road network and bridges is given in Table 5.5-1. The economic analysis has been conducted for the eight roads, as well as, the two bridges.

Table 5.5-1 Details of Road Network and Homogenous Sections

Region	No. of Roads	No. of Homogenous Road Sections	Total Road Length (km)
Assam	2 (Bridges)	-	39.36 (including approach road)
Mizoram	1	4	381
Meghalaya	3	16	321
Manipur/Nagaland	3	10	474 (31km in Nagaland)
Tripura	1	7	110
Grand Total	10	37	1325.36

Source: JICA Study Team

Inputs to the road-network included defining the parameters such as speed-flow, traffic-flow, climatic condition, carriageway width, and shoulder width, number of lanes, section lengths, traffic (AADT in base year for motorized and non-motorized vehicles), geometry and pavement details and pavement conditions of each of the homogeneous road sections. The data for it was obtained from the surveys such as road surveys and traffic surveys. Accordingly, the road-network files were prepared as an input to the economic analysis.

5.5.2 Vehicle Fleet Data Inputs

Vehicle fleet data is used for estimating the operating cost of the vehicles (motorized and non-motorized). The inputs relate to vehicle cost, cost of tire, fuel prices, maintenance labor cost and crew cost, and details on vehicle specification and performance. These input costs are given in Table 5.5-2. All the cost items are at economic cost, estimated on the basis of the method described earlier in this chapter.

Table 5.5-2 Unit Economic Cost and Vehicle Fleet Data

Item	Car	Two Wheel	Three Wheel	Bus	Mini Bus	2-Axle Truck	Multi Axle Truck	LCV	Tractor
Vehicle Price (Rs. 000)	400	51	132	880	620	960	1064	648	432
No. of Wheels	4	2	3	6	4	6	10	4	4
No. of Axles	2	2	1	2	2	2	3	2	2
Passengers	4	1	3	30	15	-	-	-	-
Tire (Rs.000)	3.1	0.73	0.96	8.75	8.75	8.75	8.75	5.60	8.75
Fuel Per/Lt. (Rs.)	36.79	36.79	36.79	37.86	37.86	37.86	37.86	37.86	37.86
Maint. Labor (Rs. per hr.)	100	60	100	180	150	180	200	150	200
Crew Wages (Rs. per hr)	16	-	14	64	39	36	41	27	-
Annual Overhead (Rs 000)	20	-	10	40	30	30	40	30	10
Interest Rate (%)	12	12	12	12	12	12	12	12	12
Pass. Time Value* (Rs. per/hr.)	76.25	60.99	60.99	51.14	51.14	-	-	-	-
PCSE	1.0	0.5	1.0	1.8	1.5	1.8	2.4	1.5	2.4
Working Hours	850	240	950	2200	1400	2600	2800	1400	650
Annual km (000)	40	12	25	75	55	85	85	50	10
Avg. life (Yrs)	8	8	8	8	8	10	10	8	8

Source: Market Survey & Previous Studies in India

The cost and performance data given in the above table was collected by the Study Team from vehicle dealers, operators, and oil companies located in and around Hyderabad. The data were readily available with these sources, however, the estimation of fuel cost and VOT for passenger and freight traffic needs further elaboration.

Fuel Cost

Fuel cost relates to the price of petrol and diesel duly netted for taxes and duties. The market price for one liter of petrol in Guwahati is Rs.61.67 and that of diesel is Rs.49.58. The total taxes and levies on petrol amount to about 40.34% and that on diesel add up to 23.64%. By this account, the economic cost of one liter of petrol becomes Rs.36.79 and that of diesel will be Rs.37.86.

The above economic costs for petrol and diesel were cross-checked by an alternate method. Considering the price of crude in the international market to be about US$70 per barrel (in the long term), the shipping and refining cost for petrol can be taken as about 30% to 35% of crude price, the transportation and distribution cost of the refined product as about 10% to 15% of the crude and refining cost; thus, on this basis, the economic price of petrol amounts to US$0.59 per liter (one barrel = 158 liters). In rupee terms, the economic cost of petrol becomes Rs.36.58 per liter (US$1 = Rs.62).

On comparing the economic cost of petrol arrived at from two different methods, it may be observed that the economic price of petrol is almost close and therefore, the economic prices of Rs.36.79 per liter for petrol and Rs.37.86 per liter for diesel are considered for the present study.

Value of Time

Assessment of value of time of passengers and cargo held in transit is a difficult task. For estimating the value of time of passengers, one method is to consider the per capita income (PCI) of the state as a surrogate for income/wages of the passengers and the other is to estimate the average income levels of the passengers. While the first method leads to underestimation of the income/wages of passengers and the latter method suffers from biased reporting by the passengers.

For the present Study, the per capita income approach has been adopted. Based on the available data, the average per capita income for the six North-Easter States for year 2014-15 (extrapolated to year 2014-15 by using past growth rates) was Rs. 63,085/-. Considering a normal working hour of 240 in a month and adjusting for 42.84% work force participation rate in the state, the value of time per hour for work related trips is estimated at Rs.51.14 per hour and has been assumed to represent the class of passengers travelling by bus. For the other passenger vehicles, appropriate factors based on similar studies done in India were used. For car passengers, a 1.5 times higher value than the bus passengers have been considered and for passengers travelling by auto-rickshaw (three-wheelers) and two-wheelers, the value has been assumed as 80% of that of car passengers.

The value of passenger time (per hour) for different class of vehicles is set out in Table 5.5-3.

Table 5.5-3 Value of Time – Passenger and Freight Vehicles

Vehicle	Value of Time (Rs./ Hr)	
	Work-time	Non-work*
Car	76.25	19.06
2-wheelers	60.99	15.25
3-Wheelers	60.99	15.25
Bus/ Mini Bus	51.14	12.79

* Estimated by applying the ratio of work to non-work values given in SP 30[1]
Source: JICA Study Team

Assigning Traffic (normal, diverted and generated) to HDM

The normal, diverted, and generated traffic for each homogeneous section have been taken from the chapter on traffic analysis. It may be indicated that separate treatment is given to 'generated traffic' for

1 Special Publication 30: Manual on Economic Evaluation of Highway Projects in India, Indian Road Congress, 1993.

project options where considerable increase in traffic flows is expected due to increase in road capacity/speed. The generated traffic has been included (in HDM-4) in the 'improvement assignment' concerning the individual road sections.

Generated Traffic

Generated traffic is expected to materialize due to improved road condition. However, it will also depend on the capacity saturation on the roads after improvement. In the event of capacity saturation, the level of service (LOS) will decrease, and would discourage generated traffic to materialize. A detailed analysis of the capacity of the Study roads and expected saturation years was carried out in Section 4.6.6 (Chapter 4: Traffic Survey, Analysis and Forecast). Based on the capacity analysis, the expected generated traffic on the Study roads has been considered.

As discussed in the chapter on "Traffic Survey, Analysis and Forecast", generated traffic to the extent of 5% of the normal traffic has been considered for the road sections where the capacity saturation (after improvement) is expected to be after at least five years from the start of operations (i.e., from 2020). Table 5.5.4 presents the list of road sections that will attain saturation within the project analysis period (2017 to 2041); the remaining road sections that are not on the list will attain capacity saturation after 2041. For the two bridges (RD-9 and RD-11), the generated traffic has been considered as 10%, on the assumption that improvement/new construction of bridges will increase accessibility for road users more as compared to improvement of road sections.

For all the road sections marked "Yes", the generated traffic has been considered, and in addition to it, for all the roads not included on the list, generated traffic has been considered.

Table 5.5-4 Expected Capacity Saturation on Road Sections after Improvement

Road ID	Road Section	Capacity Saturation Year	Generated Traffic Considered
RD-1	Aizawl - Tuipang (NH 54)		
RD-1.1	km 0 - km 55 (Ref: Aizawl)	2026	Yes
RD-3	Tura - Dalu (NH51)		
RD-3.2	km16 -km 60 (Ref: Tura)	2030	Yes
RD-4	Shillong - Dawki (NH40)		
RD-4.1	km 0 -km 28 (Ref: Shillong)	2020	No
RD-4.2	km 28 -km 43 (Ref: Shillong)	2030	Yes
RD-4.3	km 43 -km75 (Ref: Shillong)	2030	Yes
RD-4.4	km 75 -km 82 (Ref: Shillong)	2030	Yes
RD-4.5	km 82 -km 84 (Ref: Shillong)	2030	Yes
RD-5	Imphal - Jiribam (NH53)		
RD-5.2	km 3 -km 145 (Ref: Imphal)	2015	No
RD-5.3	km 145 -km 221 (Ref: Imphal)	2015	No
RD-6	Imphal - Kohima (NH39)		
RD-6.2	km 8 -km 107 (Ref: Imphal)	2022	No
RD-6.3	km 107 -km 138 (Ref: Imphal)	2022	No

Source: JICA Study Team

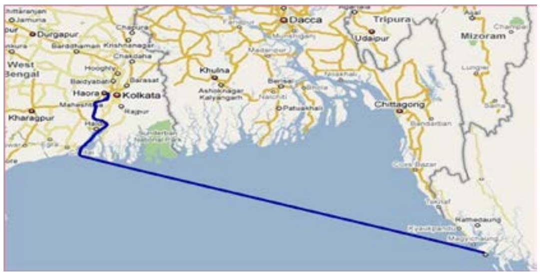
Diverted Traffic

The diverted traffic is applicable only for the new bridge construction at Dhubri, and for all other road sections, no diverted traffic is expected. The diversion as discussed in the chapter on "Traffic Survey, Analysis and Forecast" has been considered for the purpose of economic analysis. Based on the pattern of traffic movement at the existing bridge at Goalpara, it is expected that there is a potential, in number terms, for about 60% of the traffic to divert to the new bridge, mainly on account of savings in distance. On the average, the reduction in distance is expected to be of the order of about 52 km.

Kaladan Multimodal Transit Transport Project

The project is expected to start before the operation of the present project (expected by 2020). With the commissioning of the Kaladan Project, it is expected that a part of the traffic entering the North-Eastern Region from Kokrajhar (West Bengal side) shall get re-routed, and enter via NH54 (Mizoram). In a way, it is a diverted traffic, but in the absence of details about its quantity, it is not possible to quantify it for the purpose of economic analysis. But the net benefit is expected to be substantial when the transportation cost through the proposed route mentioned below is compared with the existing route.

Stretch	Mode	Distance
Kolkata to Sittwe port in Myanmar	Shipping	539 km
Sittwe to Paletwa (River Kaladan)	IWT	158 km
Paletwa to Kaletwa	Road	67 km
Kaletwa to Myeikwa (IM Border)	Road	62 km
Border to NH.54 (Lawngtlai) (in India)	Road	100 km
Lawngtlai to Aizawl	Road	334 km
Kolkata – Aizawl	Multi-Modal	1260 km



Source: Ministry of Development of North Eastern Region

Figure 5.5-1 Kaladan Multi Modal Transit Transport Project

However, for the present analysis, it is expected that an increase of 20% of the normal traffic on NH54 (first section) shall make up, though not entirely, for the net benefit to the economy. The traffic on the other sections is accordingly increased by adding the net 20% increase in the traffic of the first section, to the respective traffic on the remaining three road sections (NH54).

Kaladan Project shall also result in generated traffic on NH54. In addition to the 5% generated traffic discussed in the previous section, a 5% increase is considered for NH54 on account of the Kaladan Project. Thus, a total of 10% generated traffic is considered for NH54.

5.5.3 Works Standards and Costs

Based on the treatment required for improving each of the homogeneous road section, cost estimates were prepared by the highway engineer. It may be noted that the proposed construction works are only applicable for the improvement of the roads ('with' the project case), and are not applicable for the base case alternative ('without' the project case).

The first year of construction period is considered as 2017, with the construction period lasting for three years (i.e., up to 2019). The opening year of traffic operations is expected to be 2020. The construction is expected to be completed in a phased manner as indicated below.

Table 5.5-5 Investment Schedule for Construction

Construction Year	Percentage Investment
2017	40%
2018	30%
2019	40%

Source: JICA Study Team

5.5.4 Maintenance Standards and Costs

The maintenance (annual and periodic) cost has been taken separately for the base case alternative (do-nothing\do-minimum) and the project alternatives. The maintenance cost for the 'base case' alternative is based on the existing practices being followed by the road agency. For the project alternatives, the maintenance cost has been defined by the Study Team.

5.6 Economic Analysis

Having applied the project options and completed the data input in the HDM-4, the next step is to undertake economic analysis of the homogeneous road sections for each of the defined project options.

The economic analysis based on the method elaborated above allowed the Study Team to obtain the economic indicators for each of the project roads. The economic indicators such as EIRR and NPV are important for judging the economic feasibility of projects as well prioritizing the Study roads. The results of the economic analysis are set out in Table 5.6-1.

Table 5.6-1 Results of Economic Analysis of Study Road Sections

Road ID	Road Section	EIRR (%)
1.0	Aizawl – Tuipang Section, NH54	15.1
2.0	Dudhanal – Dalu Section, NH62	7.3
3.0	Tura – Dalu Section, NH51	22.0
4.0	Shillong – Dawki Section, NH40	16.8
5.0	Imphal – Jiribam Section, NH53	22.6
6.0	Imphal - Nagaland, NH39	18.9
7.0	Ukhrul – Tadubi Section, NH102A	14.0
8.0	Manu - Simlung Section NH44	3.5
9.0	Badarpurghat Bridge near Silchar	(-) 0.2
11.0	Dhubri – Phulbari Section	18.7

Source: JICA Study Team

5.7 Sensitivity Analysis

In order to know the economic strength of the Study roads and to identify its robustness, sensitivity analysis of the improvement option has been carried out under the adverse situation of cost and benefits. Through the sensitivity analysis, the changes in the project EIRR/NPV are estimated and compared to the minimum acceptable criteria (Table 5.7-1).

Normally, the crucial parameters impacting the performance of road projects are cost overrun and time overrun related to the project implementation aspect. The other important parameter is the decrease in estimated traffic that results in the decrease in benefits of the project. The possibility of adverse change in these three parameters has been studied by the Study Team, and accordingly, the expected change in their values has been assessed and incorporated in the sensitivity analysis.

Based on the past experience of the Study Team in similar projects, and the general practice followed in the appraisal of road projects in India, the following sensitivity cases have been considered:

Case 1: Increase in Project Cost by 15%

Case 2: Decrease in Project Benefit by 15%

Case 3: Combined Impact of Case 1 and Case 2

Table 5.7-1 Results of Sensitivity Analysis of Study Road Sections

Road ID	Road Section	EIRR (%)			
		Base Case	Case 1	Case 2	Case 3
1.0	Aizawl – Tuipang Section, NH54	15.1	12.6	12.2	9.8
2.0	Dudhanal – Dalu Section, NH62	7.3	6.1	5.9	4.7
3.0	Tura – Dalu Section, NH51	22.0	18.0	17.4	13.9
4.0	Shillong – Dawki Section, NH40	16.8	15.2	14.9	13.2
5.0	Imphal – Jiribam Section, NH53	22.6	20.4	20.1	18.0
6.0	Imphal - Nagaland, NH39	18.7	17.1	16.8	15.2
7.0	Ukhrul – Tadubi Section, NH102A	14.0	10.7	11.5	9.4
8.0	Manu - Simlung Section NH44	3.5			
9.0	Badarpurghat Bridge near Silchar	(-) 0.2			
11.0	Dhubri – Phulbari Section	18.7	15.7	15.2	12.4

Source: JICA Study Team

CHAPTER 6 PRIORITIZATION OF PROJECT IMPLEMENTATION AND SELECTION OF PROJECT FOR JICA LOAN SCHEME

6.1 Prioritization of Project Implementation

6.1.1 Evaluation Criteria

Evaluation criteria is selected to apply prioritization of project implementation for yen loan scheme based on the results of the study of present conditions and major issues, traffic demand forecast, and economic analysis in the foregoing sections. Proposed evaluation criteria are consistent with the above plan, project maturity, traffic demand, and EIRR. Table 6.1-1 shows the proposed evaluation criteria and weighting of scoring. The total length of the priority project will be around 450 km based on the annual budgetary quota for road sector project loan for India.

Table 6.1-1 Evaluation Criteria of Project Prioritization

Criteria		Evaluation Contents (Score)			Weighting (Average:10)
		High (10 - 8)	Middle (7-4)	Low (3-0)	
1	Consistency with upper plan	Listed in National Road Development Plan (e.g. SARDP-NE)	Listed in International Road Development Plan (e.g. Asia Highway)	Others	5
2	Project maturity	DPR、EIA、RAP are prepared	DPR、EIA、RAP are being prepared	DPR、EIA、RAP are not yet prepared	10
3	Traffic demand supply Gap (V/C)	Demand supply gap in year 2020 (V/C>0.75)	Demand supply gap in year 2020 (V/C 0.75-0.50)	Demand supply gap in year 2020 (V/C <0.50)	10
4	EIRR	EIRR>15%	EIRR 12% - 15%	EIRR<12%	25

Source: JICA Study Team

6.1.2 Results of Project Prioritization

Result of project prioritization based on the evaluation criteria is shown in Table 6.1-2.

Table 6.1-2 Results of Project Prioritization

Criteria		1				2			
		NH54: Aizawl-Tuipang				NH62: Dudhanai-Dalu			
		0-55	55-125	125-250	250-381	0-30	30-87	87-91	91-183
1	Consistency with upper plan	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B		*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B
		10	10	10	10		10	10	10
2	Project maturity	*DPR is being prepared	*DPR is being prepared	*DPR is mostly prepared	*DPR is mostly prepared	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		6	6	8	8	3	3	3	3
3	Traffic demand (V/C)	1.22	1.92	1.60	1.87	0.29	0.22	0.64	0.64
		10	10	10	10	3	2	6	6
4	EIRR	15.1				7.3			
		8				2			
Total Score		41	41	43	43	11	15	19	19
Combined Score (Cost Weight Base)		42				17			
Ranking		2				9			

Criteria		3		4				
		NH51: Tura-Dalu		NH40: Shillong-Dawki				
		0-10	16-60	0-28	28-43	43-75	75-82	82-84
1	Consistency with upper plan			*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1
				7	7	7	7	7
2	Project maturity	*DPR is mostly prepared	*DPR is mostly prepared	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		8	8	3	3	3	3	3
3	Traffic demand (V/C)	2.50	5.48	1.16	0.78	0.39	3.90	0.39
		10	10	10	7	4	10	4
4	EIRR	22.0		16.8				
		10		9				
Total Score		43	43	39	36	33	39	33
Combined Score (Cost Weight Base)		43		36				
Ranking		1		4				

Criteria		5			6			7
		NH53: Imphal-Jiribam			NH39: Imphal-Kohima			NH102A: Ukhrul-Tadubi
		0-3	3-145	145-221	0-8	8-107	107-138	0-115
1	Consistency with upper plan				*Asia Highway No.1	*Asia Highway No.1	*Asia Highway No.1	
					7	7	7	
2	Project maturity	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		3	3	3	3	3	3	3
3	Traffic demand (V/C)	0.17	1.28	1.28	0.25	0.78	0.78	1.71
		2	10	10	2	7	7	10
4	EIRR	22.6			18.7			14.0
		10			9			4
Total Score		30	38	38	31	36	36	23
Combined Score (Cost Weight Base)		38			36			23
Ranking		3			4			7

Criteria		8				9	11	
		NH44A: Manu-Simlung				Badarpurghat Bridge	NH127B: Dhubri-Phulbari Bridge	
		0-16	16-67	67-97	97-110	0-0.36	0-18	18-39
1	Consistency with upper plan	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B	*SARDP NE, Phase-B			
		10	10	10	10			
2	Project maturity	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured	*DPR Consultant is being procured
		3	3	3	3	3	3	3
3	Traffic demand (V/C)	2.07	1.26	1.26	1.26	1.10	0.98	9.80
		10	10	10	10	10	9	10
4	EIRR	3.5				-0.2	18.7	
		2				0	9	
Total Score		23	23	23	23	18	35	36
Combined Score (Cost Weight Base)		23				13	35	
Ranking		7				10	6	

Source: JICA Study Team

6.2 Conclusion of Project Priority for Yen Loan Scheme

The project road is categorized into three priority groups based on the project prioritization result. The remarks for project implementation are also mentioned in Table 6.2-1.

Table 6.2-1 Conclusion of Project Priority for Yen Loan Scheme

Priority Group	Project	Remarks
A	NH54, Aizawl-Tuipang Section NH51, Tura-Dalu Section	i) Design review of two projects is being carried out by the JICA Study Team in October 2015
B	NH127B, Dhubri-Phulbari Section NH40, Shillong-Dawki Section NH53, Imphal-Jiribam Section NH39, Imphal-Kohima Section	i) Submission of the DPR and transferring administrative jurisdiction from BRO to MORTH are necessary ii) Security of the Study Team at Manipur State is essential
C	NH44, Badarpurghat Bridge NH44A, Manu-Simlung Section NH102A, Ukhrul-Tadubi Section NH62, Dudhanal-Dalu Section	

Source: JICA Study Team

6.3 Selection of Projects for Preliminary Design

Project for the preliminary design are selected based on result of the project prioritization for Yen Loan Scheme and annual budgetary quota for road sector project loan for India. As a result, projects of NH54, Aizawl – Tuipang Section and NH51, Tura – Dalu Section are selected to be subjected to the preliminary design.

CHAPTER 7 PRELIMINARY DESIGN OF NH54 (AIZAWL - TUIPANG)

7.1 General

NH54 (Aizawl – Tuipang) project is prioritized as project in the Priority Group A as mentioned in Chapter 6 and this project is subjected to preliminary design to examine procurement and construction method, implementation schedule, project organization, capability of operation and maintenance, social and environmental conditions and evaluate project cost and feasibility.

NH54 is a national highway with total length of 381km connecting Aizawl and Tuipang in Mizoram State. It stretches along the mountain ridges in most sections and the average altitude of the road varies from 700 to 900m. The existing carriageway width is 5.5 m in the extent of 55km from Aizawl and 3.75 m in the remaining section of 326km.

The objective of the Project is to secure stable, efficient and safe traffic through improvement of the exiting NH54 including road widening with appropriate slope protections, installation of pavement, drainage and other road facilities.

7.2 Natural Condition Surveys

7.2.1 Meteorological and Hydrological Surveys

(1) General

The national highway shall facilitate adequate and proper drainage system to drain out rainwater falling on the road surface and flowing from mountain upstream. Specially, hill road suffers from large volume of crossing water flowing from the mountain slope. It is essential to protect the improved highway from such rainwater by appropriate arrangement of drainage facilities.

The hydrological study based on meteorological and topographical condition at the project area is conducted.

(2) Meteorological Condition

Mizoram has a mild climate, which is relatively cool during summer with temperature of 20-29 °C. Meanwhile, winter temperatures range from 7 to 22 °C. The region is influenced by monsoons, raining heavily from May to September with little rain in the dry season. The climate pattern is moist tropical to moist sub-tropical, with average state rainfall of 254 cm per annum. In the capital Aizawl, rainfall is about 215 cm and in Lunglei, another major centre, it is about 350 cm. The state is in a region where cyclones and landslides can cause weather-related emergencies.

In addition, the rainfall intensity has been increasing in the North-East States of India recently due to climate change as explained in Chapter 7.3.

(3) Topographical Condition

Mizoram has the most variegated hilly terrain in the eastern part of India. The hills are steep and separated by rivers, which flow either to the north or south creating deep gorges between the hill ranges. The highest peak in Mizoram is the Blue Mountain with a height of 2,210 m.

In the project area of NH54 between Aizawl and Tuipang, the project route passes several rivers and its tributaries, including the following rivers:

- Tuirial River in Aizawl District
- Mat River in Lunglei District
- Kawchaw River in Saiha District

(4) Hydrological Study

a) Methodology

The hydrological study is conducted with reference to IRC:SP:13 "Guidelines for the Design of Small Bridges and Culverts" and IRC:SP42 "Guidelines of Road Drainage", which are frequently used technical standards for hydrological study in Indian highway design.

The analysis is conducted based on the Rational Formula for the peak discharge from the catchment.

The size of the flood is determined by factors such as rainfall intensity, distribution in time and space, duration, catchment area, shape, slope and permeability of the soil, and vegetable cover.

Rational Formula:

$Q = 0.028 \times C \times I \times A$

C : Runoff coefficient
I : Critical intensity of rainfall (cm/hr), $I = F/T \times ((T+1)/(tc+1))$
F : Rainfall intensity (mm/hr)
T : Duration of storm (hr)
tc : Time of concentration (hr)
A : Catchment area (ha)

b) Return period

The return period is described in IRC:SP42 as follows:

- For side drain for national highway (NH): 25 years (at valley points)
- For cross-drainage for NH: 25 years (up to 2 m span) / 50 years (2 to 6 m span)

It is also suggested in IRC:SP42 to assure the discharge not only for the design flood but also for the check flood in order to protect an area from prolonged inundation when a flood rarer than the design flood hits the area. A check flood is a flood having the next higher commonly followed recurrence interval.

Since the project highway is located at a high hill, the water flood may cause high risk of fatal accidents. Also due to the increase of rainfall intensity in recent years, the application of 50 years for all drainage is not an overestimation.

Therefore, the structural dimension of all drainage is determined to be capable for the discharge of 50 years return period.

c) Rainfall Intensity

The rainfall intensity is based on the ATLAS of Statewise Generalised Isopluvial Maps of Eastern India (Part-II), published by the India Meteorological Department, Government of India.

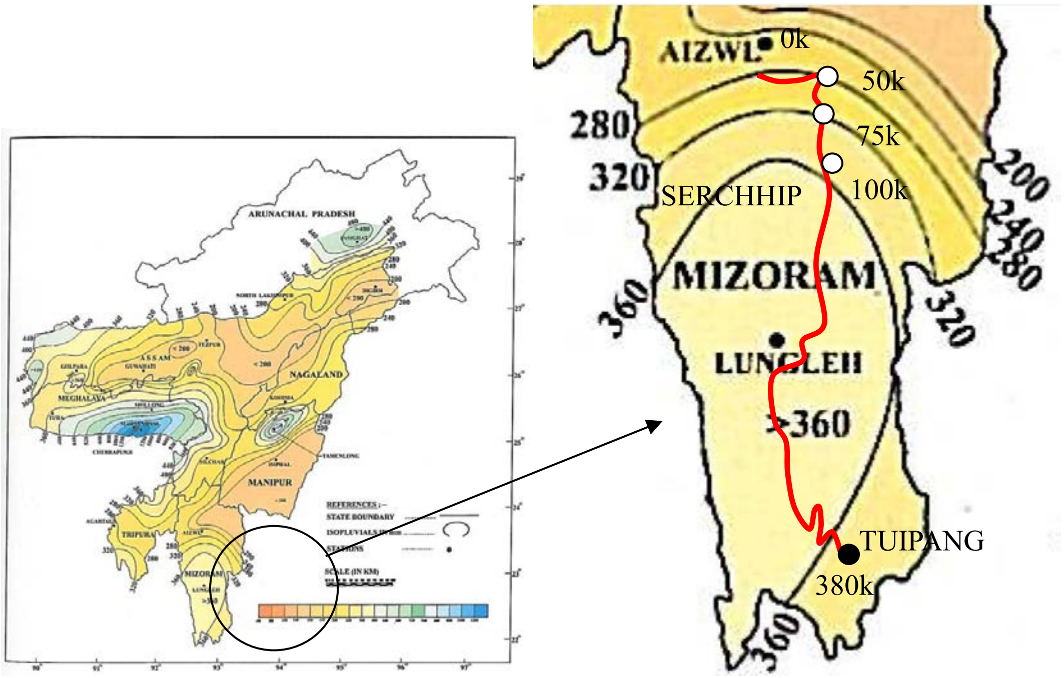
Location of the project site is identified on the isopluvial map. The isopluvial map with the project location is shown in Figure 7.2-1 below. It is categorized by the range of rainfall intensity whose value is read from the higher edge of the counter value.

Rainfall intensity for each section in NH54 is shown in Table 7.2-1 below.

Table 7.2-1 Rainfall Intensity for Each Section of NH54

From	To	50 years- 24hours Rainfall Intensity
Aizawl (Near 0 k)	Tlungvel (Near 50 k)	280mm/hr
Tlungvel (Near 50 k)	Chhingchhip (Near 75k)	320mm/hr
Chhingchhip (Near 75k)	Serchhip (Near 100 k)	360mm/hr
Serchhip (Near 100 k)	Tuipang (End Point)	400mm/hr

Source: JICA Study Team



Source: ATLAS of Statewise Generalised ISOPLUVIAL (Return Period) Maps of Eastern India (Part – II)

Figure 7.2-1 Isopluvial map with project location for NH-54 (For 50years)

d) Runoff Coefficient

The guidelines on runoff coefficient is described in IRC:SP:13.

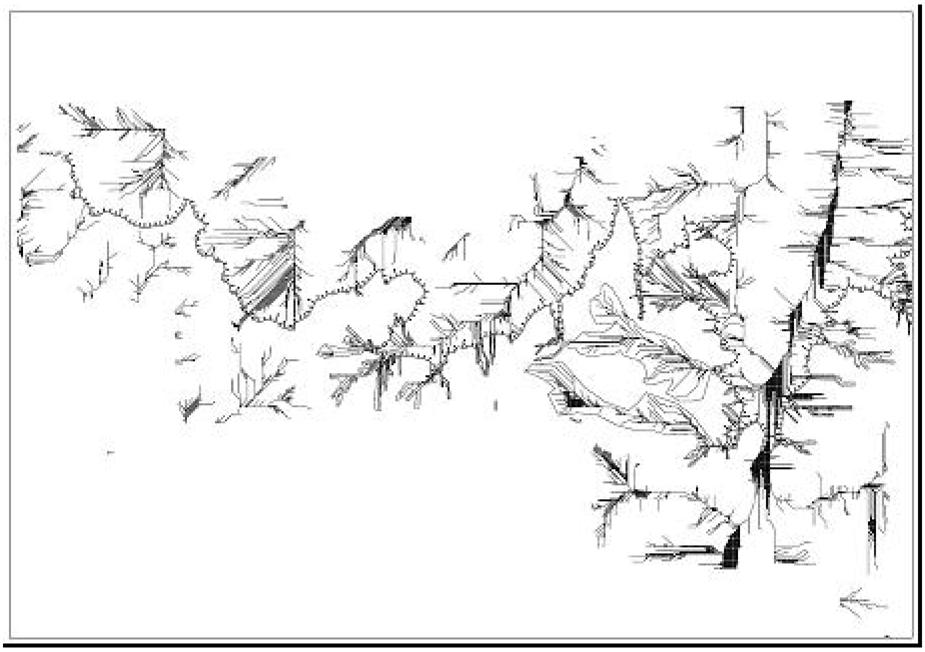
The topographical condition at the NH54 project area is generally rocky mountainous to steep terrain. Hence, runoff coefficient C: 0.8 is applied (rock, steep but wooded).

e) Catchment Parameters

Catchment parameters such as catchment area, length of tributary and difference of elevation along the project highway are obtained by computation with satellite data and GIS software.

- Satellite data : CatoSat I
- Software : Arc GIS 10.1 and Erdas

An example of catchment area map for NH54 obtained by computation is shown in Figure 7.2-2 below.



Source: JICA Study Team

Figure 7.2-2 Example of Catchment Area Map Obtained by Computation for NH54

(5) Discharge Result

Through the hydrological study, the discharge results for water crossing point with catchment area are obtained. The discharge summary for large discharge (Q>4 m^3/s) is summarized in Table 7.2-2 below. All discharge results including for small catchment area are estimated.

It is noted that cross-drainage is planned not only in the location where crossing water appears based on the hydrological computation but also in the location of existing cross-drainage. It is also planned at some locations to complement between long intervals. This is explained in the chapter on drainage design.

Table 7.2-2 Discharge Summary for Large Discharge (NH54)

Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of Elevation (m)	Discharge Q50 (m3/s)	Remark
11+220	101,743	582	226	7.91	Existing culvert location
17+745	61,680	622	298	7.09	Existing culvert location
18+025	94,592	865	264	9.72	Existing culvert location
20+695	365,983	1,221	285	22.64	Existing culvert location
21+650	435,435	948	237	27.21	Existing culvert location
24+390	54,933	622	163	5.01	Existing culvert location
25+840	51,107	458	156	4.84	
103+780	30,065	368	155	4.37	
103+890	61,680	622	298	7.09	Existing culvert location
105+625	94,592	865	264	9.72	Existing culvert location
159+300	32,654	373	146	4.60	Existing culvert location
161+705	32,654	373	146	4.60	
183+430	46,371	629	73	5.59	Existing culvert location
184+960	46,371	629	73	5.59	Existing culvert location
185+210	54,764	594	166	6.44	
190+940	38,630	580	27	4.84	Existing culvert location
191+660	80,079	671	299	8.66	
192+820	177,925	1,527	121	14.99	
193+100	258,475	1,823	448	22.03	

Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of Elevation (m)	Discharge Q50 (m3/s)	Remark
193+630	41,446	614	278	5.32	Existing culvert location
197+120	249,795	921	216	22.60	
197+330	349,554	152	56	33.38	Existing culvert location
197+440	296,185	787	231	26.94	
197+550	263,012	643	176	24.34	Existing culvert location
198+430	1,533,068	1,900	350	119.52	Existing culvert location
200+990	80,544	782	216	8.55	
206+495	31,895	262	71	4.55	Existing culvert location
217+025	73,730	100	39	8.42	Existing culvert location
217+800	93,975	1,142	277	9.44	Existing culvert location
217+920	161,093	1,145	276	14.96	Existing culvert location
222+370	30,731	922	331	4.31	Existing culvert location
223+460	214,105	816	325	20.07	Existing culvert location
223+550	63,263	607	145	4.33	
223+610	57,796	758	223	6.64	Existing culvert location
224+340	55,562	564	163	6.52	Existing culvert location
225+930	1,190,320	1,664	341	95.31	Existing culvert location
226+060	219,856	860	332	20.49	Existing culvert location
227+570	328,353	1,238	471	15.34	Existing culvert location
228+600	57,585	100	39	4.09	Existing culvert location
229+480	168,882	139	96	8.72	Existing culvert location
229+630	740,870	1,075	486	32.48	Existing culvert location
232+440	223,552	951	416	10.99	Existing culvert location
235+260	1,684,589	688	276	147.63	Existing culvert location
235+355	95,120	157	63	10.32	Existing culvert location
236+500	189,615	548	210	18.28	Existing culvert location
238+090	85,354	533	277	9.22	Existing culvert location
434+170	125,195	837	75	11.84	Existing culvert location
437+280	48,331	484	243	5.97	
437+660	38,527	87	46	5.23	Existing culvert location
439+230	33,894	561	267	4.67	Existing culvert location
441+600	15,920	304	194	3.13	Existing culvert location
469+735	44,732	485	144	5.61	Existing culvert location
484+250	134,424	665	278	13.38	Existing culvert location
485+400	31,566	439	233	4.50	Existing culvert location
486+120	28,893	115	49	4.33	Existing culvert location
486+940	148,674	923	336	14.33	Existing culvert location
490+110	26,444	515	188	4.02	Existing culvert location
490+260	55,494	604	211	6.52	Existing culvert location
491+280	320,429	1,259	487	28.39	Existing culvert location
491+440	395,465	1,423	563	34.34	Existing culvert location
491+650	230,896	1,168	489	20.10	Existing culvert location
492+315	304,607	1,542	586	26.62	Existing culvert location
492+370	513,839	47	23	48.93	Existing culvert location
492+520	59,097	683	254	6.81	
493+030	100,443	1,149	254	9.94	
493+305	146,484	1,158	248	13.68	Existing culvert location
494+740	578,042	406	109	52.51	Existing culvert location
495+215	27,022	374	88	4.08	Existing culvert location
495+845	237,195	1,579	428	20.75	
496+010	492,881	657	176	44.04	Existing culvert location
496+200	47,628	523	116	5.82	
496+825	100,372	733	194	10.26	Existing culvert location
496+900	26,150	119	36	4.07	Existing culvert location
497+210	381,311	1,131	277	33.15	

Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of Elevation (m)	Discharge Q50 (m3/s)	Remark
497+395	47,417	343	98	5.90	Existing culvert location
497+600	34,682	243	65	4.80	
497+780	878,655	1,057	231	74.23	Existing culvert location
500+260	209,268	606	155	19.73	Existing culvert location
500+340	27,755	506	137	4.12	
500+460	30,651	1,258	376	4.23	Existing culvert location
500+540	101,019	1,251	397	10.05	Existing culvert location
500+620	251,661	1,192	375	22.58	
500+940	271,365	1,365	393	23.87	
501+300	148,928	773	201	14.36	Existing culvert location
501+375	133,252	725	220	13.12	Existing culvert location
501+510	128,782	834	245	12.64	Existing culvert location
501+580	39,231	814	241	5.04	
501+870	77,668	630	257	8.46	
502+150	43,900	557	253	5.55	
502+230	40,530	713	404	5.23	Existing culvert location
502+380	120,742	793	465	12.18	
502+550	28,376	144	99	4.29	
503+040	30,636	814	241	4.51	
503+870	51,360	371	120	6.24	Existing culvert location
504+040	158,175	1,324	456	14.76	Existing culvert location
504+300	29,864	285	41	4.33	
504+630	58,351	576	154	6.75	Existing culvert location
504+880	101,516	946	296	10.27	
505+830	49,190	617	201	5.96	Existing culvert location
505+910	75,347	580	202	8.26	Existing culvert location
506+110	888,017	2,000	554	71.26	Existing culvert location
506+680	49,521	479	153	6.04	
506+800	51,066	412	131	6.20	Existing culvert location
506+980	35,343	480	148	4.79	Existing culvert location
507+635	52,231	366	159	6.35	Existing culvert location
508+080	966,820	1,685	456	78.82	Existing culvert location
508+375	36,693	368	113	4.94	Existing culvert location
509+425	526,073	166	83	49.43	Existing culvert location
510+060	68,179	526	141	7.62	Existing culvert location
511+190	514,133	1,135	424	44.80	Existing culvert location
512+615	31,084	315	148	4.48	Existing culvert location
512+850	24,089	540	162	4.48	Existing culvert location
513+050	3,877	198	84	4.46	Existing culvert location
513+970	55,446	620	283	6.54	Existing culvert location
514+100	33,508	292	145	4.70	
515+130	31,630	553	233	4.47	
525+035	31,403	198	91	4.54	Existing culvert location
527+240	38,127	504	162	5.03	Existing culvert location
528+930	29,760	358	135	4.34	Existing culvert location
530+185	60,584	563	196	6.98	Existing culvert location
530+510	30,557	485	193	4.39	
530+760	54,394	427	190	6.52	
530+870	40,714	314	133	5.34	
531+140	29,576	287	145	4.35	
531+350	28,904	365	198	4.28	Existing culvert location
531+620	31,310	300	138	4.50	Existing culvert location
532+925	29,920	294	110	4.37	Existing culvert location
533+255	32,045	256	142	4.59	
542+670	42,221	409	261	5.46	Existing culvert location

Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of Elevation (m)	Discharge Q50 (m3/s)	Remark
542+870	48,106	332	226	6.02	
543+685	100,310	43	28	10.93	Existing culvert location
543+770	80,466	758	345	8.66	Existing culvert location
544+965	224,928	163	95	22.14	Existing culvert location
545+100	28,127	393	189	4.20	Existing culvert location
548+700	28,500	80	34	4.31	

Source: JICA Study Team

7.2.2 Topographic Survey

(1) Survey Data

No additional survey was done by the JICA Study Team for the road alignment, except for short sections where new bridge is proposed by the JICA Study Team in Section-1 at Chhingcchip and cross section survey at few locations with proposed representative landslide countermeasures.

i. 1:500 scale plan survey at Chhingcchip Bridge at 74+660, survey length of about 200 m
ii. Profile survey (cross section of road) at three locations of representative landslide countermeasures

The details of the topographic survey data received by the JICA Study Team from respective DPR Consultants are shown in Table 7.2-3.

(2) Issues from the Review

- The accuracy of the topographic survey data by all three DPR Consultants for the three sections was completely different from each other.
- Due to different coordinate systems applied for the survey, the three sections cannot be continuously interlinked.
- The elevation datum for Section-2 is only arbitrary and there is no continuation with Section-1 or Section-3.
- The concept of alignment design is different in all three sections. Therefore, the extent of topographic survey also differed across the three sections. For example, in Section-2, the alignment was completely designed by cutting the hill side only. Virtually no survey data exists on the valley side beyond the existing road width.
- Section-2 has applied two sets of data, one for the existing road width and the other for the hill side slope. These two data largely differ from each other at many locations.
- The hill side slope data in Section-2 is found to be exceptionally steep at some interval of about 2-3 km, which was not observed in the site. This raised serious issues on the accuracy of the survey data of Section-2.
- The hill side slope data in Section-3 was available for limited width only. The slope grades at few locations were also found to be gentle than those observed in the site.

(3) Additional Data by the JICA Study Team

The alignment design approach of the JICA Study Team was to make a more balanced cut/fill design by shifting the alignment of DPR to the valley side. Since the topographic survey data was not available/very limited in the valley side, the slope inventory data conducted by the JICA Study Team was used to create the contour data in the valley side. However, the slope inventory was conducted at every 200-300 m interval only. Therefore, the accuracy of the valley side contour created through such data was very low.

7-8

Table 7.2-3 Details of Topographic Data Received from respective DPR Consultants

SN	Items	Ssection-1	Section-2	Section-3
1	Applied coordinate system	Local coordinate system, but the north direction seems to be correct.	Local coordinate system, but the north direction seems to be correct.	WGS84, but the data near the end (from KM470+000 to the end) seems to have rotated (diverted) towards the east.
2	Existing road survey data	3D point data and 3D line connections for centerline and road edges for existing roads are available.	3D point data for centerline and road edges of existing road are available. However, 3D line connections are not available, making it difficult to create representative digital terrain model.	3D point data and 3D line connections for centerline and road edges for existing roads are available.
3	Topographic survey data	3D point data few meters beyond the road edges in the slopes are also available. Digital terrain model can be prepared but the available width is ***limited*** to correctly calculate the earthworks.	3D point data beyond the road edges in the valley slopes are ***NOT*** available. ***Therefore, it is not possible to calculate earthworks from the available data. Elevation is based on some arbitrary datum value only.***	3D point data beyond the road edges in the slopes are available for very limited width only. Digital terrain model can be prepared, but the available width is ***very limited*** to correctly calculate earthworks.
4	Topographic data on hill side	Sufficient data is not available at some high cut sections.	Point data available on hill side but exceptionally steep slopes (not observed on site) exist at regular intervals of every 2-3 km.	Sufficient data is not available on hill side and slopes at many locations maybe gentler than observed in the site.
5	Topographic data on valley side	Data is available at few locations for limited width.	No data is available beyond the road width.	Data is available at very limited locations and for limited width only.
6	Other features	Houses and other structures are shown.	Sizes, details, and numbers largely differ from site conditions. Other features are not shown sufficiently.	Houses and other structures are shown.
7	Remarks	Data on valley side is limited.	First set of data provides the 3D points for road centerline and edges only, but with large intervals, making difficult to correctly represent the horizontal curves. Second set of data includes 3D points at the hill side only but the elevations with the first set do not match largely at many locations.	Data on both hill side and valley side are for narrow width only.

Source: JICA Study Team

7.2.3 Geological Survey

(1) General

In order to clarify the geology and geological condition along NH54 and utilize the result for the road design, the JICA Study Team conducted geological survey including data collection, site reconnaissance, slope inventory survey, and boring survey.

Before starting the site survey, the JICA Study Team collected existing data and information on geological and topographical setting, earthquake occurrence, and landslide disaster in the study area. Although several organizations such as Mizoram Remote Sensing Application Centre and Geological Survey of India have established a landslide zonation map and a geological map, they did not identify landslide distribution and they have very large scale that the survey needed to clarify the exact location of the risk sites in detail for the design of the road and landslide countermeasures.

<u>Geological and Topographical Setting</u>

North-East India is located on the northeast edge of the Himalayan orogenic belt which resulted from the Indo-Eurasian continental plate collision that took place during Cenozoic, and represents one of the youngest and the highest mountain range in the world. The Himalayan orogenic belt has a unique agglomeration with a diversified geological setup. The various topographic features include the Himalayan mountain belt in the north, the Indo-Myanmar Range in the east, Shillong Massif Plateu in the west, and the expansive Brahmaputra forming the Assam plains in between.

Mizoram State is predominantly composed of mountainous terrain of tertiary rocks. The mountain ridges strike north to south direction in parallel series. The mountain ranges are separated from one another by narrow deep river valleys. The elevation ranges from 40 m to 2,157 m, the highest point in Phawngpui. There are only few and small patches of flat lands, which are mostly intermontane basins.

Figure 7.2-3 shows the geological map of Mizoram State. The geology of the state is represented by repetitive succession of Neogene sedimentary rocks of Surma groups that mostly include sandstone, siltstone, and shale. In the formations, there are many folds caused by the plate collision. Mizoram fold belt is composed of tight linear folds with their axes mostly trending north to south and longitudinally plunging anticlines and synclines. The density of folds increases from west to east where the Indian plate has been subducting below the Burmese plate. The sedimentary rocks such as shale distributed in Mizoram State are very vulnerable to weathering, which often cause collapsing and sliding along the bedding plane.

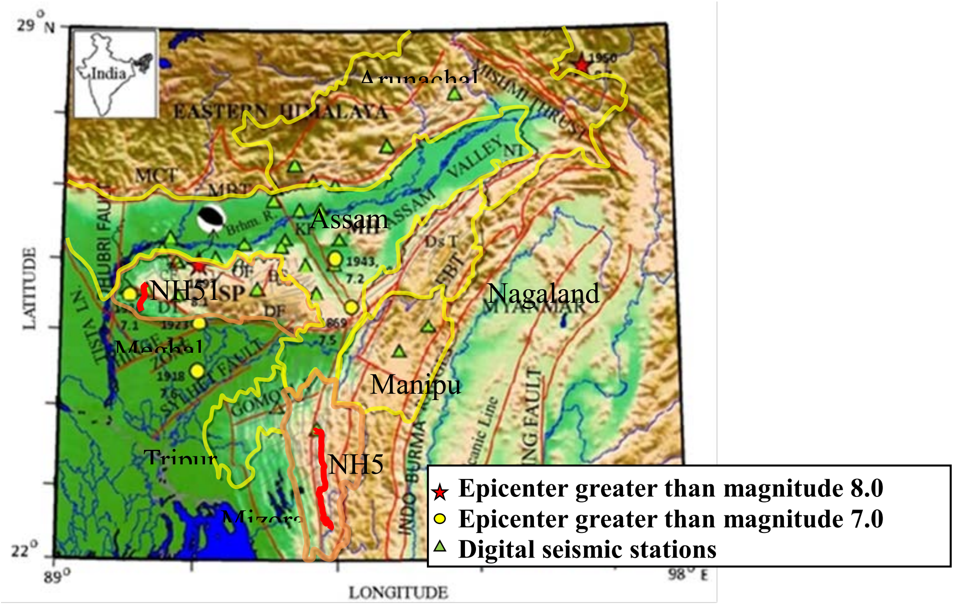
Source: Geological Survey of India

Figure 7.2-3 Geological Map of Mizoram

<u>Seismologic Situation</u>

The North-East States are located between the northern collision and eastern seduction margins of the Indian plate. Two big earthquakes with a magnitude of greater than 8.0 on the Richter scale occurred in the north of Meghalaya and northeast of Arunachal Pradesh in 1897 and 1950, respectively, as shown in Figure 7.2-4. Also, earthquake with a magnitude of more than 7.0 on the Richter scale has occurred in and around Meghalaya State along main tectonic faults.

On the other hand, earthquake is not frequent in Mizoram State. In the past, the biggest historic earthquake has magnitude 6.1 which occurred in Chittagong near the border with Bangladesh, and other earthquakes have low magnitudes from 4.0 to 5.7 on the Richter scale and comparatively low intensities from IV (Light) to VI (Strong) out of the 12 levels in the Indian earthquake intensity scale.



Source: Geological Survey of India

Figure 7.2-4 Epicenter Distribution Map

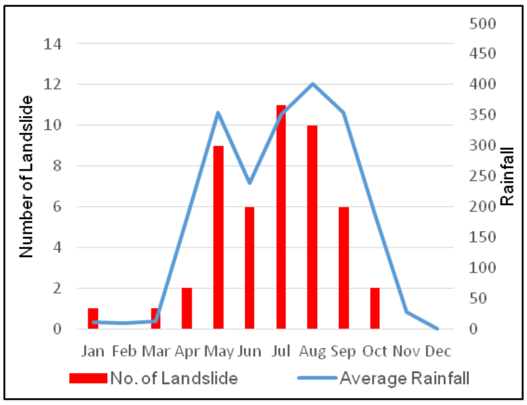
Table 7.2-4 Historical Earthquake in Mizoram

Year	Date	Location	Mag.	Intensity
1997	22-Nov	Chittagong	6.1	VI-VII
2011	19-Apr	10km from Kolasib	4.3	IV
2014	4-Apr	Champhai	4.0	IV
2014	4-Jun	42km from Saiha	4.6	IV-V
2014	9-Sep	40km from Saiha	5.4	V
2014	20-Nov	74km from Serchhip	5.7	V-VI
2014	21-Nov	Chittagong	5.4	V
2014	23-Dec	19-km from Saiha	4.4	IV
2015	15-Jan	39km from Lunglei	4.2	IV

Source: Government of Mizoram

Past Landslide Disaster

The JICA Study Team collected information on past landslide disasters in and around Mizoram State because the area is an extremely high rainfall region and mountainous area. Figure 7.2-5 shows the number of landslides reported in newspapers and academic paper from 1992 to 2015 and plotted by month. In September 2014, a large landslide occurred near PWD Office in Laipuitang, Aizawl and killed 17 people and destroyed 15 houses including PWD office buildings. As above, landslide has often occurred in this area and clearly tends to increase during the monsoon season from May to September.



Source: JICA Study Team

Figure 7.2-5 Landslide Frequency Distribution by Month

1) Geological Investigation for Bridges

In order to verify the foundation depth of planned new bridge, boring survey was conducted at the Chhingchhip Bridge site. Two boreholes were drilled up to 15 m depth with standard penetration test (SPT) on the centerline of the planned new bridge and at the top of the slope along existing road. The summary of the survey is shown in Table 7.2-5.

Table 7.2-5 Summary of Boring Survey at the Chhingchhip Bridge Site

Borehole No.			BH-1		BH-2	
		Depth (GL-m)	Beginning (Aizawl) Side		End (Serchhip) Side	
Geotechnical Condition	N-value	0 ~ 0.5	Surface Soil	-	Surface Soil	-
		0.5 ~ 3.0	Weathered Rock	27~37	Weathered Rock	32~41
		3.0 ~15.0	Hard Rock	50	Hard Rock	50

Source: JICA Study Team

According to the result of the boring survey, the site consists of shale and sandstone rocks and is covered by surface soil with 0.5 m thickness. Under the surface soil, there are highly weathered rocks 2 m thick with around 20~30 blows in SPT which cover the hard and intact bedrock layer with more than 50 blows of N-value. Therefore, the foundation layer for the planned bridge is evaluated below the highly weathered rock and around 3 m below the ground level.

2) Geological Investigation for Slope

In this study, the JICA Study Team conducted slope inventory survey (as mentioned later) to identify the location, dimension, and stability of landslide along NH54 first. Then, geological survey was conducted at three landslide sites in order to clarify the thickness and geotechnical characteristics of the landslides and design the countermeasures. These three representative landslides were selected out of around 100 critical slopes identified in the slope inventory survey based on landslide scale and stability. Table 7.2-6 shows the list of the geological survey sites. After drilling, perforated pipes were installed into the borehole and monitoring of groundwater level was carried out for eight weeks.

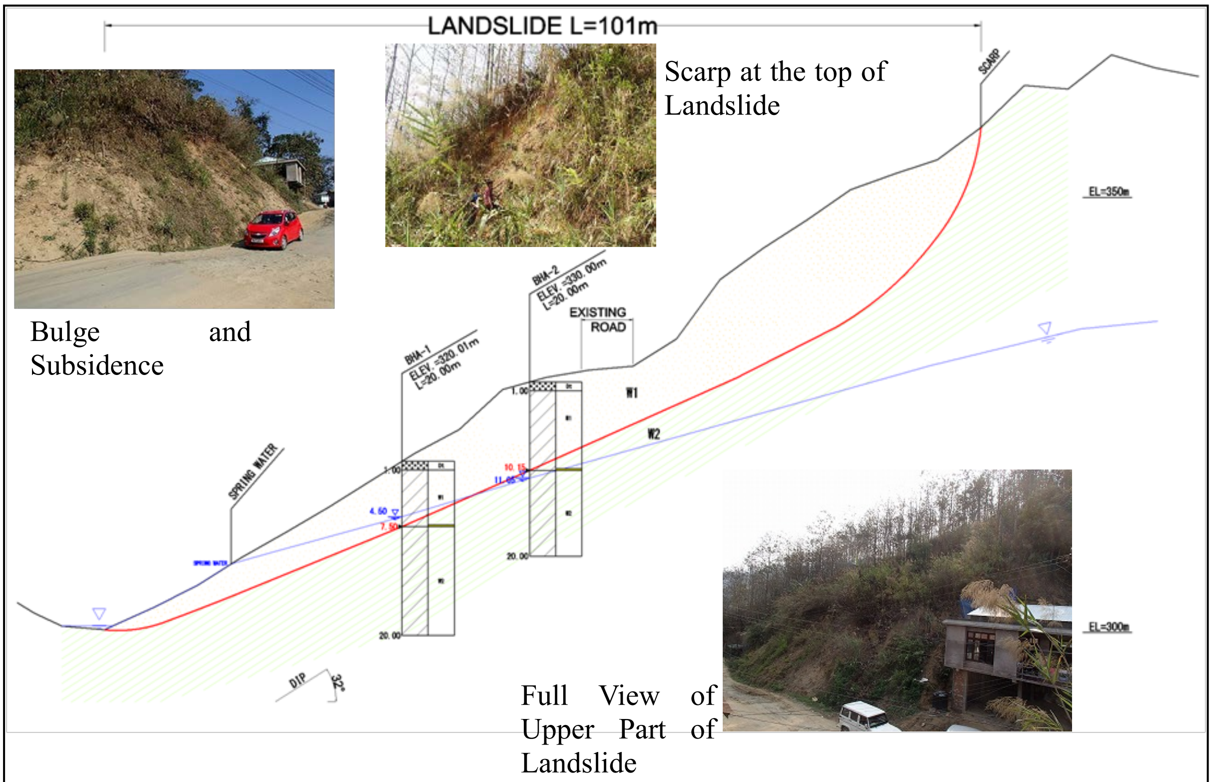
Table 7.2-6 Location of Geological Survey Sites

Landslide Site	District	Existing Road Chainage		No. of Boreholes	Borehole Depth per hole (m)
		Start	End		
Landslide A (Medium mass movement)	Aizawl	20+380	20+420	2	20
Landslide B (Large mass movement)	Serchhip	64+550	64+650	3	30
Landslide C (Small mass movement)	Lunglei	208+430	208+530	2	25

Source: JICA Study Team

Landslide A

Figure 7.2-6 presents the landslide profile based on the geological survey conducted for Landslide A. The road surface in the landslide area has sunk a maximum of 1.0 m depth and slid toward the valley side along 40 m length of the road. Road slope on the hill side has been bulging, and colluvium has fallen on the road. At the top of the landslide, continuous horse-shoe shaped scarp is clearly observed. As the result of the geological survey, depth of slip plane is considered to be around 7~12 m. Although spring water is observed on the right bank of the stream at the toe of the landslide slope, groundwater level is monitored to be low and assumed to be lower than the slip plane in the upper part of the landslide.

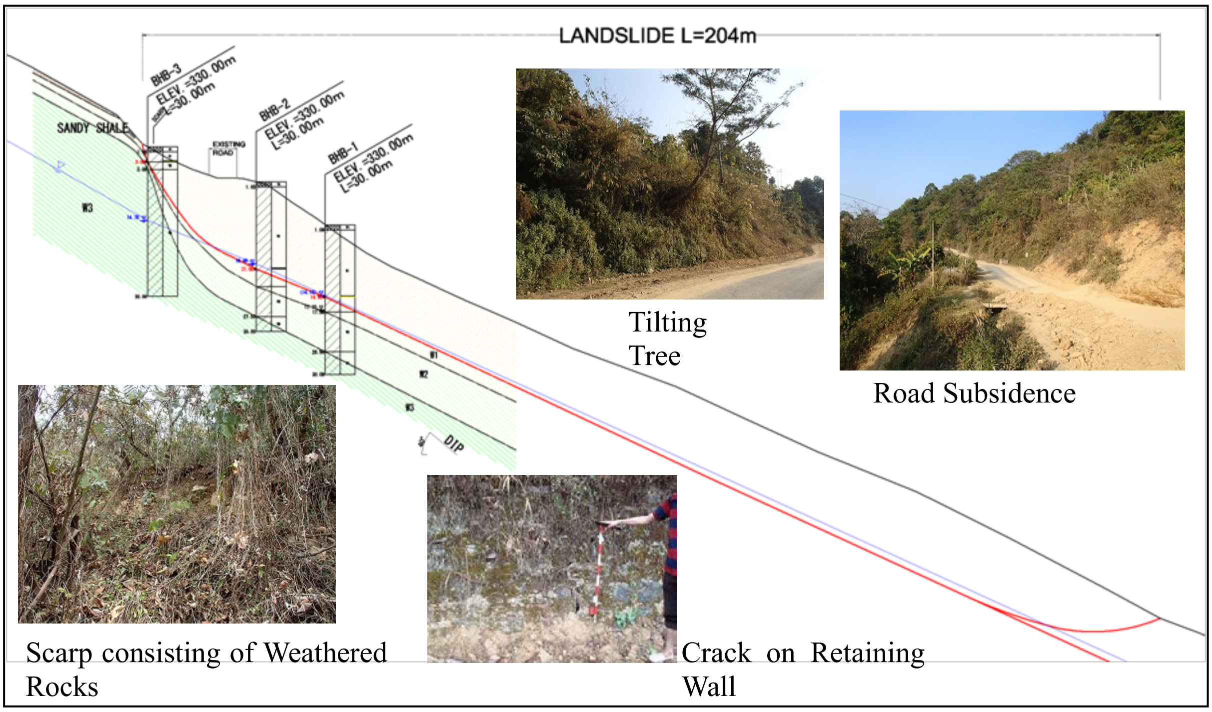


Source: JICA Study Team

Figure 7.2-6 Geological Profile of Landslide A

Landslide B

Landslide B is a large mass movement, and has approximate width of 125 m, length of 200 m, and depth of 15 m as shown in Figure 7.2-7. The road is located on the crown of the landslide and has sunk by a maximum of 1.0 m due to the landslide movement. Small collapses occurred at both banks of the landslide, and existing retaining walls along the road have been damaged and cracked. Boring survey was conducted around the road for the design of countermeasures, and clarified that the landslide does not continue above the scarp near the road and there is a comparatively hard and intact bedrock layer under the landslide body. Groundwater is assumed to be just above the slip plane and will rise during the rainy season, which triggers the landslide movement.

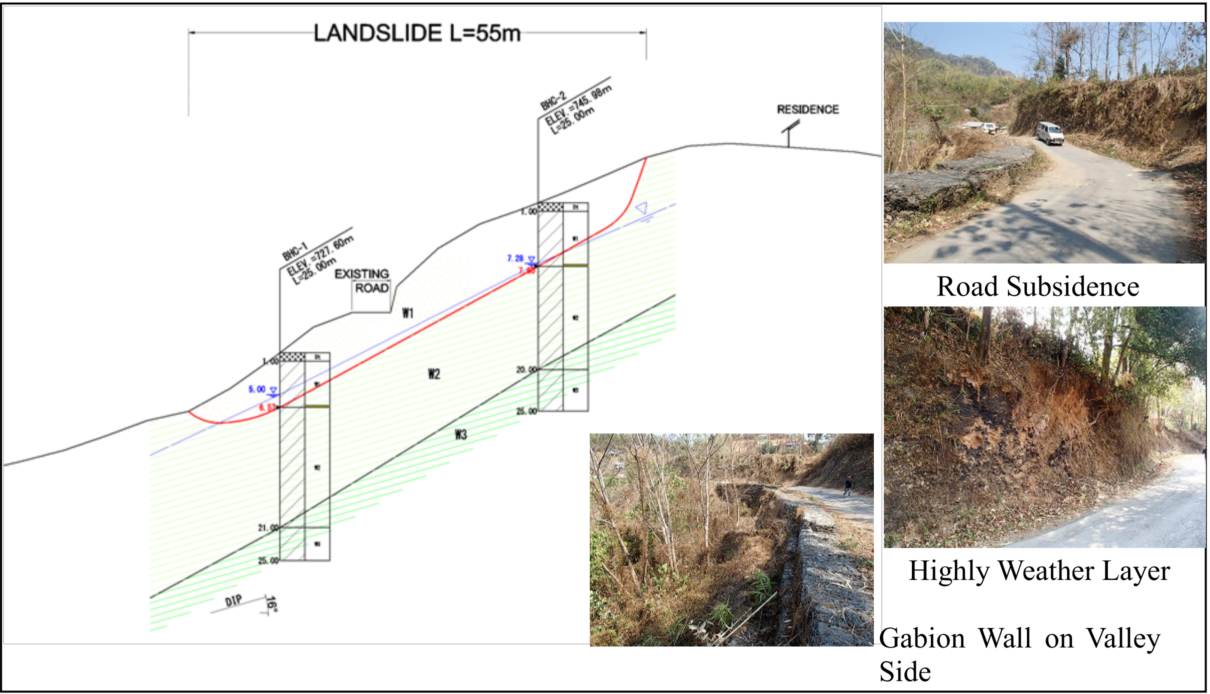


Source: JICA Study Team

Figure 7.2-7 Geological Profile of Landslide B

Landslide C

Landslide C is located near the Dawn Village, around 200 km from Aizawl. The road has sunk by a maximum of 1.2 m and gabion wall with height of 3 m was built on the valley side of the road for soil retaining. Cut slope on the hill side exposes highly weathered rock layer, which is soften and loosen completely and represents the landslide body. The slope above the road is utilized for cultivated field and residential area, and has some steps caused by the landslide movement. Based on the result of the geological survey, the landslide thickness is assumed to be about 6-7 m, and the groundwater level is fluctuating just above the slip plane.



Source: JICA Study Team

Figure 7.2-8 Geological Profile of Landslide C

7.2.4 Road Inventory Survey

(1) Outline of Road Inventory Survey

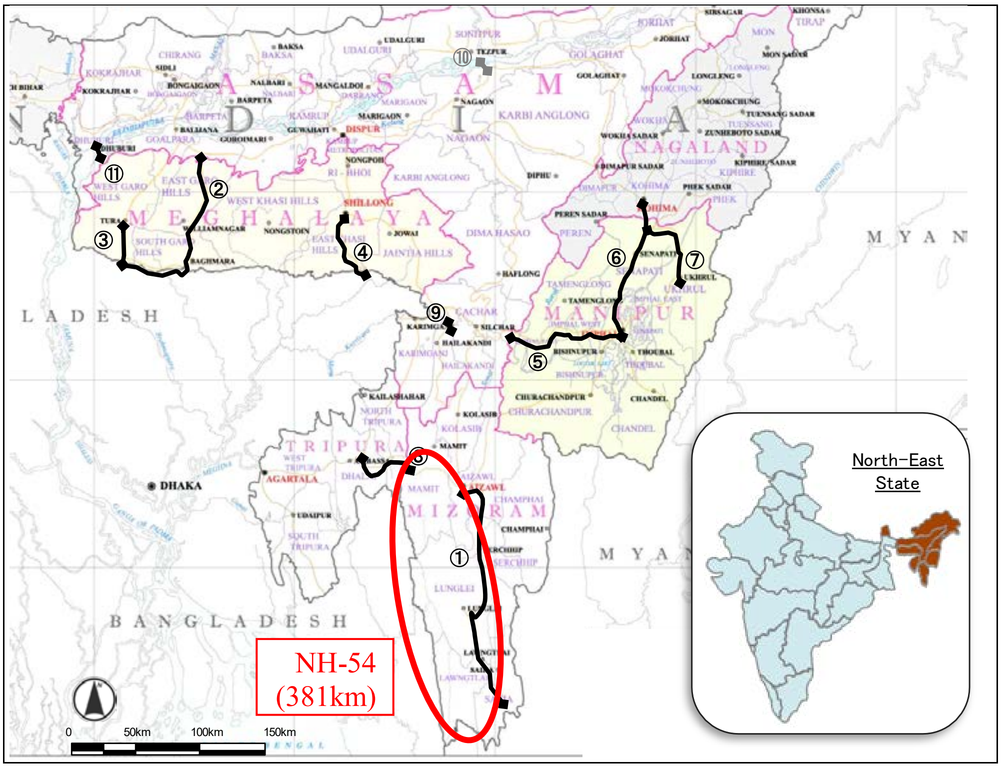
The JICA Study Team conducted a road inventory survey (hereinafter referred to as “the inventory survey”) from February 2015 to April 2015 along NH54 in Mizoram State and NH51 in Meghalaya State. The inventory survey aimed to identify the existing road characteristics, problems and issues on the structural and traffic aspects as well as the geological and social conditions of the surrounding area along the target road.

(2) Survey Method

1) Target Road

The JICA Study Team conducted the inventory survey along the following national highway in Mizoram state.

- NH-54 : 381 km (Mizoram State)



Source: JICA Study Team

Figure 7.2-9 Location Map of NH-54

2) Measurement Items

a) Road Cross Section Element

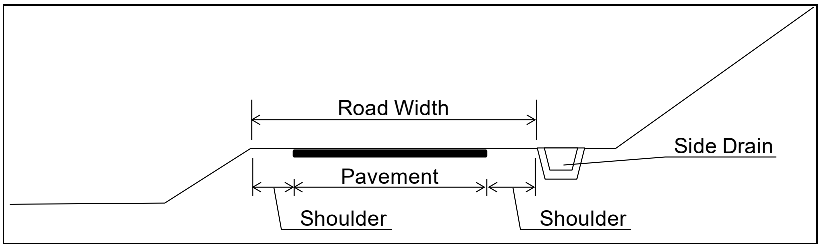
The following items were measured by measuring tape and visual observation at every 100 m section or any location where the target objects were found:

- Topography
- Land Use
- Road Width
- Pavement Condition
- Side Drain
- Side Walk

The item of pavement condition consists of four categories, namely: “Good”, “Fair”, “Poor”, and “Bad”. Each category was judged on the basis of the following criteria:

- Good: when the existing road is smooth and has no visible potholes,
- Fair: when existing road is smooth but has few visible cracks and potholes,
- Poor: when existing road has more visible potholes and surface undulation,
- Bad: when severe deterioration including cracking, surface deformation, disintegration, and surface defect of the pavement is observed.

The road width was obtained at each 100m interval along the target roads and the definition of road width is shown in the following Figure 7.2-10.



Source: JICA Study Team

Figure 7.2-10 Definition of Road Width

b) Cross Drain and Waterway

The following items were measured by measuring tape and visual observation at any locations where the target objects of cross drain and waterway were found:

- Cross Drain Structure (Type, Size)
- Condition of Cross Drain Structure
- Waterway (Width)

c) Retaining Wall and Guardrail

The following items were measured by measuring tape and visual observation at any locations where the target objects of retaining wall and guardrail were found:

- Retaining Wall (Material, Height, Length)
- Guardrail (Material, Height, Length)

d) Social Infrastructure and Religious Object

The items below were recorded based on existing local information collected in advance and visual observation at any location where the target objects of social infrastructure and religious object were found. The distance from the pavement edge to the objects was measured by measuring tape at each location.

- Social Infrastructure (Object, Distance from Pavement Edge)
- Religious Object (Object, Distance from Pavement Edge)

e) Overhead Utility Line (Side, Distance from Pavement Edge)

The items below were recorded based on existing local information collected in advance and visual observation at any location where the target objects of overhead utility line were found. The distance from the pavement edge to the objects was measured by measuring tape at each location.

- Electric Distribution Line
- Electric Transmission Line
- Transformer
- Telecommunication Line

f) Underground Utility Line (Side, Distance from Pavement Edge)

The items below were recorded based on existing local information collected in advance, hearing to local residents, and visual confirmation at sites along the target routes during the survey period. The distance from the pavement edge to the objects was measured by measuring tape at each location.

- Water Supply Line
- Optical Fiber Cable Line

g) Bridge (Width, Length)

The size and condition of bridges along the target routes were recorded at any locations where the objects were found.

(3) Summary of Results

1) Road Cross Section Element

a) Road Width (Pavement and Shoulder)

Figure 7.2-11 shows the result of road width inventory data.

- From Aizawl to Serchhip

Around 5.5 m to 8.0 m wide pavement, which can be said as dual carriage lane, was mostly observed between Aizawl and Thingsulthiah. However, around 4.0 m wide pavement, which can be judged as intermediate lane (1.5-lane), was recorded after Thingsulthiah to the middle section between Chhingchhip and Chhiahtlang, even though around 5.5 m was found partially before Darlawng for 2 to 3 km. After the middle section between Chhingchhip and Chhiahtlang to Serchhip, around 5 m to 6 m wide pavement, which can be said as dual carriage lane, was observed, although partially narrow width like around 4.0 m was recorded for a length of about 3 km.

Sufficient shoulder, i.e., around 2 m to 5 m wide, was observed on the average between Aizawl and Serchhip section.

- From Serchhip to Hrangchalkawn

Around 5 m to 6 m wide pavement was observed in some sections located near and within each settlement especially. On the other hand, around 4.0 m was observed in the sections between each settlement in terms of pavement width.

Around 2 m to 3 m wide shoulder was observed in each section.

- From Hrangchalkawn to Lawngtlai

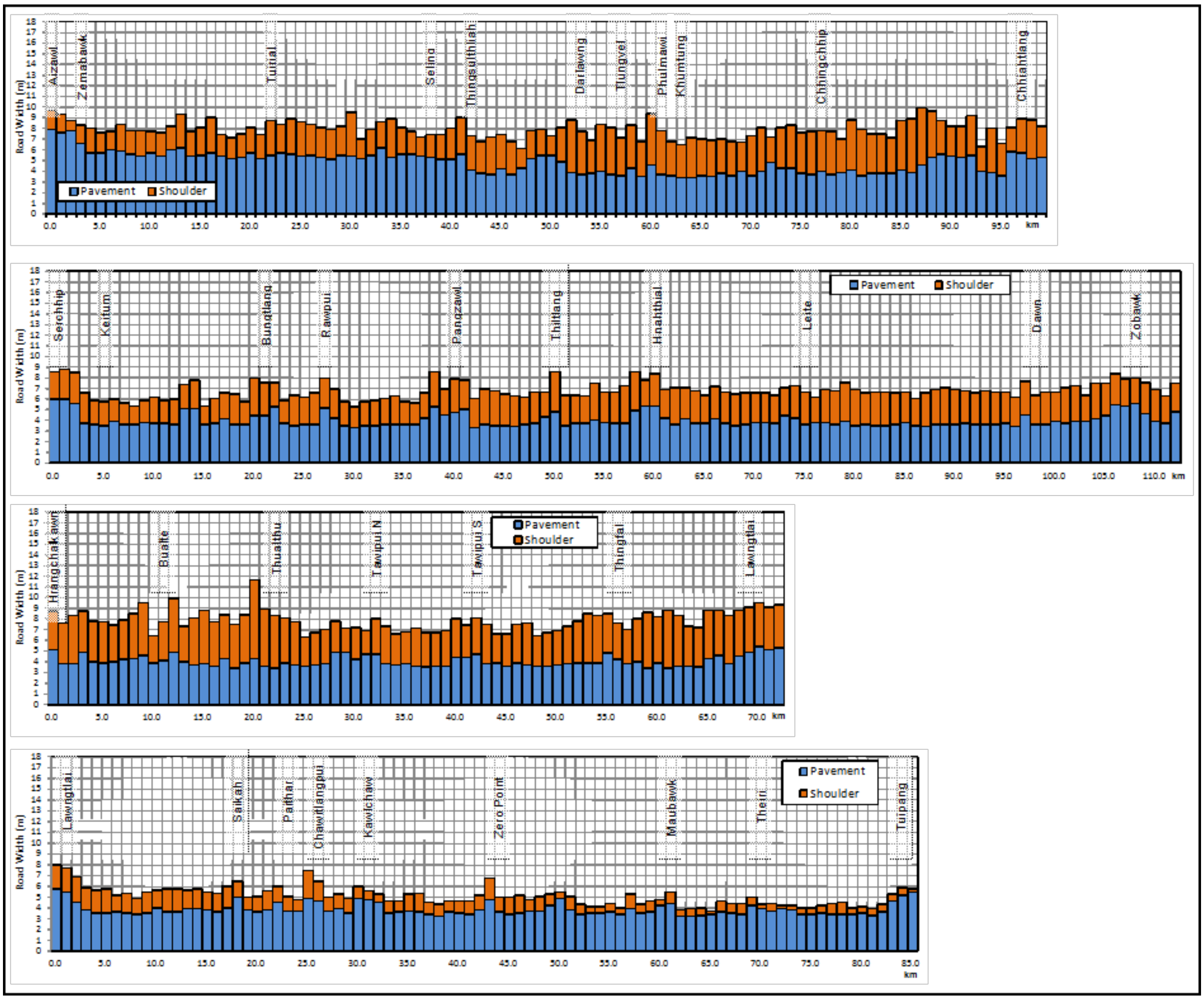
Except in Thualthu, around 5 m wide pavement was observed in the sections near and within each settlement. The sections between each settlement had around 4 m wide pavement. It is slightly narrow to consider it as dual carriage lane road in this section.

Sufficient shoulder width from 3 m to 5 m was mostly observed between Hrangchalkawn and Lawngtlai.

- From Lawngtlai to Tuipang

About 5 m to 6 m wide pavement in settlement sections was mostly observed. Same as above, around 4.0 m wide pavement was recorded in the sections between the settlements.

Around 2.0 m wide shoulder was observed from Lawngtlai to Chawitlangpui; however, after Chawitlangpui, relatively narrow shoulder of around 1.0 m or less was observed.



Source: JICA Study Team

Figure 7.2-11 Road Width (Pavement and Shoulder)

b) Others

Figure 7.2-12 shows the result of other inventory survey items for road cross section elements.

- Topography

The sections where one side is a hill and the other side is a valley occupy almost the whole section from Aizawl to Tuipang. However, several sections where both sides have hill terrain were partially observed in several 1 km sections between Zemabawk and Tuirial, Thingsulthliah and Darlawng, Khumtung and Chhingchhip, Zobawk and Hrangchalkawn, and Tawipui S and Thingfal. Only two sections where both sides have valley terrain were observed in two 1 km sections at Keitum and Rawpui.

- Land Use

In almost all sections from Zamabawk to Chhiahtlang, the range of installed side drains and pavement condition were relatively in fair or good condition, even though rural land use was observed entirely.

On the other hand, in the section from Bualte to Tuipang, the range of side drain situation as well as pavement condition can be considered poor or bad, regardless whether the road is passing many existing settlements.

- Pavement Condition

Bad pavement condition was mostly observed after Lawngtlai to Tuipang. One of the major causes might be the insufficient side drain structure which can prevent pavement damage due to rainfall.

In the sections between Aizawl and Tuirial, bad pavement condition was observed especially at the terrain transition point from hill side to valley side or the opposite condition.

The condition was relatively good in the section between Keitum and Zobawk compared with the other sections along NH54.

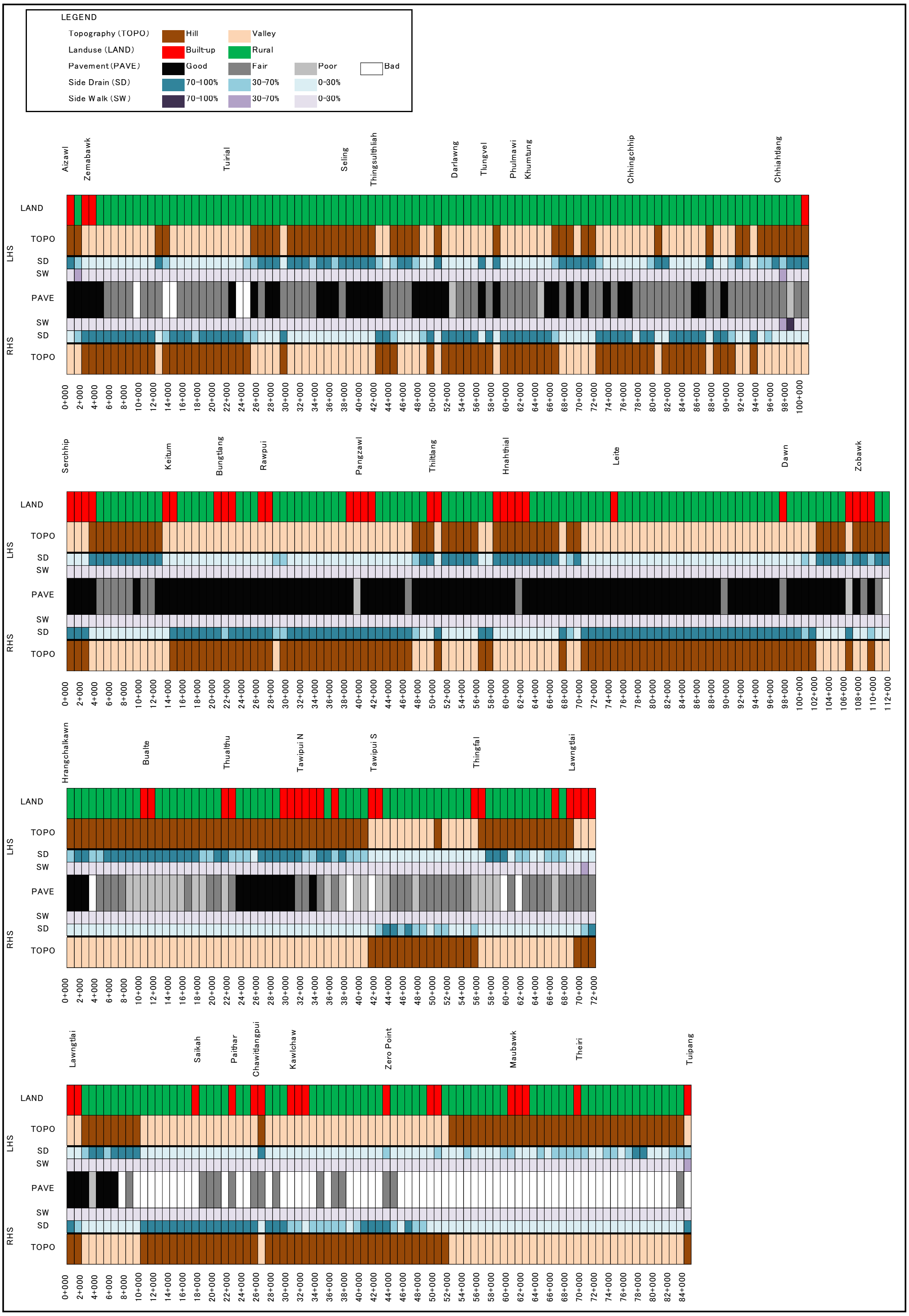
- Side Drain

The amount of installed side drains was more than 30% which can be considered good or fair in almost all sections from Aizawl to Tawipui S, although 0% to 30% was recorded in only 1 km for two sections at Keitum and Tawipui S.

However, few installation, from 0% to 30%, which can be said as bad condition, was frequently observed after Kawlchaw to Tuipang. This might be one of the major causes for the deterioration of pavement in this section.

- Sidewalk

In almost all settlement areas, only less than 30% occupations with sidewalk were observed on the average. In other words, there were very few sidewalks along NH54. Especially, only 1 km section at Chhiahtlang had sidewalk at more than 70% and there was no other such kind of settlement in this road has been recorded with good amount of sidewalk.



Source: JICA Study Team

Figure 7.2-12 Cross Sectional Elements and Pavement Condition of NH54

2) Cross Drain

The following Table 7.2-7 shows the result of cross drain inventory data. The average number of cross drain is 4.9 per km. Hume pipe type occupied majority of the cross drains in the section from Aizawl to Serchhip. Meanwhile, masonry slab type occupied majority in the section after Serchhip to Tuipang.

Table 7.2-7 Result of Cross Drain

Route	Section	Section Length (km)	No. of Cross Drain Structure					
			Hume Pipe	Masonry Slab	Other / Unknown	No Structure	TOTAL	Av. No. per km
NH54	Aizawl - Serchhip	101	160	128	5	40	333	3.3
	Serchhip - Hrangchalkawn	112	94	355	2	93	544	4.9
	Hrangchalkawn - Lawngtlai	72	12	305	0	169	486	6.8
	Lawngtlai - Tuipang	85	3	354	0	86	443	5.2
	TOTAL	370	269	1,142	7	388	1,806	4.9

Source: JICA Study Team

3) Retaining Wall

In almost the whole section along NH54, masonry type was used. The usage of RCC type was just less than 5%, 0%, and 1% between Aizawl and Serchhip, Serchhip and Lawngtlai, and Lawngtlai and Tuipang, respectively.

Table 7.2-8 Result of Retaining Wall

Route	Section	Section Length (km)	Area of Retaining Wall (m2)								
			Left			Right			TOTAL		
			Masonry	RCC	TOTAL	Masonry	RCC	TOTAL	Masonry	RCC	TOTAL
NH54	Aizawl - Serchhip	101	5,058.2	104.3	5,162.5	2,761.2	157.8	2,919.0	7,819.4	262.1	8,081.5
	Serchhip - Hrangchalkawn	112	14,383.5	0.0	14,383.5	8,508.7	0.0	8,508.7	22,892.2	0.0	22,892.2
	Hrangchalkawn - Lawngtlai	72	7,567.8	0.0	7,567.8	11,865.1	0.0	11,865.1	19,432.9	0.0	19,432.9
	Lawngtlai - Tuipang	85	9,481.2	54.0	9,535.2	14,552.6	128.0	14,680.6	24,033.8	182.0	24,215.8
	TOTAL	370	36,490.7	158.3	36,649.0	37,687.6	285.8	37,973.4	74,178.2	444.1	74,622.3

Source: JICA Study Team

4) Guardrail

The guardrails were most densely installed in the section from Lawngtlai to Tuipang. It can be said that safety measure was implemented mostly in terms of guardrail installation in this section. This might be because of many existing settlements in this section.

On the other hand, the section from Aizawl to Serchhip had the lowest density of guardrail installation and the majority of these guardrails were of the parapet and masonry types.

Table 7.2-9 Result of Guardrail

Route	Section	Section Length (km)	Length of Guardrail (m)			
			Masonry	Parapet	Steel	TOTAL
NH54	Aizawl - Serchhip	101	271.9	531.3	0.0	803.2
	Serchhip - Hrangchalkawn	112	3,593.5	66.7	0.0	3,660.2
	Hrangchalkawn - Lawngtlai	72	0.0	46.5	827.1	873.6
	Lawngtlai - Tuipang	85	10.0	6,218.8	380.3	6,609.1
	TOTAL	370	3,875.4	6,863.3	1,207.4	11,946.1

Source: JICA Study Team

5) Social Infrastructure

The surveyed stretch was 370 km in total as shown in the following Table 7.1-10. However, only four petrol pumps in total were observed. More than 1 urinal/toilet was observed per 1 km except in the section from Serchhip to Hrangchalkawn which had urinal/toilet infrastructure at every 1.3 km on the average.

Table 7.2-10 Result of Social Infrastructure

Route	Section	Section Length (km)	No. of Social Infrastructure					
			School / Orphanage Home	Water pump	Urinal/Toilet	Petrol Pump	Waiting Shed	Others
NH54	Aizawl - Serchhip	101	2	172	105	2	2	13
	Serchhip - Hrangchalkawn	112	6	55	86	1	21	31
	Hrangchalkawn - Lawngtlai	72	0	99	57	1	20	36
	Lawngtlai - Tuipang	85	4	97	37	0	20	51
	TOTAL	370	12	423	285	4	63	131

Source: JICA Study Team

6) Religious Structures

In the whole section, one church was mostly observed at every 4 to 5 km. Total number of memorial stone, grave, and monument/statue was 144. This means that one of these memorial items was recorded within every 2 km to 3 km. Only one mosque and two mandirs were observed within the whole stretch.

Table 7.2-11 Result of Religious Object

Route	Section	Section Length (km)	No. of Religious Object					
			Church	Mosque	Mandir	Memorial Stone	Grave	Monument/Statue
NH54	Aizawl - Serchhip	101	20	1	1	0	6	29
	Serchhip - Hrangchalkawn	112	17	0	0	2	2	22
	Hrangchalkawn - Lawngtlai	72	17	0	1	24	0	0
	Lawngtlai - Tuipang	85	22	0	0	25	3	30
	TOTAL	370	76	1	2	51	11	81

Source: JICA Study Team

7) Public Utilities (Electric Line, Telecommunication Line, Water Supply, Optical Fiber Cable(OFC))

The number of crossings or close passing utility lines was counted as shown in Table 7.1-12 below.

Electricity distribution lines were found in the section from Serchhip to Tuipang in which 3 to 5 lines at every 1 km were observed on the average.

Electric transmission line was mostly observed in the section from Aizawl to Serchhip and from Hrangchalkawn to Lawngtlai which respectively had 1 line at every 2 km and one line at every 1.4 km, on the average.

Telecommunication lines were found mostly in the section from Serchhip to Hrangchalkawn in which one line was observed at every 1.5 km on the average.

Water supply lines were found mostly in the section from Serchhip to Hrangchalkawn as well as from Lawngtlai to Tuipang where one line was observed at approximately every 0.5 km to 1 km on the average.

OFC lines were mainly observed in the section from Serchhip to Hrangchalkawn which had five lines at every 1 km on the average. Secondarily, 1 to 2 lines were found in the section from Lawngtlai to Tuipang at every 1 km.

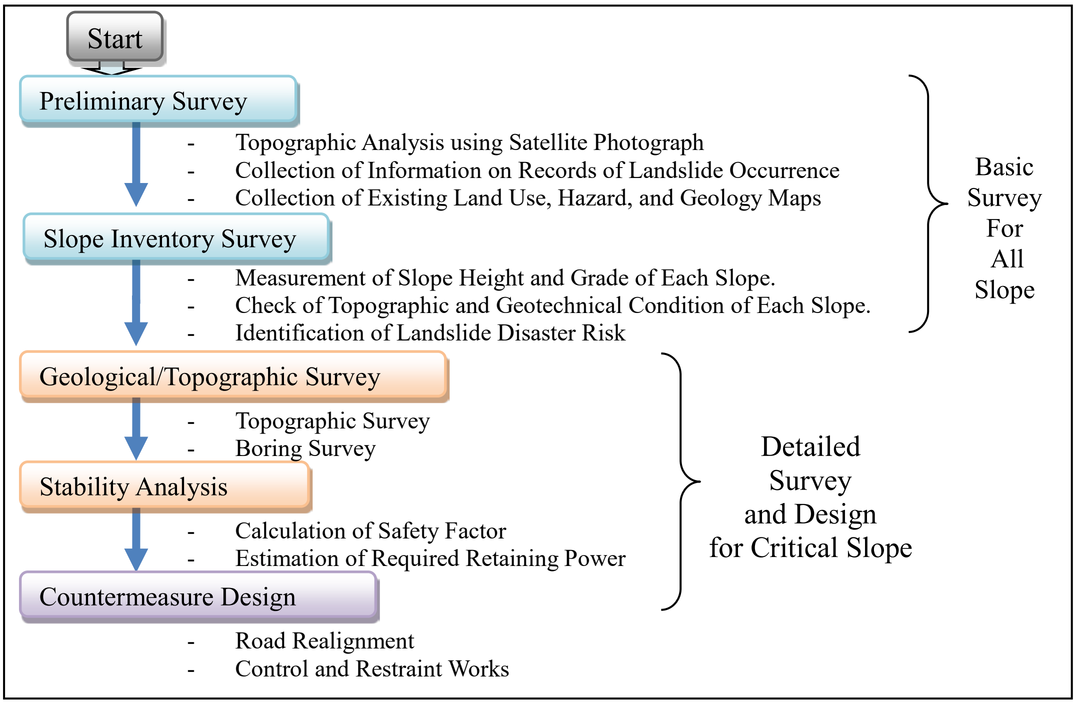
Table 7.2-12 Survey Result of Public Utilities

Route	Section	Section Length (km)	No. of Neighboring Public Utilities (Location of Crossing / Close Passage)				
			Electric Line		Telecommuni-cation Line	Water Supply	OFC
			Distribution	Transmission			
NH54	Aizawl - Serchhip	101	12	52	5	21	9
	Serchhip - Hrangchalkawn	112	497	15	77	122	537
	Hrangchalkawn - Lawngtlai	72	210	51	15	42	5
	Lawngtlai - Tuipang	85	415	10	15	198	112
	TOTAL	370	1,134	128	112	383	663

Source: JICA Study Team

7.2.5 Slope Inventory Survey

The slope inventory survey, including topographic measurement, verification of geological and geotechnical conditions, and identification of landslide risk, was conducted for the purpose of landslide disaster prevention. Figure 7.2-13 presents the flowchart of the slope study. First, as a basic survey, the slope inventory survey was implemented for all slopes along NH54 after topographic analysis using satellite and collection of existing data and information on geological map and landslide history. The inventory survey clarified the critical slopes mentioned later, and on those slopes, more detailed geological and topographic survey mentioned in Clause 7.1.3, stability analysis, and countermeasure design were implemented.



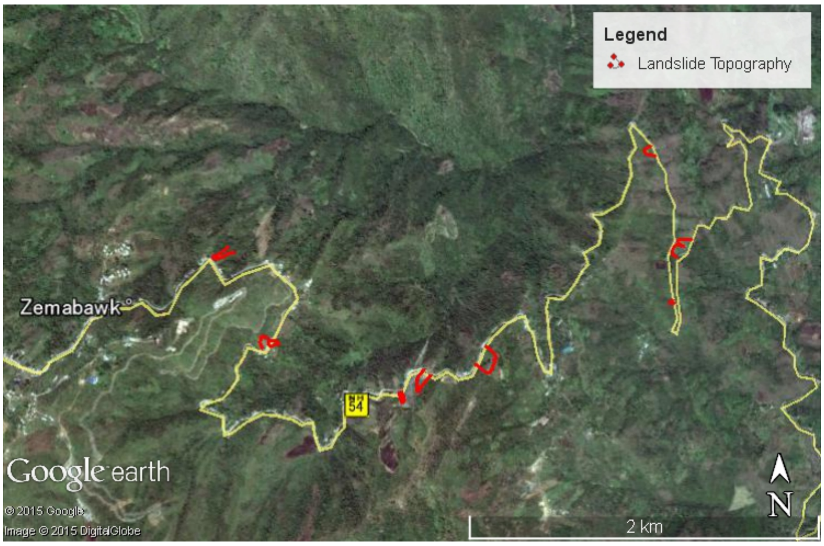
Source: JICA Study Team

Figure 7.2-13 Flowchart of Slope Study

The road stretch was divided into four sections under the slope inventory survey, namely: Section A from Aizawl to Serchhip, Section B from Serchhip to Hrangchlkawn, Section C from Hrangchlkawn to Lawgtlai, and Section D from Lawgtlai to Tuipang. The detailed result of the survey is shown in Appendix 3. Topographic data acquired in the survey supplements the existing topographic survey data conducted in the DPR studies.

(1) Topographic Analysis

Prior to the slope inventory survey, the satellite photograph was interpreted to pick out landslide topographies and existing slope failures. The selected slopes were carefully examined in the site survey so as not to overlook the potential landslide risk sites. Figure 7.2-14 shows one of the results of the topographic analysis.



Source: JICA Study Team based on Google Earth

Figure 7.2-14 Topographic Analysis Result (around Sta.8-10 km)

(2) Geological and Geotechnical Condition

The sandstone and shale of tertiary formation are distributed around NH54. The geological and geotechnical conditions on each slope along the road were classified according to hardness and weathering through the slope inventory survey as shown in Table 7.2-13. Taking into consideration spring water and dip slope which often cause landslide occurrence, cut grades with widening are set under each classification.

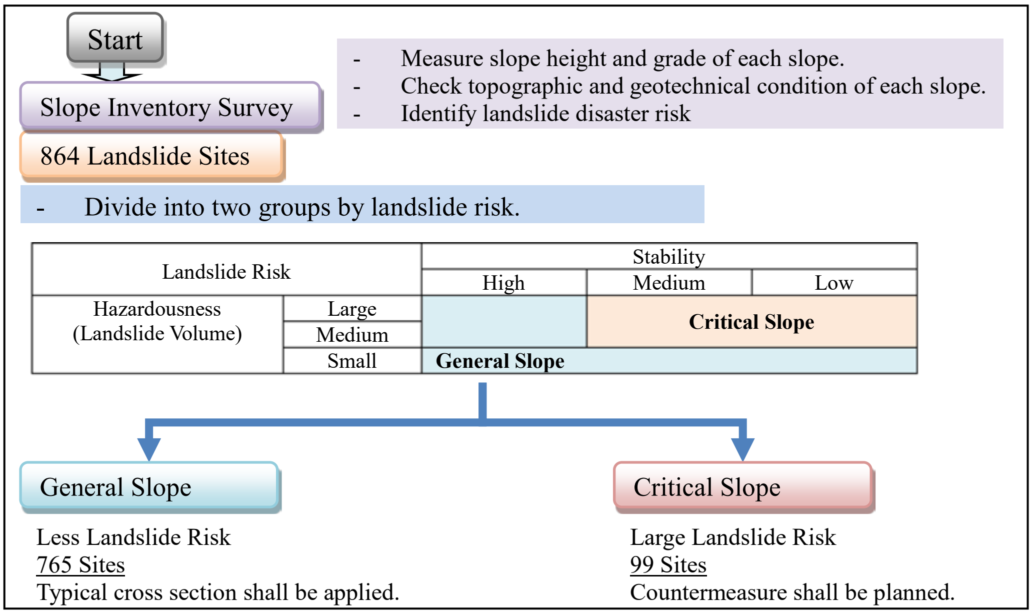
Table 7.2-13 Soil and Rock Classification

Loose Soil	Dense Soil	
		
Unconsolidated, loose and very soft Fluvial alluvium, colluvium, talus cone	Semi-consolidated and compact Conglomerate and terrace gravel	
Soft Rock	**Hard Rock**	**Very Hard Rock**
		
Strongly weathered and very soft. Can break easily. Many cracks, joint and schistosity. Relatively gentle slope	Slightly weathered. Can be broken by hammer Steep slope	Fresh and intact Hard to break Very steep slope

Source: JICA Study Team

(3) Identification of Critical Slope for Landslide Disaster

The slope inventory survey conducted the identification of landslide disaster risk along the road as well as classification of geological and geotechnical conditions and cross section measurement. For the identified risk sites, landslide countermeasures were examined depending on the topography, geology and geotechnical condition, and landslide disaster type such as "critical slope" mentioned later. Figure 7.2-15 presents the flowchart for the identification of the critical slope.



Source: JICA Study Team

Figure 7.2-15 Flowchart of Identification of Critical Slope

As a result of the slope inventory survey, a total of 864 slope disasters were observed. These have various dimensions and stability of landslide; from very small surface failure to deep mass movement, and from inactive mass movement to very active and unstable mass movement. Because it is uneconomical in case that landslide countermeasure is implemented on all slopes, the critical slope which needs landslide countermeasure was identified based on two indications of scale of landslide (influence on the road) and stability of landslide, and selectively decided the sites where the landslide countermeasures will be implemented. The slopes except for the critical slope, which is called general slope, were applied with typical cross sections. They include retaining wall to prevent surface failure and cutting with stable gradient depending on geological and geotechnical condition.

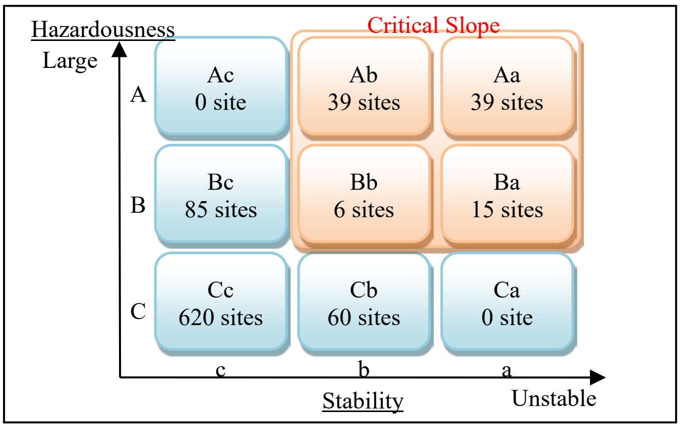
Table 7.2-14 presents the criteria of influence on the road and landslide stability, while Figure 7.2-16 presents the schematic image of the identification of critical slope. Influence of the road increases proportionally with landslide dimension; and bigger landslide gives larger damage on the road. Therefore, they are divided into three groups depending on the estimated landslide volume. Moreover, landslide stability is evaluated through visual confirmation by landslide type. The landslide risk slope, which has medium or large degree of both influence and stability, was evaluated as the critical slope, for which landslide countermeasures were examined.

Table 7.2-14 Criteria of Influence on the Road and Landslide Stability

Influence on the Road	
A	Estimated Landslide Volume: more than 1,000 m^3 (Mainly large-scale mass movement and slope failure)
B	Estimated Landslide Volume: 100-1,000 m^3 (Mainly medium-scale mass movement, slope failure, and debris flow)
C	Estimated Landslide Volume: Less than 100 m^3 (Mainly surface failure)

Landslide Stability	
a	SF/RF: There is soil mass or fragmented rock to be destabilized on the slope. MM: There is severe deformation such as cracks, subsidence, and bulges. DF: Frequent debris discharge on the road surface, and enduring unstable debris on the stream can be observed. Occurrence of debris flow in the near future is a concern.
b	SF/RF: There is less unstable soil mass and rock on slope, but no vegetation and exposed weathered rock; Expansion of the existing slope failure in the future is a concern. MM: No new deformation can be observed, but existing deformation such as crack indicates the past movement. Destabilization due to the road construction is a concern. DF: There is less debris in the stream, but according to channel width and condition of surrounding vegetation, occurrence of new debris flow is a concern.
c	SF/RF: Soil masses and rocks had completely fallen from the slope, and fresh and intact bedrock layer can be confirmed at the collapsed slope. There is no indication that the slope failure is expanding. MM: Slope can be recognized as mass movement topography, but there is no deformation which indicates recent movement on road facility and vegetation; thus, it is assumed to be stabilized. DF: Past record can be recognized, but existing cross drainage has enough capacity for entrapment and passage.

SF: Slope Failure, RF: Rockfall, MM: Mass Movement, DF: Debris Flow
Source: JICA Study Team



Source: JICA Study Team

Figure 7.2-16 Schematic Image of Critical Slope Identification

(4) Recommendation of Road Widening Side

In order to minimize the effect of landslide by road widening and alignment improvement, reduce the cost of landslide countermeasures, and decrease the maintenance cost after construction, critical slopes which have large mass movement and slope failure have been considered in road design, and road alignment design was conducted taking into consideration the effect to the critical slopes. This can avoid landslide risks which most likely happened by improper cut planned in DPR and reduce the cost of rehabilitation of landslide. In terms of successive road condition and environmental and social consideration, all critical slopes are not always avoided by realignment. Therefore, countermeasures were examined again after road alignment design.

Location of the critical slopes and recommendation of the widening side in NH54 are shown in Table 7.2-15 to Table 7.2-18 below, and countermeasures against the unstable slope or landslide after widening on the side are also shown in the table. Sta. 2+330 to Sta.3+580 in Table 7.2-17 is a very steep slope section which changes the widening side often and is examined in road design separately. The chainage in the tables shows the distance from the start point of each section.

Table 7.2-15 Recommendation of Widening Side (Sec-A)

Sec	LS No.	Landslide Location				Disaster	Road Deformation				Recommended Widening Side		
		Slope No.	Start	~	End	Type	Collapse	Sinking	Crack	Bulge	R/L	H/V	Landslide Countermeasure
A	01	009	2 + 555	~	2 + 600	MM	x		x		L	V	Soil retaining wall
A	02	009	2 + 770	~	2 + 800	SF	x		x		L	V	Soil retaining wall
A	03	011	3 + 555	~	3 + 585	MM	x		x		L	V	Rockfall prevention wall
A	04	016	5 + 320	~	5 + 340	MM			x		R	H	Earth removal
A	05	017	5 + 620	~	5 + 650	MM	x		x		L	V	Groundwater drainage
A	06	021	6 + 930	~	7 + 020	MM-p					L	V	Soil retaining wall
A	07	024	7 + 630	~	7 + 860	SF	x				L	V	Soil retaining wall
A	08	025	7 + 980	~	8 + 400	SF	x				L	V	Soil retaining wall
A	09	027	9 + 030	~	9 + 050	MM-p					R	V	Earth removal
A	10	034	12 + 260	~	12 + 340	MM-p			x		R	V	Soil retaining wall
A	11	039	13 + 420	~	13 + 510	MM-p					L	V	Groundwater drainage
A	13	039	13 + 640	~	13 + 680	MM	x		x		L	V	Soil retaining wall
A	14	042	14 + 380	~	14 + 410	MM	x			x	L	V	Soil retaining wall, Groundwater drainage
A	15	051	17 + 710	~	17 + 760	MM	x		x		R	H	Earth removal
A	16	062	20 + 950	~	20 + 990	SF	x		x		L	V	Soil retaining wall
A	17	063	21 + 080	~	21 + 150	MM-p	x		x		L	V	Soil retaining wall
A	18	081	29 + 470	~	29 + 520	SF	x		x		L	V	Soil retaining wall
A	19	085	31 + 150	~	31 + 180	SF			x		R	V	Soil retaining wall
A	20	115	49 + 400	~	49 + 430	MM-p					L	V	Soil retaining wall, Groundwater drainage
A	21	119	52 + 280	~	52 + 310	MM	x		x		L	V	Soil retaining wall, Groundwater drainage
A	22	119	52 + 310	~	52 + 370	MM	x		x		L	V	Soil retaining wall, Groundwater drainage
A	23	119	52 + 370	~	52 + 550	SF	x		x		L	V	Rockfall prevention wall
A	24	119	52 + 570	~	52 + 690	SF	x		x		L	V	Rockfall prevention wall
A	25	124	56 + 100	~	56 + 200	MM	x	x	x		L	H	Anchor
A	26	140	64 + 270	~	64 + 320	MM-p					L	V	- No need
A	27	151	71 + 200	~	71 + 220	MM-p					R	V	Soil retaining wall
A	28	152	71 + 770	~	71 + 830	MM	x	x	x		L	H	Earth removal, Crib work, Rock-bolt
A	29	153	73 + 990	~	74 + 020	MM	x		x		R	H	Earth removal, Soil retaining wall
A	30	178	87 + 470	~	87 + 510	MM-p					R	V	Groundwater drainage
A	31	178	87 + 510	~	87 + 670	MM-p					R	V	Groundwater drainage
A	32	186	91 + 130	~	91 + 150	SF	x		x		R	H	Soil retaining wall

Source: JICA Study Team

Table 7.2-16 Recommendation of Widening Side (Sec-B)

Sec	LS No.	Landslide Location				Disaster	Road Deformation				Recommended Widening Side		
		Slope No.	Start	~	End	Type	Collapse	Sinking	Crack	Bulge	R/L	H/V	Landslide Countermeasure
B	01	009	4 + 550	~	4 + 585	MM-p					R	V	Soil retaining wall
B	02	080	36 + 690	~	36 + 760	MM	x			x	L	V	Soil retaining wall
B	03	083	37 + 960	~	38 + 030	MM	x			x	L	V	Renew soil retaining wall
B	04	124	58 + 470	~	58 + 525	MM	x				R	V	Soil retaining wall
B	05	127	60 + 080	~	60 + 150	MM	x			x	L	H	Earth removal、Soil retaining wall
B	06	133	62 + 860	~	62 + 920	SF	x	x			R	V	Soil retaining wall
B	07	134	62 + 960	~	63 + 030	MM			x	x	R	V	Counterweight fill, Groundwater drainage
B	08	161	74 + 600	~	74 + 630	MM-p					L	V	Soil retaining wall
B	09	174	80 + 230	~	80 + 340	MM			x		L	V	Soil retaining walll, Groundwater drainage
B	10	195	88 + 420	~	88 + 480	MM			x		L	V	Soil retaining walll, Groundwater drainage
B	11	196	89 + 340	~	89 + 430	SF	x				R	H	Soil retaining wall
B	12	198	90 + 040	~	90 + 100	MM			x		L	V	Soil retaining walll
B	13	214	96 + 960	~	97 + 030	MM	x	x			R	H	Groundwater drainage
B	14	216	97 + 660	~	97 + 720	MM	x			x	L	V	Soil retaining walll, Groundwater drainage
B	15	243	108 + 930	~	109 + 015	MM-p					R	V	- No need

Source: JICA Study Team
MM: Mass Movement, MM-p: Inactive Mass Movement, SF: Slope Failure, RF: Rockfall, DF: Debris Flow
R: Right Side, L: Left Side, H: Hill Side, V: Valley Side

Table 7.2-17 Recommendation of Widening Side (Sec-C)

Sec	LS No.	Landslide Location				Disaster Type	Road Deformation				Recommended Widening Side		
		Slope No.	Start	~	End		Collapse	Sinking	Crack	Bulge	R/L	H/V	Landslide Countermeasure
C	01	006	2 + 330	~	2 + 540	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	02	007	2 + 540	~	2 + 570	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	03	007	2 + 570	~	2 + 700	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	04	008	2 + 700	~	2 + 750	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	05	008	2 + 750	~	2 + 870	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	06	008	2 + 870	~	3 + 010	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	07	008	3 + 010	~	3 + 240	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	08	009	3 + 240	~	3 + 580	SF	x				R/L	H/V	Cut&Retaining wall, REW
C	09	031	11 + 700	~	11 + 800	MM-p					R	V	- No need
C	10	032	11 + 850	~	11 + 950	MM-p					R	V	- No need
C	11	042	15 + 470	~	15 + 520	MM	x		x		R	V	Groundwater drainage
C	12	055	20 + 520	~	20 + 530	DF	x				R	V	Box culvert
C	13	080	31 + 400	~	31 + 450	MM	x		x		R	V	Counterweight fill, Groundwater drainage
C	14	093	37 + 710	~	37 + 720	DF	x				R	V	Box culvert
C	15	097	39 + 000	~	39 + 040	MM-p					R	V	- No need
C	16	097	39 + 200	~	39 + 280	MM-p					R	V	- No need
C	17	133	54 + 730	~	55 + 020	MM		x			L	V	Groundwater drainage
C	18	140	59 + 250	~	60 + 060	SF					R	V	Rockfall prevention wall
C	19	143	60 + 350	~	60 + 400	MM-p					R	V	- No need
C	20	145	61 + 120	~	61 + 410	SF					R	V	Rockfall prevention wall

Source: JICA Study Team

Table 7.2-18 Recommendation of Widening Side (Sec-D)

Sec	LS No.	Landslide Location				Disaster Type	Road Deformation				Recommended Widening Side		
		Slope No.	Start	~	End		Collapse	Sinking	Crack	Bulge	R/L	H/V	Landslide Countermeasure
D	01	004	2 + 770	~	2 + 880	MM-p					R	V	- No need
D	02	019	9 + 520	~	9 + 740	SF	x				R	V	Rockfall prevention wall
D	03	028	13 + 480	~	13 + 510	MM-p					L	V	- No need
D	04	029	13 + 750	~	13 + 800	MM	x		x		L	V	Soil retaining wall
D	05	030	14 + 100	~	14 + 190	MM-p					L	V	- No need
D	06	037	17 + 650	~	17 + 710	MM-p					L	V	- No need
D	07	040	18 + 920	~	19 + 100	MM-p					L	V	- No need
D	08	048	22 + 010	~	22 + 090	MM		x			L	V	Groundwater drainage
D	09	048	22 + 220	~	22 + 300	MM		x			R	H	Earth removal
D	10	050	23 + 350	~	23 + 420	MM		x			R	H	Anchor
D	11	052	23 + 840	~	23 + 940	MM-p					L	V	Groundwater drainage
D	12	064	29 + 540	~	29 + 790	MM-p					L	V	- No need
D	13	065	29 + 790	~	29 + 870	MM			x	x	L	V	Groundwater drainage
D	14	067	31 + 090	~	31 + 140	MM			x	x	L	V	Soil retaining wall, Groundwater drainage
D	15	071	33 + 060	~	33 + 020	MM-p		x			L	V	- No need
D	16	072	33 + 540	~	33 + 560	MM-p					L	V	- No need
D	17	076	35 + 400	~	35 + 450	MM			x		L	V	Soil retaining wall
D	18	077	35 + 620	~	35 + 705	MM	x		x		R	H	Earth removal
D	19	079	36 + 740	~	36 + 790	MM	x		x		L	V	Soil retaining wall, Rockfall prevention fence
D	20	080	36 + 950	~	36 + 970	SF	x				L	V	Rockfall prevention fence
D	21	087	40 + 150	~	40 + 190	MM	x				L	V	- No need
D	22	087	40 + 610	~	40 + 650	MM		x			L	V	Countermweight fill
D	23	115	53 + 430	~	54 + 320	SF					R	V	Rockfall prevention fence
D	24	118	55 + 120	~	55 + 170	MM		x			L	H	Anchor
D	25	119	55 + 360	~	55 + 480	MM		x			R	V	Anchor
D	26	122	56 + 540	~	56 + 600	MM		x			L	H	Anchor
D	27	139	65 + 350	~	65 + 440	MM-p					R	V	- No need
D	28	141	65 + 830	~	65 + 930	SF					R	V	Soil retaining wall
D	29	141	66 + 060	~	66 + 110	MM-p					R	V	- No need
D	30	147	68 + 980	~	69 + 050	SF					R	V	Soil retaining wall
D	31	151	70 + 540	~	70 + 620	SF	x		x		R	V	Soil retaining wall
D	32	153	71 + 790	~	71 + 860	SF	x		x		R	V	Earth removal, Soil retaining wall

Source: JICA Study Team

MM: Mass Movement, MM-p: Inactive Mass Movement, SF: Slope Failure, RF: Rockfall, DF: Debris Flow

R: Right Side, L: Left Side, H: Hill Side, V: Valley Side

REW: Reinforced Earth Wall

7.3 Preliminary Design

7.3.1 Review of DPR

(1) Design Standards and Design Criteria

In the DPR, NH54 was divided into the following three sections;

1. NH54-S1: km 8+000 to km125+000, section from Aizawl to Keitum
2. NH54-S2: km125+000 to km250+000, section from Keitum to near Thualthu Village
3. NH54-S3: km431+000 to km562+000, section near Thualthu Village to Tuipang (km250+000 at the end of Section-2 is the same point as the starting point of Section-3 but the chainage system in Section-3 Report takes this point as km431+000)

1) Review of Roadway Width

IRC:73-1980, which is specific to rural (non-urban) highways stipulates the following widths for two lane roads in **plain and rolling terrain**;

Table 7.3-1 Roadway Width in Plain and Rolling Terrain

Road Classification	Roadway Width (m)
National and State Highways	12.0

Source: JICA Study Team

This width is presumed to be inclusive of widths required for side drains and parapets of retaining wall or unpaved shoulders.

It separately stipulates the widths for mountainous and steep terrain, which is similar to the widths stipulated in IRC:52-1981, which is specific to hill roads, as follows:

Table 7.3-2 Roadway Width in Mountainous and Steep Terrain

Road Classification	Roadway Width (m)
National and State Highways (two lanes)	8.8

Source: IRC

It further stipulates in the note:

- The roadway width of 8.8 m is exclusive of parapets (usual width of 0.6 m) and side drains (usual width of 0.6 m).
- On hard rock stretches, or unstable locations where excessive cutting might lead to slope failure, the width of roadway may be reduced by 0.8 m on two-lane roads and 0.4 m in other cases. However, where such stretches occur in continuous long length, reduction in roadway width should not be effected unless requisite passing places are provided.
- On horizontal curves, the roadway width should be increased corresponding to the extra widening of carriageway for curvature.

The DPR Consultants applied a roadway (formation) width of 12m. However, the paved widths and drainage are different in different sections of NH54 as shown in Table 7.3-3.

There was no consistency in design in each section of NH54. Therefore, the JICA Study Team initially proposed to apply the roadway width of 10m having paved width of 8.8m as recommended by IRC73:1980. However, NHIDCL finally decided to keep the roadway width of 12m with carriageway width of 7m, paved shoulder of 1.5 m and unpaved shoulder of 1.0m, as shown in Table 7.3-3.

Table 7.3-3 Roadway Width in DPR, Initial Proposal by the JICA Study Team and Decision by NHIDCL

	Section	Carriageway Width (m)	Paved Width (m)	Roadway Width (m)	Remarks
DPR	S1	7.0	10.0	12.0	1.5 m paved shoulder and 1.0m earthen shoulder
	S2	7.0	8.9	12.0	1.9m paved shoulder on hill side and 2.5 m earthen shoulder on valley side
	S3	7.0	11.4	12.0	1.9m paved shoulder on hill side and 2.5 m earthen shoulder on valley side
Initial Proposal by the JICA Study Team	All	7.0	8.8	10.0	Based on IRC73:1980
Decision by NHIDCL	All	7.0	10.0	12.0	

Source: IRC

2) Terrain Classification

IRC:73-1980 stipulates following terrain classifications based on the percent cross slope as given in Table 7.3-4.

Table 7.3-4 Terrain Classification Based on the Percent Cross Slope

S.N.	Terrain Classification	Percent Cross Slope of the Country
1	Plain	0-10
2	Rolling	10-25
3	Mountainous	25-60
4	Steep	Greater than 60

Source: IRC

DPR on Section-1 mentions that the road corridor is in mountainous and steep terrain. DPR on Section-2 mentions that the road corridor is generally in 'steep mountainous terrain". DPR on Section-3 mentions that the road corridor is generally in mountainous terrain. However, the designed alignment satisfies only the design speed corresponding to steep terrain conditions.

Therefore, the JICA Study Team proposes to apply the terrain condition as "steep" since the country cross slope generally exceeds 60% at many stretches. This is also in line with the IRC:73-1980 which stipulates while classifying a terrain, short isolated stretches of varying terrain should not be taken into consideration.

3) Design Speed

IRC:73-1980 stipulates that the choice of design speed depends on the function of the road as well as the terrain conditions as given Table 7.3-5 below;

Table 7.3-5 Choice of Design Speed Depends on the Function of the Road

Road Classification	Mountainous Terrain		Steep Terrain	
	Ruling	Minimum	Ruling	Minimum
National and State Highways	50 km/h	40 km/h	40 km/h	40 km/h

Source: IRC

For "steep terrain", 40 km/h as ruling design speed and 30 km/h as minimum design speed are recommended. It also emphasizes that normally, the ruling design speed should be the guiding criterion for correlating the various geometric design features. Minimum design speed may, however, be adopted in sections where site conditions, including costs, do not permit a design based on the ruling design speed.

The JICA Study Team proposes to apply the design speed corresponding to steep terrain condition with a minimum design speed of 30 km/h. However, the JICA Study Team is of the view that it will be difficult to fully comply with a minimum design speed throughout the whole project road, especially along the densely built-up areas.

4) Minimum Radius of Horizontal Curve

The geometric design criteria for the adopted design speed are given in Table 7.3-6.

Table 7.3-6 Design Speed for Ruling Minimum and Abusolute Minimum

Road Classification	Ruling Minimum (m)	Absolute Minimum (m)
National and State Highways	50	30

Source: IRC

5) Widening of Carriageway on Horizontal Curves

At sharp horizontal curves, it is necessary to widen the carriageway to provide for safe passage of vehicles. The widening required at different radius is given in Table 7.3-7.

Table 7.3-7 Widening Required at Different Radius

Radius of Curve (m)	Upto 21	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Extra Width	1.5	1.5	1.2	0.9	0.6	Nil

Source: IRC

IRC also stipulates that the widening should be effected by increasing the width at an approximately uniform rate along the transition curve. The extra width should be continued over the full length of the circular curve. On curves having no transition, widening should be achieved in the same way as the superelevation, i.e. two-thirds being attained on the straight section before the start of the curve and one-third on the curve.

IRC also recommends widening on the inside of the curve on hill roads.

6) Superelevation

IRC recommends that the superelevation required on horizontal curves should be calculated from the following formula, which assumes that the centrifugal force corresponding to three-fourths the design speed is balanced by superelevation and the rest is counteracted by the side friction:

$$e = V^2 / 225\,R$$

where,
- e = superelevation in m/m
- V = speed in km/h
- R = radius in m

IRC also recommends that the superelevation obtained from the above expression should however be kept limited to 7% for plain and rolling terrain as well as snowbound areas. Although IRC allows a maximum of 10% for hilly areas not bound by snow, the JICA Study Team recommends applying a maximum superelevation of 7% for the project road in view of large heavy vehicle volume with full load and frequent built-up area along the project roads.

IRC also recommends a superelevation runoff rate of 1 in 60 in mountainous and steep terrain.

7) Transition Curves

IRC stipulates that transition curves are necessary for a vehicle to have smooth entry from a straight section into a circular curve. The transition curves also improve aesthetic appearance of the road besides permitting gradual application of the superelevation and extra widening of carriageway needed at the horizontal curves.

The lengths of transition curves at various radii recommended by IRC for mountainous and steep terrain conditions are given in Table 7.3-8 below;

Table 7.3-8 Minimum Length of Transition Curve for Mountainous/Steep Terrain from IRC:73

Radius of Curve (m)	Design Speed 40 km/h	Design Speed 30 km/h	Design Speed 20 km/h
14			30
20			20
25		Not Applicable	20
30		30	15
40	Not Applicable	25	15
50	40	20	15
55	40	20	15
70	30	15	15
80	25	15	Not Required
90	25	15	-
100	20	15	-
125	15	15	-
150	15	15	-
170	15	Not Required	-
200	15	-	-
250	15	-	-
300	Not Required	-	-

Source: IRC

IRC stipulates that the minimum length of transition curve should be determined as the higher of (i) rate of change of centrifugal acceleration not causing discomfort to drivers and (ii) superelevation runoff rate not causing discomfort to drivers with 1/60 for hill roads.

8) Vertical Gradient

IRC recommends the following values of maximum gradients for steep terrain condition upto 3000m height above mean sea level (applicable to the project roads);

Table 7.3-9 Maximum Gradients for Steep Terrain Condition

Terrain	Ruling Gradient	Limiting Gradient	Exceptional Gradient
Steep terrain upto 3,000m height above mean sea level	6%	7%	8%

Source: IRC

IRC further stipulates that the limiting gradient may be used where the topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. In such cases, the length of continuous grade steeper than the ruling gradient should be as short as possible.

Exceptional gradients are meant to be adopted only in very difficult situations and for short lengths not exceeding 100m at a stretch. In mountainous and steep terrain, successive stretches of exceptional gradients must be separated by a minimum length of 100 m having gentler gradient (i.e, limiting gradient or flatter).

IRC also restricts that the rise in elevation over a length of 2 km shall not exceed 120 m in steep terrain condition.

9) Minimum Length of Vertical Curve

For design speed of up to 35 km/h, a minimum length of vertical curve of 15 m is recommended by IRC. This value is 20 m for a design speed of 40 km/h.

10) Minimum Radius of Summit (Crest) Curves

IRC specifies the minimum length of summit curve based on the sight distances. But radius of curve (or K value = 100 x radius) is easier for design check.

IRC recommends the following formula for the length of vertical curve from various sight distances:

$L = NS^2/4.4$ from stopping sight distance (SSD), which is the absolute minimum

$L = NS^2/9.6$ from intermediate sight distance (ISD) for minimum and from overtaking sight distance (OSD) for desirable

Where,

L = length of vertical curve

N = algebraic difference between the two grades

S = sight distance

Subsequently,

K = L/N where N is in ratio

R = L/N where N is in percentage

Therefore,

R = 205 m from SSD, which is the absolute minimum

= 375 from ISD for minimum

= 1500 from OSD for desirable based on the values from Section 6.2

11) Minimum Radius of Valley (Sag) Curves

IRC specifies the minimum length of valley curve based on the SSD as follows:

$L = NS^2 / (1.5 + 0.035 S)$

Subsequently,

$R = S^2 / (1.5 + 0.035 S) = 355$ m for SSD = 30 m (design speed: 30 km/h)

12) Summary of Geometric Design Criteria

The geometric design criteria for the adopted design speed are given in 7.3.2.

(2) Review of Road Alignment Design

The following DPR data were referred for review;

Table 7.3-10 Review of Road Alignment Design

SN	Section	Main Report	Drawings	Drawing Format
1	1	Available	Plan/Profile	AutoCAD
2	2	Available	Plan/Profile/Cross Sections	AutoCAD
3	3	Available	Plan/Profile/Cross Sections	AutoCAD

Source: JICA Study Team

From the alignment data of the DPR design, the applied minimum radius and the percentage of minimum radius corresponding to the minimum design speed of 30 km/h (minimum radius 30m) and ruling design speed of 40 km/h (minimum radius 50m) were studied as given in Table 7.3-11.

Table 7.3-11 Review of DPR Horizontal Alignment of NH54

Section		R=20	20<R<25	R=25	25<R<30	R=30	30<R<50	Tot.R<30	Tot.R<50
1	No	54	71	390	9	280	200	524	1004
	(%)	3.5%	4.7%	25.6%	0.6%	18.3%	13.1%	34.4%	65.8%
2	No	0	0	2	0	18	159	2	179
	(%)	0%	0%	0.2%	0%	1.5%	13.5%	0.2%	15.2%
3	No	14	0	22	0	275	369	36	680
	(%)	0.9%	0%	1.4%	0%	18.1%	24.3%	2.4%	44.7%

Source: JICA Study Team

The following were observed in the design of horizontal alignment of each section by the DPR Consultants:

- As much as 34.4% of the total curves applied in Section S1 do not satisfy the minimum design speed of 30 km/h.
- Horizontal alignment of Section-2 is designed basically with a design speed of 40 km/h all throughout with about 15% with minimum design speed of 30 km/h irrespective of the terrain conditions. Alignments were modified from the existing road to a large extent which resulted in very big quantity of earthwork as will be discussed later.
- Horizontal alignment of Section-3 follows basically with a design speed below the ruling design speed of 40 km/h with 44.7% less than that required by this speed. However, the alignment generally satisfies the minimum design speed of 30 km/h except at 36 curves (2.4%) of the total number of designed curves.
- Transition curves were not applied in the design of horizontal alignment in Section-1. Whereas, Section-2 generally applied transition curves. Transition curves were either omitted completely or one side of the curve at various locations in Section-3.

Therefore, it can be concluded that the concept of alignment design by each DPR Consultant largely differs with each other and thus requires uniform design concept.

Based on these, the applied design speed for each DPR section was compared with the applied design standard as shown in Table 7.3-12.

Table 7.3-12 Relationship between Excavation Volume and Applied Design Speed

SN	Section	Design Speed	Design Feature	Volume of Excavation
1	1	Basically 30 km/h with exceptional cases of design speed less than 30 km/h at many locations (34.4%)	Alignment generally follows existing road and follows terrain conditions. Transition curves were completely not applied.	Not reported
2	2	Basically 40 km/h with 30 km/h at few locations (15.2%)	Higher design standard is attempted but diverts largely from existing road and terrain condition is largely not considered.	23.5 million m^3
3	3	Basically 30 km/h with very few exceptional cases of design speed less than 30 km/h (2.4%)	Comparatively balance between design standard and terrain condition. Transition curves are not applied at many locations.	7.1 million m^3

Source: JICA Study Team

Therefore, it is concluded that:

- Uniform design policy with a balance between design standard and terrain condition is required.
- Volume of excavation is very huge and therefore, a more balanced cut/fill considering widening in the valley side is required wherever practicable.

(3) Slope Protection Design

Slope protection works planned in the DPRs of each section in NH54 were reviewed. Table 7.3-13 shows the comparison between the DPRs of each section and the proposal by the JICA Study Team.

In the DPRs conducted by several Indian consultants, road widening was planned mostly on hill side with cutting slope, and it resulted in huge volume of cut soil. The large volume of cut soil is not always economical compared with the retaining wall on the valley side due to cost for disposal of soil, construction of temporary access road to the top of the cut slope, and safety measures in construction for high cut slope. Therefore, the JICA Study Team proposed to NHIDCL and its consultants that widening should be carried out on both hill and valley on case-by-case basis to reduce the cut soil volume and improve economy.

Table 7.3-13 Review of DPR Regarding Slope Protection Work

Item	Section-1 0~125 km*	Section-2 125~250 km**	Section-3 250 km~End**	JICA Study Team Proposal***
Widening Side	Mainly hill side	Mainly hill side	Mainly hill side	Plan to widen both hill and valley side on case-by-case basis.
Cut Grade Soil Soft Rock Hard Rock	Not defined	60° 60° 80°	1:0.5 1:0.25 80-90°	Decided based on classification of rock and soil.
Cut Soil Amount (m³)	Unclear	23.5 million	7.1 million	Reduce by widening on valley side and balance with embankment volume.
Embankment Amount (m³)	Unclear	0.018 million	0.085 million	Will increase with widening on valley side.
Slope Protection	Retaining wall Breast wall	Nil	Retaining wall Gabion wall	Appropriately adopted on landslide risk slope.
Landslide Sites Countermeasure Plan	Not recognized. Nil	Recognized 2 sites Gabion wall Valley revetment (Wooden fence)	Recognized 4 sites Nil	Identify landslide risk sites in inventory survey and plan its countermeasures.

Source: *DPR as of May 2015, **DPRs as of April 2015, ***JICA Study Team

(4) Bridge Design

The comments for bridge plan by DPR are as follows.

- The general information for existing bridges are not provided well for all DPRs. Details such as structural type, span, carriageway width, design load and estimated construction year for each bridge are required.
- In the DPR section for all DPRs, information such as structural type, span, carriageway width, and design load on existing bridge shall be included. It does not include comprehensive evaluation with consideration of carriageway width and design load.
- One of the explained bridges in DPR Section-2 is small slab bridge which is classified as slab culvert in DPR Section-3. Hence, it is uncertain that bridge condition was evaluated by same viewpoints in all sections among different DPR consultants.

Evaluation of damage condition is subjective so that it is difficult to grasp the actual condition of existing bridges through the description in DPR alone. Also, some bridges are judged as sound but no status is mentioned in DPR Section-3.

In such case, site investigation to check each bridge condition is required.

In the study, general information of existing bridge such as structural type, span, carriageway width and damaged condition are investigated at the site. Also, some important information such as construction year and design load are obtained through interview with PWD.
The necessity of bridge replacement should be carefully determined with several viewpoints such as carriageway width, design load, and soundness.

Table 7.3-14 Proposal for bridges by DPR (NH54)

	DPR Proposal	Comment
NH-54 Section-1	Existing one major bridge is explained. No rehabilitation was proposed because major damage is not seen.	DPR explains only the damage condition to evaluate the necessity of replacement of existing bridge.
NH-54 Section-2	Existing one major bridge and three minor bridges are explained. Re-construction was proposed for the three minor bridges.	DPR explains only the damage condition to evaluate the necessity of replacement of existing bridge. (Including one large slab culvert)
NH-54 Section-3	No explanation for bridge.	No explanation even for general information of existing bridges such as number or location.

Source: Based on DPR

(5) Drainage Design
The drainage design by DPR was reviewed. The proposed quantity for each type and size of cross drainage structures are summarized in Table 7.3-15 below. The concrete lined ditch is applied to the road side ditch for cut side in almost all sections.
The comments on the cross drainage design by DPR are as follows:

- Damage condition and structural features for each existing culverts are not explained enough.
- All existing culverts are proposed to be dismantled and re-constructed to new culverts with 12 m width. The reason why existing culvert is not feasible to be retained with the extension of partial new culvert is not clarified.
- Due to the separated section for DPR implementation, culvert type and size do not have uniformity throughout the whole section. Box type is only proposed for all culverts in DPR Section-1 and slab culvert is only proposed for all sections in DPR Section-2. Also, box type is mostly proposed in DPR Section-3. (Refer to Table 7.3-15.)
- In all DPRs, the plan does not explain the basis for utilization of precast pipe culverts. In general, pipe culvert is most economical, and would enable fast construction and easy to ascertain quality. The pipe culvert should be capable at most locations except in some locations where large discharge is estimated.
- It is assumed that hydrological analysis was not conducted in DPR. Specially, there is no description regarding discharge calculation for DPR Section-1 and Section-2. In DPR Section-1, newly added culvert was not proposed at all. In order to decide the type and dimensions of culvert, the water discharge obtained by hydrological analysis is to be referred to.

Table 7.3-15 Proposed Culvert by DPR for NH54

	Type	Size	Existing Location	Newly Added	Sum
NH54 Section - 1 8 to 125	Box Culvert	1.0x 1.5	406	0	406
		2.0x 1.0	20	0	20
		2.0x 1.5	6	0	6
		2.0x 2.0	31	0	31
		3.0x 3.0	4	0	4
		4.0x 4.0	0	0	0
		Total	467	0	467
NH54 Section - 2 125 to 237.86	Slab Culvert	1.5x 1.5	298	72	370
		2.0x 2.0	157	24	181
		3.0x 2.5	4	0	4
		3.5x 2.5	1	1	2
		6.0x 3.0	4	1	5
		Total	464	98	562
NH54 Section - 3 431 to 553.6	Box culvert	1.5x 1.5	394	0	394
		2.0x 2.0	88	0	88
		3.0x 3.0	6	0	6
		6.0x 4.0	1	0	1
	Pipe Culvert	ϕ 1.2 x 1	106	90	196
		Total	595	90	685

Note: The number of culverts in the bypass section is not included.
Source: Based on DPR

(6) Accuracy of Design Data

In the topographic survey of DPR, the consultant of each section applied different coordinate systems (Section Section-1 and Section-2 applying arbitrary local coordinates), making it difficult to unify the data of all the project roads. There was also mismatch of data at the boundary of each section. The JICA Study Team did not have any leverage to rectify this problem and the revised design by the JICA Study Team had to use the same data from the DPR consultants which were adjusted to the same system of Section Section-3 by manually moving all the data of Section-1 and Section-2. Therefore, the accuracy of the coordinate system cannot be established.

The DPR Consultant of Section Ssection-2 applied arbitrary elevation datum and hence is different than in Section-1 and Section-3. The profile of all three sections cannot be established in the same elevation datum system as well. Therefore, there is no continuity in the vertical profile between each section, which was not possible to be rectified by the JICA Study Team without any topographic survey.

The topographic survey data in all the sections lacked the data in the valley side, especially for Section-2 where no data on the valley side was available. The JICA Study Team tried to supplement the data in the valley side through the inventory survey of the slopes at an interval of 200 m-300 m. However, the accuracy of the data cannot be established in comparison with the actual ground topographic survey.

Therefore, the revised design based on such data may have large variations in the design quantities.

7.3.2 Road Geometric Design

(1) Design Standards

Basically the Design Standards given in Indian Roads Congress (IRC) Standards, Codes, Guidelines and Special Publications will be referred. Following IRC Standards for Highway Geometric Design are referred;

- IRC:73-1980 – Geometric Design Standards for Rural (Non-urban) Highways
- IRC:52-2001 – Recommendations about the Alignment Survey and Geometric Design of Hill Roads
- IRC:SP:48-1998 – Hill Road Manual

Where no provisions exist in those standards, the relevant standards of AASHTO (A Policy on Geometric Design of Highways and Streets, 2011) or JRSO (Japan Road Structure Ordinance, 2004) will be referred if necessary.

(2) Design Policy and Design Criteria

The major objectives of the Study are;

- To analyze the existing data/reports and review of existing Detailed Project Reports (DPR)
- To examine procurement and construction method, implementation schedule, project organization, capability of operation and maintenance, social and environmental conditions and evaluate project cost and feasibility of target sections.

However, after review of the DPR data, it was concluded that the accuracy of topographic survey data and design policies of each section of NH54 designed by separate DPR Consultants were not unified and varied largely from each other.

Therefore, although, redesign was not a part of the objectives of the Study, redesign to the extent possible from the available data was attempted to come up with some meaningful quantities and cost of the Project.

The following Design Policies are established;

- There were differences in design concept in each section of DPR with different road width, application of minimum design speed, minimum radius of horizontal curves and application of transition curves etc. Therefore, uniformity in the design criteria is required for all sections of NH54.
- Design of alignment shall be based on a policy with a balance between application of minimum design standard and the terrain condition, such that the improved alignment does not largely deviate from the existing road.
- Widening shall be done with a concept to minimize the earthwork imbalance and alignment shall be shifted to valley side to the extent not to increase the construction cost sharply.
- Especially at the landslide prone areas, identified by the JICA Study Team, widening side shall be decided based on the results of the study.
- Widening shall be done with a concept to minimize the relocation of houses along the existing road.
- As per the instruction by NHIDCL and IRC:37-1980, transition curves shall be designed for all horizontal curves. Exceptions maybe with the length of transition curves at difficult locations.

The established Geometric Design Criteria is given in Table 7.3-16.

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Table 7.3-16 Summary of Geometric Design Criteria for Highway

Design Elements			Type/Value	Remarks
1	Highway Classification		National	
2	Terrain Classification		Steep	
3	Design Speed (km/h)			
		Ruling (km/h)	40	
		Minimum (km/h)	30	
4	Cross-Sectional Elements	Basic Lane Width (m)	3.5	
		Number of Lanes	2	
		Formation Width (m) Carriageway Width (m) Outer Shoulder Paved Width (m) Outer Shoulder Earthen Width (m)	12.0 (10.0) 2 x 3.5 2 x 1.5 (0.9) 2 x 1.0 (0.6)	() for exceptional sections
		Crossfall of Roadway (%)	2.5	
		Slope of Earthworks Fill Cut (soil) Cut (rock)	 V : H = 1:1.75 V : H = 1:1.2 V : H = 1:0.2-	 Varies Varies
5	Sight Dist.	Stopping Sight Distance, SSD (m) Intermediate Sight Distance, ISD (m) Overtaking Sight Distance, OSD (m)	30 (45) 60 (90) (165)	() 40 km/h () 40 km/h () 40 km/h
6	Horizontal Alignment	Horizontal Curve Absolute Minimum Radius of Horizontal Ruling Minimum Radius of Horizontal Curve	 30 50	
		Widening of Carriageway on Horizontal Curves		
		Widening for Absolute Minimum Radius	1.5	
		Widening for Ruling Minimum Radius (41m-	1.2	
		Superelevation (Se) Maximum Se for Absolute Minimum Radius Superelevation Runoff Rate	 7.0 1/60	
		Transition Curve Minimum Length for Absolute Minimum Minimum Length for Ruling Minimum	 30 20	
7	Vertical Alignment	Vertical Gradient Ruling Gradient (%) Critical length of continuous Ruling Limiting Gradient (%) Exceptional Gradient (%) Critical Length for Exceptional Gradient	 6.0 2000 7.0 8.0 100	 120m rise in 2km for steep
		Minimum Gradient for Drainage (%)	0.5	Cut sections with lined side
		Vertical Curve Minimum Length of Vertical Curve (m) Minimum Radius of Summit (Crest) Curve Absolute Minimum Radius (m) Minimum Radius (m) Desirable Minimum Radius (m) Minimum Radius of Valley (Sag) Curve (m) Absolute Minimum Radius (m)	 15 205 375 1500 355	 From SSD From ISD From OSD

Source: JICA Study Team

(3) Design Conditions

As stated earlier, one of the major objectives of the Study was to analyze the existing data/reports and review of existing Detailed Project Reports (DPR).

However, the alignment design by each DPR Consultant for each section was completely with different design policy and uniformity in design was required.

Widening of existing road in DPR was exclusively by widening in the hill side only, due to which very big excavation volume was resulted, raising serious environmental concerns.

Therefore, re-design of the entire project road was required by applying uniform design standards and making a more balanced cut/fill design by shifting the alignment to valley side wherever practicable.

However, the topographic data on the valley side was not available in all DPR sections. The scope of the Study did not include topographic survey of the road and it was also not possible to be conducted during the short duration of the Study.

The scope of the Study included slope inventory survey where the road side slopes were measured approximately by the use of Distance Meter at an interval of about 200-300m.

The results from the slope inventory survey were used to create the digital terrain model of the valley side. However, since the data was available at an interval of every 200-300m only, the accuracy cannot be expected.

Moreover, the hill side data of Section-2 showed exceptionally steep terrain at regular intervals of 2-3km which were not observed in the site. However, it was not possible to rectify it without conducting topographic survey. It was also not possible to combine the survey data of DPR with the results of the inventory in the hill side since mixing of data from two different sources with different accuracy levels will complicate the terrain model more.

In the contrary, the hill side data of Section-3 showed gentler terrain at some locations than were observed in the site. The extent of data available was also to a narrow width only.

The topographic data of Section-2 also largely lacks the details of existing features such as houses, structures etc.

Therefore, the re-design of the alignment was done with the constraints mentioned above which would affect to the desired degree of accuracy.

The Coordinate System used by each DPR Consultant was different and hence it was not possible to directly superimpose all sections in one system. Since Section Section-3 applied WGS-84 coordinate system, the Study Team approximately adjusted the coordinate system of Section S1 and Section Section-2 based on the coordinate system of Section-3. However, there was some mismatch between the end of Section Section-1 and starting of Section Section-2. The natural features and the details were also different at this overlap section between Section-1 and Section-2, details of Section-1 being much closer to the existing conditions.

(4) Horizontal Alignment Design

The starting and ending chainages of each section in NH54 are given in Table 7.3-17.

Table 7.3-17 Start and End Chainages of Each Section in NH54

Section	Start Chainage	End Chainage	Remarks
1	km 8+000	km 116+710	km 116+710 (S1) is the revised design chainage which is set at the km post on the existing road and is the starting point for Section S2 with km 125+000 (S2)
2	km 125+000	km 243+330	km 243+330 (S2) is the revised design chainage which is at same location as km 431+100 (S3) on the existing road
3	km 431+100	km 554+410.287	The end point is at the roundabout in Tuipang

Source: JICA Study Team

The details of the revised alignment for each section of NH54 are given in Table 7.3-18, showing the percentage of radius less than the value required for minimum design speed of 30 km/h. These were applied only at the hairpin bends and IRC allows a minimum radius of 20 m at hairpin bends.

Table 7.3-18 Application Rates of Minimum Radius in Each Section of NH54

Section		R=20	20<R<25	R=25	25<R<30	R=30	Tot.R<30	Remarks
S1	No	10	0	4	0	495	14	R<30m mainly at hairpin curves
	(%)	0.8%	0%	0.3%	0%	40.2%	1.1%	
S2	No	11	0	0	0	605	11	
	(%)	0.7%	0%	0%	0%	40.8%	0.7%	
S3	No	10	0	10	0	317	20	
	(%)	0.7%	0%	0.7%	0%	21.2%	1.3%	

Source: JICA Study Team

The quantities of excavation and spoil volume for the revised alignments are also given for each section in Table 7.3-19 in comparison with the volume in DPR.
From the results, it may also be concluded that the terrain conditions of Section-1 and Section-2 may be steeper than for Section-3 where the application rate of minimum radius of 30 m is only 21.2%, compared with the above 40% for Section-1 and Section-2 and yet the excavation volume is almost the same.
After the revision of the design from the original DPR, the excavation and spoil volumes for the revised design are given in Table 7.3-19 in comparison with the DPR volume.

Table 7.3-19 Excavation and Spoil Volume for the Revised Design by JICA Study Team

SN	Section	Revised Design		DPR	
		Excavation Volume (m^3)	Spoil Volume (m^3)	Excavation Volume (m^3)	Spoil Volume (m^3)
1	S1	3.44 million	2.40 million	Not reported	Not reported
2	S2	3.71 million	2.44 million	23.5 million	23.48 million
3	S3	3.55 million	2.46 million	7.1 million	7.01 million

Source: JICA Study Team

(5) Vertical Alignment Design

- Minimum gradient is designed as 0.5% at cut sections for drainage.
- The ruling gradient is designed as 6% as per the design standard given in Section 7.3.2 (1).
- The limiting gradient is 7% at difficult locations.
- The exceptional gradient is 8%, which is applied for unavoidable situations only and the maximum length is 100 m.

The length of the designed vertical profile grade range is given in Table 7.3-20 in percentage of the total length of each section.

Table 7.3-20 Length of Designed Vertical Profile Grade Range

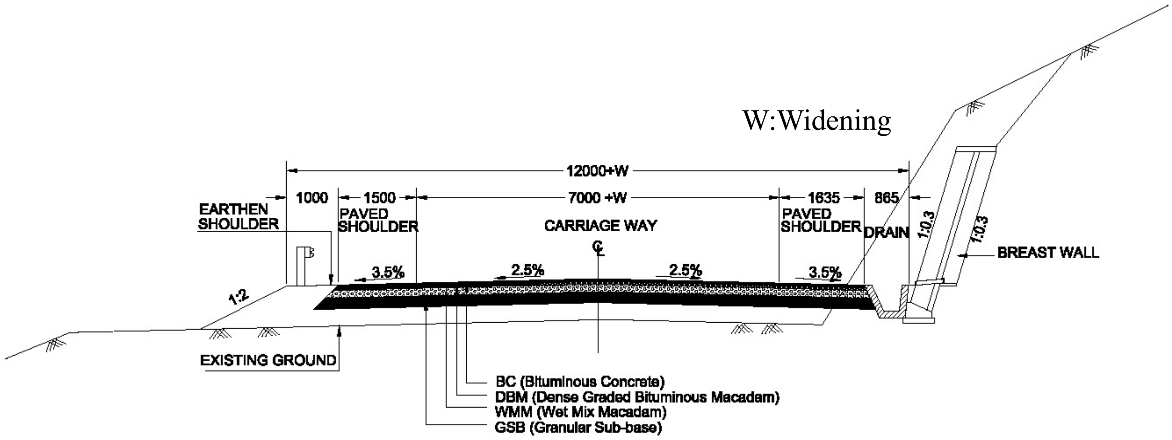
Section	Vertical Grade Range								
	0.5%	0.5%-1%	1%-2%	2%-3%	3%-4%	4%-5%	5%-6%	6%-7%	7%-8%
1	5.3%	2.5%	7.6%	11.6%	12.4%	26.9%	22.8%	10.6%	0.4%
2	3.3%	6.7%	9.1%	15.1%	21.7%	21.1%	14.4%	8.2%	0.3%
3	4.2%	4.3%	11.6%	21.5%	23.5%	15.9%	12.6%	6.2%	0.2%

Source: JICA Study Team

- The vertical grade higher than the ruling gradient of 6% but less than or equal to the limiting gradient of 7% was applied at a total percentage length of 10.6%, 8.2%, and 6.2% for Sections-1, 2, and 3, respectively.
- Exceptional gradient of 8% was applied at four locations (total of 400 m) each in Sections 1 and 2 and at two locations (200 m) in Section-3.

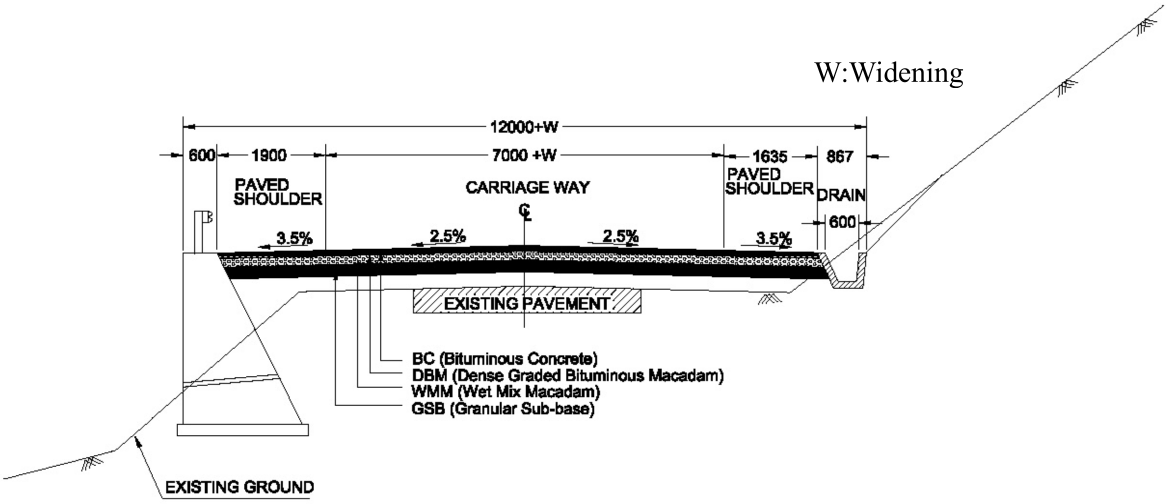
(6) Typical Cross Section

The typical cross section of the project is as given in Figure 7.3-1 for widening primarily to the hill side and Figure 7.3-2 for widening primarily to the valley side.



Source: JICA Study Team

Figure 7.3-1 Typical Cross Section for Widening Primarily to Hill Side



Source: JICA Study Team

Figure 7.3-2 Typical Cross Section for Widening Primarily to Valley Side

The minimum paved shoulder width is 1.5 m. However, the small width between the end of the paved shoulder and the side drain shall also be paved smooth surface drainage to the drain and also to avoid damaging this small unpaved area by the intrusion of water.

Similarly, when there is retaining wall in the valley side, the width between the end of the paved shoulder and the parapet of retaining wall shall also be paved for the same reason.

7.3.3 Bridges and Structures Design

(1) General

It is necessary for bridges on NH54 to provide functions adaptinged to the current nNational hHighway standards. If the existing bridge is adequate for based on the requirement of the current nNational hHighway, it can be retained with or without some repairing works. If the existing bridge is deemed to be inadequate, it should be replaced by ato new bridge.

The necessity of bridge replacement should be carefully determined based onwith the following viewpoints:

- Road width on bridge: The road width for bridges should be sufficient for national highway standards. Although the road width for general road section is planned as 12.0 m (3.5 m x 2 for vehicle lane and 2.5 m x 2 for side lane), the road width for existing bridges is considered enough if more than 7.5 m with reference to IRC:73.

- Design load: The existing bridge is utilized only if it follows the design load to be applicable for current national highway standard. Specially, live load is an important factor because it directly works at the girder. Hence, the application of live load (IRC Class 70R Loading) as mentioned in IRC:6 is confirmed for determination.

- Soundness: The existing bridge is utilized only if the condition is basically sound without major damages. It is said that the road was originally constructed around 1970. It means that the existing bridges constructed at the origin of the road are aging to nearly 50 years. The project can be a suitable occasion for such old bridges to be replaced with new bridge.

(2) Existing Bridge Condition

According to IRC:5, the bridge is defined as a structure with span of more than 6m. On the road, several RC slab structures with masonry abutments whose span is approximately 5 m to 7 m are existing. In the study, such structure is classified as large slab culvert. This is explained in the chapter on cross drainage.

Hence, six existing bridges can be recognized in the target section of the Project. The outline, condition, and comment for these existing bridges are summarized in Table 7.3-21.

Construction years are different across the bridges. For newly constructed bridges, road width and design load are in accordance with the national highway standard. Also, there are no issues in terms of soundness. On the other hand, old bridges provide only narrow width and light design load, and has deterioration.

Table 7.3-21 Outline and Conditions of existing bridges on NH54

Location	Outline	Condition	Comment
22+670 (Tuirial)	・Bridge name：Tuirial Bridge ・River name：Tuirial River ・Construction year：1989 ・Structural type：3-span PC box girder bridge ・Length and span：3-span 1x12+1x47+1x12=71.0 m ・Roadway width：7.5 m ・Design load：70R	・No major damages are seen at girder and piers. But pavement is damaged. ・Concrete railing and kerbs are deteriorated. ・The slab at the back of abutment at E.P. side is deteriorated.	The existing bridge can be retained because: -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.
74+660 (Chhingchhip)	・Bridge name：N/A (Temporary Bridge) ・River name：No river ・Construction year：N/A	・It is a temporary bridge constructed after slope collapsed at the location of old road. The bridge	A new bridge should be constructed instead of temporary bridge because the existing bridge is not

Location	Outline	Condition	Comment
	・Structural type：Steel truss bridge（Bailey bridge） ・Length：44 m ・Roadway width：3.4 m ・Design load： 18 t（Weight limitation）	is capable only of load within 18 t and one-way traffic.	suitable for permanent use as national highway.
190+190 (Maudarh)	・Bridge name：Maudarh Bridge ・River name：Maudarhlui River ・Construction year：1980 ・Structural type：RC T-beam ・Length：12 m ・Roadway width：4.0 m ・Design load：40R	・Girders and piers are aging completely. ・Scouring is seen at the bottom of piers. ・Pavement is damaged. ・Concrete railing and kerbs are quite deteriorated.	<u>The existing bridge should be replaced to a new bridge because:</u> -The bridge is deteriorating and has damages -Shortage of roadway width -Less design load
193+420 (Before Matbawk)	・Bridge name：Mat Bridge ・River name：Mat River ・Construction year：1992 ・Structural type：PC girder bridge ・Length and span：3 span 1x16.7+1x45.1+1x31.2=98.0 m ・Roadway width：7.5 m ・Design load：70R	・No major damages are seen at girder, pier, and pavement. ・A part of concrete railing is deteriorated.	The existing bridge can be retained without special repairs because: -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.
216+450 (Zobawk)	・Bridge name：Zobawk Bridge ・River name：(Tlawng Hnar) ・Construction year：1980 ・Structural type：RC slab bridge ・Length：7.5 m ・Roadway width：5.0 m ・Design load：30R	・Girders and piers are aging completely. ・Scouring is seen at the bottom of piers. ・Pavement is damaged. ・Concrete railing and kerbs are quite deteriorated.	<u>The existing bridge should be replaced to a new bridge because:</u> -The bridge is deteriorating and has damages -Shortage of roadway width -Less design load
503+600 (Kawichaw)	・Bridge name：Kawlchaw Bridge ・River name：Mat River ・Construction year：2000 ・Structural type：Continuous PC box bridge ・Length and span：3+1 span, total length 285 m ・Roadway width：7.5 m（2 lanes） +1.5 m x 2（Walkway both side） ・Design load：70R	・No major damages are seen at girder, pier, and pavement. ・A part of concrete railing is deteriorated.	The existing bridge can be retained without special repairs because: -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.

Remarks) The outline data is based on the site measurement, bridge record plate and listening information from Executive Engineers of PWD. in the district.
Source: JICA Study Team

Hence, it can be proposed to replace the following three bridges with new bridges

(a) 74+660 (Steel truss bridge in Chhing chip)
(b) 190+190 (RC T-beam bridge in Maudarh)
(c) 216+450 (RC slab bridge in Zobawk)

Source: JICA Study Team

Figure 7.3-3 Temporary Bridge in Chhingchhip at 74+660

Source: JICA Study Team

Figure 7.3-4 RC T beam Bridge in Maudarh at 190+190

Source: JICA Study Team

Figure 7.3-5 Slab Bridge in Zobawk at 216+450

(3) Design Standard

The design is based on the IRC standards in principle. For the detailed design stage, it shall be designed based on IRC standards as far as applicable.

Major codes and typical drawings regarding bridge design are summarized in Table 7.3-22 below. Also, the following codes for road design, among others, shall be referred to:

Table 7.3-22 List of Major Codes for Bridge Design

IRC: 5-1998	Standard Specification & Code of practice for Road Bridges. Section – I General Features of Design (Seventh Revision)
IRC: 6-2014	Standard Specification & Code of practice for Road Bridges. Section – II Loads & Stresses (Revised Edition)
IRC: 21-2000	Standard Specification & Code of practice for Road Bridges. Section – III Cement Concrete Plain & Reinforced (Third Revision)
IRC: 24-2010	Standard Specification & Code of practice for Road Bridges, Steel Road Bridges (Limit State Method) (Third Revision)
IRC: 45-1972	Recommendations for Estimating the Resistance of soil below the maximum Scour Level in the Design of Well Foundations of Bridges.
IRC: 73-1980	Geometric Design standards for Rural (Non-Urban) Highways.
IRC: 78-2014	Standard Specification & Code of practice for Road Bridges. Section – VII Foundation & Substructure (Revised Edition)
IRC: 112-2011	Code of Practice or Concrete Road Bridges
MORTH	Standard Plans for 3.0m to 10.0m Span Reinforcement Cement Concrete Solid Slab Structure with and without Footpaths for Highways, 1991
MORTH	Standard Plans for Highway Bridges R.C.C. T-Beam & Slab Superstructure – Span from 10m to 24m with 12m width, 1991

Source: JICA Study Team

The design load condition shall be determined by taking into account the regional and project characteristics. Major load conditions are as follows:

- Live load: IRC Class 70R Loading (Based on IRC:6 Clause201)
- Live load combination: One lane of Class 70R or two lanes of ClassA (Based on IRC:6 Clause204.3)
- Impact load: (Based on IRC:6 Clause208)
- Temperature load: +5 to +40 degrees (Based on IRC:6 Clause215)
- Seismic load: Zone-V, Important Factor: 1.5 (Based on IRC:6 Clause219)

Other load conditions, these shall also be determined based on IRC standards.

(4) New bridge planning

1) Major bridge

It is a new bridge plan located at valley point near Chhingchhip Town.

A bailey bridge is facilitated to pass over the valley at present. In the past, the route was positioned just on the slope with small radius curve.

Due to the collapse of the slope on the previous route, the bridge is temporary provided to pass over the slope.

In DPR, the route was proposed by making shortcut of 400 m section for the valley point connecting straight towards the road at the opposite side of the hill with the excavation of the hill. The proposed route needs large volume of hill excavation and removal of obstacles such as several numbers of local houses that are located at the slope.

In the JICA study, the route passing over the valley with new bridge is proposed in order to reduce the influence on the local environment, to reduce the hill excavation volume, and to improve the alignment smoothness at the section. The alignment needs small curve if it goes through near the hill slope or bailey bridge. Therefore, the new alignment is proposed to connect straight to two more remote points at the valley side. (see Figure 7.3-6 and Figure 7.3-7)

For the selection of bridge type, appropriate bridge type should be selected considering the condition of 130 m length and valley terrain at the site.

Steel arch type is frequently applied in valley terrain in the mountain area. It does not require pier construction at deep valley point through an arch rib built on rigid ground at both slopes.

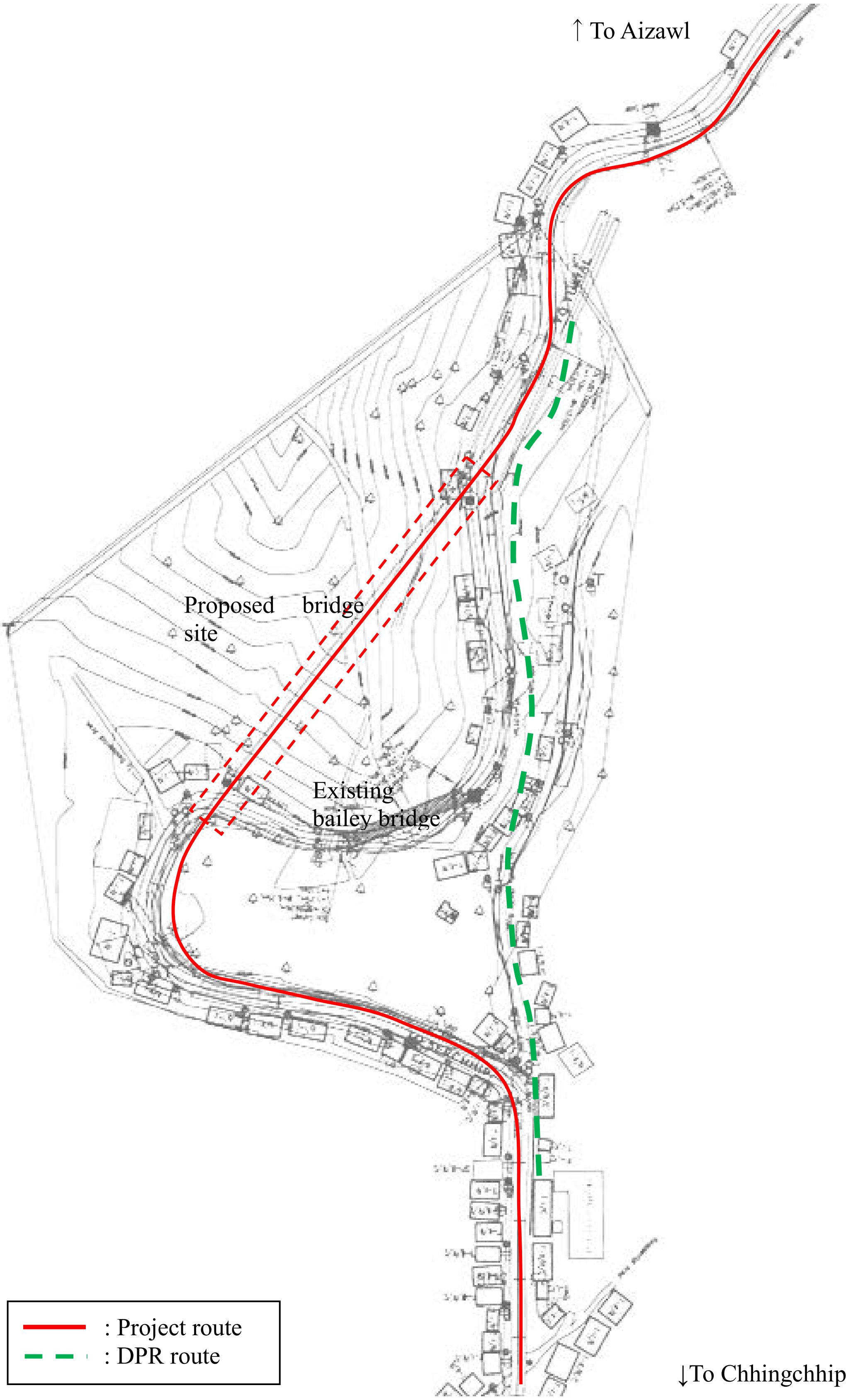
Manufacture of steel arch member in the factory enables comparably short construction period. The valley terrain and shape of arch rib are well harmonized and result in good landscape.

As alternative to the PC type bridge, T-type rigid frame bridge, which is frequently used for similar scales, is compared.

Comparison of bridge type is summarized in Table 7.3-23. Because steel arch type is superior based on the total evaluation, steel arch bridge is proposed.

Source: JICA Study Team

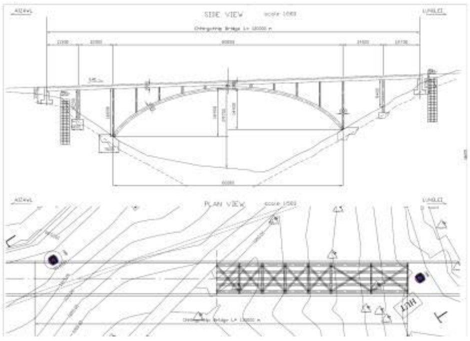
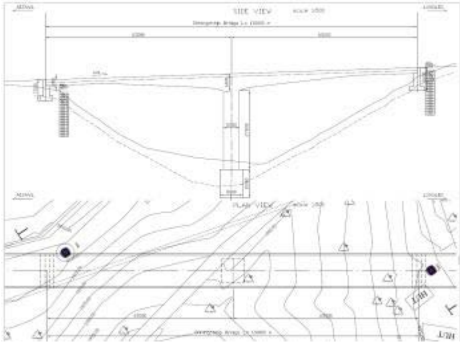
Figure 7.3-6 Chhingchhip bridge site (View from E.P. side)



Source: JICA Study Team

Figure 7.3-7 Route Map at Around Chhingchhip Bridge Site

Table 7.3-23 Comparison of Structural Type for Chhingchhip Bridge

	Steel Arch Bridge (Upper-deck Type Lohse Bridge)	T-type Rigid Frame Bridge (Cantilever PC Box Bridge)
Layout		
Abstract	Steel arch type is frequently applied in valley terrain in mountain area. Long span is provided by arch effect of rib which is supported on rigid ground. It can be built by cable erection method with cable crane facilities and temporary steel tower.	PC cantilever type is applied on condition where bent support is unsuitable due to high location. The girder is built by cantilever method with mobile work machine from the constructed pier head.
Construction Cost Ratio	1.00 - It is supposed that an overseas contractor such as from Japan is procured. A part of the equipment and staff will need to be imported.	0.82 - It is well familiar method in India. All materials, equipment, and staffs will be procured from domestic.
Construction Period	1.5 years - The sub-structural work can proceed during the manufacturing of the member of steel arch in factory. Hence, construction period can be comparably short. -Because site work is less, the construction period is more reliable.	2 years - The cantilever work is mobilized after the pier head is completed. Hence, the construction period takes comparably long. - The concrete work is mostly influenced by weather condition. It has a risk of huge delay.
Landscape	Good - The arch bridge is generally considered to have good landscape. The valley terrain and shape of arch rib are well harmonized.	Poor - Due to large dimension of main pier and box girder, the bridge looks so artificial and heavy.
Construction Condition	Good -It can be built by cable erection method from existing road side. -Steel member is manufactured in factory so that quality control is well provided.	Poor - Material and equipment need to be transported to the pier construction point at the bottom of the slope via the construction road. - Large concrete work on site for long period needs more notification to control quality.
Evaluation	✓	-

Source: JICA Study Team

Geographical and Geological Condition

- Topographical survey at bridge plan site was conducted. Bridge length will be 130 m between the two abutments. The height at the center is approximately 30 m from the natural ground. The elevation difference between the two points reaching to the existing road is approximately 5 m. Vertical gradient of road on the bridge is 3.4%.
- Geological survey was conducted at two locations near both abutments. For both boreholes, SPT test results show N-values of over 50 when depth becomes deeper than 3 m. By observation of gathered core condition, the composition of ground at site is assumed as:
  - Surface: Sedimentary soil
  - Until 3 m depth: Heavily weathered clayey shale rock
  - Deeper than 3 m: Weakly weathered clayey shale rock

  It is noted that BH1 at B.P. side indicates more weathered ground condition compared with BH2 at E.P. side.
- Because the weakly weathered rock is located at comparably shallow depth, all substructures for arch rib, pier, and abutment can be designed as spread foundation. The footing depth should reach into the weakly weathered rock layer.

Outline of Bridge Plan

- The bridge width is 12 m in total based on IRC standards. The sidewalk is not planned on the bridge because the walkway can be provided easily by utilizing the existing bailey bridge or new path along the slope side.
- Crash barrier needs to be facilitated due to the high location of the bridge.

Design

- Design condition shall be based on current IRC standards. Live load class is to be IRC Class 70R.
- The North-East Region has experienced several large earthquakes in the past. The area is categorized as Zone-V under the seismic zone classification. It requires seismic design based on IRC standards taking into account the characteristics of steel arch structure.
- It is an option to add the application of weathering steel, which is known to be effective to reduce the total initial cost plus life cycle cost. Japanese manufacturer provides such innovative technology.

Construction

- Member of steel arch will be manufactured in the factory and transported to the construction site.
- The steel arch will be erected through the cable erection method with cable crane and temporary steel tower facilitated at the site.

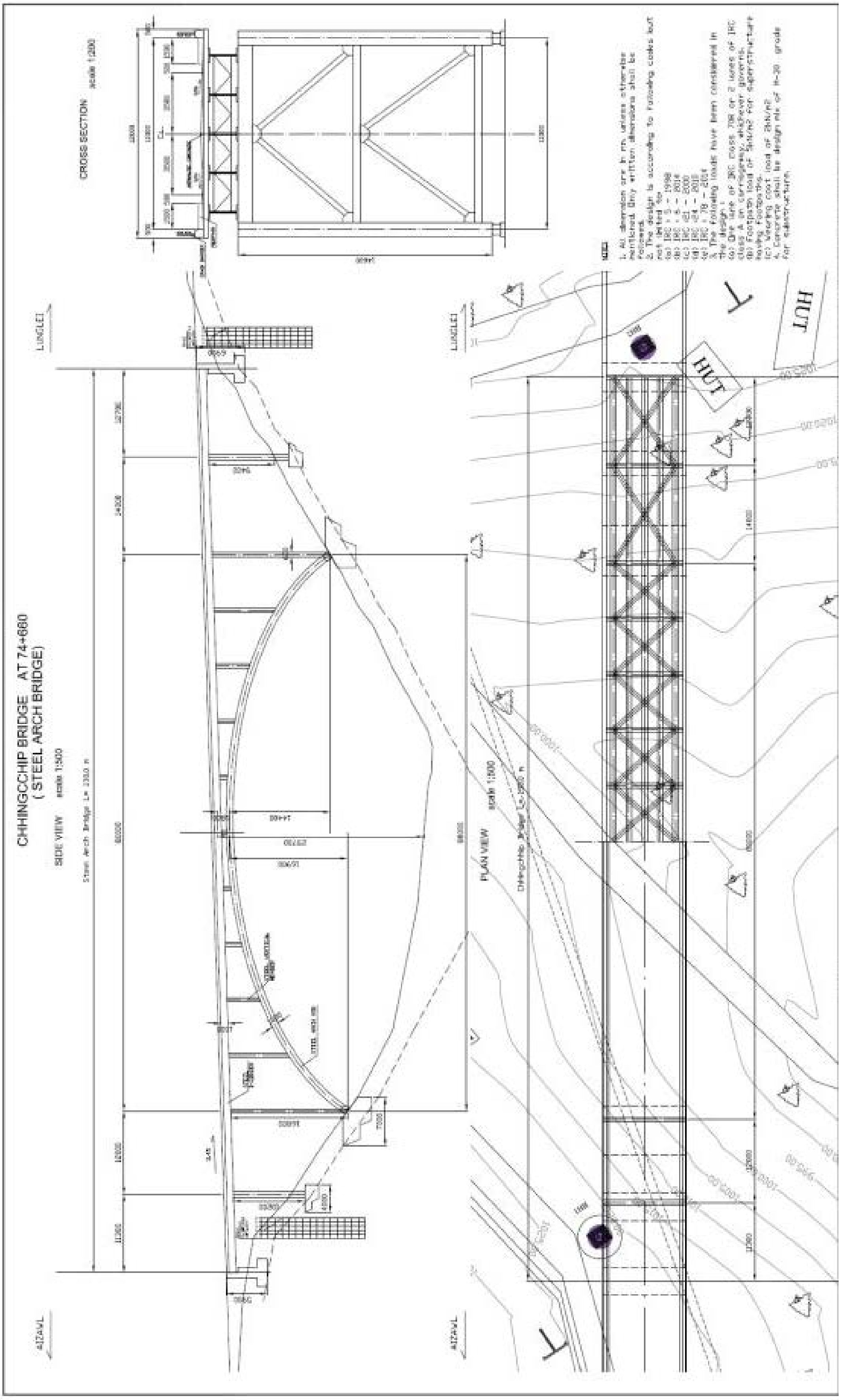


Figure 7.3-8 Steel Arch Bridge

Source: JICA Study Team

2) Minor Bridge

Bridge replacement is proposed for the following two minor bridges.

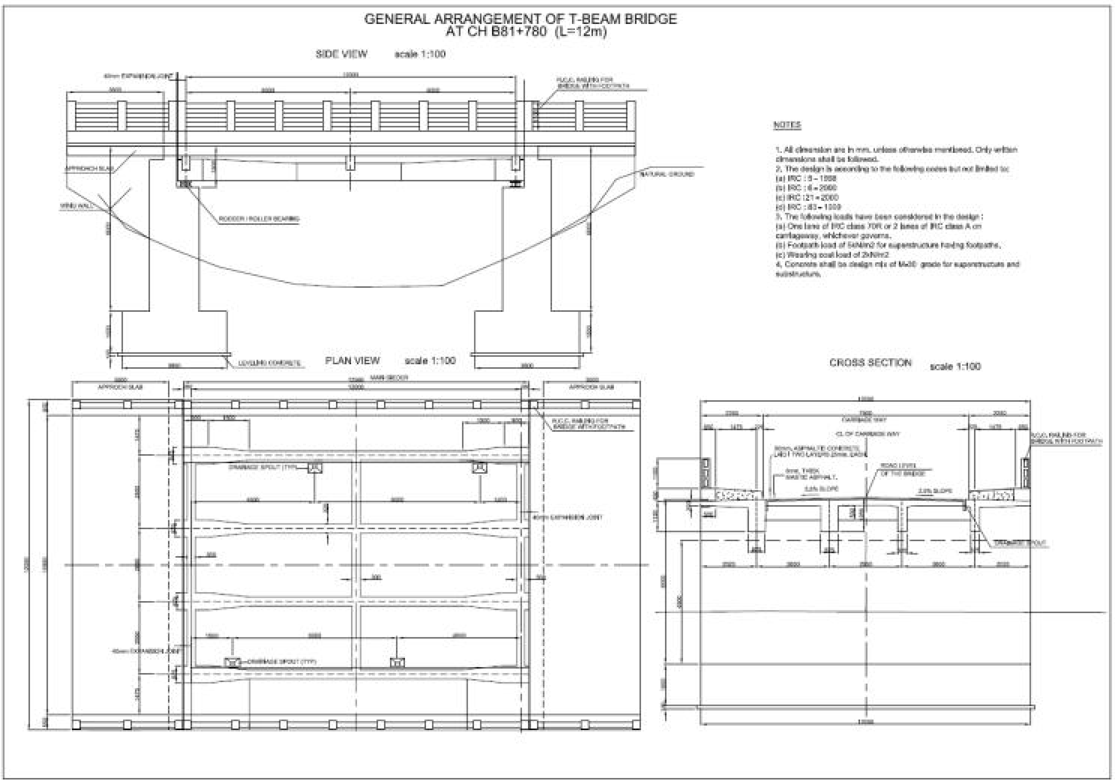
Table 7.3-24 Bridge Replacement for NH54

Location	Structural type	Outline
190+190 (Maudarh)	RC T-beam Bridge	Bridge length: L=12.0m, Total width: W=12m (Without footpath) Foundation: Spread foundation
216+450 (Zobawk)	RC Slab Bridge	Bridge length: L=8.0m, Total width: W=12m (Without footpath) Foundation: Spread foundation

Source: JICA Study Team

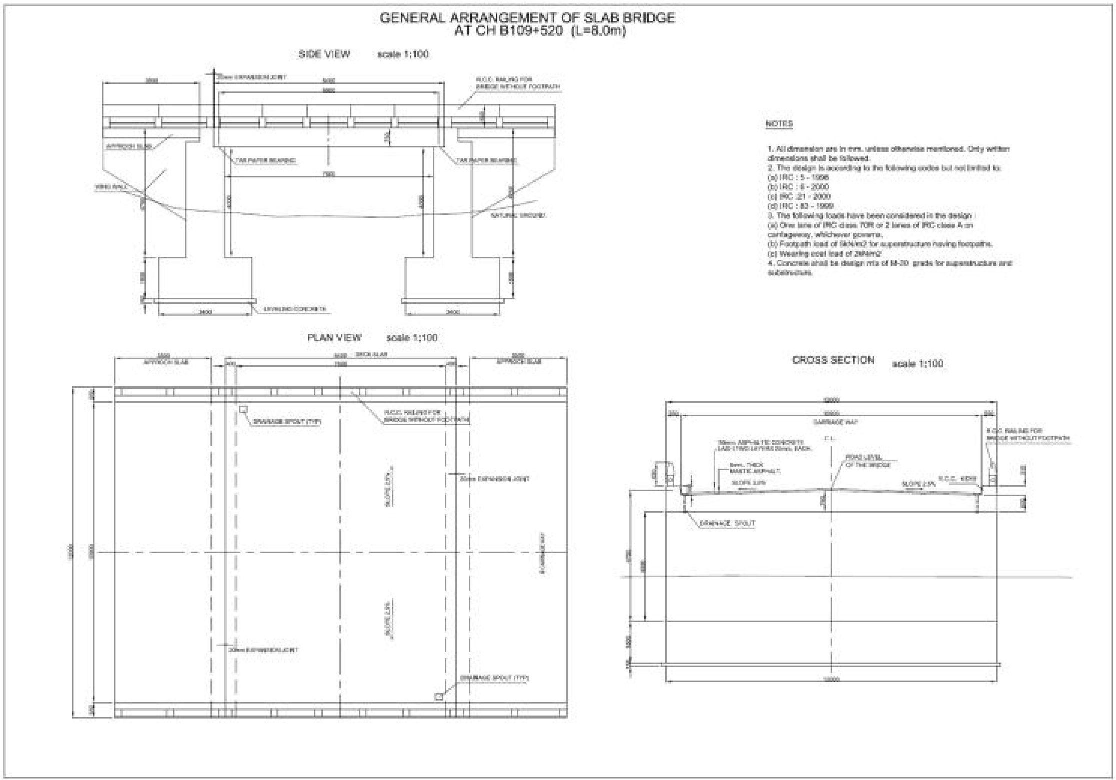
- Both bridges have comparably short spans. Hence, IRC typical drawing can be applied. The superstructure is planned based on the IRC typical drawing. Range for RC slab is 6 m to 10 m and for RC T-beam, it is 10 m to 24 m. Hence, structural types for proposed new bridges are RC T-beam and RC slab bridge, respectively.
- The bridge width is planned as 12 m based on IRC:73. Footpath of 1.5 m width is provided at both sides.
- No trace of submergence is seen in the existing bridge. Hence, the clearance under the girder similar to that of the existing bridge is to be provided. The road level is to be decided by the approach road level.
- Spread foundation with comparably shallow depth is supposed because some rocks appeared above the ground surface around the site.

- Because the bridge is composed of RC and masonry members only, concrete work with mixer at the site is proposed. After the demolition of the existing bridge, foundation is constructed. The superstructure concrete will be by cast in-situ on the support.
- Temporary road is required for traffic diversion during construction. Construction during the dry season is recommended.



Source: JICA Study Team

Figure 7.3-9 T-beam Bridge (L=12m)



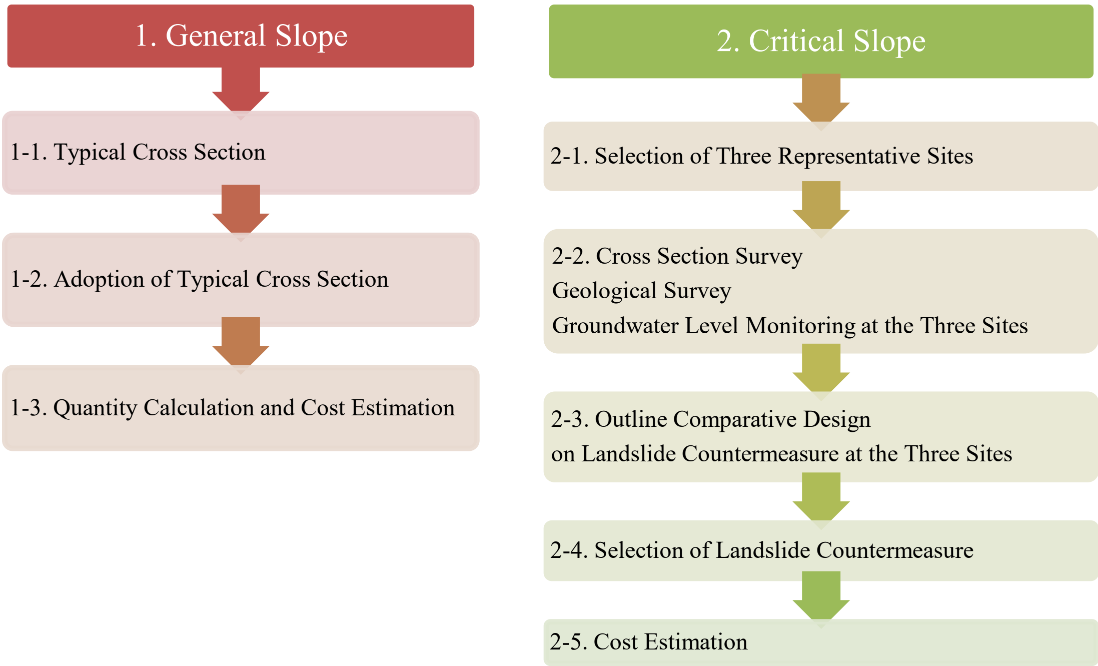
Source: JICA Study Team

Figure 7.3-10 Slab Bridge (L=8m)

7.3.4 Earthworks / Slope Protection / Landslide Prevention Design

(1) Methodology

Figure 7.3-11 shows the flow of the methodology of planning for earthworks, slope protection, and landslide prevention works. Based on the slope inventory survey as mentioned above, slopes all along the road were evaluated as either critical slope which has existing landslide disaster or risk of large-scale mass movement and slope failure or general slope which has less landslide risk. It is necessary to survey geology, geotechnical condition, geography, aquifer, and slide surface in detail, and design countermeasures individually for the critical slope.



Source: JICA Study Team

Figure 7.3-11 Flowchart of Plan on Slope Protection Work

(2) Proposed Design Policy and Design Criteria

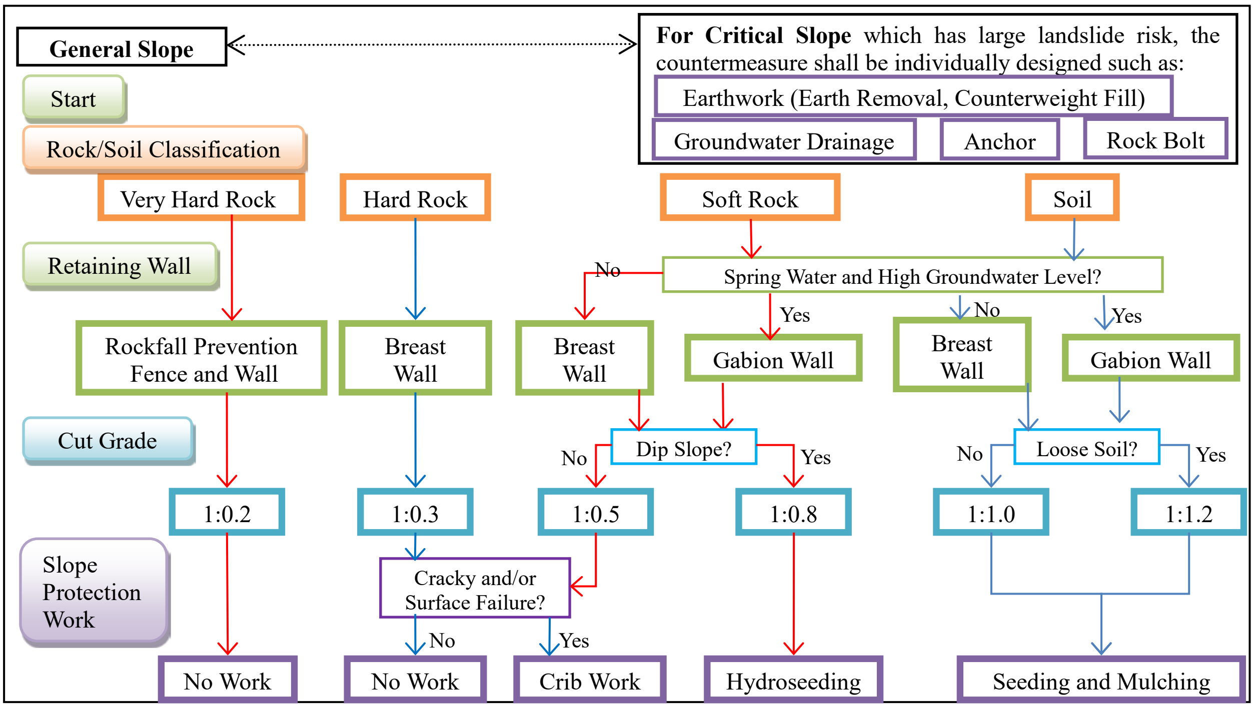
Against the general slopes, slope protection work, retaining wall, and grade of cut/embankment slope shall be planned based on natural condition including geology, geotechnics, and topography of each slope following the design criteria mentioned below. Especially, in order to prevent slope disaster, the design policies are established as below.

- Stable cut slope of soil and soft rock shall be covered with vegetation work.
- Unstable slope and unsuitable slope for vegetation shall adopt slope protection work.
- Height of one row of cut slope shall be 7 m at the maximum. In case exceeded, a berm with 1.5 m width shall be set between slopes.
- Total height of cut slope shall basically be 20 m at the maximum considering environment, construction workability, and disaster prevention.
- To prevent high cut slope, slope shall be cut steeper than stable grade and shall adopt slope protection work.
- Breast wall shall be built at the toe of slope on hill side to prevent small collapse and to maintain the side drain.
- Slope protection work shall be selected among common construction methods in India and Japan.
- Landslide site shall be avoided by road realignment as much as possible.

- If road cannot be planned not to pass the landslide area, landslide countermeasures such as groundwater drainage, counterweight fill, earth removal, and anchor work shall be examined for landslide stabilization.

Figure 7.3-12 summarizes the flowchart of selection of retaining wall type, cut grade, and slope protection works for cut slope on hill side. The critical slope which has large landslide with more than 1.0m depth and is expected to give huge damage to the road shall be individually surveyed and designed its countermeasures e.g. Earthworks including landslide removal and counterweight fill, groundwater drainage, anchor work, and rock-bolt work.

The JICA Study Team reviewed the existing manuals in India published by IRC (SP:48-1998, Hill Road Manual and Special Report, State of the Art: Landslide Correction Techniques, 1995), and started the design of the slope protection works. The criteria of earthworks such as cut and embankment based on the actual geotechnical condition at the site were improved. Because the manual is not enough for determination of dimension, specification of materials, and quantity of anchor work and reinforced earth wall, the JICA Study Team designed them utilizing the Japanese technical guideline for road works published by the Japan Road Association. Table 7.3-25 presents the result of the review of IRC regarding design of slope protection work.



Source: JICA Study Team

Figure 7.3-12 Flowchart of Selection of Slope Protection Work for Cut Slope

Table 7.3-25 Review of IRC for Slope Protection Design

Item	Clause	JICA Study Team Evaluation	
Earthwork			
Cut	IRC: 11.8 SR: 7.9.3.1	A	Modified the design criteria of cut grade in IRC based on the current condition of the slope. Berm presented in SR is so wide (6-11 m) that the JICA Study Team proposes 1.5 m wide following the Japanese guidelines.
Embankment	-	A	Not shown in the Hill Road Manual. Utilized the design criteria in Rural Road Manual (SP:20-2002).

Item	Clause	JICA Study Team Evaluation	
Retaining Wall			
Gravity Wall	IRC: 9.2	B	Improved the dimension because that in IRC is not economical and difficult to apply on steep slope.
Breast Wall	IRC: 9.3	C	The exact dimension is not shown in IRC.
Reinforced Earth Wall	IRC: 9.7	B	Explanation of the design method including the design calculation is not sufficient. IRC introduces only band steel strip type and does not mention about panel material of the front slope.
	SR 7.6.	B	SR shows the basic formulae of internal stability. It does not show the typical soil and tensile coefficient of embankment and reinforcing material for economical design.
Slope Protection			
Vegetation Work	IRC: 11.7.3 SR: 7.5.7.	B	Turfing and netting are introduced for prevention of erosion. Hydroseeding is not shown in IRC and SR.
Crib Work	-	C	Not shown in both IRC and SR.
Wire Rope Crib Work	-	C	Not shown in both IRC and SR.
Rockfall Prevention Wall and Fence	SR: 7.9.4.	C	SR presents the location to set the rockfall prevention fence. However, height and specification of the fence including allowable rockfall energy and calculation of the rockfall energy are not presented as well as implementation of rockfall simulation.
Landslide Countermeasure			
Groundwater Drainage	IRC: 11.6.2(c)	C	Specification in IRC is not effective for large landslide, but effective only for small collapse.
	SR 7.8.1.	B	Design criteria are unclear to decide length, alignment, and number of drilled groundwater drainage.
Counterweight fill	-	C	Not shown in IRC.
	SR 7.4.1.6.	A	SR suggests road realignment and embankment at the toe of the landslide slope. But any points to be considered such as stability and permeability of the embankment are not mentioned.
Erath Removal	-	C	Not shown in IRC.
	SR 7.4.1.6.	B	Similar to counterweight fill, SR suggests to reduce soil amount at the top of the landslide slope. But any point to be considered such as stability of the back slope is not mentioned.
Anchor Work	-	C	Not shown in IRC.
	SR: 7.3.8. SR: 7.9.3.5. SR: 8.3.3.	C	SR introduced anchor wall and practical example; however, it does not show the design method including calculation.
Rock-bolt Work	-	C	Not shown in IRC.
	SR: 7.9.3.5.	C	SR introduced the basic information on rock bolt. Design method including specification, length, and alignment of rock bolt are not explained in SR.

<u>Evaluation</u> A: Applicable to design
B: Necessary to add detailed design criteria for detailed design
C: No description, necessary to be introduced

Source: JICA Study Team

(3) Design of Earthworks

<u>Cut Slope</u>

Cut grade of slope above the retaining walls along the road shall be decided based on the geological and geotechnical conditions of the slope. Table 7.3-26 presents the design criteria of cut grades for each rock and soil classification compared with those in IRC. Because there are many slope failures on the existing cut slope with 1:0.3 consisting of weathered and loosen rock, the soft rock shall be cut with gentler grade than IRC and 1:0.5 to 1:0.8 grades. Harder rock slope can be applied with steeper cut grade, namely, very hard rock and hard slope shall be cut with 1:0.2 and 1:0.3, respectively. On the other hand, loosen and weakened rock and soil slope shall be carefully cut with gentler cut grades of more than 1:0.8.

Against rock slope which is cracky and has a risk of rockfall or slope failure, crib work shall be applied for prevention of damage, which can deter surface failure and rockfall with around 10 m^3 (less than 3 m width and less than 1 m depth) on the cut slope. In case that larger landslide is concerned, landslide countermeasures such as anchor and rock bolt works need to be planned individually under the countermeasure design for the critical slopes.

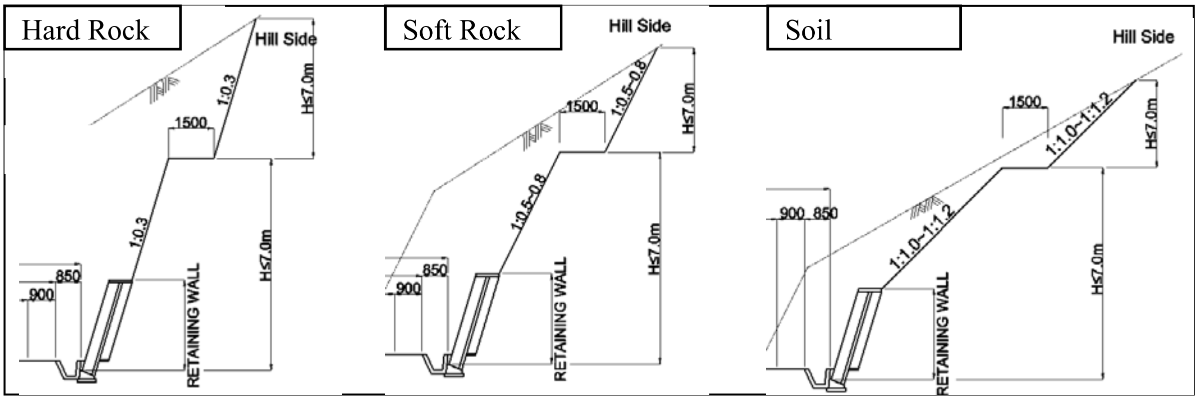
For prevention of erosion and surface failure and also for landscape improvement, most of the cut slope shall be covered by hydroseeding work or seeding and mulching, and will be greened. The thickness of the sprayed hydroseeding shall vary from 3 cm to 7 cm depending on the geotechnical condition. The cut slope of soft rock which is cut with 1:0.8 is applied with 5 cm thick hydroseeding. Seeding and mulching are applied for soil cut slope. As very hard or hard rock slope consists of intact bedrock and is cut with steep grade, the vegetation work including hydroseeding cannot be applied because the plant cannot be expected to grow on such slope.

Table 7.3-26 Design Criteria of Cut Grade and Protection Work

IRC Standard*		JICA Study Team Rock/Soil Classification			Cut Grade	Slope Protection Work
Classification	Cut Grade					
Hard Rock	**80 ~ 90 degree**	Rock	Very Hard		**1:0.2**	No protection work
			Hard	No Risk	**1:0.3**	No protection work
				Landslide Risk		Crib work
Ordinary Soft Rock	**1:0.25 ~ 1:0.125**		Soft	Non-dip Slope	**1:0.5**	No protection work
				Dip Slope	**1:0.8**	Hydroseeding (t=5 cm)
Ordinary Soil/ Heavy Soil	**1:1.0 ~ 1:0.5**	Soil	Dense Soil		**1:1.0**	Seeding and Mulching
			Loose Soil		**1:1.2**	Seeding and Mulching

*IRC: SP:48:1948 Clause 7.4

Source: JICA Study Team



Source: JICA Study Team

Figure 7.3-13 Typical Cross Section of Cut Slope

<u>Embankment on the Valley Side</u>

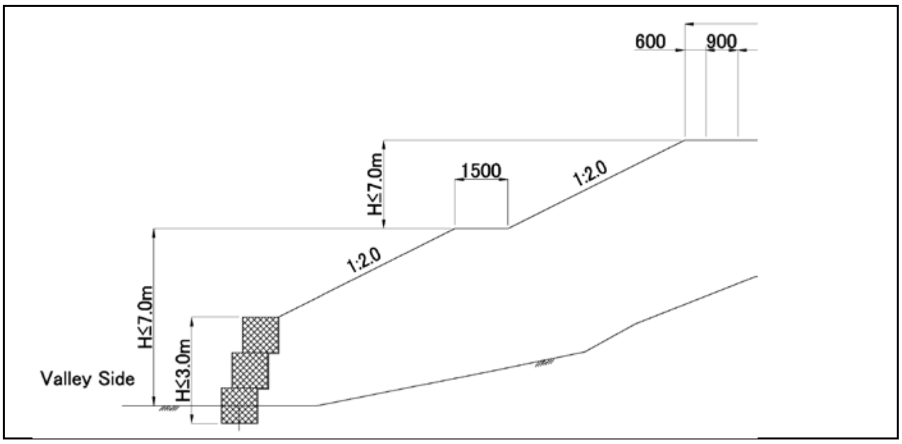
Slope grade of embankment slope is generally decided based on the embankment material and total slope height. Because surplus soil by cutting is expected to be utilized as embankment material in this project, the embankment material is composed of gravelly soil derived from sandstone and shale. The slope grade of embankment is proposed as shown in

Table 7.3-27. In order to prevent surface failure on the embankment slope, retaining wall such as gabion wall shall be built at the toe of the slope. Also, turfing shall be implemented on the embankment slope for prevention of erosion and landscape improvement.

Table 7.3-27 Design Criteria of Embankment Slope and Slope Protection Work

IRC Standard*		Embankment Material	Height	Grade	Slope Protection Work
Classification	Grade				
Embankment	**1:2.0**	Gravelly Sand derived from Cutting	less than 5 m	**1:1.5**	Turfing
			5 ~ 20 m	**1:2.0**	Turfing

*IRC: 36-1970
Source: JICA Study Team



Source: JICA Study Team

Figure 7.3-14 Typical Cross Section of Embankment Slope

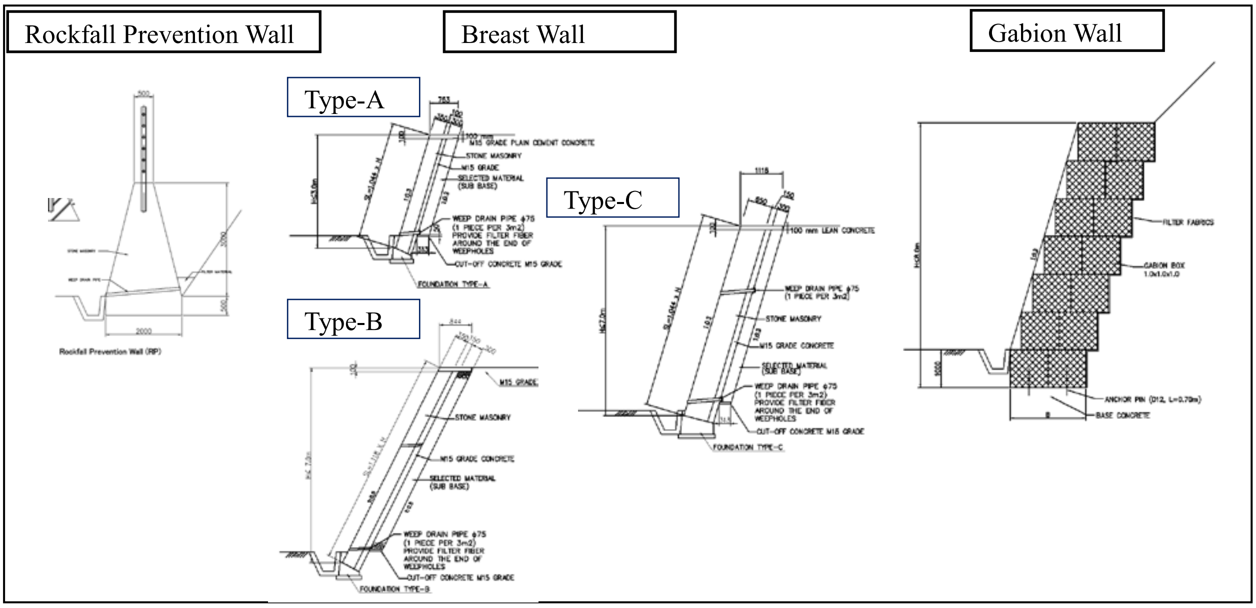
(4) Retaining Wall

Retaining walls shall be built on the toe of almost all slopes on the hill side along the road in order to prevent small debris fall on the cut and natural slopes from accumulating in the side drainage that can result in the damage of pavement due to flooding discharged water. Table 7.3-28 shows the design criteria of the retaining wall. To reduce cut soil amount, the type of the retaining wall shall be changed by slope topography. Namely, large retaining wall with 65 cm thickness shall be applied for higher slope, and small one with 35 cm thickness shall be applied for other lower slope and soil slope. Gabion wall, which has high permeability, shall be adopted for the slope where spring water was found at the site and groundwater level was assumed to be high. In high and steep slopes consisting of very hard rock strata, gravity-type retaining wall with high-intensity rockfall prevention fence shall be built at the toe of the cut slope in order to prevent rocks from falling on the road.

Table 7.3-28 Design Criteria of Retaining Wall on Hill Side

Slope Type			Wall Height	Retaining Wall Type (Grade on Front Slope)	
Rock	Very Hard		**Less than 3.0 m**	Rockfall Prevention Wall	1:0.25
	Hard		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
			3.0 ~ 7.0 m	Breast Wall Type-C	1:0.3
	Soft		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
			3.0 ~ 7.0 m	Breast Wall Type-C	1:0.3
		High Groundwater Level	**Less than 8.0 m**	Gabion Wall	1:0.3~
Soil	Dense Soil		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
		High Groundwater Level	**Less than 8.0 m**	Gabion Wall	1:0.3~
	Loose Soil		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
		High Groundwater Level	**Less than 8.0 m**	Gabion Wall	1:0.3~

Source: JICA Study Team



Source: JICA Study Team

Figure 7.3-15 Typical Cross Section of Retaining Walls

(5) Embankment Structure

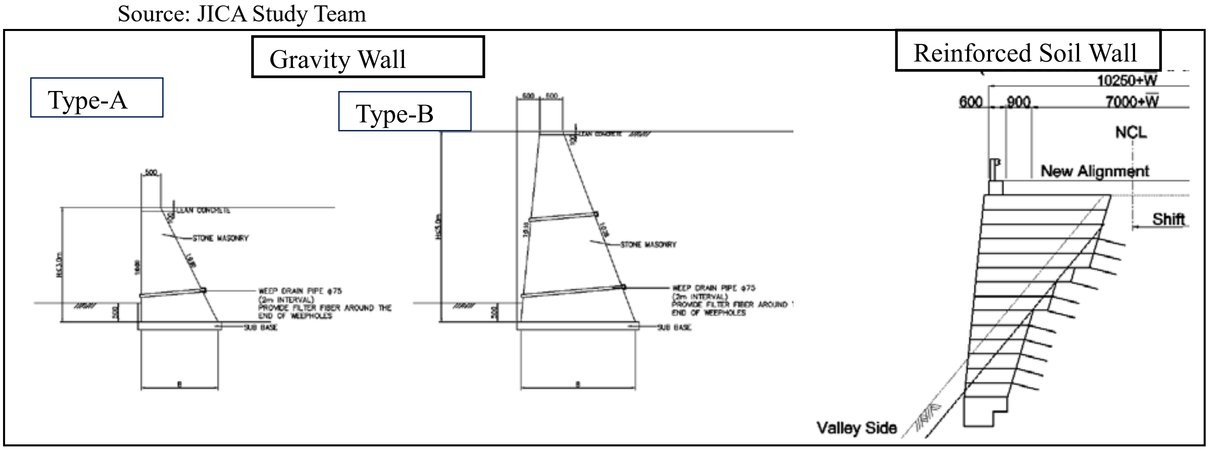
Retaining walls are built in front of the road embankment with road widening on the valley side. The type of retaining wall should be selected depending on the slope topography on the valley side. For gentle and low valley slope which is gentler than 30 degrees, gravity wall is frequently used for soil retaining. Because the gravity wall which has vertical or very steep grade on the front slope needs to excavate largely behind the wall during construction, it is necessary to pay attention to ensure the present traffic during construction. Steep and high slopes, as frequently seen in NH54, need the reinforced earth wall which can be built with steep gradient on its front slope and more than 20 m in height.

As there is often loose soil dumped in the past road construction on slope of valley side, embedded depth for foundation of the retaining wall shall be 2 m on soil slope and 1 m on rock slope.

Table 7.3-29 Design Criteria of Embankment Structure

Retaining Wall Type		Height	Grade of Front Slope	Apply to
Gravity Wall	Type-A	less than 3 m	**Vertical**	Gentle and Low Slope
	Type-B	less than 5 m	**1:0.1**	Gentler than 30 degrees
Reinforced Earth Wall		5 ~ 20 m	**1:0.1**	High and Steep Slope

Source: JICA Study Team

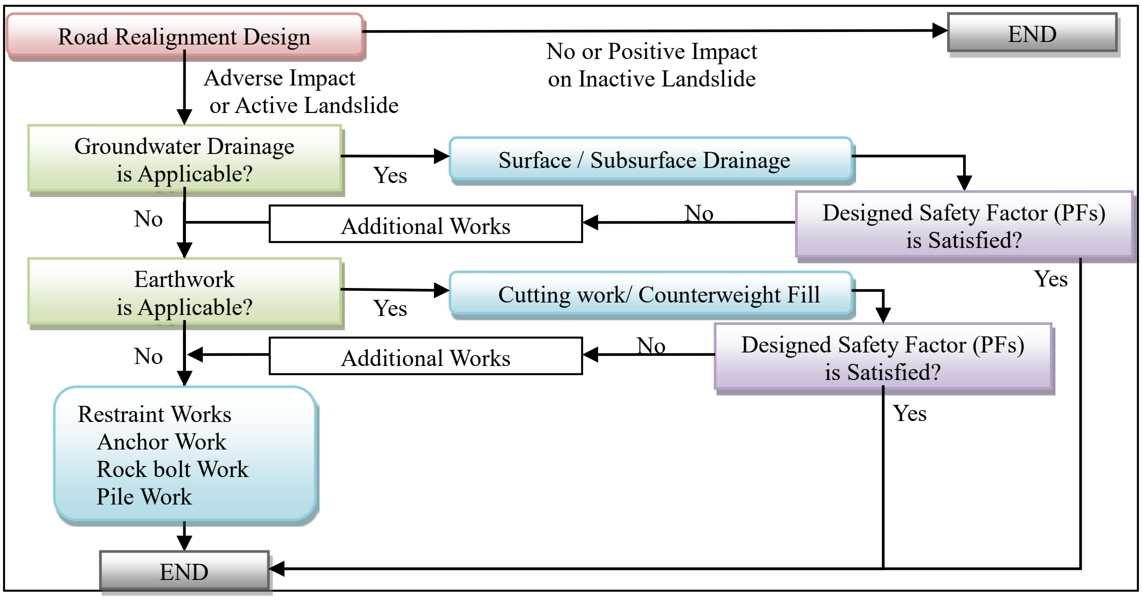


Source: JICA Study Team

Figure 7.3-16 Typical Cross Section of Retaining Walls

(6) Landslide Prevention Design

Landslide prevention measure was planned and designed for the critical slopes identified in the slope inventory survey. Figure 7.3-17 shows the flowchart of selection of the landslide prevention measures. As mentioned in 7.3.2, the design of road alignment with widening was carried out taking into consideration the location of the critical slopes so as not to give adverse impact on the landslide movement. Then, if there is no or positive impact on the inactive landslide, any prevention measure is not necessary. However, if landslide is active or is concerned to be destabilized by road widening, landslide countermeasure shall be implemented. The landslide prevention measures are mainly divided into three types, namely: groundwater drainage work, earthwork such as earth removal and counterweight fill, and restraint work including anchor, rock bolt, and pile work. In general, groundwater drainage work is the cheapest followed by earthwork. But they are often constrained by topographical, geotechnical, and geohydrogical conditions. On the other hand, restraint work which prevents the landslide movement by force is commonly expensive, but they can be adapted to most landslides because they can be implemented in limited space. Therefore, groundwater drainage and earthwork shall be introduced or combined with other method as much as possible in order to reduce the cost of the countermeasures.



Source: JICA Study Team

Figure 7.3-17 Flowchart of Landslide Prevention Measure

Table 7.3-30 Process of Safety Factor by Landslide Prevention Measures

Landslide Site	Groundwater Drainage		Earthwork		Restraint Work	
A	Not Applicable	0.980	Not Applicable	0.980	Anchor Work	1.100
B	Applicable	1.015	Not Applicable	-	Anchor Work	1.100
C	Applicable	1.023	Applicable	1.123	Not Necessary	-

Fs0=0.098, PFs=1.100

Source: JICA Study Team

Against the three representative landslides where boring works were carried out as mentioned in Clause 7.2.3, outline design of the landslide prevention measure was conducted. Table 7.3-30 shows the progress of safety factor by planned landslide countermeasures. Because these landslides are unstable and assumed to slide actively during the rainy season, initial safety factor in stability analysis was set at Fs0=0.980. And designed safety factor of pFs=1.10 is aimed to be raised by 12% from the initial safety factor.

Groundwater level in Landslide A is so low that groundwater drainage work is expected to be ineffective. Also, earthwork is not applicable because of limited topographic condition and surrounding houses. Therefore, Landslide A shall adopt anchor work of restraint works.

Landslide B has groundwater level just above the slip plane. Groundwater drainage is applicable, but it cannot satisfy the designed safety factor by itself and additional earthwork including earth removal is not applicable because the road is located near the top of the landslide slope. It is necessary to implement anchor work of restraint works to prevent the progression of road sinking.

Landslide C is also assumed to have groundwater level above the slip plane, and earth removal at the top of the slope and counterweight fill at the toe of slope can be feasible. Therefore, both groundwater drainage and counterweight fill are so effective that both are planned for landslide stabilization without restraint work.

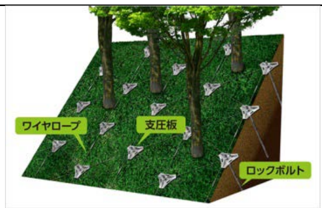
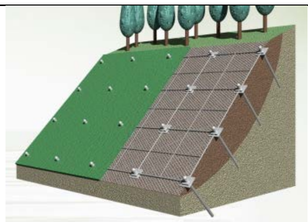
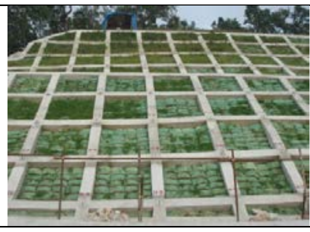
The planned landslide prevention measures are shown in the drawings in Annex-5 of this report.

(7) Slope Failure Prevention Measures on Natural Slope

Against slope failures on natural slope above the retaining walls at the toe of the slope or cut slope with stable grade, prevention measure shall be planned in the same manner as the landslide prevention measures mentioned above. But because construction will be done on natural slope, not only economy but also landscape is taken into consideration when selecting the countermeasure.

Table 7.3-31 presents the comparison of three countermeasures against the slope failure on natural slope. Two countermeasures, namely, non-frame methods and GF rock bolt measure, which are manufactured by Japanese companies, are compared with the traditional methods, i.e., crib work with rock bolts. These two countermeasures have advantage in that they can be forested after construction and improve landscape. But they need to install rock bolts in the whole construction area, so their economies are worse than the crib work in many cases. Non-frame method can be constructed without deforestation and can preserve existing trees in the construction area. It is also more economical than GF rock bolt method. Therefore, non-frame method shall be adopted against the slope failure on natural slope. And crib works with rock bolt can be adopted for cut slope where slope failure is concerned.

Table 7.3-31 Comparison of Three Slope Failure Prevention Measures on Natural Slope

Construction Method	Non-frame	GF Rock Bolt and Rope Net	Crib Work with Rock Bolts
Photo/ Schematic Image			
Manufacturer	Nippon Steel and Sumikin Metal Products Co., Ltd.	Tokyo Rope MFG Co., Ltd.	-
Environment	Unnecessary to deforest and environmentally-friendly. <good>	Necessary to deforest due to installation of metal mesh. Planting and seeding are available after construction. <fair>	Planting and seeding are available inside the frame. Landscape is not better than the other methods. <poor>
Economy	More expensive than crib work with rock bolts in many cases due to rock bolt installed in the whole construction area. <fair>	Need more materials than the non-frame method and more expensive. <poor>	Unnecessary to install the rock bolt on whole area and more economical than the other methods in many cases. <good>
JICA Study Team Proposal	Adopted only for natural slope	Not adopted	Not adopted (Adopted on cut slope)

Source: JICA Study Team

(8) Slope Management

This study planned and designed slope protection works as structural measure to prevent landslide disaster. In order to realize high safety and reliability of mountainous road network such as NH54 in Mizoram, it is very important to implement nonstructural measures such as (1) daily, routine, and emergency inspection, (2) maintenance/countermeasure, and (3) development and operation of early warning system in addition to structural measures above. According to the interview survey by the JICA Study Team, NHIDCL is planned to be the main implementation organization of road operation and maintenance after this road improvement project. Table 7.3-32 proposes the main items of slope management and planned implementation.

Table 7.3-32 Slope Management Method and Planned Implementation

Item		Implementation (Draft)	Description
Inspection	Daily Inspection	NHIDCL/ Contractor	To confirm condition of road and slope. Frequency is set depending on the traffic amount.
	Routine Inspection	Consultant	To formulate and upgrade disaster prevention record. Basically once a year.
	Emergency Inspection	NHIDCL / Consultant	In case of extreme weather and disaster such as heavy rain above a certain size and earthquake, to confirm damage on road facilities and plan emergency and permanent countermeasures.
	Data Collection/ Analysis	NHIDCL / Consultant	To analyze data of daily, routine, and emergency inspection, upgrade database and hazard map, and formulate disaster prevention program. To prioritize the sites for maintenance and countermeasure.
Mentenance/ Contermeasure	Daily Maintenance	NHIDCL / Contractor	To improve function of road facilities and clear road hazard. Clean road surface and side drainage and weeding and pruning on road shoulder and slope for improvement of visibility.
	Routine Maintenance	Constructor	To construct countermeasures against the deformation and damage detected in the routine inspection based on the prioritization.
	Emergency Maintenance	NHIDCL/ Contractor/ Constructor	To remove debris and construct countermeasures with emergency when landslide occurs during heavy rainfall in order to clear road hazard early.
Development and Operation of Early Warning System		NHIDCL/ Relevant Organization	To enforce traffic control when extreme weather and disaster such as heavy rain and earthquake in cooperation with relevant organization (PWD, police). NHIDCL conducts observation of rainfall and landslide movement.

Source: JICA Study Team

Inspection:

Inspection detects road deformation and hazard early and understands the deterioration of road facilities. Daily inspection is conducted once in one to three days depending on traffic amount and importance of road section. On the other hand, routine inspection confirms the progress of road deformation by simple measurement of distance between pins driven along cracks as well as visual check. Emergency inspection confirms the presence of damage and hazard mainly on the routine inspection sites just after disaster occurrence such as heavy rain and earthquake. Those inspection records are saved and accumulated in fixed format, and utilized for prioritization of the inspected slopes and planning and upgrading of effective, efficient, and economical disaster prevention program. The daily and emergency inspection shall be conducted by NHIDCL project office directly or its contractor. The routine inspection shall be conducted utilizing hired consultants so that they formulate and upgrade disaster prevention record and hazard map and formulate a workable disaster prevention program.

Maintenance/Countermeasure:

Based on the formulated disaster prevention program, maintenance and countermeasures such as slope protection works are implemented in order of priority. Cleaning on road and weeding on road slope are implemented on a daily basis. Daily maintenance including cleaning is the responsibility of NHIDCL or contacted company, but routine maintenance is expected to be implemented by constructor which is selected through the usual procurement process. Disaster rehabilitation shall be implemented by a constructor contracted in advance or NHIDCL directly in order to reopen road traffic as early as possible.

Early Warning System:

Because frequency of local heavy rain has increased with climate change, there is high possibility of road closure due to landslide disaster due to heavy rain. Control standard values of continuous and hourly rainfall for road closure are set up based on past rainfall data and disaster history of the road in order to prevent road disaster before landslide occurs. Therefore, the JICA Study Team proposes the early warning system including rainfall gauge as shown inFigure 7.3-18. Early warning system shall be installed and it shall notify the current road condition to the road users. In order to detect local heavy rain and follow disaster occurrence, NHIDCL should install and operate rainfall gauges as well as utilize the existing gauges of the India Meteorological Department. Furthermore, because sufficient rainfall data and disaster history are not organized so far, the control standard value for road closure should be examined taking into consideration safety based on much data collected for the period from detailed design to construction. The control standard value will be pulled down step-by-step based on the experienced rain and road condition.

Electrical Bulletin Board Solar Panel Rainfall Gauge

Source: The Project for the Operation and Maintenance of the Sindhuli Road, Photo by Nippon Koei Co., Ltd.

Figure 7.3-18 Example of Early Warning System in Nepal

7.3.5 Pavement Design

(1) Design Standards and Guidelines

Design guideline for flexible pavement is published by IRC as “Tentative Guidelines for the Design for Flexible Pavements (IRC37-2012).

(2) Pavement Design

Pavement design for NH54 is decided by NHIDCL in the meeting held on 14 August 2015 at NHIDCL as shown in Table 7.3-33.

Table 7.3-33 Pavement Conposition of NH54

Pavement Layer	Thickness (mm)
BC (Bituminous Concrete)	40
DBM (Dense Graded Bituminous Macadam)	100
WMM (Wet Mix Macadam)	250
GSB (Granular Sub-Base)	300
Total	690

Souce: JICA Study Team

7.3.6 Drainage Design

(1) General

It is required to facilitate culvert or side ditch on the road for draining water surrounding or upstream of the road to the downstream section properly. Specially, hill road always suffers from large volume of water falling from mountain slope towards the road. It is quite important to protect the road by arranging cross-drainage appropriately to satisfy the discharge from crossing water.

On the existing NH54, a large number of culverts exist that are crossing under the road. Because the road improvement includes road widening and alignment modification in most section, appropriate measures for culverts such as demolition/reconstruction or extension of existing culverts are considered to be undertaken in each location.
However, it is considered that retention of existing culverts with extension measure is not practical under the situation. The reasons are explained below.

- Position shift due to road improvement: The culvert length needs to be extended due to road widening from existing 6-7 m to 12 m width. Also, the culvert position to be placed is changed because the road centerline is shifted by the alignment modification. Specially, it can be shifted to the valley side at every valley section where the curve radius is modified to be larger by alignment modification. Hence, the extension measure on existing culverts does not reduce the volumes compared with new construction. In addition, it makes the work more complicated.

- Condition of existing culvert: The existing structures constructed at the origin of the road are aging at nearly 50 years. It was confirmed by the investigation that these structures do not provide appropriate durability, structural features, and maintenance performance to be utilized in an improved national highway.

Moreover, it cannot be ensured that existing culverts are well durable for the next several decades. The replacement on one occasion of the road improvement would be much advantageous in terms of economy and serviceability of the road compared with frequent occasional replacement in the near future.
Hence, it is general policy that existing culverts are demolished and new culverts are constructed.

The new drainage system is designed based on the hydrological calculation result. Based on the obtained location of water crossing and water discharge, the dimensions and locations of the drainage system are determined. For cross-drainage structure, appropriate culvert type is selected by taking into account the economy, construction workability, and maintenance ability.

(2) Outline and Condition of Existing Culvert

Existing culverts on NH54 can be categorized into four types. The structural outline and condition of each type of culvert are summarized in Table 7.3-34.

Generally, existing RC concrete and masonry culverts have the tendency to deteriorate over time. Also, many culverts fully accumulate soil in the inside.

Table 7.3-34 Outline and Condition of Existing Culverts

Type	Outline	Condition
Slab Culvert	It is the structure of RC slab plate with masonry abutments. Stones are laid at the bottom. For some of these, an inlet or outlet wall is integrated with the retaining wall. Mostly, the dimension is 1 m to 1.5 m. Some are 5 to 6 m like small bridge. It is assumed that these slab culverts have been retained since the original construction of NH-54.	-Concrete exfoliation and exposure of steel bar at back side and edge of slab plate -Shortage of concrete cover at the back side of slab plate, as seen, exposure of steel and coating of mortar -Collapse of slab plate and pavement -Exfoliation of masonry abutment
Slab Culvert (Large Type)	It is a large type of slab culvert which spans approximately 5 m to 7 m. This type exists at about ten locations in NH54.	-For some culverts, concrete exfoliation and exposure of steel bar at the edge of slab plate
RC Hume Pipe	It is the structure of reinforced concrete (RC) hume pipe connecting same pieces. Diameter ranges from 0.8 m to 1.5 m approximately. For some of these, an inlet or outlet wall is integrated with the retailing wall. It is assumed that these RC pipes were installed recently.	-Concrete exfoliation and exposure of steel bar at joint between pipes -Clacks at surface of concrete
GCI Sheet Pipe	It is the structure of galvanized corrugated iron (GCI) sheet. Diameter ranges from 0.6 m to 1.5 m. A masonry headwall is at the inlet or outlet of the pipe. Construction year is unknown.	-Deformation and tear of parts -Settlement and collapse of pavement

Source: JICA Study Team

Examples of existing culverts at the site for each type are shown in Figure 7.3-20 to Figure 7.3-23.

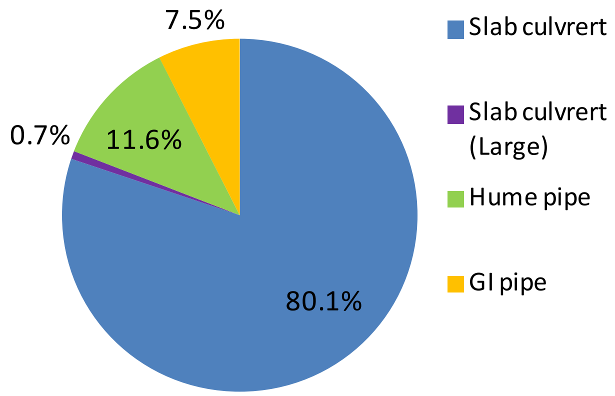
According to the results of the inventory survey conducted in the study, slab culvert covers approximately 80% of the existing culverts in NH54. The quantity of slab culvert is larger near to the Tuipang side.

The rate of structural type of existing culvert is summarized in Table 7.3-35 below.

Table 7.3-35 Rate of Structural Type of Existing Culvert

Section (DPR border)	Section-I 8-125km		Section-II 125-250km		Section-III 250-380km		Total	
	Nos.	Rate(%)	Nos.	Rate(%)	Nos.	Rate(%)	Nos.	Rate(%)
Slab Culvert	148	47.3%	411	80.4%	543	98.5%	1102	80.1%
Slab Culvert (Large)	0	0.0%	5	1.0%	5	0.9%	10	0.7%
Hume pipe	118	37.7%	39	7.6%	3	0.5%	160	11.6%
GI pipe	47	15.0%	56	11.0%	0	0.0%	103	7.5%
Total	313	100.0%	511	100.0%	551	100.0%	1375	100.0%

Source: JICA Study Team



Source: JICA Study Team

Figure 7.3-19 Rate of Structural Type of Existing Culvert

Large type of slab culvert is located at several points on the existing road. It should cause large volume of crossing water during the rainy season at such location. Hence, large sized culvert will be planned at the location.

The large slab culvert confirmed by site investigation is summarized in Table 7.3-36.

In the table, the structure at B90+240 was classified as a bridge in DPR. According to PWD, the design live load for the structure is 40R.

Table 7.3-36 Large Slab Culvert

Chainage	Opening Width (Span Length)	Road Width (Inlet to Outlet)	Average Height	Condition
At 198+430	6 m	10 m	4.0 m	
At 225+930	7 m	6.7 m	4.5 m	
At 229+480	5 m	9.6 m	5.0 m	Concrete exfoliation and exposure of steel bar at edge of slab plate
At 229+630	6 m	6.3 m	4.5 m	
At 235+260	6 m	9.8 m	4.5 m	Scouring at bottom of masonry wall
At 437+660	6 m	7.4 m	4.5 m	
At 503+870	7 m	9.8 m	4.5 m	
At 506+110	5.5 m	7 m	4.0 m	
At 508+080	6.5 m	7 m	3.5 m	
At 511+190	6.6 m	7 m	5.0 m	

Source: JICA Study Team

By considering structural viewpoint, it is recommendable for all existing culverts to be replaced with new culverts during the same occasion of the road improvement because:

- Slab culvert: Improper work for slab concrete, less design load, aging of RC slab and masonry abutment
- Slab culvert (Large type): Less design load, aging of RC slab and masonry abutment
- RC pipe: Unknown pipe class for existing (NP-2 according to DPR); Soil accumulation issue for small diameter pipes
- GCI sheet pipe: Structural weakness

(3) Design Standard

The design is based on the IRC standards in principle. For the detailed design stage, it shall be designed based on the IRC standards.

Major codes regarding drainage design is referred to the bridge design. The additional codes and typical drawings for drainage design are as follows:

Table 7.3-37 List of Major Codes for Drainage Design

IRC:SP: 13-2004	Guidelines for the Design of Small Bridges and Culverts (First Edition)
IRC: SP:42-2014	Guidelines on Road Drainage (First Edition)
MORTH	Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion
IS458 (2013)	Precast Concrete Pipes (with and without Reinforcement)

Source: JICA Study Team

Source: JICA Study Team

Figure 7.3-20 An Example of Existing Slab Culvert

Source: JICA Study Team

Figure 7.3-21 An Example of Existing RC Hume Pipe

Source: JICA Study Team

Figure 7.3-22 An Example of Existing GCI Sheet Pipe

Source: JICA Study Team

Figure 7.3-23 An Example of Existing Large Slab Culvert

(4) New Drainage Design

1) Cross Drainage Structure

Structural types of cross drainage include pipe culvert, box culvert, and slab culvert.

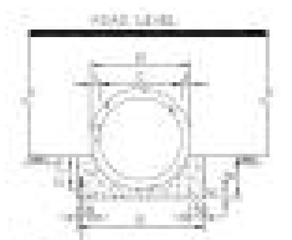
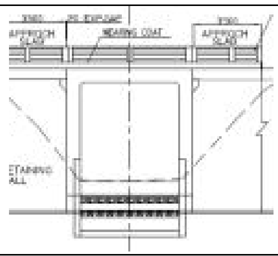
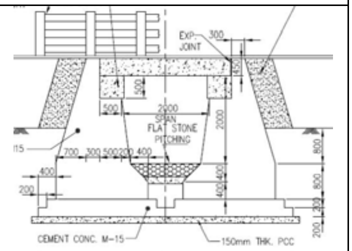
Pipe culvert is the most appropriate structure where the water discharge is comparably small. It has advantage of economy, and provision of quality because of precast manufacturing for RC pipes.

Box culvert is appropriate where the water discharge is more than the pipe capacity. Because box culvert is composed of all RC structures, it has higher durability and construction quality than slab culvert which is composed of slab plate and masonry abutment.

For such reason, box culvert was applied to the World Bank road which is a neighboring road of NH54 constructed few years before.

Each type of culvert is compared in Table 7.3-38 below.

Table 7.3-38 Comparison of Culver Type

	Pipe Culvert	Box Culvert	Slab Culvert
Layout			
Economy	◎	○	△
Construction Ability	◎	○	△
Durability	○	○	△
Capacity	○	◎	◎
Comment	To be applied for small discharge point	To be applied for large discharge point	Not applied

Source: JICA Study Team

Hence, pipe culvert is proposed where the water discharge is comparably small. Box culvert is proposed where the water discharge is comparably large. The size is determined to satisfy the water discharge obtained by hydrological calculation.

The contents of pipe culvert and box culvert are explained below.

- Culvert length from inlet to outlet is 12 m which is the same as the road width in the general section. However, it shall be widened to match the widening in curved section.
- Box culvert is based on the IRC standard drawings. Approach slab is needed for the approach part. RC railing is needed at the kerb at both sides. The inner dimension of box culverts is arranged between 2 m x 2 m and 4 m x 6 m to satisfy the discharge in each location. However, the dimension shall also take into account the topographical condition in each location during the detailed design.
- Pipe culvert is NP4 type based on IRC:13. It is based on the standards of IS458: Precast concrete pipes. The diameter of 1.2 m is planned to satisfy the capacity for discharge.
- At the inlet of the culvert, catch pit is required. For the section of excavation at slope side, the chute is required.
- At the outlet of the culvert, gabion is required to protect against erosion due to the flowing water at the hill slope.

- The headwall is required to retain earth at the inlet and outlet. It should be considered with retaining wall at the back and front side.

The capacity for each size of culvert is summarized Table 7.3-39 below.

Table 7.3-39 Capacity for Each Size of Culverts

	Size	A(m^2)	n	i (%)	Capacity (m^3)	Applied Condition
Pipe culvert	ϕ 1.2 m	1.028	0.013	5.0	4.17	Flowing full condition
BOX culvert	2 m x 2 m	4.000	0.033	5.0	15.88	Flowing full condition
	3 m x 3 m	9.000	0.033	5.0	36.19	Flowing full condition
	4 m x 4 m	12.400	0.033	5.0	95.71	Open section with vertical clearance of 0.9 m
	4 m x 6 m	18.600	0.033	5.0	166.95	Open section with vertical clearance of 0.9 m

Source: JICA Study Team

General arrangement plans for box culvert and pipe culvert are shown in the figures below.

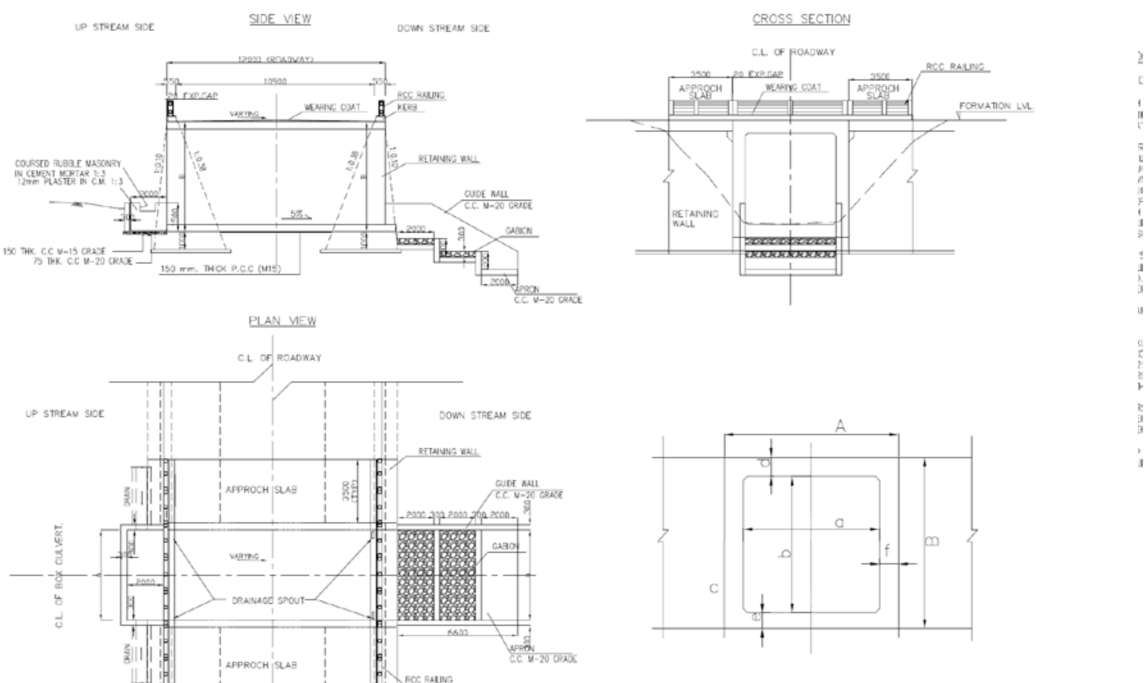
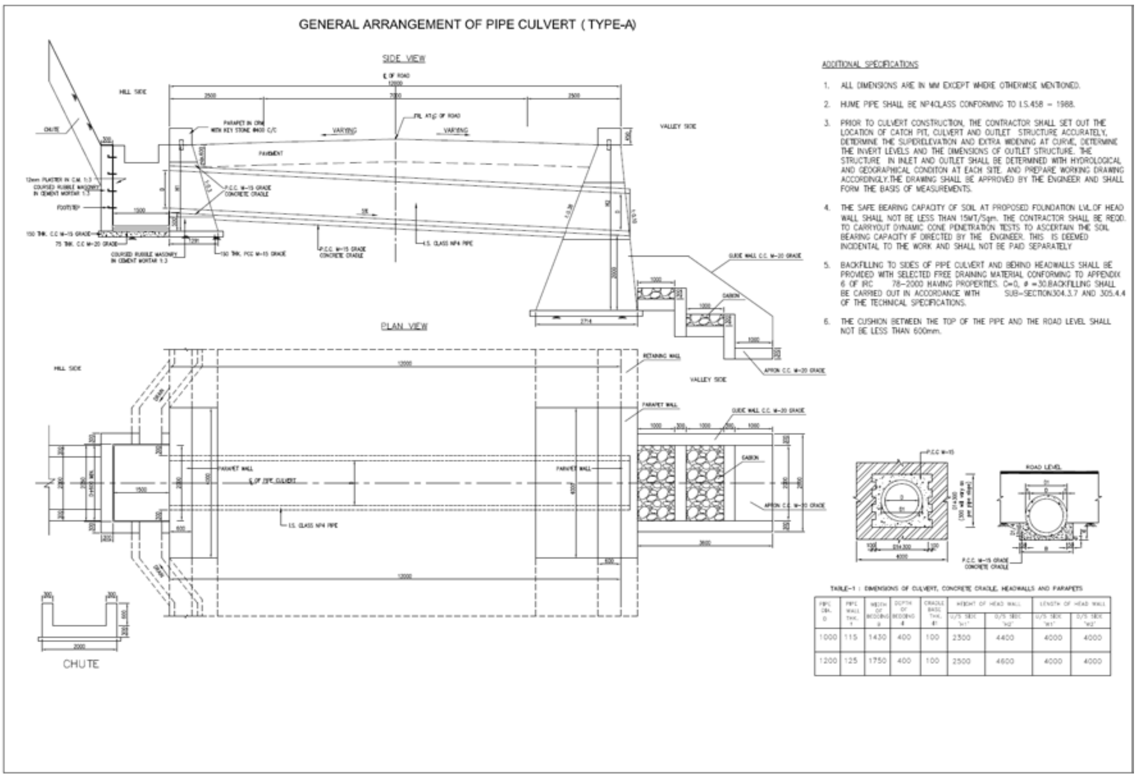


TABLE SHOWING SALIENT DIMENSIONS

BOX TYPE	a (mm)	b (mm)	c (mm)	d (mm)	e (mm)	f (mm)	A (mm)	B (mm)
2mx2m	2000	2000	500	350	380	300	2600	2730
3mx3m	3000	3000	900	420	420	420	3840	3840
4mx4m	4000	4000	1200	480	550	550	5100	5030
5mx5m	5000	5000	1500	580	680	700	6400	6260
6mx6m	6000	6000	1800	700	800	850	7700	7500

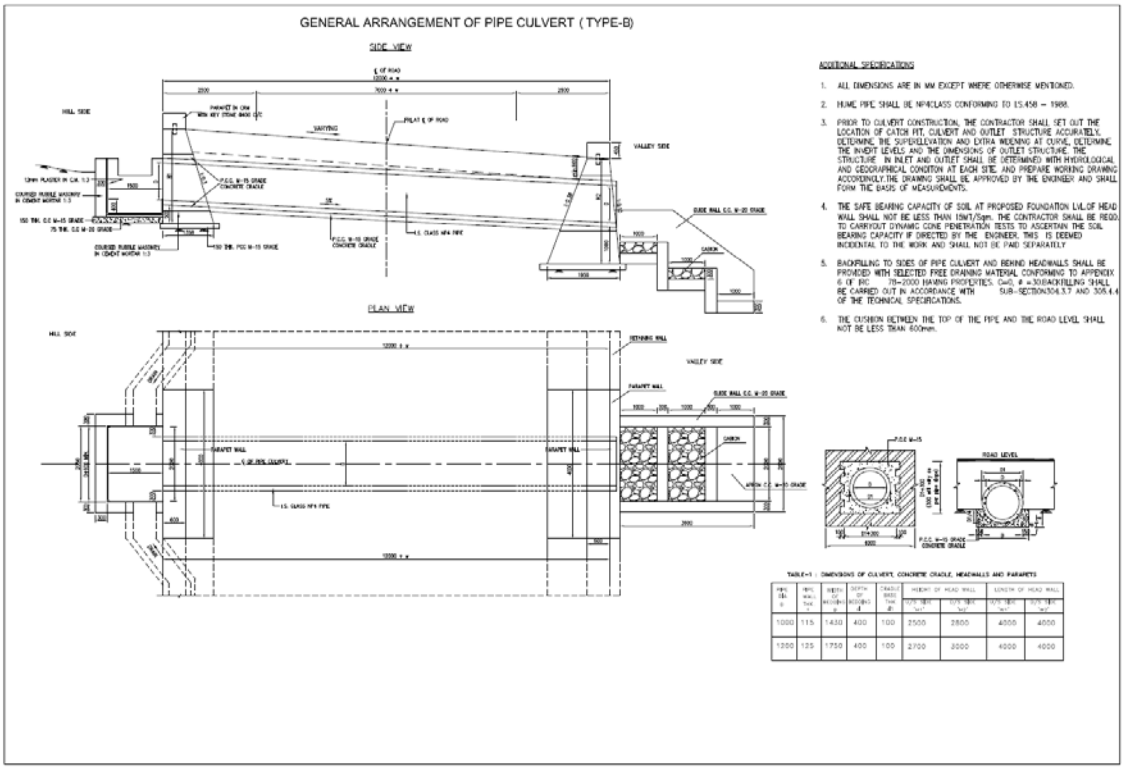
Source: JICA Study Team

Figure 7.3-24 General Arrangement Plan for Box Culvert



Source: JICA Study Team

Figure 7.3-25 General Arrangement Plan for Pipe Culvert (Type-A)

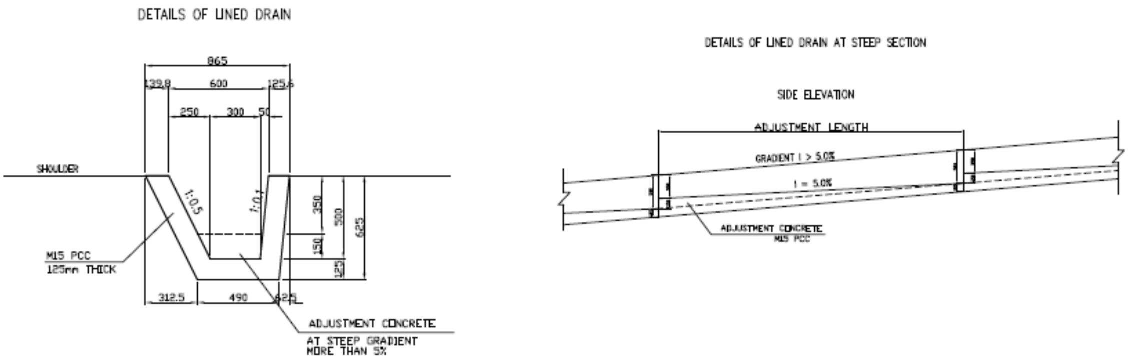


Source: JICA Study Team

Figure 7.3-26 General Arrangement Plan for Pipe Culvert (Type-B)

2) Side Ditch Structure

The side ditch on the road is designed as concrete lined ditch for all sections of cut side. General arrangement plan for side ditch is shown in the figure below.



Source: JICA Study Team

Figure 7.3-27 General Arrangement Plan for Side Ditch

3) Drainage Arrangement Plan

The cross drainage arrangement is planned with the following policy:

(i) The cross drainage which has adequate dimension for the estimated discharge is arranged at the location where the crossing water is estimated by hydrological map computation.

(ii) The location of existing culvert has high possibility of crossing water flowing. Hence, a pipe culvert of 1.2 m is planned at all locations of existing culverts even if crossing water does not appear based on the hydrological map computation.
The existing culvert location is based on topographical surveyed map prepared by DPR.

(iii) Side ditch capacity is not satisfied if the interval between cross drainages is too long. Hence, a pipe culvert of 1.2 m is planned to complement and shorten the long interval to to 300 m at the maximum.

The quantity of each culvert for each section is summarized Table 7.3-40 below.

Table 7.3-40 Quantity for Each Culverts

	DPR Section-1	DPR Section-2	DPR Section-3	All NH54
Pipe culvert 1.2 m	693	724	675	2,092
(Type-A)	277	290	270	837
(Type-B)	416	434	405	1,255
Box culvert 2x2 m	8	22	69	99
Box culvert 3x3 m	2	9	11	22
Box culvert 4x4 m	0	2	7	9
Box culvert 4x6 m	0	3	2	5
Total	703	760	764	2,227

Source: JICA Study Team

7.3.7 Traffic Safety Facilities Plan

(1) Scope of Traffic Safety Facilities

Traffic safety facilities are to be provided on roads or roadside to secure safety of all road users as well as nearby residents. In this study, considering road function of rural roads and usage situation of the target roads, the facilities listed in Table 7.3-41 are discussed for application to the project.

Table 7.3-41 Traffic Safety Facilities to be Applied for NH54

No.	Item	Remarks / Related Code
1	Traffic Sign	IRC67-2001, IRC7-1971, IRC-SP-31-1992
2	Road Marking	IRC35-1997, IRC-SP-31-1992, IRC2-1968
3	Road Delineator	IRC79-1981
4	Guardrail	
5	Street Furniture (Blinker, Road Stud/Cat's Eye)	MoRTH's Research Project R-63

Source: JICA Study Team

(2) Traffic Safety Facilities Proposed in DPR

The JICA Study Team received some documents that constitute DPR of the target roads, although they are not necessarily the full set of documents. Table 7.3-42 summarizes the traffic safety facilities that are considered to be proposed in DPR.

Table 7.3-42 Traffic Safety Facilities Proposed in DPR for NH54

ITEM	NH54-S1	NH54-S2	NH54-S3
Traffic Sign	To be provided in accordance with IRC67. No detailed quantities are available in Report.	To be provided in accordance with IRC67. Detailed quantities are as follows: (i) 90 cm equilateral triangle: 5 (ii) 60 cm equilateral triangle: 9 (iii) 60 cm circular: 12 (iv) 80 mm x 60 mm rectangular: 10 (v) 60 cm x 45 cm rectangular: 20 (vi) 60 cm x 60 cm square: 15	To be provided in accordance with IRC67. Detailed quantities are as follows: (i) 90 cm equilateral triangle: 24 (ii) 60 cm equilateral triangle: 55 (iii) 60 cm circular: 65 (iv) 80 mm x 60 mm rectangular: 50 (v) 60 cm x 45 cm rectangular: 55 (vi) 60 cm x 60 cm square: 60
Road Marking	Edge line marking (yellow continuous, thermoplastic paint) and center line marking (white broken) are to be provided. No detailed quantities are available in Report.	Center line marking (thermoplastic paint) is to be provided. Detailed quantities are as follows: Road Marking: 28,215 sqm (250 sqm/km)	Center line marking (thermoplastic paint) is to be provided. Detailed quantities are as follows: Road Marking: 31,131 sqm (253.92 sqm/km)
Road Delineator	To be provided where necessary. No detailed quantities are available in Report.	To be provided. Detailed quantities are as follows: Road Delineator: 100 (0.89 /km)	No information is available in Report.
Guard Rail	To be provided in built up areas. No detailed quantities are available in Report.	To be provided at bridge approaches and high embankments. Detailed quantities are as follows: Guard Rail: 10,000 metre (88.61 metre/km)	To be provided at bridge approaches. Detailed quantities are as follows: Guard Rail: 6,500 metre (53.02 metre/km)
Street Furniture (Blinker, Road Stud/ Cats Eye)	No information is available in Report.	No information is available in Report.	To be provided. No detailed quantities are available in Report.

Source: DPR Summarized by the JICA Study Team

(3) Approach for Traffic Safety Facilities Plan

The objectives of the preparation of traffic safety facilities plan in this study are to confirm the facilities proposed in DPR and to propose alternative plans where necessary. Furthermore, it will become a part of the basis of the project cost estimate. However, since the documents are available only partially, some information are still missing as shown in Table 7.3-42.

In this study, every effort is made to consider facilities in the similar manner as in the DPR in case where they are clear and reasonable. The quantities are estimated by assuming various conditions. Therefore, it shall be noted that further examination shall be made in the next stage, that is, modification of DPR based on their design basis.

(4) Traffic Sign

Traffic signs are to be installed to promote road safety and efficiency by providing the orderly movement of all road users in both urban and non-urban areas. Road signs notify road users of regulations and provide warning and guidance needed for safe, uniform, and efficient operations.

IRC:67-2012 stipulates three types of traffic signs, namely: 1) Mandatory/Regulatory Signs, 2) Cautionary/Warning Signs, and 3) Informatory/Guide Signs.

Figure 7.3-28 shows some of the typical traffic signs to be installed for the target roads.

Source: IRC:67-2012 Code of Practice for Road Signs (Third Revision)

Figure 7.3-28 Typical Traffic Signs

The number of traffic signs largely depends on the number and scale of towns/communities where the road passes. In this regard, the condition of Section-1 is considered to have a similarity with that of Section-3. Section-1 has Serchhip with population of 21,000 while Section-3 has Lawngtlai with almost the same population. Thus, it is assumed, in this study, that the same traffic signs are to be installed in Section-1 and Section-3. In this study, as a result, traffic signs shown in Table 7.3-43 are considered for the whole target road.

Table 7.3-43 Traffic Signs Estimated for NH54

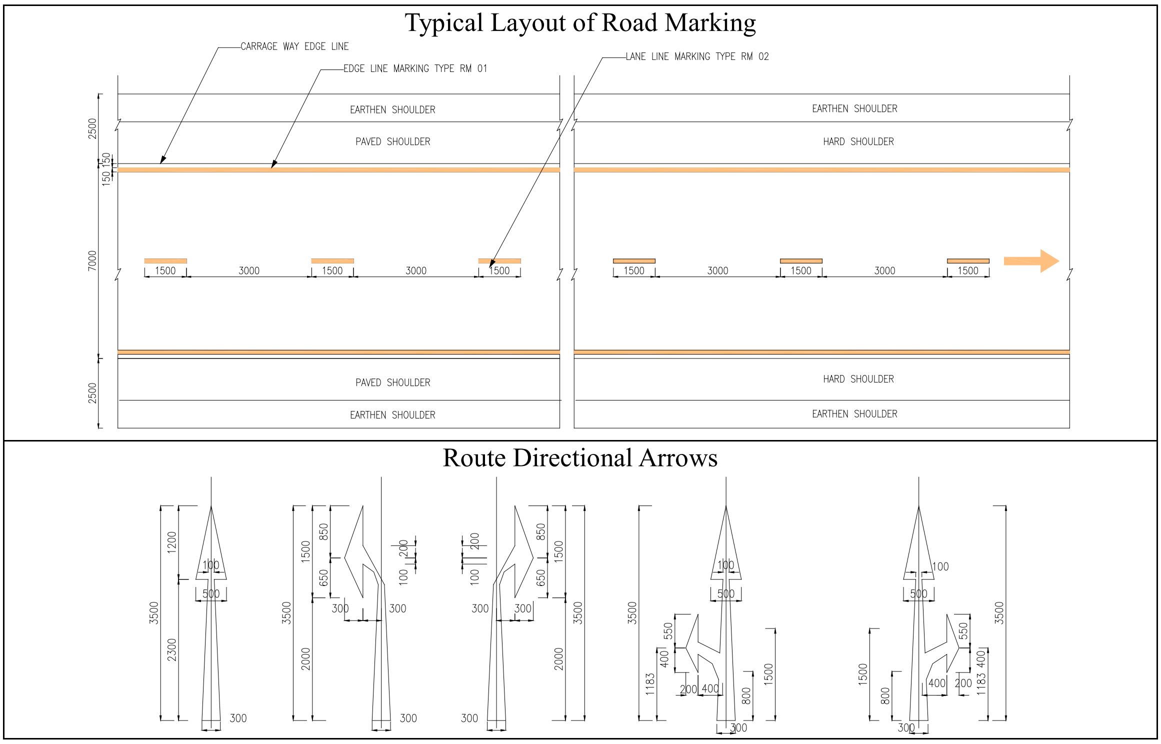
SOR No.	Item	Unit	Number
8.4	Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign as per IRC:67 made of encapsulated lens type reflective sheeting vide Clause 801.3, fixed over aluminium sheeting, 1.5 mm thick supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing		
(i)	90 cm equilateral triangle	Each	53
(ii)	60 cm equilateral triangle	Each	119
(iii)	60 cm circular	Each	142
(iv)	80 mm x 60 mm rectangular	Each	110
(v)	60 cm x 45 cm rectangular	Each	130
(vi)	60 cm x 60 cm square	Each	135

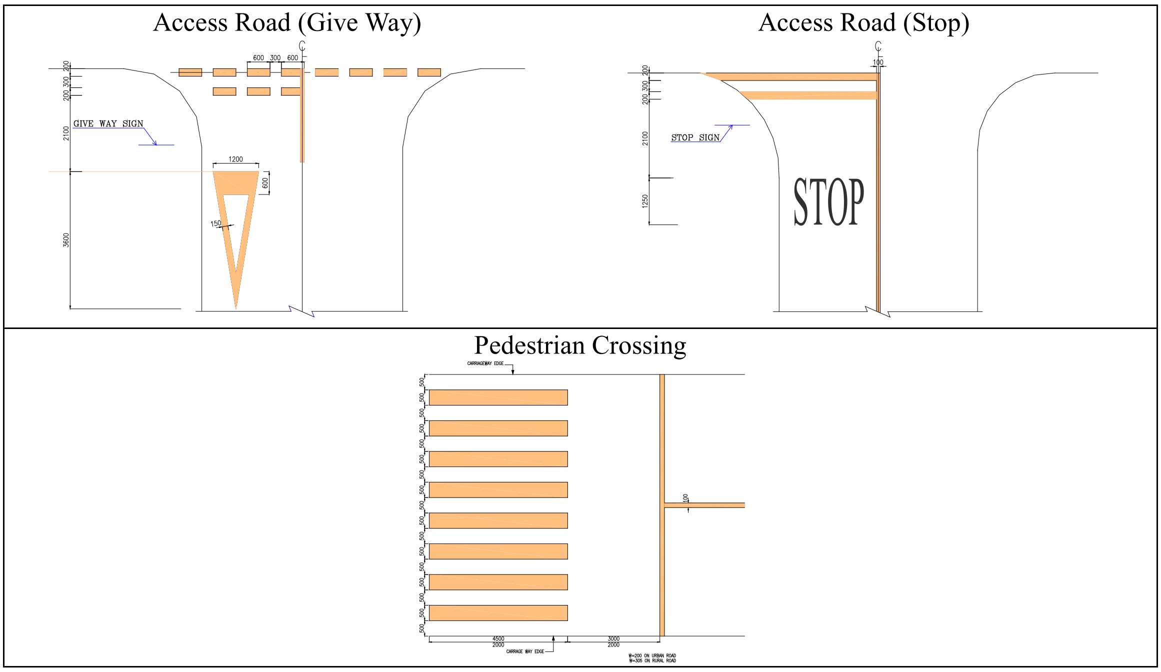
Source: JICA Study Team

(5) Road Marking

Road markings perform important functions of guiding and controlling traffic on roads. They serve as a psychological barrier and signify the delineation of traffic hazards for safe movement of traffic. Traffic markings also channelize, and ensure smooth and orderly flow of traffic. Therefore, suitable road markings shall be provided on roads in accordance with IRC:35-1997.

Figure 7.3-29 shows some of the typical road markings to be provided for the target roads.





Source: Detailed Project Report for National Highway No.54 Section-2

Figure 7.3-29 Typical Road Markings

In this study, the road markings shown in Table 7.3-44 are considered for the whole target road based on unit quantity per kilometer of 250 m^2 which is adopted in DPR.

Table 7.3-44 Road Markings Estimated for NH54

SOR No.	Item	Unit	Number
8.13	Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250 gms per sqm area, thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC:35. The finished surface to be level, uniform and free from streaks and holes	sqm	87,298

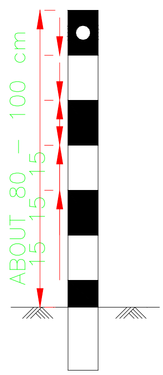
Source: JICA Study Team

(6) Road Delineator

Retro-reflective road delineators are to be installed to provide visual assistance for drivers to obtain information on the alignment of the road ahead particularly at night. These are effective at locations involving change in horizontal/vertical geometry and during severe weather conditions such as heavy rain, fog, or snow. IRC:79-1981 stipulates the standards for the post type delineators with retro-reflective units.

Figure 7.3-30 shows typical type of road delineator with circular retro-reflector.

In this study, road delineators shown in Table 7.3-45 are considered for the whole target road based on unit quantity per kilometer of 0.89 which is derived from DPR.



Source: Detailed Project Report for National Highway No.54 Section-2

Figure 7.3-30 Typical Road Delineator

Table 7.3-45 Road Delineators Estimated for NH54

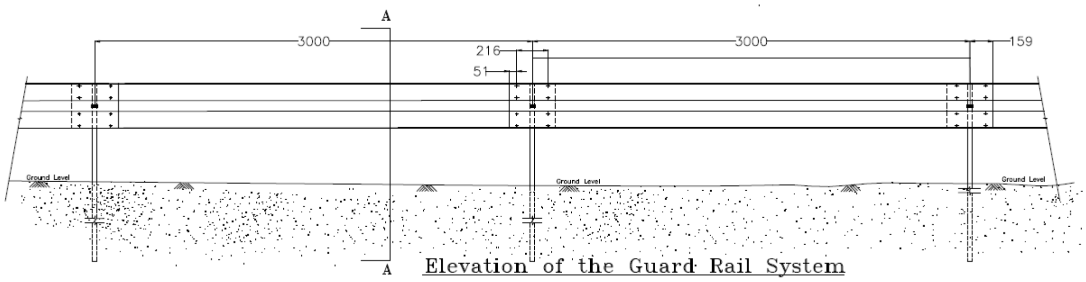
SOR No.	Item	Unit	Number
8.15	Road Delineators (Supplying and installation of delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 15 cm wide stripes, fitted with 80 x 100 mm rectangular or 75 mm dia circular	each	429

Source: JICA Study Team

(7) Guardrail

DPR adopts single "W" type steel Guardrails for selected locations including valley side of curves, high embankment sections, approaches to bridges, and built-up areas.

Figure 7.3-31 shows typical single "W" type of Guardrail.



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 7.3-31 Typical Guardrail

In this study, considering unit quantity per kilometer adopted in DPR, the guardrails shown in Table 7.3-46 are considered for the whole target road.

Table 7.3-46 Guardrails Estimated for NH54

SOR No.	Item	Unit	Number
8.23-A	Type - A, "W": Metal Beam Crash Barrier (Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2	metre	27,670

Source: JICA Study Team

(8) Street Furniture

Street furniture known as road studs, blinker or cat's eye include equipment installed on road or roadside to assist visibility of road alignment/structures. They are retro-reflective safety devices used in road marking. Generally, it consists of two pairs of reflective glass spheres set into a white rubber dome, mounted in a cast-iron housing. This is the kind that marks the centre of the road, with one pair of devices showing in each direction. A single-ended form has become widely used in other colors at road margins and as lane dividers.

In this study, considering unit quantity per kilometer adopted in DPR, street furniture shown in Table 7.3-47 are considered for the whole target road.

Table 7.3-47 Street Furniture Estimated for NH54

SOR No.	Item	Unit	Number
8.35	Road Markers/Road Stud with Lense Reflector (Providing and fixing of road stud 100x 100 mm, die cast in aluminium, resistant to corrosive effect of salt and grit, fitted with lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm upto a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS 873 part 4:1973)	each	38,778

Source: JICA Study Team

(9) Locations Requiring Special Consideration

1) Hair-Pin Bends

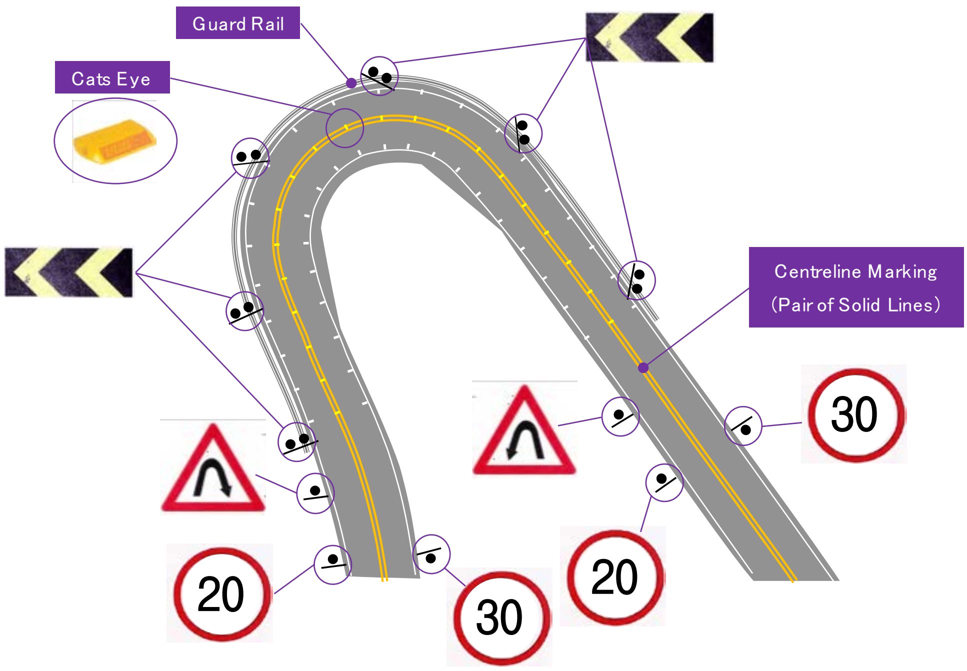
Since the target road is located in mountainous region, hair-pin bends are unavoidable from the viewpoint of cost and environmental impact. Design speed of 20 km/h is applied for hair-pin bends, while design speed of 30 km/h is adopted in general. Small horizontal curves such as R20m-R25 m are used in steep terrain to avoid large-scale earthwork and/or demolition of houses. At these sub-standard sections, securing traffic safety by applying combination of facilities shall be considered.

In hair-pin bends, it is difficult to secure overtaking sight distance and thus, the section shall be designated as no-overtaking section. In order to inform that to drivers, the double centre line with marking of pair of solid lines is applied.

Cats eyes to delineate road alignment are to be installed on the center line and lane edges so that drivers will be able to identify the direction he should go before entering into the curve.

Furthermore, traffic signs and Guardrails shall be properly equipped to avoid hazardous accidents.

Figure 7.3-32 shows an example of combined traffic safety facilities to be installed at hair-pin bends.



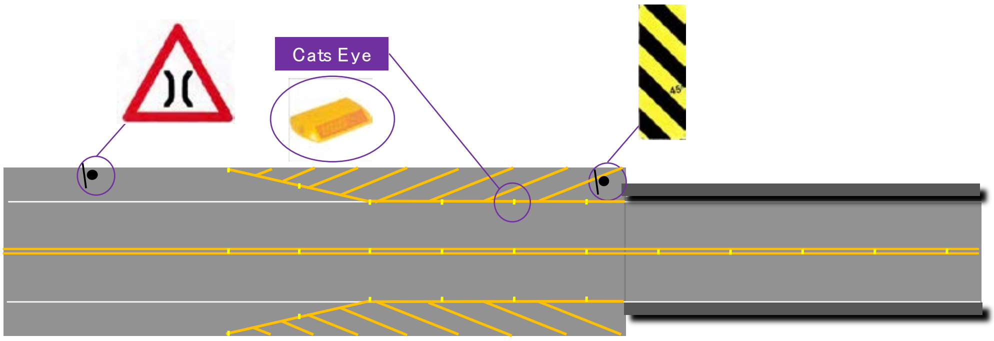
Source: JICA Study Team

Figure 7.3-32 Traffic Safety Facilities to be Installed at Hair-Pin Bends

2) Bridges with Narrow Width

In the locations where the existing bridges are to be utilized with rehabilitation works, carriageway width becomes narrower than that of earthwork sections due to the difference in shoulder width. It is, therefore, proposed to install facilities that notify drivers the decrease in carriageway width and existence of concrete curb.

Figure 7.3-33 shows an example of combined traffic safety facilities to be installed at narrow bridges.



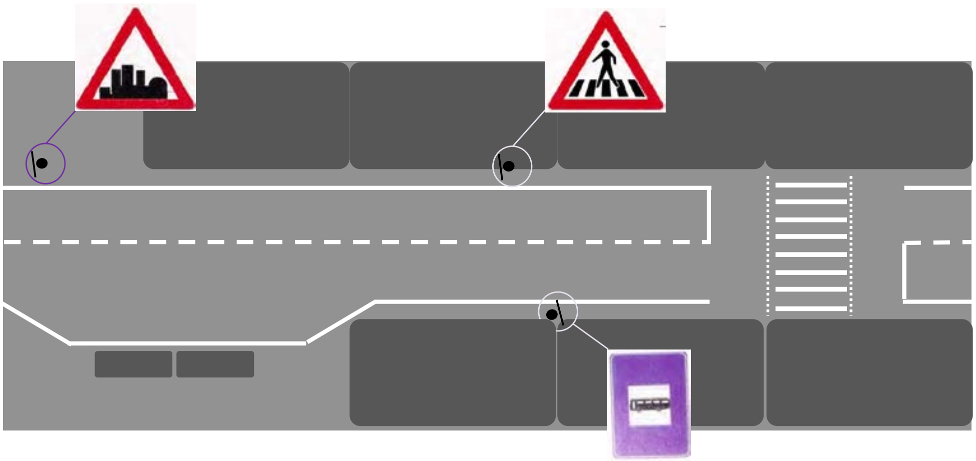
Source: JICA Study Team

Figure 7.3-33 Traffic Safety Facilities to be installed at Narrow Bridges

3) Built-up Sections

In built-up sections, there are lots of buildings, shops, or houses at roadside as well as pedestrians along the sidewalk and crossing the road. Furthermore, more kinds of road facilities such as bus stops are necessary than in rural sections. Therefore, drivers have to handle much information on roads/traffic and decide their maneuvers in a short time at built-up areas. In order to assist road users in obtaining information, appropriate traffic signs and road markings shall be provided properly.

Figure 7.3-34 shows an example of combined traffic safety facilities to be installed at built-up sections.



Source: JICA Study Team

Figure 7.3-34 Traffic Safety Facilities to be Installed at Built-up Sections

7.3.8 Road Appurtenances Plan

(1) Scope of Road Appurtenances

Road appurtenances are miscellaneous facilities for road users to take a rest and obtain road-related information as well as for road administrators to maintain their roads efficiently. In this study, considering road function of rural roads and usage situation of the target roads, the facilities listed in Table 7.3-48 are discussed for application to the project.

Table 7.3-48 Road Appurtenances to be Applied for NH54

No.	Item	Remarks / Related Code
1	Kilometer Stone	IRC8-1980, IRC26-1967
2	Boundary Stone	IRC25
3	Bus Bay	w/Bus Shed, IRC80-1981
4	Road Amenity	Public Toilet, Bazar Shed
5	View Spot	Parking space to be developed at locations with good view

Source: JICA Study Team

(2) Road Appurtenances Proposed in DPR

Table 7.3-49 summarizes the road appurtenances that are considered to be proposed in DPR.

Table 7.3-49 Road Appurtenances Proposed in DPR for NH54

ITEM	NH54-S1	NH54-S2	NH54-S3
Kilometer Stone	200m, 1km and 5km stones are to be provided in accordance with IRC. No detailed quantities are available in Report.	200m, 1km and 5km stones are to be provided in accordance with IRC. Detailed quantities are as follows: (i) 5th kilometre stone (precast): 22 (ii) Ordinary Kilometer stone (Precast): 91 (iii) Hectometer stone (Precast): 452	200m, 1km and 5km stones are to be provided in accordance with IRC. Detailed quantities are as follows: (i) 5th kilometre stone (precast): 25 (ii) Ordinary Kilometer stone (Precast): 99 (iii) Hectometer stone (Precast): 498
Boundary Stone	To be provided at ROW boundaries. No detailed quantities are available in Report.	To be provided at ROW boundaries. Detailed quantities are as follows: Boundary Stone: 2,260 (20.02 /km)	To be provided at ROW boundaries. Detailed quantities are as follows: Boundary Stone: 1,500 (12.23 /km)
Bus Bay	To be provided at 3 locations: 1) 9+867 Km (Zemabawk), 2) 39+618 Km (Seling), and 3) 95+355 Km (Serchhip).	To be provided at 14 locations.	To be provided. No detailed quantities are available in Report.
Road Amenity	Includes toilets, tea/coffee and snacks bar, drinking water and other articles of emergency. To be provided at 2 locations: 1) Seling, and 2) Serchhip	2 nos of Rest Houses are to be provided	Includes public toilet, public urinal, bus shed and bazar shed. To be provided at 16 locations 1)Tawipui North-2, 2)Tawipui North-1, 3)Tawipui South, 4)Thingfal, 5)Thingka, 6)AOC, 7)Lawngtlai City, 8)Saika, 9)Chawntlangpui, 10)Sihtlangpui, 11)Kawlchaw, 12)Zero Point, 13)Maubawk, 14)Theiva, 15)Theihri, and 16)Tuipang
Truck Lay By	To be provided at 2 locations: 1) 7.00 Km away from Aizawl, and 2) 114+110 Km (Serchhip)	Not to be provided.	No information is available in Report.

Source: DPR Summarized by JICA Study Team

(3) Approach for Road Appurtenances Plan

The objectives of the preparation of road appurtenances plan in this study are to confirm the facilities proposed in DPR and to propose alternative plans where necessary. Furthermore, it will become a part of the basis of the project cost estimate. However, since the documents are available only partially, some information are still missing as shown in Table 7.3-49.

In this study, every effort is made to consider facilities in a similar manner as in the DPR in case where they are clear and reasonable. The quantities are estimated by assuming various conditions. It is, therefore, noted that further examination shall be made for the modification of DPR based on their design basis.

(4) Kilometer Stone

Kilometer stone is one of a series of numbered markers placed along a road or boundary at specific intervals. They are typically located at the side of the road. They are alternatively known as mile stones, mile markers or mileposts. Design of kilometer stones shall be made in accordance with IRC:8-1980.

Table 7.3-50 shows the estimated number of kilometer stones for the whole target road.

Table 7.3-50 Kilometer Stones Estimated for NH54

SOR No.	Item	Unit	Number
8.14	Kilometer Stone (Reinforced cement concrete M15grade kilometer stone of standard design as per IRC:8-1980, fixing in position including painting and printing)		
(i)	5th Kilometer Stone (Precast)	each	69
(ii)	Ordinary Kilometer Stone (Precast)	each	281
(iii)	Hectometer Stone (Precast)	each	1,405

Source: JICA Study Team

(5) Boundary Stone

Boundary stones are to be provided to establish the right of way (ROW) and those shall be incorporated in the as-built drawings for future use. Design of boundary stones shall be made in accordance with IRC:25-1967.

Table 7.3-51 shows the estimated number of boundary stones for the whole target road.

Table 7.3-51 Boundary Stones Estimated for NH54

SOR No.	Item	Unit	Number
8.16	Boundary Pillar (Reinforced cement concrete M15 grade boundary pillars of standard design as per IRC:25-1967, fixed in position including finishing and lettering but excluding painting)	each	6,035

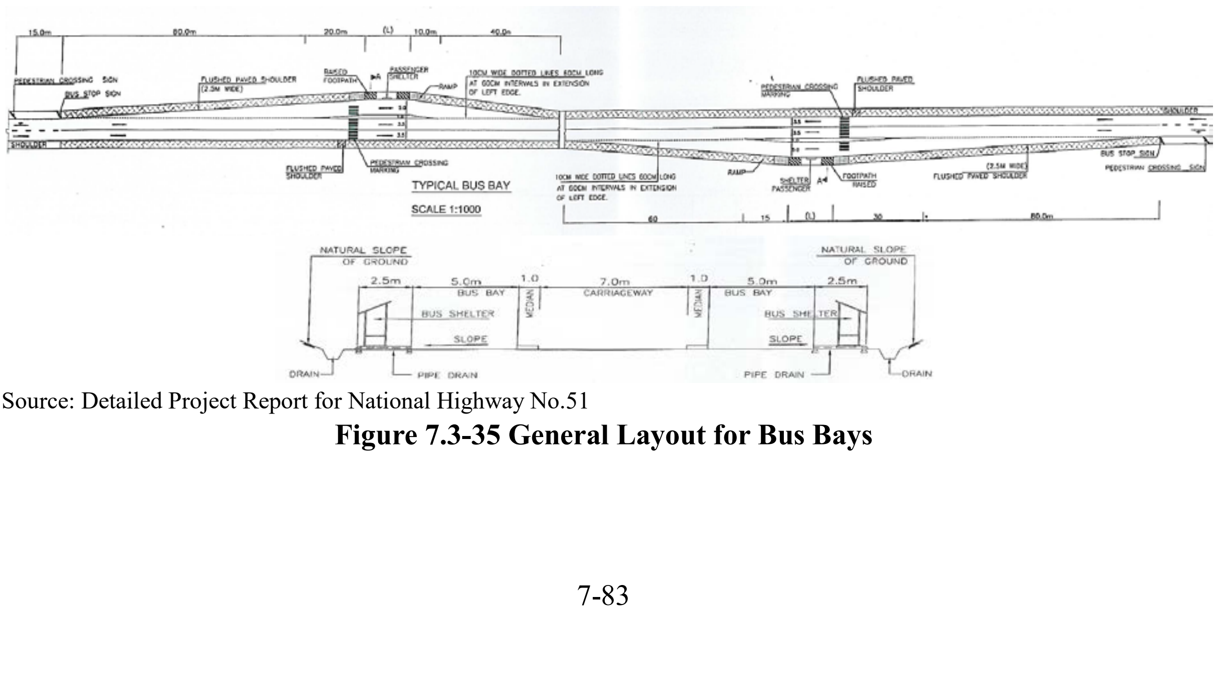
Source: JICA Study Team

(6) Bus Bay and Road Amenity

Buses standing indiscriminately on the carriageway to drop or pick-up passengers can seriously affect capacity of the roadway, besides being a source of accidents. It is, therefore, desirable that on all busy non-urban highways, consideration should be given to the construction of bus lay-byes of suitable design at required locations to ensure orderly movement of the through traffic.

Since the target road is part of the national highway with the function of an important artery of the region, it is recommended to develop bus bays at appropriate locations.

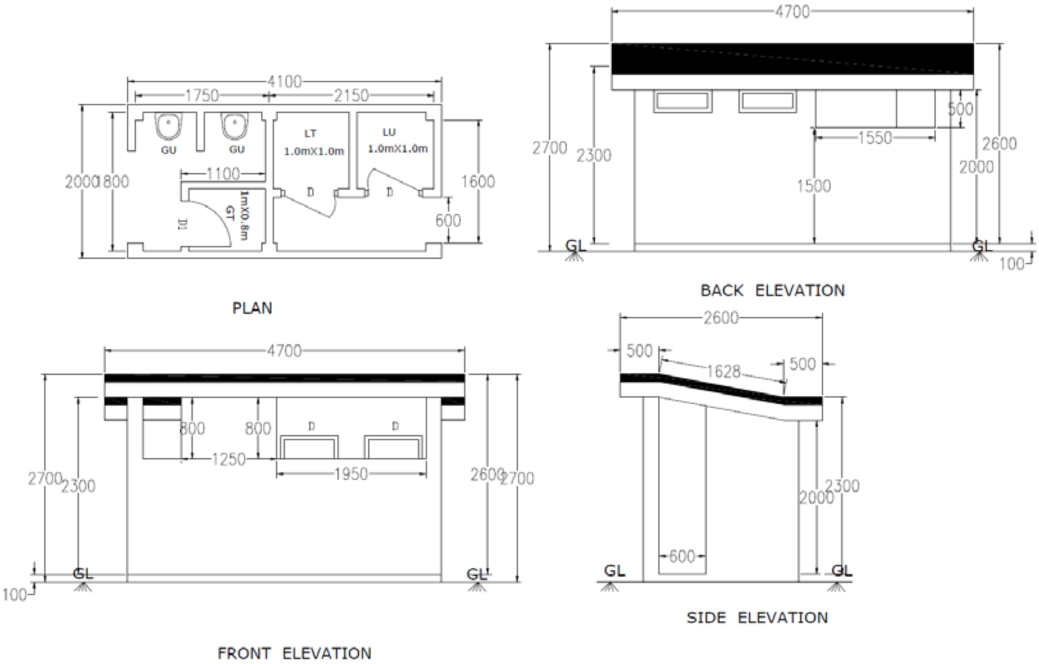
IRC:80-1981 stipulates the general requirements for bus bays. DPR has applied the general layout suggested in that standard. This study also follows the recommendations of IRC and assumes the application of the general plan shown in Figure 7.3-35.



Source: Detailed Project Report for National Highway No.51

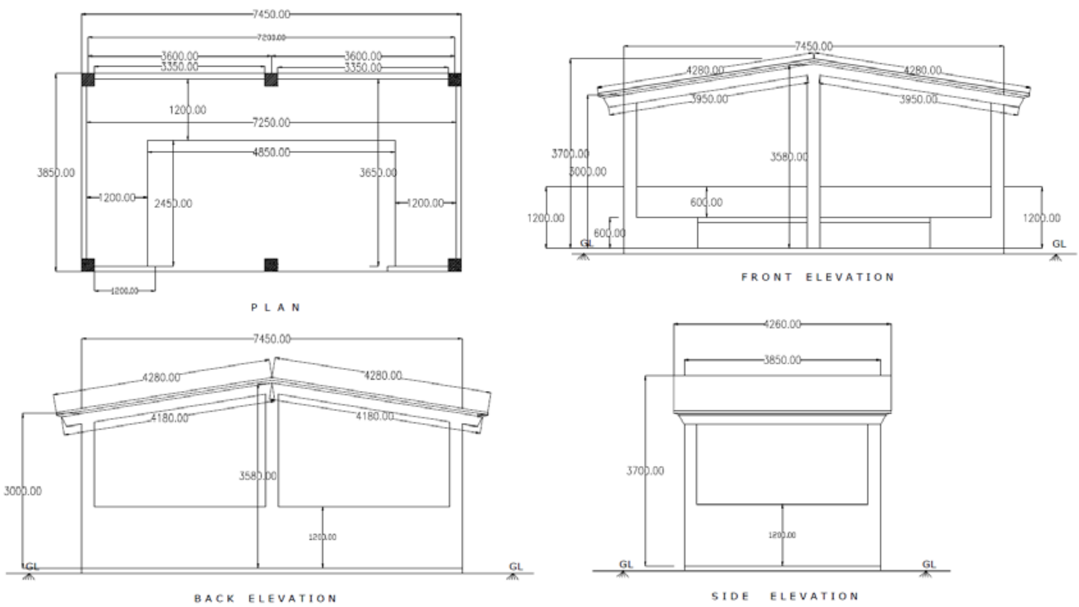
Figure 7.3-35 General Layout for Bus Bays

Road amenities for tourists to use the road comfortably shall be developed at suitable intervals. It is therefore suggested to equip road amenities including public toilets and bazaar shed at bus bays. Figure 7.3-36 and Figure 7.3-37 present the general view of public toilet and bazaar shed proposed in DPR.



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 7.3-36 General View of Public Toilet



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 7.3-37 General View of Bazaar Shed

The proposed locations of bus bays for NH54 are presented in Table 7.3-52.

Table 7.3-52 Proposed Bus Bay Locations for NH54

No.	Section	Location	Distance from Aizawl (km)	Section Length (km)	No.	Section	Location	Distance from Aizawl (km)	Section Length (km)
1	1	Aizawl	-		22	2	Dawn	206	16
2	1	Zemabawk	4	4	23	2	Zobawk	219	13
3	1	Tuirial	22	18	24	2	Hrangchalkawn	222	3
4	1	Seling	38	16	25	2	Bualte	231	9
5	1	Thingsulthliah	42	4	26	2	Thualthu	243	12
6	1	Darlawng	53	11	27	3	Tawipui N-II	251	8
7	1	Tlungvel	57	4	28	3	Tawipui N-I	256	5
8	1	Phulmawi	61	4	29	3	Tawipui S	264	8
9	1	Khumtung	63	2	30	3	Thingfal	277	13
10	1	Baktawng	67	4	31	3	Lawngtlai	292	15
11	1	Chhingchhip	77	10	32	3	Saikah	311	19
12	1	Chhiahtlang	97	20	33	3	Paithar	314	3
13	1	Serchhip	107	10	34	3	Chawitlangpui I	316	2
14	2	Keitum	122	15	35	3	Sihtlangpui	319	3
15	2	Bungtlang	130	8	36	3	Kawlchaw	324	5
16	2	Rawpui	135	5	37	3	Zero Point	337	13
17	2	Pangzawl	148	13	38	3	Maubawk	354	17
18	2	Thiltlang	158	10	39	3	Theiva	355	1
19	2	Hnahthial	169	11	40	3	Theiri	363	8
20	2	Leite	182	13	41	3	Tuipang	379	16
21	2	Maudarh	190	8					

Source: JICA Study Team

(7) View Point

Along NH54, there are some places where impressive views of mountains and/or rivers are seen against the background of the wide sky. It is, therefore, recommended to develop parking spaces for such view points along the road for the road users to enjoy natural panoramas and feel refreshed after a long drive. Figure 7.3-38 shows sample pictures of sceneries taken from NH54.

Source: JICA Study Team

Figure 7.3-38 Sample Pictures of Sceneries Taken from NH54

Figure 7.3-39 shows samples of parking spaces developed along the roads in the mountainous region in Japan.

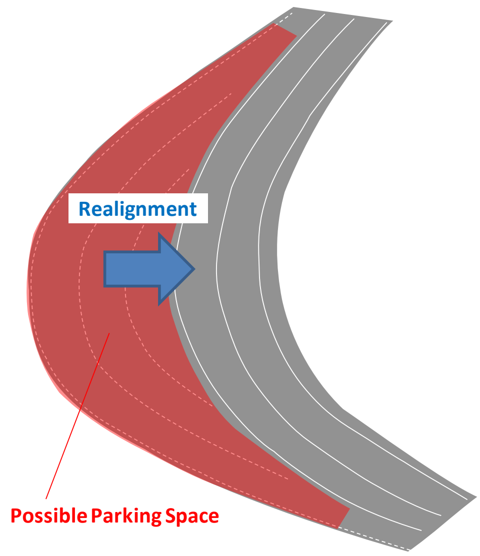
Source: JICA Study Team

Figure 7.3-39 Samples of Parking Spaces along the Roads

Parking spaces for the view point can be developed utilizing flat spaces which are produced by improvement of the horizontal alignment to be made especially in sharp curves as illustrated in Figure 7.3-40.

The land with the area of around 25 m^2 would be necessary for a small car to park including the space for movement within the parking space.

The JICA Study Team preliminarily estimated that around 20 locations can be utilized as possible parking spaces for view points along NH54. Specific locations and design of the view point shall be further examined in the next stage of the project.



Source: JICA Study Team

Figure 7.3-40 Possible Land for Parking Space

7.3.9 Preliminary Study of Bypass Route

(1) General

The JICA Study Team has preliminarily designed NH54 lengthily stretching at about 380 km with widening to 12 m width in principle from its existing width of about 5 m. Because of its long stretch, the widening might trigger large impact to existing social environment especially in built-up areas along NH54. Therefore, the JICA Study Team has examined the applicability of bypass route for all the 48 built-up settlements identified along the target section of 380 km to mitigate its negative impact.

(2) Procedure for Consideration of Built-up Sections

The JICA Study Team conducted the examination in accordance with following procedure (from 1) to 3)) to assess the applicability of bypass route for consideration of 48 existing built-up sections:

1) To Assess Social Impact Based on Number of Affected Houses

Number of affected houses built within the construction limit of 12 m road widening has been counted to assess the social impact for each settlement. Two types of affected houses, namely, "Partial Demolition" and "Total Demolition", are assumed to distinguish the extent of affected level.

In principle, set-back option and not resettlement can be selected if houses are slightly and not largely occupying within the construction limit. Therefore, bypass route should be considered more severely where many houses are largely occupying within the construction limit. In this concept, the JICA Study Team has examined the scores for respective types in accordance with the following rules and assumptions:

❖ Partial Demolition

- When the area of the house encroaching within the construction limit is less than 30% of its total,
- Settlement where there are more than 50 houses categorized under "Partial Demolition" type shall score 5 points,
- It shall score 1 point in the case where there are 50 or less than 50 houses and more than 25 houses are slightly and not largely within the construction limit

❖ Total Demolition

- When the area of a house occupying within the construction limit is 30% or more of its total,
- Settlement where there are more than 50 houses categorized under "Total Demolition" type shall score 10 points,
- It shall score 5 points in the case where there are 50 or less than 50 houses and more than 25 houses that are judged as "Total Demolition" type.

2) To Evaluate Applicability of Bypass Route Based on Population Scale of Settlement

The JICA Study Team has conducted an evaluation of the applicability of bypass route in terms of population scale for each settlement. If a settlement is largely urbanized, there might be much generated traffic driving within the settlement and sometimes traffic congestion may occur due to the reduction of road traffic capacity induced by the occupation of the generated traffic. In these areas, construction of bypass route can be one of the effective solutions to secure the road capacity appropriately for coping with through traffic which have destinations in other areas. In this concept, the JICA Study Team has examined the scores for population scales in respective settlements in accordance with following rules and assumptions:

❖ If a settlement has more than 8,000 population, the settlement shall score 20 points.

- ❖ Similarly, if it has 8,000 or less than 8,000 and more than 4,000 population, the settlement shall score 10 points.
- ❖ Furthermore, if it has 4,000 or less than 4,000 and more than 2,000 population, the settlement shall score 5 points.

3) To Examine Geometrical Feasibility of Bypass Route

The JICA Study Team has examined the feasibility of bypass route in terms of physical aspect whether the route does not become extremely longer than the existing road alignment geometrically or not. In this concept, each settlement has been judged as “Feasible” or “Not feasible”.

(3) Result of Consideration

Table 7.3-53 below shows the results of the examined scores for all the target settlements in terms of the number of affected houses, population scale, and geometrical feasibility to mitigate the impact of these existing settlements along the designed alignment. The scores have been calculated to clarify the settlements where it is recommendable to construct the bypass route, without considering the set back option or any other options.

Table 7.3-53 Result of Bypass Route Consideration

No.	Name[*1]	From	To	Section Length (km)	Number of Affected Houses[*2]							Population Scale				Total Score	Geometrical Feasibility	Result of Consideration	
					Partial Demolition (PD)	Total Demolition (TD)	Total Affected Houses (TAH)	No. of PD > 50	No. of PD > 25	No. of TD > 50	No. of TD > 25	Population[*3]	Population > 8,000	Population > 4,000	Population > 2,000		1: Feasible 0: Infeasible	12m Widening	Bypass with 10m Widening of Existing NH-54
								Score: 5	Score: 1	Score: 10	Score: 5		Score: 20	Score: 10	Score: 5				
1	Aizawl (Zemabawk)	8+000	12+500	4.50	Out of Scope														
2	Bung IB	13+000	14+300	1.30	5	6	11					257			5	5	0	✓	
3	Tuirial	14+600	24+000	9.40	34	35	69		1		5	824			5	10	1	✓	
4	Tuikhurhlu	24+840	31+000	6.16	8	8	16					190			5	5	0	✓	
5	Phaibawk	31+000	34+300	3.30	3	4	7					69			5	5	1	✓	
6	Seling	34+300	38+750	4.45	18	47	65				5	2,289			5	10	0	✓	
7	Thingsul Tlangnuam	39+000	41+150	2.15	30	43	73		1		5	1,587			5	10	1	✓	
8	Thingsulthliah	41+150	46+000	4.85	20	27	47				5	3,402			5	10	1	✓	
9	Darlawng	46+000	53+000	7.00	15	43	58				5	653			5	10	1	✓	
10	Tlungvel	53+000	58+000	5.00	22	41	63				5	2,529			5	10	0	✓	
11	Phulmawi	58+000	60+720	2.72	18	18	36					277			5	5	1	✓	
12	Khumtung	61+000	62+640	1.64	28	33	61		1		5	1,150			5	10	0	✓	
13	Chanin/Baktawng	63+160	67+620	4.46	5	3	8					151			5	5	0	✓	
14	Bukangkawn	68+230	69+840	1.61	2	3	5					151			5	5	1	✓	
15	Chhingchhip	70+420	86+500	16.08	38	38	76		1		5	3,741			5	10	1	✓	
16	Chhiahtlang	86+500	97+260	10.76	17	57	74			10		4,071		10		20	1		✓
17	Serchhip (NT)	97+260	113+650	16.39	78	51	129	5		10		21,158	20			30	1		✓
18	Keitum	113+950	131+100	17.15	11	25	36					2,022			5	5	0	✓	
19	E.Bungtlang	131+420	134+920	3.50	24	71	95			10		1,966			5	15	1	✓	
20	Rawpui	134+920	143+900	8.98	11	40	51				5	835			5	10	1	✓	
21	Pangzawl	143+900	155+230	11.33	28	73	101		1	10		2,428			5	15	0	✓	
22	Thiltlang	155+230	165+650	10.42	8	47	55				5	1,064			5	10	0	✓	
23	Hnahthial (NT)	165+650	176+810	11.16	18	65	83			10		7,187		10		20	1		✓
24	Leite	176+810	189+180	12.37	4	30	34				5	665			5	10	1	✓	
25	Maudarh	189+180	190+990	1.81	1	3	4					62			5	5	1	✓	
26	New Dawn	190+990	207+840	16.85	9	46	55				5	384			5	10	1	✓	
27	Zobawk	208+960	216+320	7.36	4	78	82			10		3,166			5	15	0	✓	
28	Lungpuizawl	216+320	218+200	1.88	0	12	12					774			5	5	1	✓	
29	Hrangchal Kawn (Vawngzawl)	218+200	224+000	5.80	3	19	22					723			5	5	0	✓	
30	Thaizawl	224+000	228+100	4.10	0	30	30				5	378			5	10	1	✓	
31	Bualte	228+100	234+000	5.90	0	23	23					437			5	5	1	✓	
32	Thualthu	234+000	243+200	9.20	0	10	10					604			5	5	1	✓	
33	Tawipui 'N' II	431+000	435+000	4.00	11	23	34					677			5	5	0	✓	
34	Tawipui 'N' I	435+000	441+000	6.00	11	42	53				5	809			5	10	1	✓	
35	Tawipui 'S'	441+000	450+000	9.00	10	33	43				5	1,259			5	10	0	✓	
36	Thingfal	450+000	461+300	11.30	9	24	33					1,365			5	5	0	✓	
37	Thingkah	461+300	469+100	7.80	6	11	17					1,157			5	5	1	✓	
38	Lawngtlai	469+100	488+000	18.90	38	59	97		1	10		20,830	20			30	1		✓
39	Saikah	488+000	495+000	7.00	3	4	7					553			5	5	1	✓	
40	Chawntlangpui	495+000	497+000	2.00	6	11	17					354			5	5	1	✓	
41	Sihtlangpui	497+000	503+000	6.00	11	12	23					630			5	5	1	✓	
42	Kawlchaw 'W'	503+000	503+500	0.50	1	0	1					419			5	5	0	✓	
43	Kawlchaw 'E'	503+700	514+800	11.10	7	9	16					1,071			5	5	0	✓	
44	Zeropoint	514+800	521+000	6.20	7	15	22					759			5	5	0	✓	
45	Maubawk 'L'	521+000	531+500	10.50	8	12	20					599			5	5	1	✓	
46	Theiva	531+500	537+500	6.00	0	14	14					551			5	5	1	✓	
47	Theiri	538+300	544+700	6.40	10	14	24					626			5	5	0	✓	
48	Tuipang	544+700	554+410	9.71	8	34	42				5	1,655			5	10	0	✓	
	Total			351.99	608	1346	1954												

*1: Names of settlement have been identified by JST survey collecting through interveiwing local government office and so on. The station of each settlement is assumed by JST.
*2: Number of affected houses has been identified with counting on DPR Topgraphic Drawing prepared by MORTH and PWD of GOI
*3: Population are for the entire village/town beyond the road side.

Source: JICA Study Team

Based on the examination above, the four settlements below have scored more than 20 points and are geometrically feasible. Therefore, it is recommendable to construct bypass route for avoiding densely populated area to mitigate the impact of resettlement as well as to secure smooth traffic coping with through traffic which have destinations to other settlements. Furthermore, in these four sections, the JICA Study Team recommended to apply an improvement of only 10 m road widening with black top pavement for the time being along the existing NH54 before completion of the bypass route. This recommendation can make few impacts to avoid resettlement or set-back of existing houses as much as possible.

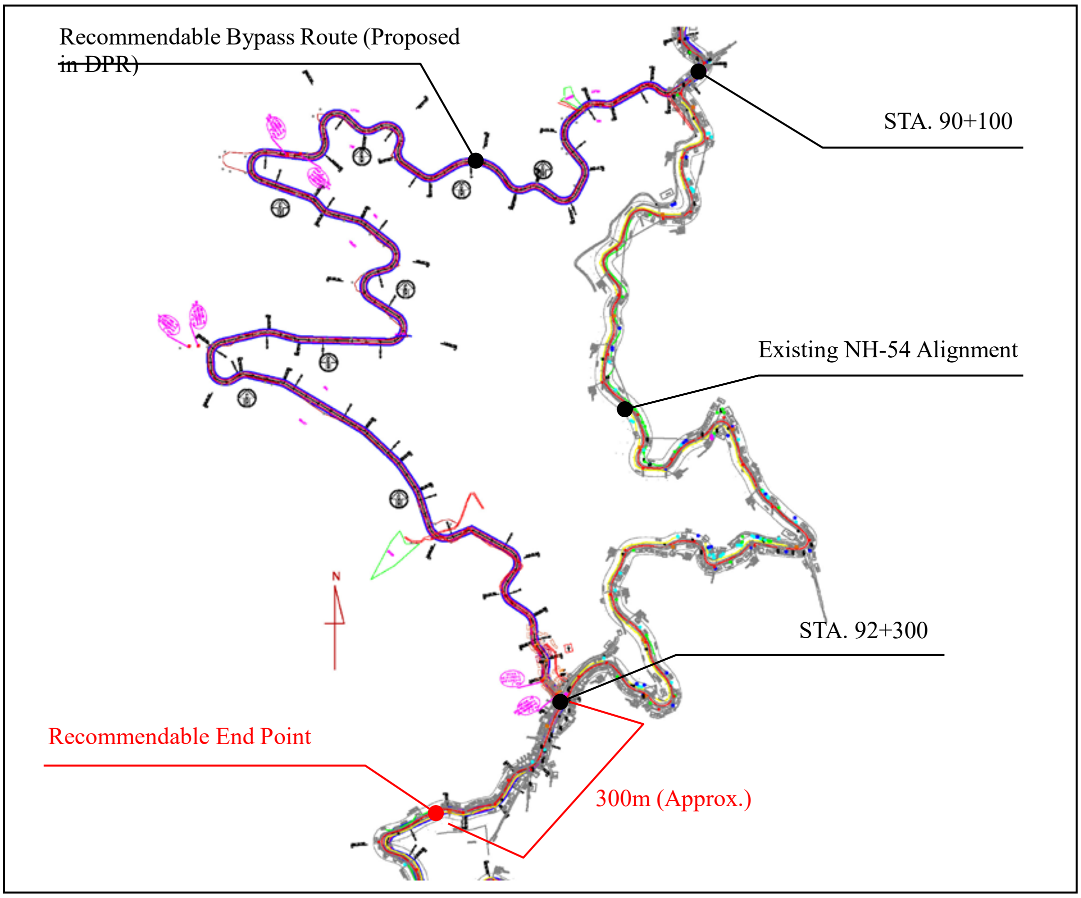
1) Chhiahtlang
2) Serchhip
3) Hnathial
4) Lawngtlai

(4) Concept of Bypass Route for Four Areas

The concepts of bypass route for each of the above-recommended four areas are summarized below.

1) Chhiahtlang Bypass

It is confirmed that there is national park in the eastern part of Chhiahtlang. Therefore, the JICA Study Team recommended to follow the bypass route of DPR-selected western route from the existing NH54 to avoid the conservation area of the national park. The bypass route starts from STA. 90+100 and ends at STA. 92+300 in Section-1. However, local residences are observed around the proposed end point area in DPR. Therefore, it is recommendable to shift the endpoint to 300 m ahead at around STA. 90+600 area to mitigate the impact on the local community.

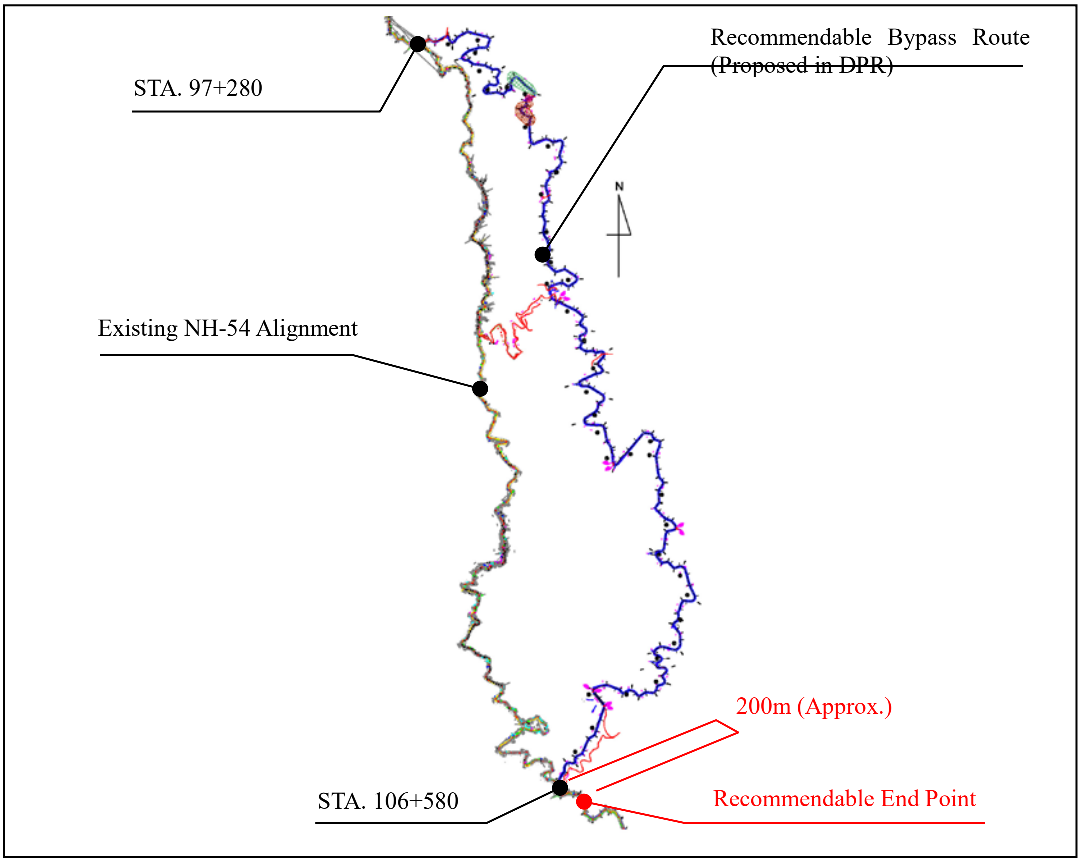


Source: JICA Study Team

Figure 7.3-41 Recommendable Chhiahtlang Bypass Route

2) Serchhip Bypass

Topographically, it is required to have a very long stretch if western route is selected for bypassing Serchhip area. Therefore, the eastern route proposed in DPR is recommendable for the Serchhip bypass. The bypass starts from STA. 97+280 and ends at STA. 106+580 in Section-1. Some residences can be observed in the area near the endpoint based on the examination of the JICA Study Team. Thus, it is more applicable to shift the endpoint to 200 m ahead for mitigation of the local community.

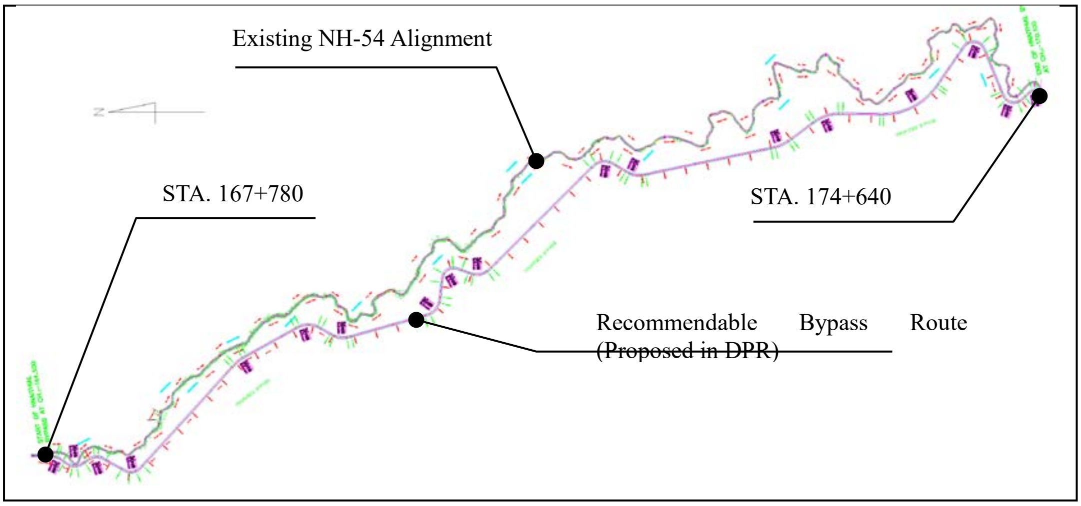


Source: JICA Study Team

Figure 7.3-42 Recommendable Serchhip Bypass Route

3) Hnathial Bypass

Because it is difficult for the east side of Hnathial area to attract linear alignment due to the steep topography, the western route is reasonable for Hnathial Bypass as designed in DPR, but it is recommended to adjust the bypass alignment with consideration of actual topographical condition in the western route of DPR. The bypass shall start from STA.167+780 and end at STA. 174+640 in Section-2.

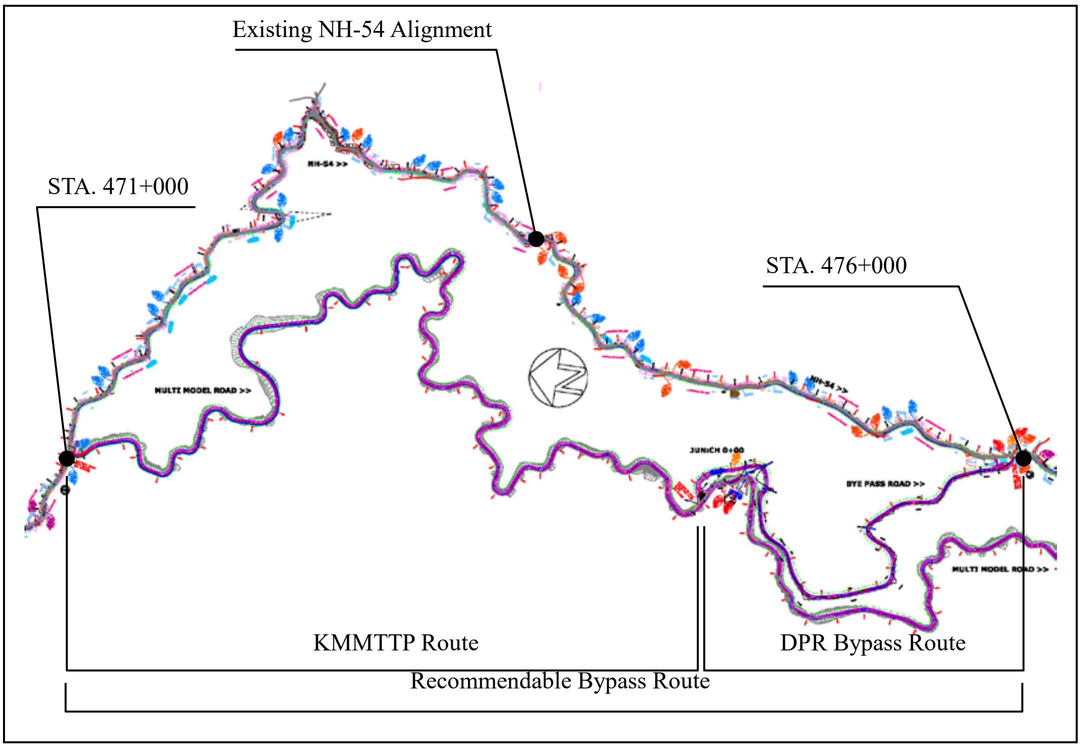


Source: JICA Study Team

Figure 7.3-43 Recommendable Hnathial Bypass Route

4) Lawngtlai Bypass

In Lawngtlai area, there is another road construction project called as “Kaladan Multi-Modal Transit Transport Project (KMMTTP)” which is under implementation at present and will avoid the route along the urbanized area of Lawngtlai. Therefore, it is recommendable to follow the Lawngtlai Bypass route consisting of KMMTTP route and the route designed by DPR. The bypass route starts from STA. 471+000 and ends at STA. 476+000 in Section-3.



Source: JICA Study Team

Figure 7.3-44 Recommendable Lawngtlai Bypass Route

7.3.10 Preliminary Study of Spoil Bank

(1) General

Concerning the result of the preliminary design of NH54 of the JICA Study Team, the necessary volume of spoil bank has been calculated as shown in Table 7.3-54 where Sections 1, 2 and 3 at least require about 2.40, 2.44, and 2.47 million m^3 capacities, respectively.

Table 7.3-54 Required Volume for Spoil Bank

Highway No.	Sec.	Item	Unit	Volume of Generated Soil	Coefficient of Compation	Volume of Compacted Soil	Required Volume of Spoil Bank
				Cu.m		Cu.m	Cu.m
NH54	S1	Cut Soil	cu.m	3,442,909	0.9	3,098,618	2,400,495
		Fill Soil	cu.m			698,123	
	S2	Cut Soil	cu.m	3,710,629	0.9	3,339,566	2,437,522
		Fill Soil	cu.m			902,044	
	S3	Cut Soil	cu.m	3,560,596	0.9	3,204,536	2,465,129
		Fill Soil	cu.m			739,407	
	Total						7,303,146

Source: JICA Study Team

(2) Condition of Spoil Bank Selection

The JICA Study Team has examined and identified target locations which seem to have sufficient and required conditions for spoil bank construction. The following are assumed conditions for the suitable locations:

- ❖ To find out suitable place at every 5 km length along NH54 with following conditions:
  - Ground shape with concavity topography
  - Less ground gradient than 22 degrees which is assumed as average angle of spoil bank slope with necessary steps
  - No built-up area
  - No national sanctuary area
- ❖ To be able to construct the spoil bank with less than 30 m height

(3) Result of Examination for Spoil Bank Location

In accordance with the above assumed conditions, 115 locations in 381 km stretch of NH54 have been totally identified for spoil bank construction. There are 41, 32, and 42 numbers of spoil bank having about 2.43, 2.90, and 2.51 million m^3 capacities in Section-1, 2, and 3, respectively. The following tables show the list of spoil banks with station no. and capacities.

Table 7.3-55 List of Spoil Banks (Section-1)

Section 1

No.	Section	Sta.	Capacity of Spoil Bank
			Cu.m
1	S1 − 1	10+600	75,900
2	S1 − 2	13+200	68,250
3	S1 − 3	15+500	24,553
4	S1 − 4	19+000	167,913
5	S1 − 5	21+700	247,680
6	S1 − 6	25+400	66,640
7	S1 − 7	29+500	50,460
8	S1 − 8	33+600	92,810
9	S1 − 9	36+700	47,266
10	S1 − 10	37+600	203,286
11	S1 − 11	38+400	11,090
12	S1 − 12	39+000	120,000
13	S1 − 13	40+200	38,326
14	S1 − 14	42+100	28,120
15	S1 − 15	44+100	60,060
16	S1 − 16	44+700	26,666
17	S1 − 17	45+600	98,666
18	S1 − 18	46+100	14,186
19	S1 − 19	48+700	53,760
20	S1 − 20	49+400	46,666
21	S1 − 21	50+600	45,013
22	S1 − 22	53+100	8,970
23	S1 − 23	53+600	19,110
24	S1 − 24	59+000	93,620
25	S1 − 25	65+400	73,670
26	S1 − 26	68+900	13,770
27	S1 − 27	73+100	54,370
28	S1 − 28	68+800	84,370
29	S1 − 29	79+600	31,666
30	S1 − 30	81+500	99,750
31	S1 − 31	82+100	43,120
32	S1 − 32	83+300	19,370
33	S1 − 33	83+800	62,500
34	S1 − 34	88+500	18,120
35	S1 − 35	88+900	31,250
36	S1 − 36	90+700	50,000
37	S1 − 37	93+400	23,750
38	S1 − 38	94+300	46,666
39	S1 − 39	97+800	37,500
40	S1 − 40	105+800	17,273
41	S1 − 41	111+000	13,960
Total in Section I			2,430,116

Source: JICA Study Team

Table 7.3-56 List of Spoil Banks (Section-2)

Section 2

No.	Section	Sta.	Capacity of Spoil Bank
			Cu.m
42	S2 － 1	127+100	13,120
43	S2 － 2	130+200	230,170
44	S2 － 3	136+600	67,410
45	S2 － 4	137+300	151,870
46	S2 － 5	138+500	196,350
47	S2 － 6	144+800	185,760
48	S2 － 7	145+800	107,660
49	S2 － 8	147+500	25,760
50	S2 － 9	148+400	98,130
51	S2 － 10	150+700	15,680
52	S2 － 11	157+800	57,910
53	S2 － 12	159+800	93,960
54	S2 － 13	167+200	35,133
55	S2 － 14	168+800	114,240
56	S2 － 15	173+700	27,400
57	S2 － 16	176+200	143,060
58	S2 － 17	180+000	56,350
59	S2 － 18	187+000	50,000
60	S2 － 19	190+200	163,800
61	S2 － 20	196+100	130,680
62	S2 － 21	198+400	109,150
63	S2 － 22	207+600	92,500
64	S2 － 23	209+600	123,750
65	S2 － 24	215+000	128,386
66	S2 － 25	216+400	119,000
67	S2 － 26	224+100	18,750
68	S2 － 27	226+000	92,686
69	S2 － 28	229+400	25,000
70	S2 － 29	232+600	53,130
71	S2 － 30	235+300	99,200
72	S2 － 31	238+300	46,410
73	S2 － 32	241+900	25,620
Total in Section II			2,898,025

Source: JICA Study Team

Table 7.3-57 List of Spoil Banks (Section-3)

Section 3

No.	Section	Sta.	Capacity of Spoil Bank
			Cu.m
74	S3 － 1	432+400	14,433
75	S3 － 2	433+600	186,373
76	S3 － 3	434+900	100,230
77	S3 － 4	436+000	62,340
78	S3 － 5	437+500	212,850
79	S3 － 6	439+000	52,500
80	S3 － 7	441+100	43,746
81	S3 － 8	441+900	77,960
82	S3 － 9	444+900	15,620
83	S3 － 10	446+400	62,340
84	S3 － 11	452+500	43,500
85	S3 － 12	453+900	36,800
86	S3 － 13	456+700	69,230
87	S3 － 14	457+300	56,250
88	S3 － 15	459+100	56,250
89	S3 － 16	465+200	186,000
90	S3 － 17	470+900	153,120
91	S3 － 18	473+000	56,250
92	S3 － 19	474+600	15,300
93	S3 － 20	482+100	50,000
94	S3 － 21	484+400	59,500
95	S3 － 22	491+500	21,780
96	S3 － 23	492+900	22,000
97	S3 － 24	493+700	31,250
98	S3 － 25	495+900	26,400
99	S3 － 26	497+400	73,780
100	S3 － 27	499+900	49,140
101	S3 － 28	505+400	4,533
102	S3 － 29	514+800	2,520
103	S3 － 30	520+200	13,770
104	S3 － 31	521+600	91,233
105	S3 － 32	523+400	14,166
106	S3 － 33	525+900	23,760
107	S3 － 34	529+100	38,720
108	S3 － 35	543+900	60,000
109	S3 － 36	554+600	46,030
110	S3 － 37	547+600	153,450
111	S3 － 38	550+300	10,970
112	S3 － 39	550+700	40,090
113	S3 － 40	551+500	60,000
114	S3 － 41	552+500	22,130
115	S3 － 42	553+100	93,280
Total in Section III			2,509,594

Source: JICA Study Team

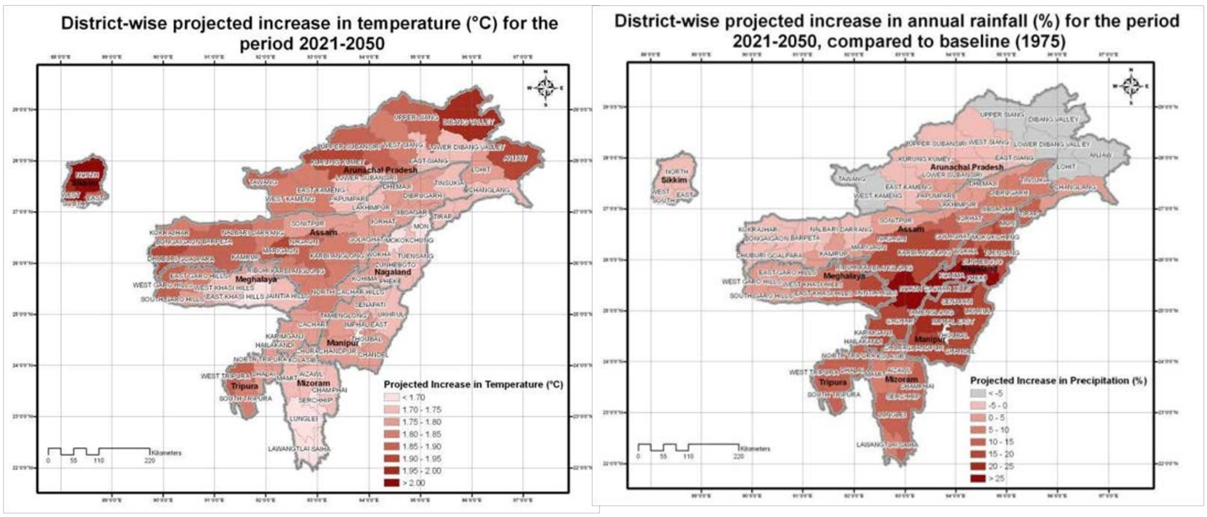
7.4 Consideration of Climate Change Adaption

(1) Climate Change Situation in India

Increase of frequency and intensity of rainfall with climate change often causes overflow from road drainage system, shut down by landslide disaster, traffic accident, and frequent traffic controls, which result in economic loss and delay of rehabilitation work for disaster. And due to rising of river level and variation of wind load with the increase of frequency and intensity of cyclone, it will be necessary to improve and reinforce the road facilities.

In the North-East States in India, the North East Climate Change Adaptation Programme has been carried out by KfW Development Bank and adaptation against climate change is examined together with the Ministry of Development of North-East Region. The Project Document in the programme mentioned the prediction of impact of climate change in the North-East States as shown below.

- The annual mean maximum temperatures in the North-East States are rising at the rate of 0.11 °C per decade.
- The annual mean temperatures in the states are also increasing at a rate of 0.04 °C per decade.
- The projected temperature increase is high in the central and western parts including NH51 of the states (see Figure 7.4-1, left). And those regions are expected to become warm at about 2 °C by the 2030s.
- According to the rainfall data for the 1901-2007 period, the annual mean precipitation has increased by 51 cm in 100 years.
- The projected increase in annual rainfall is high in the central and eastern parts of the states (see Figure 7.4-1, right). Especially, rainfall increase in the rainy season (June-September) is expected to be significant in the eastern part including Mizoram State.
- Extreme rainfall events of 100-150 mm per day and greater than 150 mm are predicted to increase at around 20% and 38%, respectively.



Source: North East Climate Change Adaptation Programme

Figure 7.4-1 Projected Increase in Temperature (°C) (left) and Annual Rainfall (%) (right) for the period of 2021-2050

(2) Vulnerability to Climate Change

Largest impact of climate change is increase of rainfall intensity in the subject roads, both NH54 and NH51. As presented in Figure 7.4-1, the increase of annual rainfall is predicted to be 5-15% in NH54 and 5-10% in NH51 for the period of 2021 to 2050. Increase of intensity and frequency of rainfall and groundwater rise and erosion by rainfall cause slope failure and mass movement. Then, they damage the road directly and have possibility to decrease road drainage capacity and cause flood damage and destabilization of road structure. The possible impact on the road is shown in Table 7.4-1.

Table 7.4-1 Impact on the Road by Climate Change

Factor	Vulnerability
Rainfall Higher rainfall causing flash floods, higher groundwater and moisture content in soil	· Overflow and wash out by flood discharge · Inundation on the road · Decrease of drain capacity by increase of silt discharge · Occurrence of landslide disaster · Instability of road structure and road embankment failure
Temperature Rising maximum temperature	· Damage on road pavement
Wind (Cyclone) Higher wind speed and load	· Deterioration of bridge safety · Fallen tree and facilities such as electrical pole around road

Source: JICA Study Team

(3) Adaptation Measure

The design policy of each item mentioned in Clause 7.3 takes into consideration the adaptation measures against climate change. They are examined in order to enhance the safety of the road and the road facilities and to limit the extent of damage. Especially, decrease in drainage function was observed in both NH54 and NH51 because of fallen debris from the slope that has caused heavy damage on the pavement. Therefore, the retaining wall and slope protection works are planned all along the road in this study.

Table 7.4-2 shows the adaptation measures for climate change that were taken into consideration in the road design.

Table 7.4-2 Adaptation Measures for Climate Change in NH54

Factor	Design Policy Considering Adaptation
Side Slope	· Retaining wall is built all along the road. · Slope protection work is constructed on some weathered and loosen slopes. · Cut slope is covered with vegetation works to prevent erosion and collapse. · Designed safety factor in landslide stability analysis is set in consideration of high groundwater level. · Countermeasure including restraint works is planned for unstable landslide.
Embankment	· Drain filter is sandwiched in embankment.
Bridge and Drainage System	· Rainfall intensity is carefully determined based on the authorized data: ATLAS of Statewise Generalised Isopluvial Maps of Eastern India published by Indian Meteorological Department. The isopluvial value from higher edge of counter range is applied. · The capacity of all structures is determined to be capable for the discharge of 50 years return period.
Pavement	· Superelevation is installed properly. · Pavement material is examined not to rise over 60 °C on the surface.
Road Sign	· Wind load and visibility are taken into consideration.

Source: JICA Study Team

CHAPTER 8 PRELIMINARY DESIGN OF NH51 (TURA-DALU)

8.1 General

NH51 (Tura – Dalu) project is prioritized as project in the Priority Group A as mentioned in Chapter 6 and this project is subjected to preliminary design to examine procurement and construction method, implementation schedule, project organization, capability of operation and maintenance, social and environmental conditions and evaluate project cost and feasibility.

NH51 is a national highway with total length of 54km connecting Tura and Dalu in Meghalaya State. It passes rolling terrain in most sections and the average altitude of the road varies from 110 to 260m. The existing carriageway width is 3.75 m.

The objective of the Project is to secure stable, efficient and safe traffic through improvement of the exiting NH51 including road widening with appropriate slope protections, installation of pavement, drainage and other road facilities. Tura bypass is not included in scope of the preliminary design in consideration of small scale economic benefit.

8.2 Natural Condition Surveys

8.2.1 Meteorological and Hydrological Surveys

(1) General

The national highway should have an efficient drainage system to properly drain out rainwater on the road surface that flows from mountains upstream. Specially, a hilly road suffers from large volume of crossing water flowing from the mountain slopes. It is essential to protect the improved highway from such rainwater through appropriate planning of drainage facilities.

The hydrological study based on meteorological and topographical conditions at the project area was thus conducted.

(2) Meteorological Condition

Chilly weather commences from December and comes to an end in the month of February, while hot weather commences from the month of May and soon after this, the rainy season commences and continues until the end of September. The climate during chilly weather is pleasant. The days are bright and warm and the sun is not too hot. As soon as the sun sets, the temperature falls and the heat of day yields place to a sharp bracing cold. The maximum temperature recorded is 34 °C at Tura.

In addition, rainfall intensity has been increasing in the North-East States of India due to recent climate changes as explained in Chapter 8.3.

(3) Topographical Condition

Meghalaya has mountainous/rolling terrain. Tura is a valley located at the foothills of the Tura Hills and right below the Tura Peak. Elevation of Tura is approximately 350 m. It is the district capital of the West Garo Hills District. It is filled with small rivulets and green valleys all around. Dalu is the end of National Highway 51 and National Highway 62, elevated at 20 m, which is 33 km north-east of Tura in Meghalaya.

In the project area of NH51 between Tura to Dalu, the project route passes several rivers and its tributaries, including the following:

- Ganol River
- Rongkhon River
- Rongnabak River
- Mason River
- Jintal River
- Debok River

(4) Hydrological Study

1) Methodology

The hydrological study is conducted with reference to IRC: SP: 13 "Guidelines for the Design of Small Bridges and Culverts" and IRC: SP 42 "Guidelines of Road Drainage", which is a well used technical standard for hydrological study in Indian highway design.

The analysis is conducted based on the Rational Formulae for peak-off from catchment. The size of the flood are determined by factors such as rainfall intensity, distribution in time and space, duration, catchment area, shape, slope and permeability of the soil and vegetable cover.

Rational Formulae

$$Q = 0.028 \times C \times I \times A$$

C : Runoff coefficient
I : Critical intensity of rainfall (cm/hr), $I = F/T \times ((T+1)/(tc+1))$
F : Rainfall intensity (mm/hr)
T : Duration of storm (hrs)
tc : Time of concentration (hrs)
A : Catchment area (hectares)

2) Return Period

The return period is described in IRC: SP42 as follows:

-For side drain of NH : 25 years (at valley points)
-For cross-drainage of NH : 25 years (up to 2 m span) / 50 years (2 to 6 m span)

It is also suggested in IRC: SP42 to ensure the discharge is not only for design flood but also for check flood in order to protect an area from prolonged inundation when a flood rarer than the design flood hits the area. A check flood is the flood having the next higher commonly followed recurrence interval.

The project highway is located at a high hill, and the flood water may cause a high risk for fatal accidents. Also, due to the increase in rainfall intensity in recent years, an application of a 50-year flood for all drainage structures is not an overestimation.

Therefore, the structural dimensions of all drainage structures are determined to be capable for a design discharge of 50-year return period.

3) Rainfall Intensity

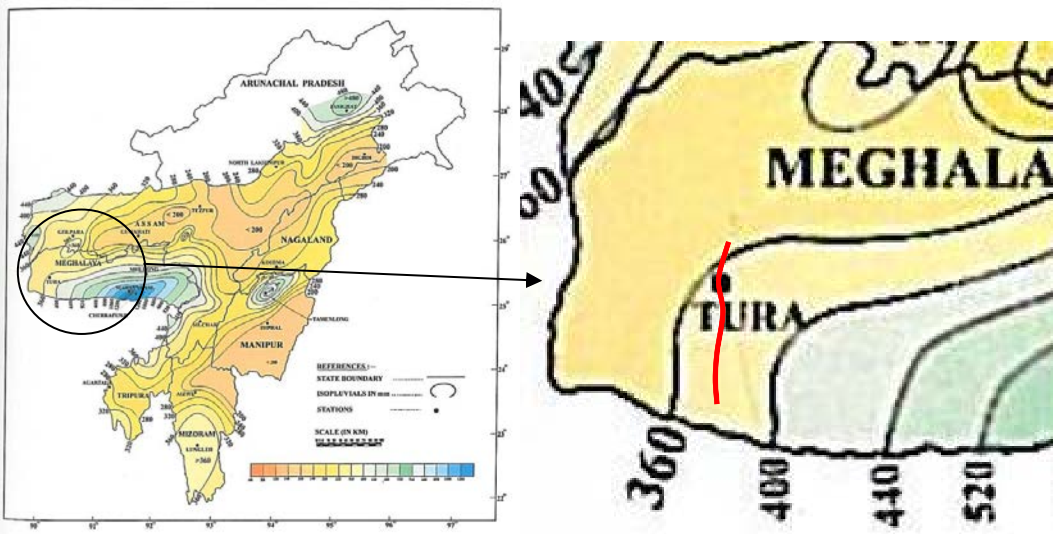
The rainfall intensity is based on the ATLAS of Statewise Generalised Isopluvial Maps of Eastern India (Part-II), published by the India Meteorological Department, Government of India.
Location of the project site is identified on the isopluvial map, which is shown in the figure below. It is sectioned by the range of rainfall intensity, of which value is read from the higher edge of counter value.

Rainfall intensity for each section in NH51 is shown in the table below.

Table 8.2-1 Rainfall Intensity for Each Section in NH51

City From	City To	50 years - 24hours rainfall intensity
B.P. of project section (near 90 k)	E.P. of project section (near148k)	400mm/hr

Source: JICA Study Team



Source: ATLAS of Statewise Generalised Isopluvial (Return Period) Maps of Eastern India (Part – II)

Figure 8.2-1 Isopluvial Map With Project Location for NH51 (For 50 Years)

4) Runoff Coefficient

The guidance of runoff-coefficient is described on IRC:SP:13.

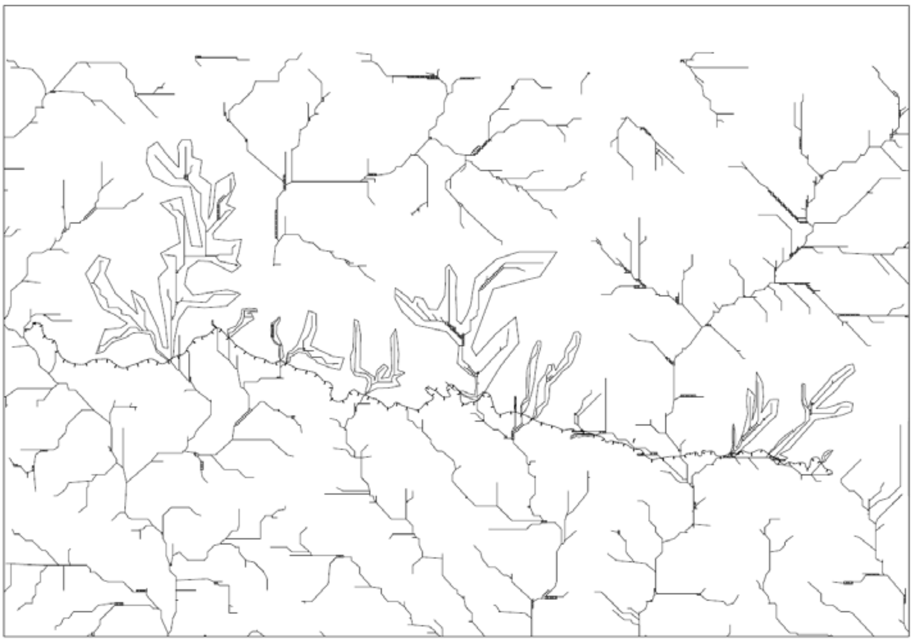
The topographical condition at the project area on NH51 is mostly rocky mountainous to steep terrain. Hence, runoff coefficient C: 0.8 is applied. (Rock, steep but wooded)

5) Catchment Parameters

Catchment parameters such as catchment area, length of tributary and difference of elevation along the project highway are obtained by computation using satellite data and GIS software.

- Satellite data: CatoSat I
- Software: Arc GIS 10.1 & Erdas

An example of a catchment area map obtained by computation for NH51 is shown in the figure below.



Source: JICA Study Team

Figure 8.2-2 An example of Hydrological Area Map Obtained by Computation for NH51

(5) Discharge Result

Through the hydrological study, discharge results for water crossing point with catchment area are obtained.

The discharge summary for large discharges (Q>4 m3/s) is summarized in the table below.

All discharge results including small catchment areas are estimated.

It is noted that cross-drainage is planned not only for locations where crossing water appear on the hydrological computation but also for the locations of existing cross-drainage, as well as some locations to complement between long intervals. This is explained in the chapter for drainage design.

Table 8.2-2 Discharge Summary for Large Discharges (NH51)

Chainage (Project Alignment)	Catchment Area (m^2)	Length of Tributary (m)	Difference of Elevation (m)	Discharge Q50 (m^3/s)	Remarks
86+570	898,275	1,832	68	76.34	Existing culvert location
87+885	80,401	474	16	8.38	Existing culvert location
88+850	102,637	17	8	10.23	
90+395	569,853	101	10	54.31	Existing culvert location
91+020	38,628	561	257	4.37	
91+120	79,986	782	216	9.08	
93+080	76,662	782	216	8.77	Existing culvert location
93+490	145,099	923	336	15.08	Existing culvert location
138+150	970,671	1,718	50	91.32	Existing culvert location
139+225	52,495	427	14	6.55	
139+910	402,207	1,204	41	38.84	Existing culvert location
141+560	700,998	1,239	40	66.42	

Source: JICA Study Team

8.2.2 Topographic Survey

(1) Survey Data

No additional survey was done by the JICA Study Team for the road alignment in NH51.

The details of topographic survey data received by the JICA Study Team from the DPR Consultant are shown in Table 8.2-3.

Table 8.2-3 Details of Topographic Data Received from the DPR Consultant

SN	Items	Description
1	Applied coordinate system	Local Coordinate System, but the north direction seems to be correct
2	Existing road survey data	3D point data and 3D line connections for centerline and road edges for existing roads are available.
3	Topographic survey data	3D point data are available basically within the existing road width only and very limited beyond the road edges making it difficult to make representative digital terrain model for quantity calculations
4	Topographic data on hill side	No sufficient data is available for the hillside area
5	Topographic data on valley side	Data is available at few locations for limited width
6	Other features	Houses and other structures are not fully shown
7	Remarks	Data on hill slopes are limited.

Source: JICA Study Team

(2) Issues from the Review

- The coordinate system for the survey works is unknown.
- The topographic data in the hill and valley slopes are very limited

(3) Additional Data by the JICA Study Team

The alignment design approach of the JICA Study Team was to make a more balanced cut/fill design by shifting the alignment of DPR to the valley side. Since the topographic survey data was not available/very limited in the valley side, the slope inventory data conducted by the JICA Study Team was used to create the contour data in the hill slopes. However, the slope inventory was conducted at every 200 m-300 m interval only. Therefore, the accuracy of the contour created for the slopes through such data is very low.

8.2.3 Geological Survey

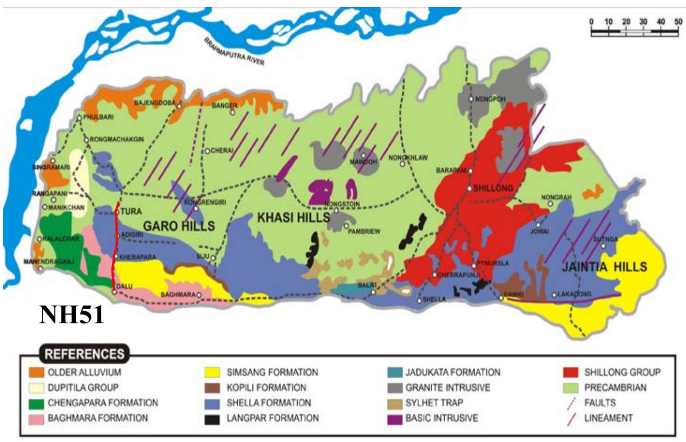
(1) General

Similar to NH54, the JICA Study Team conducted slope inventory survey and road alignment soil survey for the design of slope protection work and pavement respectively in NH51.

Meghalaya State where NH51 runs is located within the Shillong Massif Plateau lying in the south of the Brahmaputra Valley geomorphologically. Meghalaya is one of the wettest place in India with average annual rainfall as high as around 12,000 mm. The western part of the plateau, where the Garo Hills with lower elevations are located, has high temperature for most of a year.

Figure 8.2-3 presents the geological map of the Meghalaya. Although the Shillong Massif Plateau is geologically composed of various formations from Precambrian complex to the recent alluvium, tertiary to quaternary deposits are distributed in the western part of the plateau where NH51 runs. The tertiary formation is composed of Shella and Baghmara formations which mainly consist of clayey and sandy shale and sandstone sandwiching limestone and conglomerate. In the southern part of NH51, near the border with Bangladesh, fluvial alluvium overlies tertiary rocks. The unconsolidated soil is vulnerable to erosion and collapse, which causes slope failure and road subsidence.

The result of the slope inventory survey is mentioned in Section 8.2.5 below.



Source: Department of Mining and Geology, Meghalaya

Figure 8.2-3 Geological Map of Meghalaya

8.2.4 Road Inventory Survey

(1) Outline of Road Inventory Survey

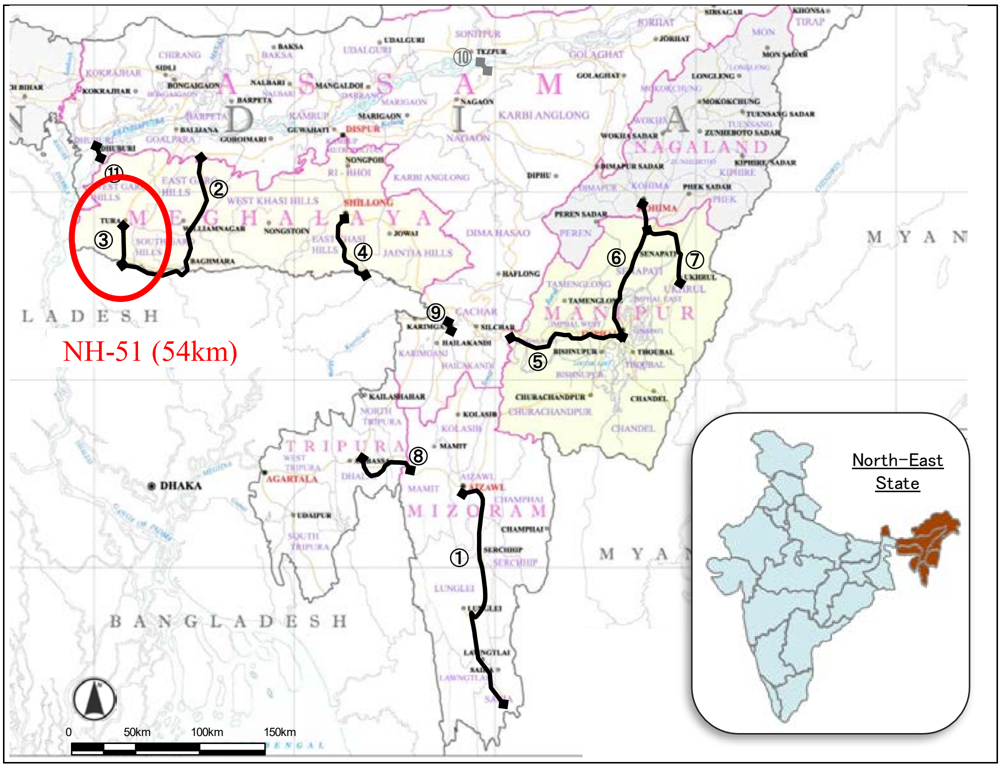
The JICA Study Team conducted a road inventory survey (hereinafter referred to as the“inventory survey”) from February 2015 to April 2015 along the national highway of NH54 in Mizoram State and NH51 in Megaraya State. The inventory survey aimed to identify the existing road characteristics, problems, and issues on the structural and traffic aspects as well as the geological and social conditions of the surrounding area along the target road.

(2) Survey Method

1) Target Road

The JICA Study Team conducted the inventory survey along to the following national highway in Meghalaya states.

- NH-51 : 54 km (Meghalaya State)



Source: JICA Study Team

Figure 8.2-4 Location Map of NH-51

2) Measurement Items

a) Road Cross Section Element

The following items were measured by measuring tape and visual observation at every 100 m section or any location where the target objects were found:

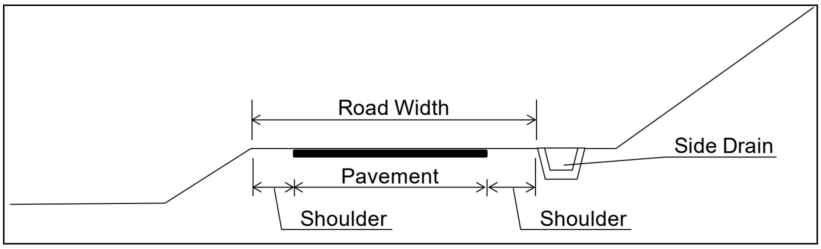
- ➢ Topography
- ➢ Residence Condition
- ➢ Road Width
- ➢ Pavement Condition

- Side Drain
- Side Walk

The pavement condition item consists of four categories: “Good”, “Fair”, “Poor” and “Bad”. Each category was judged on the basis of the following criteria:

- Good: when the existing road was smooth and had no visible potholes,
- Fair: when the existing road was smooth but had few visible cracks and potholes,
- Poor: when the existing road has more visible potholes and surface undulation, and
- Bad: when severe deterioration including cracking, surface deformation, disintegration and surface defect of the pavement was observed.

The road width was obtained at every 100 m interval along target roads. The definition of road width is shown in the following figure.



Source: JICA Study Team

Figure 8.2-5 Definition of Road Width

b) Cross Drain and Waterway

The following items were measured by measuring tape and visual observation at all locations where the target objects of cross drain and waterway were found.

- Cross Drain Structure (Type, Size)
- Condition of Cross Drain Structure
- Waterway (Width)

c) Retaining Wall and Guardrail

The following items were measured by measuring tape and visual observation at all locations where the target retaining walls and guardrails were found.

- Retaining Wall (Material, Height, Length)
- Guardrail (Material, Height, Length)

d) Social Infrastructure and Religious Objects

The following items were recorded based on existing local information collected in advance and visual observation at any location where the target social infrastructure and religious object were found. The distance from the pavement edge to the objects was measured by measuring tape at each location.

- Social Infrastructure (Object, Distance from Pavement Edge)
- Religious Object (Object, Distance from Pavement Edge)

e) Overhead Utility Line (Side, Distance from Pavement Edge)

The following items were recorded based on existing local information collected in advance and visual observation at any locations where the target overhead utility lines were found. The distance from the pavement edge to the objects was measured by measuring tape at each location.

- Electric Distribution Line
- Electric Transmission Line
- Transformer
- Telecommunication Line

f) Underground Utility Line (Side, Distance from Pavement Edge)

The following items were recorded based on existing local information collected in advance, from hearings of local residents and visual confirmation at the sites along the target routes during the survey period. The distance from the pavement edge to the objects was measured by measuring tape at each location.

- Water Supply Line
- Optical Fiber Cable Line

g) Bridge (Width, Length)

The size and condition of bridges along the target routes were recorded at any location where a bridge was found.

(3) Summary of Results

1) Road Cross Section Elements

a) Road Width (Pavement and Shoulder)

Figure 8.2-6 shows the results of the road width inventory survey.

- Rongram to Tura

  In this section, a relatively narrow shoulder of around 1.0 m was observed compared with the section after Tura to Barengapara. It can be said that this section is mostly dual carriage lane where pavement widths of 5.0 m to 6.5 m was observed entirely.

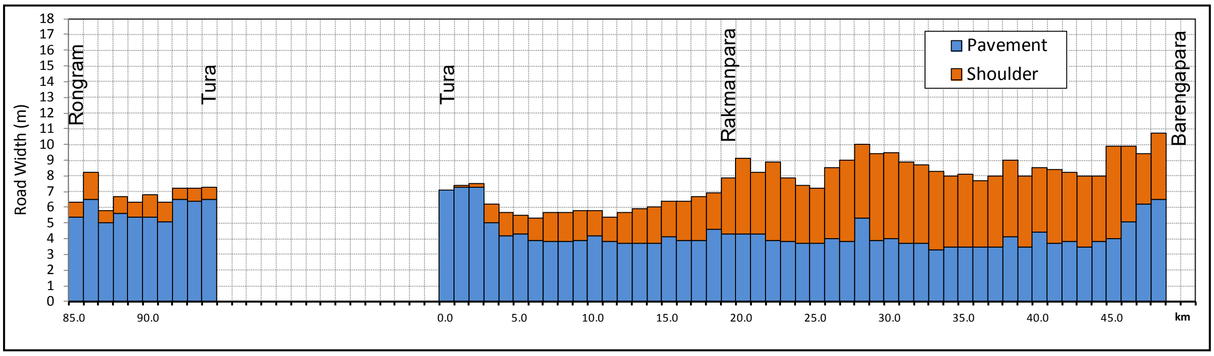
- Tura to Rakmanpara

  Around 7 m pavement width was recorded for 3 km after Tura. On the average however, around 4.0 m of pavement width was observed in this section. Therefore, this section is slightly narrower than a dual carriage.

  The shoulder width was increasing gradually after Tura to Rakmanpara from less than 1.0 m to 5.0 m. It has thus relatively more than enough passing space than the usual intermediate lane after the Tura section.

- Rakmanpara to Barengapara

  This section can likely be dual carriage lane because of the sufficient shoulder width recorded from 5.0 m to 6.0 m on the average in spite of the narrow pavement width observed of around 4.0 m. Just 2 km to 3 km nearby Barengapara, around 5.0 m pavement width with sufficient shoulder was recorded, so that this section can be said as dual carriage lane.



Source: JICA Study Team

Figure 8.2-6 Road Width (Pavement and Shoulder)

b) Others

- Topography

The sections where one side was hill and the other side was valley occupied in almost whole sections from Rongram to Barengapara. However, several sections where both sides were hill terrain was partially observed in the 3-km stretch from Rongram to Tura. The sections where both sides were on valley terrain was observed in the 5-km stretch from Tura to Rakmanpara as well as the 5-km stretch nearby the Barengapara area.

- Land Use

The stretch from Rongram to Tura was continuously observed as built-up area. On the other hand, 2 km and 3 km built-up areas in Bakmanpara and Barengapara were found after Tura.

- Pavement Condition

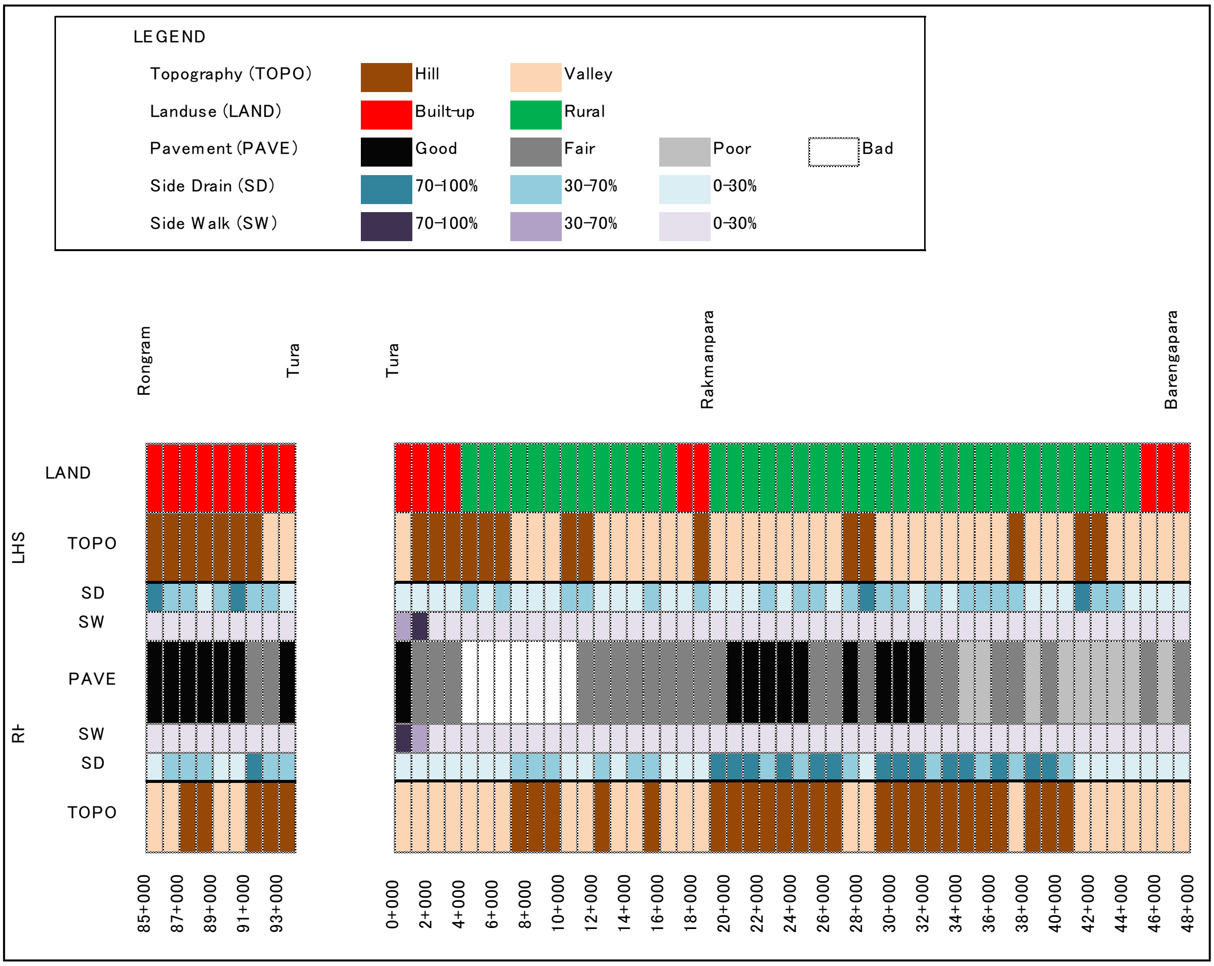
In the 7-km stretch between Tura to Rakmanpara, the pavement condition was continuously judged as "Bad". In the section from Rakmanpara to Barengapara, poor condition was observed for the 9-km total length especially nearby Barengapara side.

- Side Drain

Poor range having only less than 30% side drain on both sides of the road cross section was observed in the 8-km stretch from Tura to Rakmanpara and 4-km stretch nearby the Barengapara area.

- Sidewalk

Good range having 70% to 100% sidewalk infrastructure was observed in the 2-km stretch nearby Tura area only. Poor range having less than 30% was observed in the whole other sections.



Source: JICA Study Team

Figure 8.2-7 Cross Sectional Elements and Pavement Condition of NH51

2) Cross Drain

In the whole section, an average of 4 to 5 cross drains were observed for every one km of road. Hume pipe-type occupied about 82% and 59% of existing cross drains in the section from Bakmanpara to Barengapara and from Rongram to Rakmanpara, respectively.

Table 8.2-4 Survey Result on Cross Drains

Route	Section	Section Length (km)	No. of Cross Drain Structure					
			Hume Pipe	Masonry Slab	Other / Unknown	No Structure	TOTAL	Av. No. per km
NH51	Rakmanpara - Barengapara	28.9	102	22	7	7	138	4.8
	Rongram-Tura-Rakmanpara	28.8	65	46	13	10	134	4.7
	TOTAL	57.7	167	68	20	17	272	4.7

Source: JICA Study Team

3) Retaining Wall

The RCC type retaining wall was not observed in whole section. In other words, all of retaining walls were of masonry type in accordance with following table.

Table 8.2-5 Survey Result on Retaining Walls

Route	Section	Section Length (km)	Area of Retaining Wall (m2)								
			Left			Right			TOTAL		
			Masonry	RCC	TOTAL	Masonry	RCC	TOTAL	Masonry	RCC	TOTAL
NH51	Rakmanpara - Barengapara	28.9	1,997.3	0.0	1,997.3	1,469.0	0.0	1,469.0	3,466.3	0.0	3,466.3
	Rongram-Tura-Rakmanpara	28.8	4,799.5	0.0	4,799.5	3,271.5	0.0	3,271.5	8,071.1	0.0	8,071.1
	TOTAL	57.7	6,796.8	0.0	6,796.8	4,740.5	0.0	4,740.5	11,537.3	0.0	11,537.3

Source: JICA Study Team

4) Guardrails

In the section from Rakmanpara to Barengapara, steel type guardrails were mostly observed. On the other hand, masonry type was mostly found in the section from Rongram to Rakmanpara.

Table 8.2-6 Survey Result on Guardrails

Route	Section	Section Length (km)	Length of Guardrail (m)			
			Masonry	Parapet	Steel	TOTAL
NH51	Rakmanpara - Barengapara	28.9	5.8	0.0	223.7	229.5
	Rongram-Tura-Rakmanpara	28.8	1,448.4	419.2	0.0	1,867.6
	TOTAL	57.7	1,454.2	419.2	223.7	2,097.1

Source: JICA Study Team

5) Social Infrastructure

One school/orphanage home was found per approximately 4 km to 5 km in the section from Rongram to Rakmanpara. A waiting shed was observed at approximately every 1 km to 2 km section in the whole stretch.

Table 8.2-7 Survey Result on Social Infrastructure

Route	Section	Section Length (km)	No. of Social Infrastructure					
			School / Orphanage Home	Water pump	Urinal/Toilet	Petrol Pump	Waiting Shed	Others
NH51	Rakmanpara - Barengapara	28.9	0	2	1	1	20	6
	Rongram-Tura-Rakmanpara	28.8	7	2	0	1	13	0
	TOTAL	57.7	7	4	1	2	33	6

Source: JICA Study Team

6) Religious Structure

Few objects were observed in terms of all types of religious structures through this whole section. To stretch a point, a church and mosque were found at every 5 km to 6 km and about 10 km, respectively, on the average for whole section.

Table 8.2-8 Survey Result on Religious Structures

Route	Section	Section Length (km)	No. of Religious Object					
			Church	Mosque	Mandir	Memorial Stone	Grave	Monument/Statue
NH51	Rakmanpara - Barengapara	28.9	3	0	0	0	0	1
	Rongram-Tura-Rakmanpara	28.8	7	4	0	0	0	3
	TOTAL	57.7	10	4	0	0	0	4

Source: JICA Study Team

7) Public Utilities (Electric Line, Telecommunication Line, Water Supply, Optical Fiber Cable(OFC))

The number of crossings or close passing utility lines was counted as shown in Table 8.2-9 below.

Electricity distribution lines were found at approximately every 3 km and 4 km in the section from Rakmanpara to Barengapara and Rongram to Rakmanpara, respectively on the average. Electric transmission line was observed approximately at every 3 km to 4 km in the whole section on the average.

Telecommunication lines were found at approximately every 4 km in the whole section. Water supply lines were densely found at approximately every 0.5 km in the whole section on the average. OFC lines were mostly and densely observed in the section from Rongram to Rakmanpara at approximately every 0.5 km on the average.

Table 8.2-9 Result of Public Utilities

Route	Section	Section Length (km)	No. of Neighboring Public Utilities (Location of Crossing / Close Passage)				
			Electric Line		Telecommuni-cation Line	Water Supply	OFC
			Distribution	Transmission			
NH51	Rakmanpara - Barengapara	28.9	84	9	10	35	3
	Rongram-Tura-Rakmanpara	28.8	124	9	4	79	57
	TOTAL	57.7	208	18	14	114	60

Source: JICA Study Team

8.2.5 Slope Inventory Survey

The slope inventory survey was conducted for the purpose of the implementation of topographic measurement, verification of geological and geotechnical condition, and identification of landslide risks, which also include NH54. The detailed result of the survey is shown in Appendix-3.

Table 8.2-10 shows critical slopes identified in the survey and recommendation of side widening in NH51. Many subsidence parts caused by poor subsurface soil and drainage system were frequently found on NH51. For the subsidence portions, subsurface drainage shall be built for the improvement of drainage regardless of widening side.

Table 8.2-10 Recommendation of Widening Side (NH51)

Sec	LS No.	Landslide Location				Disaster Type	Road Deformation				Recommended Widening Side		
		Slope No.	Start	~	End		Collapse	Sinking	Crack	Bulge	R/L	H/V	Landslide Countermeasure
NH-51	01	221	93 + 400	~	93 + 420	SF	x				L	V	Soil retaining wall
	02	014	4 + 480	~	4 + 540	SF	x				R	V	Soil retaining wall
	03	015	4 + 540	~	4 + 580	SF					R	V	Soil retaining wall
	04	030	10 + 181	~	10 + 219	SF	x		x	x	L	H	Earth removal
	05	046	15 + 440	~	15 + 480	SF	x	x			-	-	Subsurface drainage
	06	055	18 + 520	~	18 + 560	SB		x			-	-	Subsurface drainage
	07	057	19 + 430	~	19 + 470	SB		x			-	-	Subsurface drainage
	08	058	19 + 700	~	19 + 720	SB		x			-	-	Subsurface drainage
	09	059	20 + 000	~	20 + 020	SB		x			-	-	Subsurface drainage
	10	060	20 + 240	~	20 + 280	SB		x			-	-	Subsurface drainage
	11	060	20 + 480	~	20 + 520	SB		x			-	-	Subsurface drainage
	12	061	20 + 640	~	20 + 660	SB		x			-	-	Subsurface drainage
	13	061	20 + 850	~	20 + 870	MM		x	x		R	V	Road realignment
	14	062	21 + 020	~	21 + 060	SB		x			-	-	Subsurface drainage
	15	062	21 + 200	~	21 + 250	SB		x			-	-	Subsurface drainage
	16	063	21 + 360	~	21 + 600	SB		x			-	-	Subsurface drainage
	17	064	21 + 660	~	21 + 720	SB		x			-	-	Subsurface drainage
	18	069	23 + 700	~	23 + 780	SB		x			-	-	Subsurface drainage
	19	070	23 + 940	~	24 + 010	MM-p		x			R	H	- No need
	20	070	24 + 120	~	24 + 220	SB		x			-	-	Subsurface drainage
	21	071	24 + 420	~	24 + 480	SB		x			-	-	Subsurface drainage
	22	074	25 + 680	~	25 + 700	MM		x			L	V	Soil retaining wall
	23	091	32 + 020	~	32 + 040	MM		x			L	V	Retaining wall

Source: JICA Study Team
MM: Mass Movement, MM-p: Inactive Mass Movement, SF: Slope Failure, SB: Subsidence
R: Right Side, L: Left Side, H: Hill Side, V: Valley Side

8.3 Preliminary Design

8.3.1 Review of DPR

(1) Design Standards and Design Criteria

In the DPR, NH51 was divided into the following two sections;

1. North section from km85 to km 95 before Tura City
2. South section from km101 after Tura City to km145 in Dalu

Other details are the same as for NH54 presented in Section 7.3.1.

The roadway widths in the original DPR of NH51 is given in Table 8.3-1 in comparison to the initial proposal by the JICA Study Team and final decision by NHIDCL.

Table 8.3-1 Comparison of Proposed and Final Roadway Widths

	Carriageway Width (m)	Paved Width (m)	Roadway Width (m)	Remarks
DPR	7.0	7	12.0	
Initial Proposal by the JICA Study Team	7.0	8.8	10.0	Based on IRC73:1980
Decision by NHIDCL	7.0	10.0	12.0	

Source: JICA Study Team

(2) Review of Road Alignment Design

From the DPR Consultant, only the topographic survey data and the horizontal alignment were made available for review. The profile, detailed cross section data and other details including design reports were not made available.

From the alignment data of the DPR design, the applied minimum radius and the percentage of minimum radius corresponding to the minimum design speed of 30 km/h (minimum radius 30m) and ruling design speed of 40 km/h (minimum radius 50m) were studied as given in Table 8.3-2.

Table 8.3-2 Review of DPR Horizontal Alignment of NH51

Section		R<20	R=20	20<R <25	R=25	25<R <30	R=30	30<R <50	Tot.R<30	Tot.R<50
All	No	10	17	2	16	8	31	101	53	185
	(%)	1.6%	2.8%	0.3%	2.6%	1.3%	5.0%	16.4%	8.6%	30.1%

Source: JICA Study Team

The following were observed in the design of the horizontal alignment by the DPR Consultant;

- The minimum radius of curve applied was as low as 14m only.
- In total, ten curves were designed with radius of less than 20 m.
- About 8.6% of the total number of curves applied in DPR or NH51 do not satisfy the minimum design speed of 30 km/h.
- Transition curves were not applied in the design of the entire horizontal alignment in NH51.

Therefore, it can be concluded that the alignment design by the DPR Consultant did not fully satisfy the requirements of IRC73:1980 in terms of minimum radius.

(3) Slope Protection Design

Slope protection works planned in the DPR of NH51 were reviewed. Table 8.3-3 shows the comparison with the DPRs of each section and proposal by the JICA Study Team.

Similar to the DPRs in NH54, road widening was planned mostly on hill sides with cutting slope and it resulted in very huge volume of cut soil compared with the embankment volume. The JICA Study Team proposed to NHIDCL and his consultant that widening should be applied on both hill and valley sides on a case-by-case basis to reduce the cut soil volume and plan landslide prevention measures against sediment disaster risk sites and road subsidence area sites as well as NH54.

Table 8.3-3 Review of DPR Regarding Slope Protection Work

Item	DPR*	Proposal **
Widening Side	Hill side only	Plan to widen on both hill and valley side in case by case basis.
Cut Grade	1:0,.6	Decide based on classification of rock and soil.
Cut Soil Volume (m3)	1.45 million	Reduce by widening on valley side and balance with embankment volume.
Embankment Volume (m3)	0.13 million	Will increase with widening on valley side.
Slope Protection	Retaining wall Brest wall	Appropriately adopt on landslide risk slope.
Landslide Sites Countermeasure Plan	Not recognized. Nil	Identify landslide risk sites in inventory survey and plan its countermeasures.

Source: *DPR as of May 2015, **JICA Study Team

(4) Bridge D The comments on the bridge plan by DPR are as follows.

- The general information for existing bridges are not provided well. Details such as structural type, span, carriageway width, design load and estimated construction year for each bridge are required.
- Re-construction was proposed for one minor bridge and rehabilitation was proposed for eleven bridges. However, the damage conditions and contents of rehabilitation are not explained.

Therefore, site investigation to check each bridge condition is required.

In the study, general information of existing bridges such as structural type, span, carriageway width and damaged condition are investigated on site. Also, some valuable information such as the construction year and design load is interviewed to PWD.

The necessity of bridge replacement should be carefully determined with several viewpoints such as carriageway width, design load, and soundness.

Table 8.3-4 Proposal for Bridges by DPR (NH51)

	DPR Proposal	Comment
NH51	One major bridge and eleven minor bridges were indicated as existing. Re-construction was proposed for one minor bridge and rehabilitation was proposed for eleven bridges.	Shortage of general information such as structural type or carriageway width. No explanation on damage conditions and the contents of rehabilitation.

Source: Based on DPR

(5) Drainage Design

The drainage design by DPR was reviewed. The proposed quantity for each type and size of cross drainage structures are summarized in the table below. The concrete lined ditch is applied to the road side ditch for cut side in almost all sections.
The comments on the cross drainage design by DPR are as follows:

- There is not enough explanation on the damaged conditions and structural features for each existing culvert.
- All existing culverts are proposed to be dismantled and re-constructed to new culverts with 12 m width. No reason was given on why it is not feasible to retain the existing culvert with extension of a partial new culvert.
- It is assumed that hydrological analysis was not conducted in DPR. Not any description regarding discharge calculation was included in the DPR. Newly added culvert was not proposed at all. In order to decide the type and dimensions of culvert, the water discharge obtained by hydrological analysis is to be referred to.

Table 8.3-5 Proposed Culvert by DPR for NH51

	Type	Size	Existing Location	Newly Added	Sum
NH51 85 to 95 101 to 145	Slab culvert	1.0 x 1.0	1	0	1
		1.0 x 1.5	28	0	28
		1.5 x 2.0	1	0	1
		2.0 x 1.0	8	0	8
		2.0 x 2.0	2	0	2
		2.5 x 2.5	3	0	3
	Box culvert	1.0 x 2.0	3	0	3
	Pipe	ϕ 1.2 x 1	162	0	162
		ϕ 1.2 x 2	19	0	19
		Total	227	0	227

Note : The number of culverts in the bypass section is not included.
Source: Based on DPR

(6) Accuracy of Design Data

- In the topographic survey of DPR, the consultant applied the local coordinate system. It is better to unify the topographic survey in the national coordinate system of India or the most popularly used WGS-84 system so that the data can be interchanged with other commonly used platform like Google Earth for checking purposes.
- The topographic survey lacked the data on the hill side as well as valley side. The JICA Study Team tried to supplement the data in the valley side through the inventory survey of the slopes at an interval of 200 m-300 m length. However, the accuracy of the data cannot be established in comparison with the actual ground topographic survey.

Therefore, the revised design based on such data may have large variations in the design quantities.

8.3.2 Road Geometric Design

(1) Design Standards

Basically, the design standards given in the Indian Roads Congress (IRC) Standards, Codes, Guidelines and Special Publications will be referred. The following IRC standards for highway geometric design are referred to:

- IRC:73-1980 – Geometric Design Standards for Rural (Non-urban) Highways
- IRC:52-2001 – Recommendations about the Alignment Survey and Geometric Design of Hill Roads
- IRC:SP:48-1998 – Hill Road Manual

Where no provisions exist in these standards, the relevant standards of AASHTO (A Policy on Geometric Design of Highways and Streets, 2011) or JRSO (Japan Road Structure Ordinance, 2004) will be referred to if necessary.

(2) Design Policy and Design Criteria

The major objectives of the study are:

- To analyze the existing data/reports and review the existing detailed project reports (DPRs); and
- To examine procurement and construction method, implementation schedule, project organization, capability for operation and maintenance, social and environmental conditions and evaluate project cost and feasibility of target sections.

However, after review of the DPR data, it was concluded that the accuracy of topographic survey data and design standards were not properly applied.

Therefore, although not a part of the scopes of the study, redesign to the extent possible from the available data was attempted to come up with some meaningful quantities and cost of the project.

The following design policies are established:

- There were differences in the design concept with NH54 and with different road width, application of minimum design speed, minimum radius of horizontal curves, and application of transition curves. Therefore, uniformity in the design criteria is required for all roads in the project.
- Design of alignment shall be based on the policy of balance between application of minimum design standard and the terrain condition, such that the improved alignment does not largely deviate from the existing road.
- Widening shall be done with a concept to minimize the earthwork imbalance and alignment shall be shifted to the valley side up to the extent so as not to increase the construction cost sharply.
- At landslide-prone areas identified by the JICA Study Team, the widening side shall be decided based on the results of the study.
- Widening shall be done with a concept to minimize the relocation of houses along the existing road.
- As per the instruction of NHIDCL and IRC:37-1980, transition curves shall be designed for all horizontal curves. Exceptions maybe applied with the length of transition curves at difficult locations.

The established geometric design criteria is given in Table 7.3-16 in the previous chapter.

(3) Design Conditions

- As stated earlier, one of the major objectives of the study was to analyze the existing data/reports and review the existing DPRs.
- However, the alignment design by each DPR Consultant for each section and road was completely with different design policy, while uniformity in design was required.
- Widening of the existing road in DPR was exclusively designed for the hillside only, due to which very big excavation volume resulted, raising serious environmental concerns.
- Therefore, re-design of the entire project road was required by applying uniform design standards and making a more balanced cut/fill design by shifting the alignment to the valley side wherever practicable.

- However, the topographic data on the valley side was not available in DPR. The scope of the study did not include topographic survey of the road and it was also not possible to conduct the survey during the short duration of the study.
- The scope of the study included slope inventory survey where the roadside slopes were measured approximately by the use of a distance meter at an interval of about 200 m-300 m.
- The results from the slope inventory survey were used to create the digital terrain model of the valley side. However, since the data was available at an interval of every 200 m-300 m only, accuracy cannot be expected.
- Therefore, the re-design of the alignment was done with the constraints mentioned above which would affect to the desired degree of accuracy.

(4) Horizontal Alignment Design

The starting and ending chainages of each section in NH51 are given in Table 8.3-6.

Table 8.3-6 Start and End Chainages of Each Section in NH51

SN	Section	Start Chainage	End Chainage	Remarks
1	North	km 85+000	km 94+226.4	Revised design ends at same location as original km 95
2	South	km 101+000	km 143+289.9	The end point is recommended to extend until the intersection with NH62, which is 575 m south to the existing kilometer post of 145. According to PWD staff in Tura, DPR of this section towards the border of Bangladesh has already been completed under a separate contract from PWD. The data was requested to PWD but was not made available.

Source: JICA Study Team

The details of the revised alignment for NH51 are given in Table 8.3-7, showing the percentage of radius less than the value required for minimum design speed of 30 km/h. These were applied only at the residential area in the north section, which otherwise would require resettlement of large houses.

Table 8.3-7 Application Rates of Minimum Radius in Each Section of NH51

Section		R=20	20<R<25	R=25	25<R<30	R=30	Tot.R<30	Remarks
North	No	2	0	0	0	19	2	R=20 m at the residential area only
	(%)	2.1%	0%	0%	0%	20.2%	2.1%	
South	No	0	0	0	0	51	0	All horizontal curves satisfy minimum design speed of 30km/h
	(%)	0%	0%	0%	0%	11.9	0%	

Source: JICA Study Team

The quantities of excavation volume for the revised alignments are also given for each section in Table 8.3-8. The DPR design details were not made available.

Table 8.3-8 Excavation and Spoil Volume for the Revised Design by the JICA Study Team

SN	Section	Revised Design	
		Excavation Volume (m^3)	Spoil Volume (m^3)
1	All NH51	0.66 million	0.41 million

Source: JICA Study Team

(5) Vertical Alignment Design

- Minimum gradient is designed as 0.5% at cut sections for drainage.
- The ruling gradient is designed as 6% as per the design standard given in Section 7.2.3(1).

- The limiting gradient is 7% at difficult locations.
- The exceptional gradient is 8%, which is applied for unavoidable situations only and the maximum length is 100 m.

The length of the designed vertical profile grade range is given in Table 8.3-9 in percentage of the total length of each section is presented below.

Table 8.3-9 Length of Designed Vertical Profile Grade Range

SN	Section	Vertical Grade Range									
		≤0.5%	0.5%-1%	1%-2%	2%-3%	3%-4%	4%-5%	5%-6%	6%-7%	7%-8%	11%
1	North	5.8%	5.5%	5.0%	9.9%	5.7%	3.5%	6.0%	55.4%	2.2%	1.1%
2	South	7.5%	13.5%	18.2%	8.7%	14.2%	18.1%	13.8%	5.1%	1.0%	0%

Source: JICA Study Team

At the approach of the bridge from km 91+397 to km 91+497 in the north section, exceptional grade of 11% is applied for a length of 100 m due to unavoidable situations.

- The vertical grade higher than the ruling gradient of 6% but less than or equal to the limiting gradient of 7% was applied at a total percentage lengths of 10.6%, 8.2%, and 6.2% for Sections S1, S2, and S3, respectively.
- Exceptional gradient of 8% was applied at four locations (total of 400 m) each in Sections S1 and S2 and two locations (200 m) in Section S3.

(6) Typical Cross Section

The typical cross section of the project is as given in Figure7.2-12, which is basically the same as that for NH54.

8.3.3 Bridges and Structures Design

(1) General

It is necessary for bridges on NH51 to provide functions adapted to current national highway standards. If the existing bridge is adequate per requirement of current national highway, it can be retained with or without some repair works. If the existing bridge is deemed to be inadequate, it should be replaced by a new bridge.

The necessity of bridge replacement should be carefully determined based on the following viewpoints:

- Road width on bridge: The road width for bridges should be sufficient for national highway standards. Although the road width for general road section is planned as 12.0 m (3.5 m x 2 for vehicle lane and 2.5 m x 2 for side lane), the road width for existing bridges is considered enough if more than 7.5 m as referred to IRC:73.
- Design load: The existing bridge is utilized only if it follows the design load to be applicable for current national highway standard. Specially, live load is an important factor because it directly works at the girder. Hence, the application of live load (IRC Class 70R Loading) as mentioned in IRC:6 is confirmed for determination.
- Soundness: The existing bridge is utilized only if the condition is basically sound without major damages. It is said that the road was originally constructed in around 1970. It means that the existing bridges constructed at the origin of the road are aging to nearly 50 years. The project can be a suitable occasion for such old bridges to be replaced with new bridge.

(2) Existing Bridge Condition

Fourteen existing bridges are identified in the project area of NH51. The outline, conditions, and comments for these existing bridges are summarized in Table 8.3-11.

Construction years are different across the bridge. Carriageway width 7.5 m is roughly provided in all bridges. Aging deterioration is seen for all bridges except few new bridges.

According to information obtained from PWD in Tura, IRC Class A Loading is applied to all existing bridges On the other hand, both of IRC Class 70R loading and ClassA loading need to be verified on current national highway standard. (It is simply called IRC Class 70R loading.)

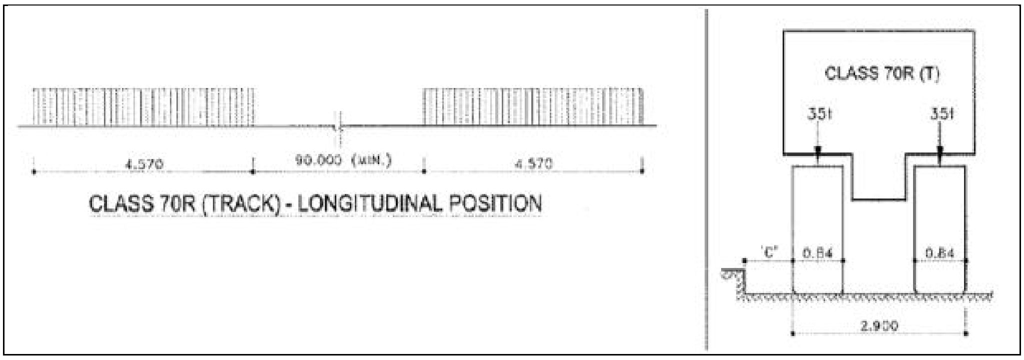
Because axle intervals and weight between two live load models are different, Class A load may become lighter design condition in case of some bridge length.

Here, the total amount of axle load for both live load model loaded at simple supported beam is compared. Class A load becomes lighter than 70R loading in the case that one span of girder is less than 15 m. It means that a bridge of less than 15 m cannot meet the condition for 70R loading and it seems to be shortage of design load.

Table 8.3-10 Comparison of Total Axle Load Between IRC Models on Simple Supported Girder

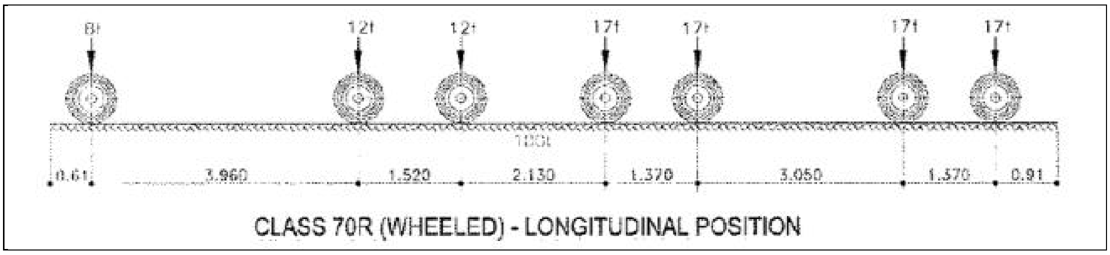
Bridge Length	Live load total		
	70R (Tracked Vehicle)	70R (Wheeled Vehicle)	Class-A
Lanes	One lane load	One lane load	Two lane loads
L=5m	70t	46t	51.0t
L=10m	70t	92t	70.0t
L=12.5m	70t	92t	78.2t
L=15m	70t	100t	100t
L=20m	70t	100t	110.8t
L=30m	70t	100t	110.8t

Source: JICA Study Team



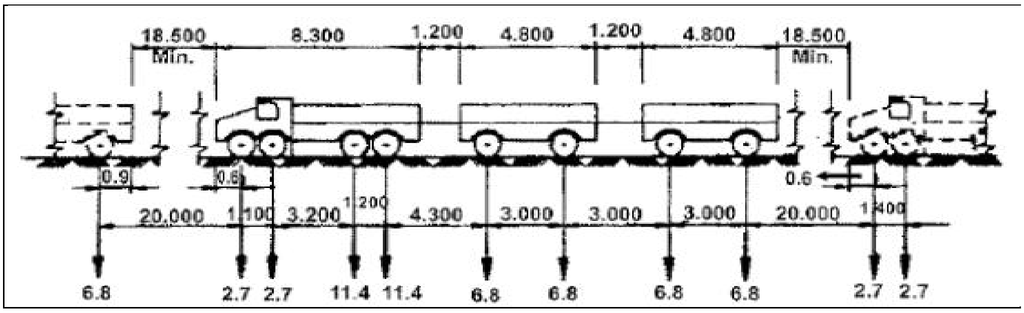
Source: IRC:6

Figure 8.3-1 Wheel Arrangement for 70R (Tracked) Vehicle



Source: IRC:6

Figure 8.3-2 Wheel Arrangement for 70R (Wheeled) Vehicle



Source: IRC:6

Figure 8.3-3 Class A Train of Vehicles

Table 8.3-11 Outline and Conditions of Existing Bridges on NH51

Location	Outline	Conditions	Comments
86+310	・Bridge name：Ganol Bridge ・River name：Ganol River ・Construction year：2002 ・Structural type ：4-span RC girder ・Length and span：4-span 98.9 m ・Roadway width：7.5 m +sidewalk at both sides ・Bridge overall width : 12 m ・Design load：Class A	・No major damages are seen at girder, pier, abutment, pavement, and railing.	The existing bridge can be retained without special repairs because: -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.
90+077	・Bridge name：Dapu Bridge ・River name：Dapu Stream ・Construction year：1994 ・Structural type：RC slab ・Length and span：1 x 12.8 m ・Roadway width：7.5 m ・Bridge overall width : 8.5 m ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated.	The superstructure of the existing bridge should be replaced by a new one Because: -Design load for existing girder is less than standard load
91+385	・Bridge name：Jongme Bridge ・River name：Jongme stream ・Construction year：1985 ・Structural type：RC slab ・Length and span：1 x 8.8 m ・Roadway width：7.5 m ・Bridge overall width : 11 m +sidewalk at both sides ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated.	The superstructure of the existing bridge should be replaced by a new one because: - Design load for existing girder is less than standard load
92+442	・Bridge name：Rongkhon Bridge(N) ・River name：Rongkhon River ・Construction year：2003 ・Structural type：RC girder ・Length and span：1 x 37.0 m ・Roadway width：7.5 m + sidewalk at both sides ・Bridge overall width : 12 m ・Design load：Class A	・No major damages are seen at girder, pier, abutment, pavement, and railing.	The existing bridge can be retained without special repairs because: -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.

Location	Outline	Conditions	Comments
92+532	・Bridge name：Rongkhon Bridge(S) ・River name：Rongkhon River ・Construction year：2003 ・Structural type：RC girder ・Length and span：1 x 17.1 m ・Roadway width：7.5 m + sidewalk at both sides ・Bridge overall width : 12 m ・Design load：Class A	・No major damages are seen at girder, pier, abutment, pavement, and railing.	The existing bridge can be retained without special repairs because: -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.
103+240	・Bridge name：Deran Bridge ・River name：Deran Stream ・Construction year：1990 ・Structural type：RC slab ・Length and span：1 x 11.5 m ・Roadway width：7.5 m ・Bridge overall width : 8.5 m ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated. ・Concrete exfoliation and exposure of steel bar is seen at girder side.	The superstructure of the existing bridge should be replaced by a new one because: - Design load for existing girder is less than standard load
107+335	・Bridge name：Rongnabak Bridge ・River name：Rongnabak River ・Construction year：1990 ・Structural type：RC girder ・Length and span：1 x 25.8 m ・Roadway width：7.5 m ・Bridge overall width : 8.5 m ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated, however, there is no serious damage.	The existing bridge can be retained without special repairs because; -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.
136+990	・Bridge name：Mason Bridge ・River name：Mason River ・Construction year：1993 ・Structural type：RC girder ・Length and span：1 x 25.3 m ・Roadway width：7.5m ・Bridge overall width : 8.5 m ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated, however, there is no serious damage.	The existing bridge can be retained without special repairs because; -No major damages are seen. -Roadway width is satisfied. -Design load is satisfied.
137+825	・Bridge name：Jintal Bridge ・River name：Jintal River ・Construction year：1996 ・Structural type：3-span RC slab ・Length & span： 9.0 m+17.4 m+9.0 m =35.4 m ・Roadway width：7.5 m ・Bridge overall width : 8.5 m ・Design load：Class A	・Change of color on concrete at girder side for center span due to drain water. ・Girders at side span are aging and wholly deteriorated. ・Pavement has settled a little at the approach part.	For side span, the superstructure of the existing bridge should be replaced by a new one because: - Design load for existing girder is less than standard load.
140+690	・Bridge name：- ・River name：- ・Construction year：N/A ・Structural type： RC slab ・Length and span：1 x 6.0 m ・Roadway width：4.0 m ・Bridge overall width : 5 m ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated . ・Concrete railing is quite deteriorated.	The superstructure of the existing bridge should be replaced by a new one because: -Shortage of carriageway width - Design load for existing girder is less than standard load.

Location	Outline	Conditions	Comments
140+990	・Bridge name：Debok Bridge ・River name：Debok River ・Construction year：1990 ・Structural type：3-span RC slab ・Length and span： 3 x 9.7 m =29.0 m ・Roadway width：7.5 m ・Bridge overall width : 8.5 m ・Design load：Class A	・Girders, piers, and abutments are aging and wholly deteriorated.	The superstructure of existing bridge should be replaced to new one because; - Design load for existing girder is less than standard load.
141+928	・Bridge name：- ・River name：- ・Construction year：1991 ・Structural type： RC slab ・Length and span：1 x 7.5 m ・Roadway width：7.5 m ・Bridge overall width : 8.5 m ・Design load：Class A	・Girders and abutments are aging and wholly deteriorated. ・Exposure of steel bar is seen at girder side.	The superstructure of the existing bridge should be replaced by a new one because: - Design load for existing girder is less than standard load

Note) The outline data is based on the site measurement and interview information from the Executive Engineer of PWD in Tura District.
Source: JICA Study Team

Hence, the proposal is for reconstruction of one bridge and replacement of superstructures for seven bridges as summarized below.

The bridge to be reconstructed ・・・1 location

(a) 140+690 (RC slab L=6.0 m)

The bridges' superstructure for replacement・・・6 locations

(b) 90+077 (RC slab L=12.8 m)
(c) 91+385 (RC slab L=8.8 m)
(d) 103+240 (RC slab L=11.5 m)
(e) 137+825 (Side span of 3-span RC slab side span 2 nos x 9.0 m)
(f) 140+990 (3-span RC slab L: 3 x 9.7 m)
(g) 141+928 (RC slab L=7.5 m)

Table 8.3-12 Existing Bridges to be Replaced or Rehabilitated

At 140+690	
At 90+077	
At 91+385	

At 103+240	
At 137+825	
At 140+990	

At 141+928	

Source: JICA Study Team

(3) Design Standard

The design is based on the IRC standards in principle. For the detailed design stage, it shall be designed based on IRC standards as far as applicable.

Major codes and typical drawings regarding bridge design are summarized in **Table 8.3-13** below. Also, the codes for road design are to be referred to, but not limited to:

Table 8.3-13 List of Major Codes for Bridge Design

IRC: 5-1998	Standard Specification & Code of practice for Road Bridges. Section – I General Features of Design (Seventh Revision)
IRC: 6-2014	Standard Specification & Code of practice for Road Bridges. Section – II Loads & Stresses (Revised Edition)
IRC: 21-2000	Standard Specification & Code of practice for Road Bridges. Section – III Cement Concrete Plain & Reinforced (Third Revision)
IRC: 24-2010	Standard Specification & Code of practice for Road Bridges, Steel Road Bridges (Limit State Method) (Third Revision)
IRC: 45-1972	Recommendations for Estimating the Resistance of soil below the maximum Scour Level in the Design of Well Foundations of Bridges.
IRC: 73-1980	Geometric Design standards for Rural (Non-Urban) Highways.
IRC: 78-2014	Standard Specification & Code of practice for Road Bridges. Section – VII Foundation & Substructure (Revised Edition)
IRC: 112-2011	Code of Practice or Concrete Road Bridges
MORTH	Standard Plans for 3.0m to 10.0m Span Reinforcement Cement Concrete Solid Slab Structure with and without Footpaths for Highways, 1991
MORTH	Standard Plans for Highway Bridges R.C.C. T-Beam & Slab Superstructure – Span from 10m to 24m with 12m width, 1991

Source: JICA Study Team

The design load condition shall be determined by taking into account the regional and project characteristics. Major load conditions are as follows:

- Live load: IRC Class 70R Loading (Based on IRC:6 Clause 201)
- Live load combination: One lane of Class 70R or two lanes of Class A (Based on IRC:6 Clause 204.3)
- Impact load: (Based on IRC:6 Clause 208)
- Temperature load: +5 to +40 degrees (Based on IRC:6 Clause 215)
- Seismic load: Zone-V, Important factor: 1.5 (Based on IRC:6 Clause 219)

For other load conditions, these shall also be determined based on IRC standards.

(4) Bridge Design

1) Bridge Replacement for Minor Bridge

Bridge replacement is proposed for the following one minor bridge.

Table 8.3-14 Bridge Replacement for NH51

Location	Structural Type	Outline
140+690	RC Slab Bridge	Bridge length：L=6.0 m Total width：W=12 m (Without footpath) Foundation：Spread foundation

Source: JICA Study Team

- The bridge is comparably of short span. Hence, IRC typical drawing can be applied. The superstructure is planned based on the IRC typical drawing. Range for RC slab is 6 m to 10 m. Hence, the structural type for the proposed new bridge is RC slab bridge.
- The bridge width is planned as 12 m based on IRC:73. Footpath is not provided because the proposed bridge is of quite short length and the existing bridge is quite short.
- No trace of submergence is seen for the existing bridge. Hence, the the same clearance under the girder as the existing bridge is to be provided. The road level is to be decided based on the approach road level.
- Based on information for the existing bridge, spread foundation is proposed to be the same as the existing.
- Because the bridge is composed of RC and masonry members only, concrete work with mixer at the site is proposed. After the demolition of the existing bridge, foundation is constructed. The superstructure concrete will be by cast in-situ on the support.
- Temporary road is required for traffic diversion during construction. Construction during the dry season is recommended.

2) Bridge Replacement for Minor Bridge

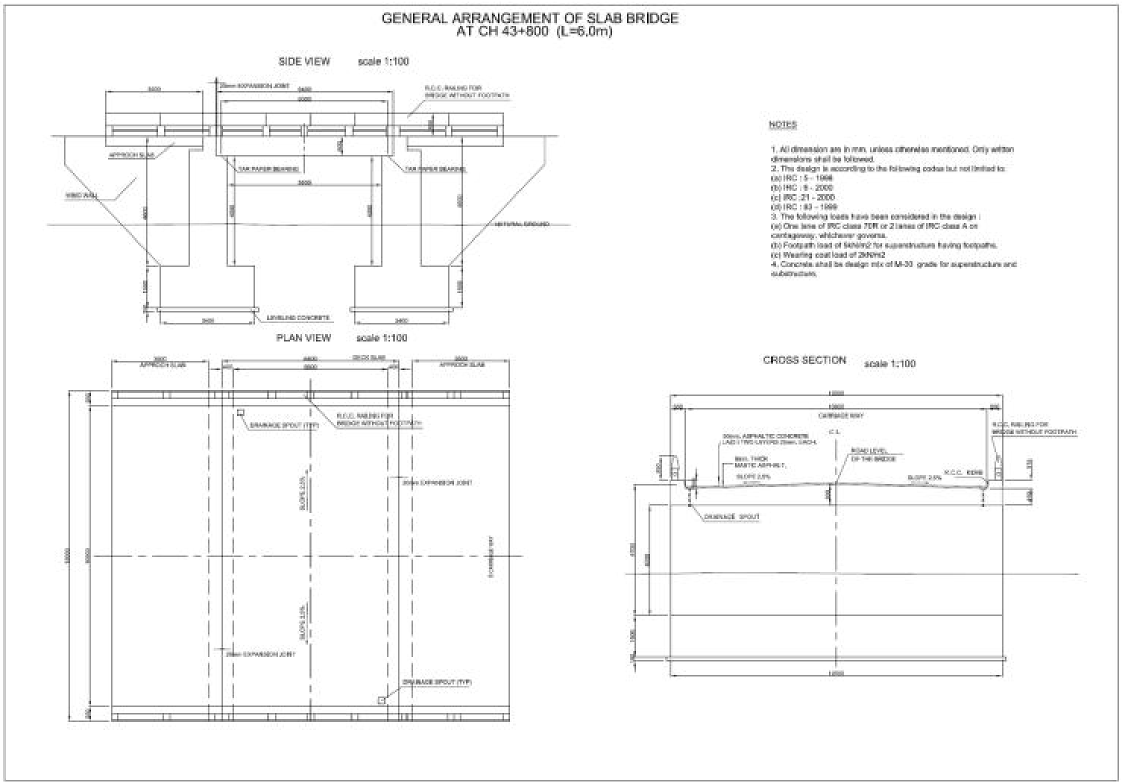
Replacement of superstructures is proposed for the following seven minor bridges.

Table 8.3-15 Replacement of Superstructures for NH51

Structural Type	Bridge Width	Location and Length for Replacement
RC Slab Bridge	With footpath (width :11 m)	91+385（L=8.8 m）
RC Slab Bridge	Without footpath (width :8.5 m)	137+825（L : 9.0 m x 2 spans at side） 140+990（L : 9.7 m x 3 spans） 141+928（L=7.5 m）
RC T-beam Bridge	With footpath (width :12 m)	90+077（L=12.8 m） 103+240（L=11.5 m）

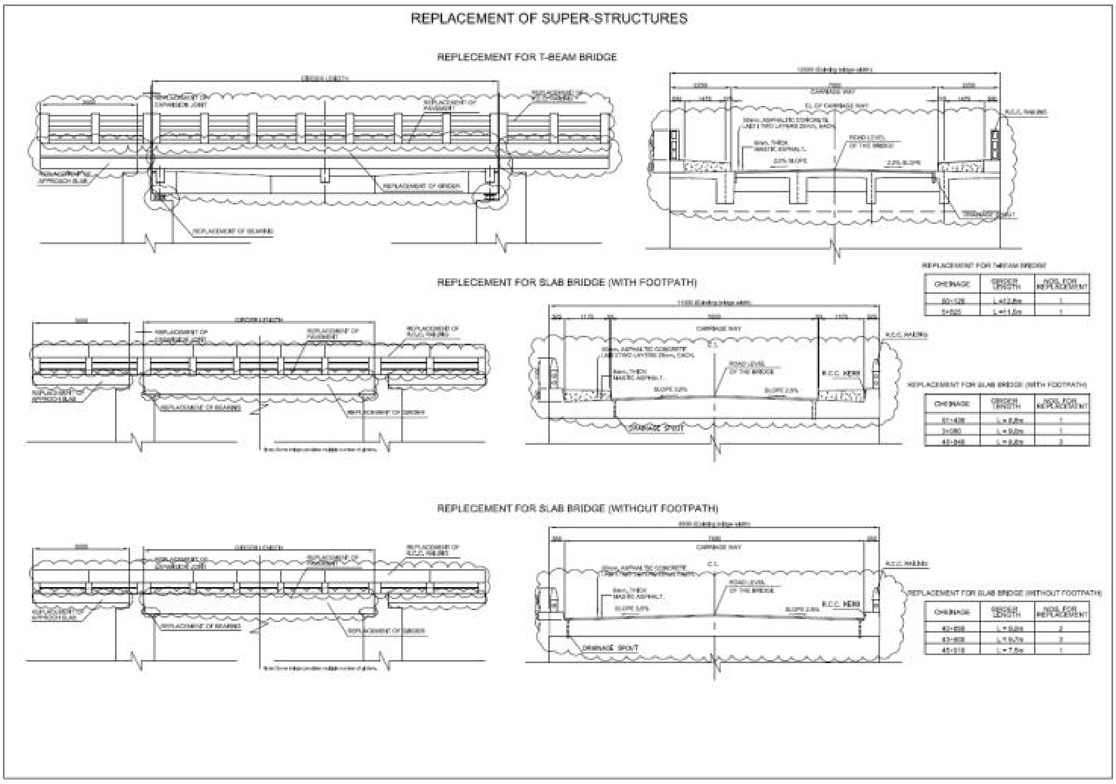
Source: JICA Study Team

- All is comparably short span. Hence, IRC typical drawing can be applied. The superstructure is planned based on the IRC typical drawing. Range for RC slab is 6 m to 10 m and for RC T-beam is 10 m to 24 m. Hence, the type of superstructures for replacement is RC T-beam or RC slab girder type.
- The bridge width is determined by taking into account the girder type and size of substructure for the existing bridge.
- Because the bridge is composed of RC and masonry members only, concrete work with mixer at site is proposed. After the demolition of the existing bridge, foundation is constructed. The superstructure concrete will be by cast in-situ on the support.
- Temporary road is required nearby for traffic diversion during construction. Construction in the dry season is recommended.



Source: JICA Study Team

Figure 8.3-4 Slab Bridge (L=6 m)



Source: JICA Study Team

Figure 8.3-5 Replacement of Superstructures

8.3.4 Earthworks / Slope Protection / Landslide Prevention Design

The JICA Study Team used the same design standardss for earth works, slope protection, and landslide prevention measures for NH51 as NH54 mentioned in Clause 7.3.4 .

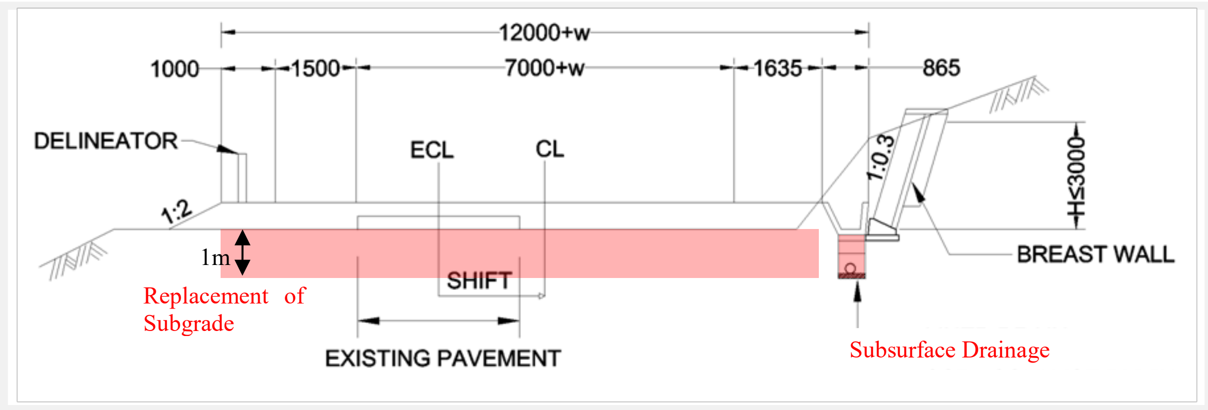
Slope along NH51 is covered by very loose quaternary alluvium. One concern is that slope failure and erosion have frequently occurred on cut slopes along NH51. Therefore, such loose soil slope shall be cut with 1:1.2 slope, which is gentler than IRC standard for landslide prevention as shown in Table 8.3-16. The cut slope shall be greened by seeding and mulching consisting of jute netting, including seeds which cover all over the slope and prevent erosion by rain water.

Table 8.3-16 Design Criteria of Cut Slope and Slope Protection Work

IRC Standard*		JICA Study Team Rock/Soil Classification		Cut Grade	Slope Protection Work
Classification	Cut Grade				
Ordinary Soil/ Heavy Soil	**1:1.0 ~ 1:0.5**	Soil	Dense Soil	**1:1.0**	Seeding and Mulching
			Loose Soil	**1:1.2**	Seeding and Mulching

*IRC: SP:48:1948 Clause 7.4
Source: JICA Study Team

The JICA Study Team identified a lot of road subsidence sites in the slope inventory survey, which was assumed to occur due to consolidation of loosened subsurface soil and high groundwater level except for embankment sliding. Therefore, replacement with 1.0 m thick subgrade and subsurface drainage are the planned countermeasures for sinking as shown in Figure 8.3-6.



Source: JICA Study Team

Figure 8.3-6 Typical Cross Section of Countermeasures for Sinking

8.3.5 Pavement Design

(1) Design Standards and Guidelines

Design guideline for flexible pavement is published by IRC as “Tentative Guidelines for the Design for Flexible Pavements (IRC37-2012).

(2) Pavement Design

Pavement design for NH51 is decided by NHIDCL in the meeting held on 14 August 2015 at NHIDCL as shown in Table 8.3-17.

Table 8.3-17 Pavement Conposition of NH51

Pavement Layer	Thickness (mm)
BC (Bituminous Concrete)	40
DBM (Dense Graded Bituminous Macadam)	70
WMM (Wet Mix Macadam)	250
GSB (Granular Sub-Base)	300
Total	660

Souce: JICA Study Team

8.3.6 Drainage Design

(1) General

It is required to facilitate culvert or side ditch on roads for draining surrounding water or upstream of road to downstream properly. Specially, hill roads always suffer from large volume of water falling from the mountain slopes towards to the road. It is quite important to protect the road by appropriately arranging cross drainage to release the discharge from crossing water.

On the existing NH51, many culverts exist crossing under the road. Because road improvement includes road widening and alignment modification in most sections, appropriate measures for culverts such as demolition/reconstruction or extension of the existing ones are considered to be taken in each location.

However, it is considered that retaining the existing culvert with extension measure is not practical for the situation. The reasons are explained below.

- Position shift due to road improvement : The culvert length needs to be extended due to road widening from existing 6-7 m to 12 m width. Also, the culvert position to be placed is changed because the road centerline is shifted by alignment modification. Specially, it can be shifted to the valley side at each section where the curve radius is modified to be larger by alignment modification. Hence, the extension measure on existing culverts does not reduce much the work volumes as compared with new construction. In addition, it makes the work more complicated.

- Condition of existing culvert：The existing original structures constructed at the beginning of the road are aged near to 50 years. It was confirmed by the investigation that these structures do not provide appropriate durability, structural features, and maintenance performance to be utilized in an improved national highway.

Moreover, it cannot be assured that existing culverts will be durable for next several decades. The replacement on this one occasion of road improvement would be of more advantage in terms of economy and serviceability of the road than frequent occasional replacements in the near future.

Hence, it is the general policy that existing culverts are demolished and new ones are constructed.

The new drainage system is designed based on hydrological calculation results. Based on the obtained location of water crossing and discharge, the dimensions and locations for drainage system are determined. For cross drainage structures, the appropriate culvert type is selected by taking into account economy, construction workability, and maintenance ability.

(2) Outline and Conditions of Existing Culverts

Existing culverts on NH51 can be categorized into four types. The structural outline and conditions for each type of culvert are summarized in the table below.

As a whole, the tendency is that RC concrete and masonry in existing culverts are aged and deteriorated. Also, many culverts have fully accumulated soil in the inside.

Table 8.3-18 Outline and Condition of Existing Culverts

Type	Outline	Conditions
Slab Culvert	The structure consists of RC slab plate with masonry abutments. Stones are laid at the bottom. For some of these culverts, an inlet or outlet wall is integrated with retaining wall. Some structures have narrow inner width. It is assumed that these slab culverts will be retained since original construction of NH51.	-Concrete exfoliation and exposure of steel bar at the back side and edge of slab plate -Shortage of concrete cover at the back side of slab plate, as seen through steel exposure and coating of mortar -Collapse of slab plate and pavement -Exfoliation of masonry abutment
RC Hume Pipe	The structure consists of RC hume pipe connecting same pieces. Diameter ranges approximately 0.8 m to 1.5 m. For some of these culverts, an inlet or outlet wall is integrated with retaining wall. It is assumed that these RC pipes were installed comparably recently.	-Concrete exfoliation and exposure of steel bars at the joint between pipes. -Cracks at the concrete surface
RC Hume Pipe (Double)	The structure consists of RC hume pipes lined in two rows.	Same as above

Source: JICA Study Team

Examples of existing culverts at the site for each type are shown in Figure8.3.8 to 8.3.10.

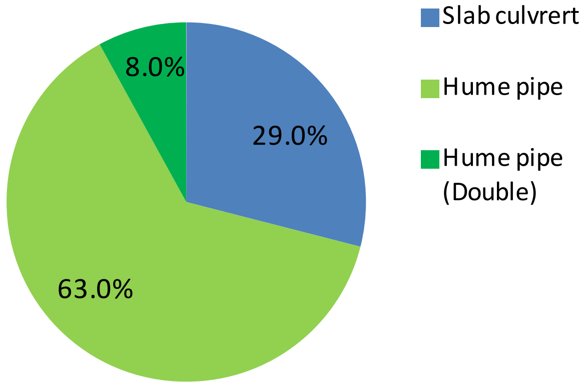
According to the inventory survey result conducted in the study, hume pipe culverts cover approximately 70% of existing culverts in the project range of NH51. According to DPR, these hume pipes are NP2 or NP3 types.

The percentage for each structural type of existing culvert is summarized below.

Table 8.3-19 Percentage per Structural Type of Existing Culvert

Section	Section-A 85-95km		Section-B 110-148km		Total	
	Nos.	Rate(%)	Nos.	Rate(%)	Nos.	Rate(%)
Slab Culvert	12	41.4%	57	27.3%	69	29.0%
Hume pipe	17	58.6%	133	63.6%	150	63.0%
Hume pipe (Double)	0	0.0%	19	9.1%	19	8.0%
Total	29	100.0%	209	100.0%	238	100.0%

Source: JICA Study Team



Source: JICA Study Team

Figure 8.3-7 Percentage per Structural Type of Existing Culvert

From the structural viewpoint, it is recommended that all existing culverts be replaced by new ones in one event of road improvement because:

- Slab culvert : improper work for slab concrete, less design load, aging of RC slab and masonry abutment
- RC pipe : Unknown pipe class for existing (NP-2 according to DPR) and soil accumulation issue for small diameter pipes

Figure 8.3-8 Example of Existing Slab Culvert

Figure 8.3-9 Example of Existing Slab Culvert with Narrow Inner Width

Figure 8.3-10 Example of Existing Pipe Culvert

(3) Design Standards

The design is based on the IRC standards in principle. For the detailed design stage, it shall be designed based on the IRC standards.

Major codes regarding drainage design is referred to in addition to codes for the bridge design. The additional codes and typical drawings for drainage design are as follows:

Table 8.3-20 List of Major Codes for Drainage Design

IRC:SP: 13-2004	Guidelines for the Design of Small Bridges and Culverts (First Edition)
IRC: SP:42-2014	Guidelines on Road Drainage (First Edition)
MORTH	Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion
IS458 (2013)	Precast Concrete Pipes (with and without Reinforcement)

Source: JICA Study Team

(4) New Drainage Design

1) Cross Drainage Structure

The structural types of cross drainage is classified as pipe culvert, box culvert and slab culvert.

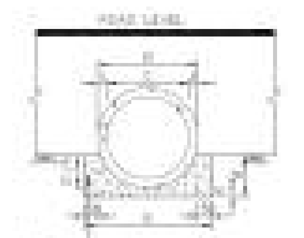
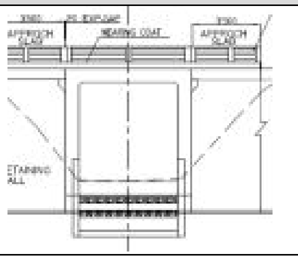
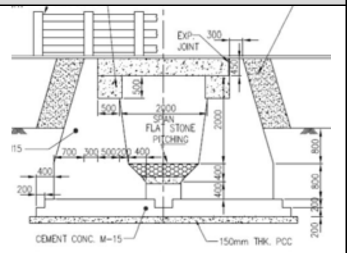
Pipe culvert is the most appropriate structure where the water discharge is comparably small. It has the advantage on economy and provision of quality because of precast manufacturing for RC pipes.

Box culvert is appropriate where the water discharge is more than pipe capacity. Because a box culvert is composed of all RC structures, it is reliable to keep durability and construction quality more than slab culvert which is composed of a slab plate and masonry abutment.

Due to the above reasons, box culvert type was applied to the World Bank road, which is adjacent to NH54, constructed a few years before.

Each type of culvert is compared inTable 8.3-21 below.

Table 8.3-21 Comparison for Culvert Type

	Pipe Culvert	Box Culvert	Slab Culvert
Layout			
Economy	◎	○	△
Construction ability	◎	○	△
Durability	○	○	△
Capacity	○	◎	◎
Comment	To be applied for small discharge point	To be applied for large discharge point	Not applied

Source: JICA Study Team

Hence, a pipe culvert is proposed where the water discharge is comparably small, and box culvert is proposed where the water discharge is comparable large. The size is determined to accommodate the water discharge obtained by hydrological calculation.

Details for the pipe culvert and box culvert are explained below.

- Culvert length from inlet to outlet is 12 m, which is the same as the road width in general section. However, it shall be widened to match with the side widening in curve sections.
- Box culvert is based on the IRC standard drawings. Approach slab is needed for the approach part. RC railing is needed at the kerb on both sides. The size of 2 m x 2 m to 4 m x 6 m is planned to be arranged in order to contain the capacity for discharge.
- Pipe culvert is a type of NP4 based on IRC:13. It is based on the standard of IS458: Precast Concrete Pipes. It is planned that the pipe size be of diameter 1.2 m in order to accommodate the capacity for discharge.
- At the inlet of the culvert, a catch pit is required. For the section of excavation at slope side, a chute is required.
- At the outlet of the culvert, gabion is required to protect an erosion by the flowing water at hill slope.
- The headwall is required to retain earth at inlet and outlet. It should be considered with retaining wall at back and forth side.

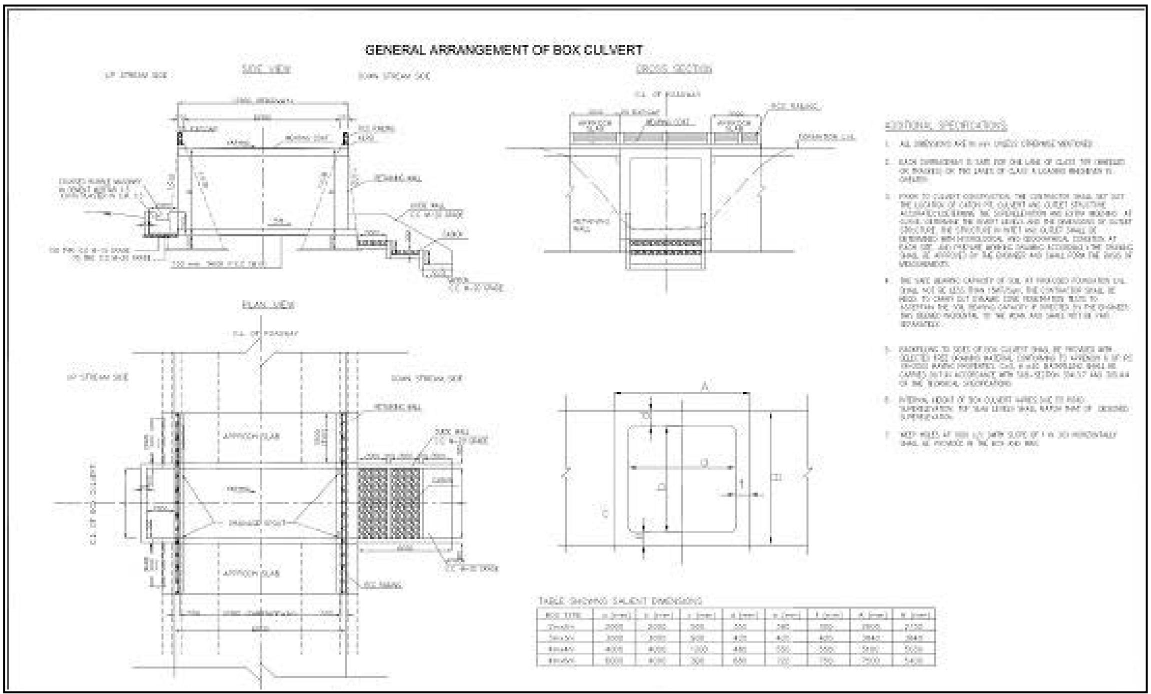
The capacity for each size of culverts is summarized in Table 8.3-22 below.

Table 8.3-22 Capacity for Each Size of Culverts

	Size	A(m2)	n	i (%)	Capacity (m3)	Applied Condition
Pipe Culvert	ϕ 1.2 m	1.028	0.013	5.0	4.17	Flowing full condition
BOX Culvert	2 m x 2 m	4.000	0.033	5.0	15.88	Flowing full condition
	3 m x 3 m	9.000	0.033	5.0	36.19	Flowing ful condition
	4 m x 4 m	12.400	0.033	5.0	95.71	Open section with vertical clearance of 0.9 m
	4 m x 6 m	18.600	0.033	5.0	166.95	Open section with vertical clearance of 0.9 m

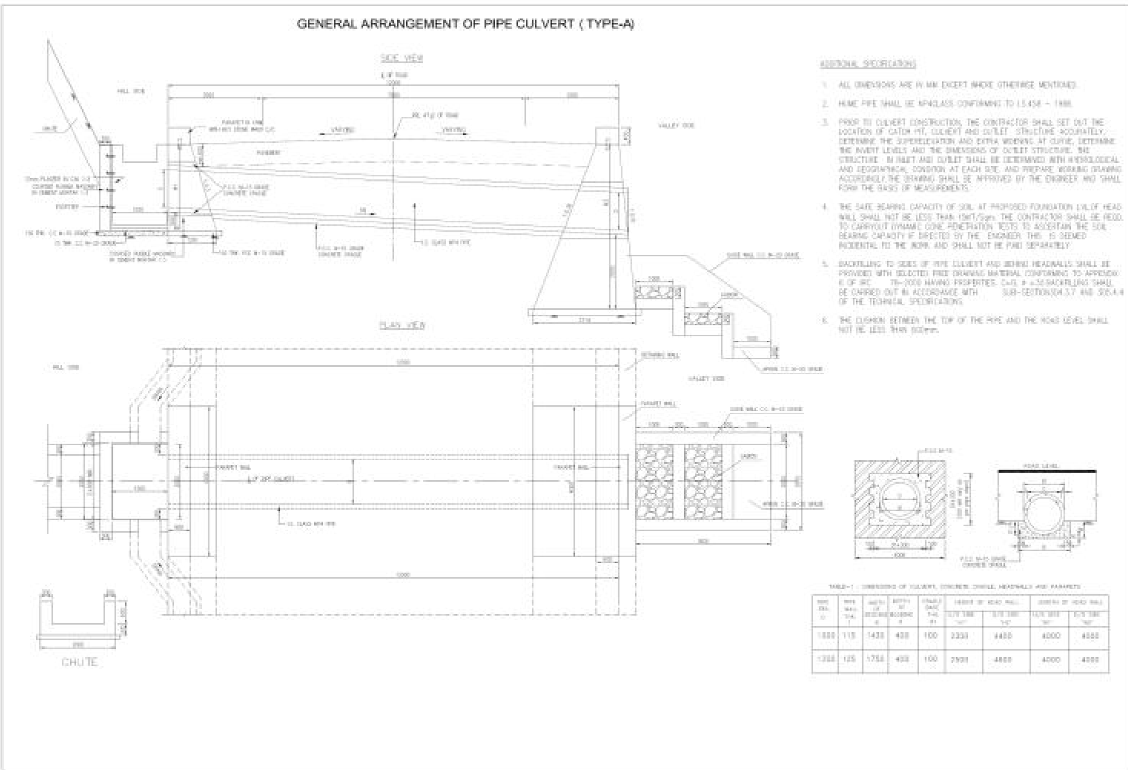
Source: JICA Study Team

General arrangement plan for box culvert and pipe culvert is shown in Figure 8.3-11 below.



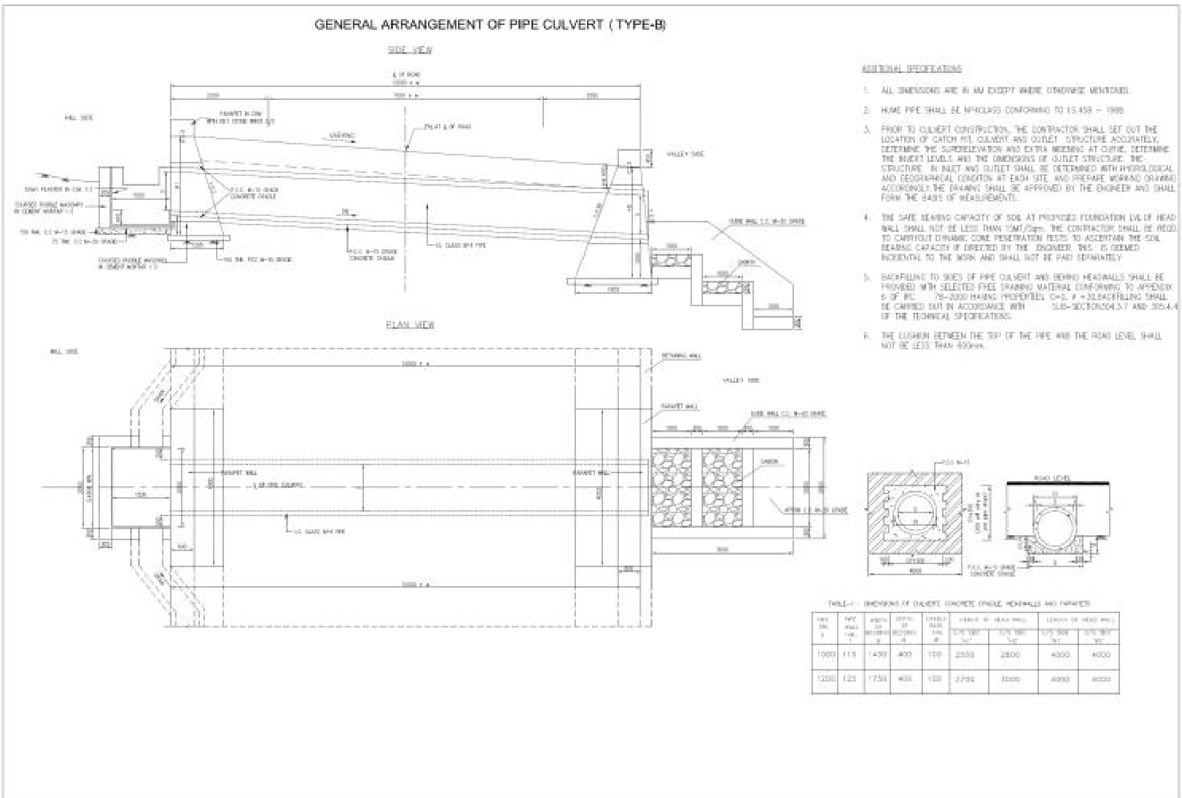
Source: JICA Study Team

Figure 8.3-11 General Arrangement Plan for Box Culvert



Source: JICA Study Team

Figure 8.3-12 General Arrangement Plan for Pipe Culvert (Type-A)



Source: JICA Study Team

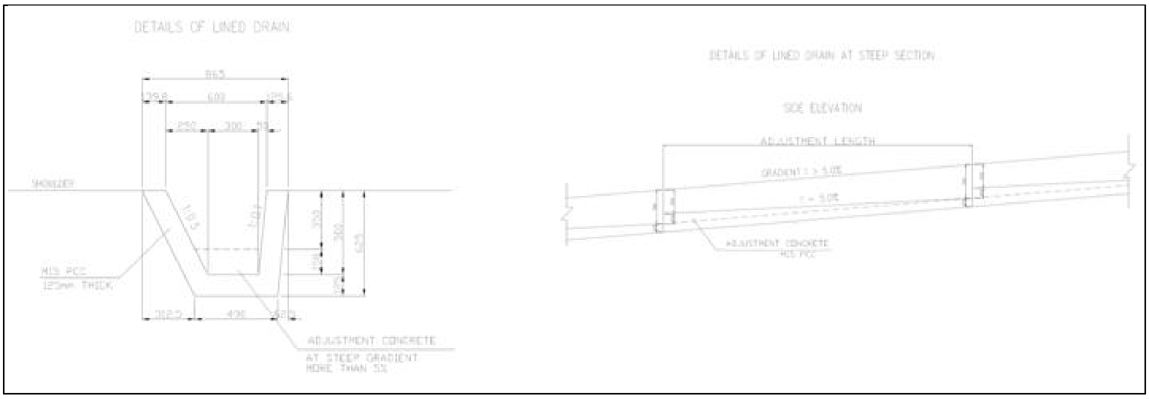
Figure 8.3-13 General Arrangement Plan for Pipe Culvert (Type-B)

2) Side Ditch Structure

The side ditch on the road is designed as concrete lined ditch for all sections of cut side.

The subsurface drain is designed under the side ditch to appropriately deal with groundwater.

The general arrangement plan for side ditch is shown in Figure 8.3-14 below.



Source: JICA Study Team

Figure 8.3-14 General Arrangement Plan for Side Ditch

3) Drainage Arrangement Plan

The cross-drainage arrangement is planned with the following policies:

(i) Cross-drainage with sufficient dimension for the estimated discharge is arranged at the location where the crossing water was estimated from the hydrological map computation.

(ii) The location of the existing culvert has a high possibility for flowing water crossing. Hence, a pipe culvert 1.2 m is planned at all locations of existing culverts, even when the crossing water does not appear in the hydrological map computation.
The existing culvert location is based on the surveyed topographic map prepared by DPR.

(iii) Side ditch capacity is not satisfied if the interval between cross-drainages is too far. Hence, a pipe culvert 1.2 m is planned to complement the long interval to shorten it to a maximum of 300 m.

The quantity of each culvert for each section is summarized in Table 8.3-23 below.

Table 8.3-23 Quantity for Each Culvert

	Quantity for NH51
Pipe culvert 1.2 m	287
(Type-A)	115
(Type-B)	172
Box culvert 2x2 m	6
Box culvert 3x3 m	1
Box culvert 4x4 m	5
Box culvert 4x6 m	0
Total	299

Source: JICA Study Team

8.3.7 Traffic Safety Facilities Plan

(1) Scope of Traffic Safety Facilities

Traffic safety facilities are to be provided on roads or roadsides to secure safety of all road users as well as nearby residents. In this study, considering the road function of rural roads and usage situation of the target roads, facilities listed in Table 8.3-24 are discussed for application to the project.

Table 8.3-24 Traffic Safety Facilities to be Applied for NH51

No.	Item	Remarks / Related Code
1	Traffic Sign	IRC67-2001, IRC7-1971, IRC-SP-31-1992
2	Road Marking	IRC35-1997, IRC-SP-31-1992, IRC2-1968
3	Road Delineator	IRC79-1981
4	Guardrail	
5	Street Furniture (Blinker, Road Stud/Cat's Eye)	MoRTH's Research Project R-63

Source: JICA Study Team

(2) Traffic Safety Facilities Proposed in DPR

The JICA Study Team received some documents that constitute DPR of the target roads, although they are not necessarily a full set of the documents. Table 8.3-25 summarizes traffic safety facilities that are considered and proposed in DPR.

Table 8.3-25 Traffic Safety Facilities Proposed in DPR for NH51

ITEM	NH51
Traffic Sign	To be provided in accordance with IRC67. No detailed quantities are available in Report.
Road Marking	Center line, Edge line, Continuity line, Stop line, Give-way line, Diagonal/Chevron, Zebra crossing and Parking areas No detailed quantities are available in Report.
Road Delineator	To be provided in accordance with IRC. No detailed quantities are available in Report.
Guard Rail	To be provided. No detailed quantities are available in Report.
Street Furniture (Blinker, Road Stud/Cats Eye)	To be provided. No detailed quantities are available in Report.

Summarized by the JICA Study Team

(3) Approach for Traffic Safety Facilities Plan

The objectives of preparation of traffic safety facilities plan in this study are to confirm the facilities proposed in DPR and to propose alternative plans, where necessary. Furthermore, it will become part of the basis of the project cost estimate. However, since the documents are available only partially, some information is still missing as shown in Table 8.3-25.

In this study, every effort is made to consider facilities in a similar manner as DPR in case where they are clear and reasonable. The quantities are estimated by assuming various conditions. Therefore, it shall be noted that further examination shall be made in the next stage, that is, modification of DPR in accordance with their design basis.

(4) Traffic Sign

Traffic signs are to be installed to promote road safety and efficiency by providing orderly movement of all road users in both urban and non-urban areas. Road signs notify road users of regulations and provide warning and guidance needed for safe, uniform, and efficient operations.

IRC:67-2012 stipulates three types of traffic signs, namely: 1) Mandatory/Regulatory Signs, 2) Cautionary/Warning Signs, and 3) Informatory/Guide Signs.

Figure 8.3-15 shows some of typical traffic signs to be installed for the target roads.

Source: IRC:67-2012 Code of Practice for Road Signs (Third Revision)

Figure 8.3-15 Typical Traffic Signs

In the DPR Report, no detailed information is available on the proposed traffic signs.

In this study, therefore, traffic signs shown in **Table 8.3-26** are considered for the whole target road based on unit quantity per kilometer of NH54 Section-3.

Table 8.3-26 Traffic Sign Estimated for NH51

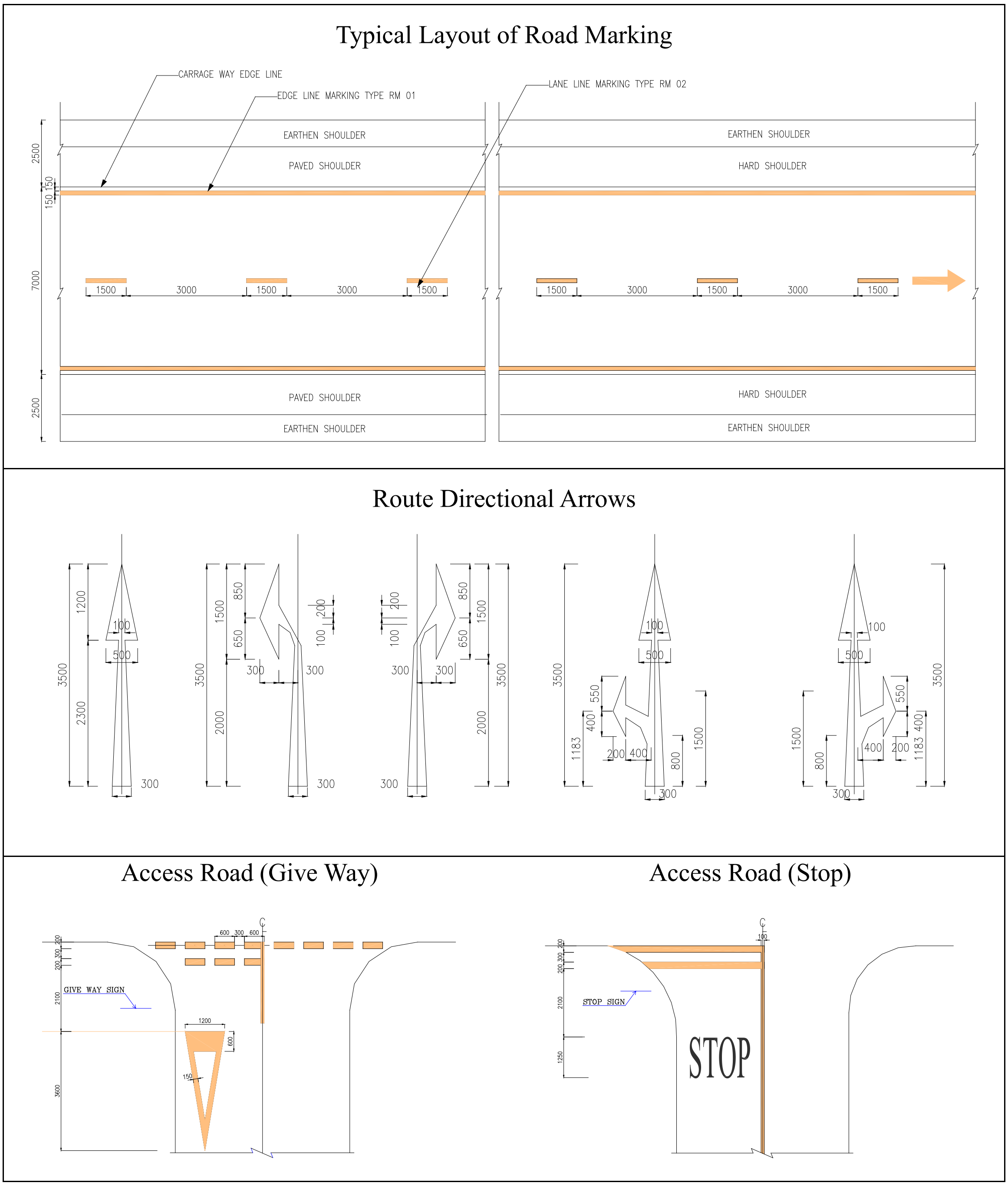
SOR No.	Item	Unit	Number
8.4	Providing and fixing of retro-reflectorised cautionary, mandatory, and informatory sign as per IRC:67 made of encapsulated lens type reflective sheeting vide Clause 801.3, fixed over aluminium sheeting, 1.5 mm thick supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing		
(i)	90 cm equilateral triangle	Each	11
(ii)	60 cm equilateral triangle	Each	24
(iii)	60 cm circular	Each	29
(iv)	80 mm x 60 mm rectangular	Each	22
(v)	60 cm x 45 cm rectangular	Each	24
(vi)	60 cm x 60 cm square	Each	26

Source: JICA Study Team

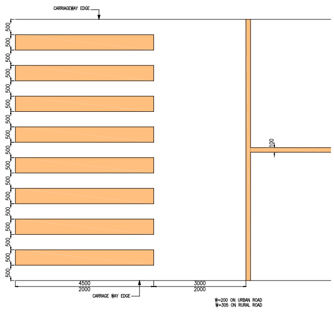
(5) Road Markings

Road markings perform important functions of guiding and controlling traffic on roads. They serve as a psychological barrier and signify the delineation of traffic hazards for safe movement of traffic. Traffic markings also channelize to ensure smooth and orderly flow of traffic. Therefore, suitable road markings shall be provided on roads in accordance with IRC:35-1997.

Figure 8.3-16 shows some of typical road markings to be provided for the target roads.



Pedestrian Crossing



Source: Detailed Project Report for National Highway No.54 Section-2

Figure 8.3-16 Typical Road Markings

In this study, the road markings shown in Table 8.3-27 is considered for the whole target road based on the unit quantity per kilometer of 250 m^2, which is adopted in DPR.

Table 8.3-27 Road Markings Estimated for NH51

SOR No.	Item	Unit	Number
8.13	Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250 gms per sqm area, thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC:35 .The finished surface to be level, uniform and free from streaks and holes	sqm	13,500

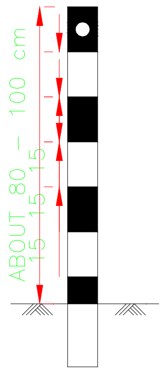
Source: JICA Study Team

(6) Road Delineator

Retro-reflective road delineators are to be installed to provide visual assistance for drivers to obtain information on the alignment of the road ahead, particularly at night. These are effective at locations involving change in horizontal/vertical geometry and during severe weather conditions of heavy rain, fog, or snow. IRC:79-1981 stipulates the standards for the post-type delineators with retro-reflective units.

Figure 8.3-17 shows a typical type of road delineator with circular retro-reflector.

In this study, road delineators shown in **Table 8.3-28** are considered for the whole target road based on unit quantity of one unit per 2-m road section where the guardrail is furnished.



Source: Detailed Project Report for National Highway No.54 Section-2

Figure 8.3-17 Typical Road Delineator

Table 8.3-28 Road Delineators Estimated for NH51

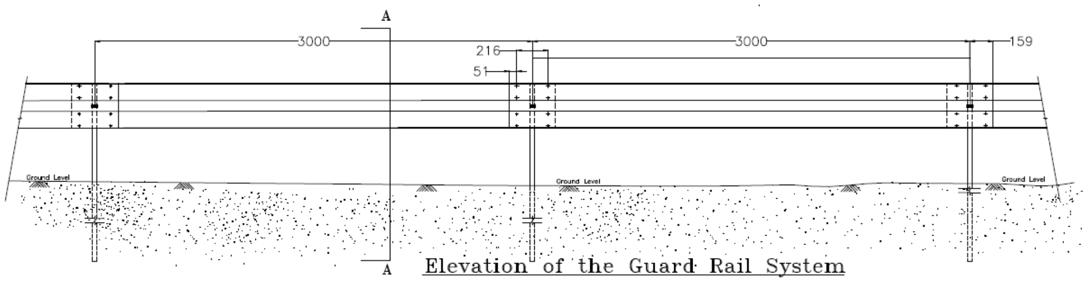
SOR No.	Item	Unit	Number
8.15	Road delineators, supplying and installation of delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 15 cm wide stripes, fitted with 80 x 100 mm rectangular or 75 mm dia circular	each	5,239

Source: JICA Study Team

(7) Guardrail

The DPR adopts single “W” type steel guardrails for selected locations including the valley side of curves, high embankment sections, approaches to bridges and built-up areas.

Figure 8.3-18 shows a typical single “W” type of guardrail.



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 8.3-18 Typical Guardrail

In this study, it is assumed that the guardrail is provided for the road section where gravity wall or reinforced earth wall is installed at the valley side. As a result, guardrails shown in Table 8.3-29 are considered for the whole target road.

Table 8.3-29 Guardrails Estimated for NH51

SOR No.	Item	Unit	Number
8.23-A	Type - A, "W" : Metal Beam Crash Barrier (Providing and erecting a "W" metal beam crash barrier comprising 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2	meter	10,477

Source: JICA Study Team

(8) Street Furniture

Street furniture known as road studs, blinker, or cat’s eye include equipment installed on road or roadside to assist visibility of road alignment/structures. These are retro-reflective safety devices used in road marking. Generally, it consists of two pairs of reflective glass spheres set into a white rubber dome, mounted in a cast-iron housing. This is the kind that marks the centre of the road, with one pair of devices showing in each direction. A single-ended form has become widely used in other colors at road margins and as lane dividers.

In this study, considering unit quantity per kilometer adopted in DPR, guardrails shown in **Table 8.3-30** are considered for the whole target road.

Table 8.3-30 Street Furniture Estimated for NH51

SOR No.	Item	Unit	Number
8.35	Road Markers/Road Stud with Lense Reflector (Providing and fixing of road stud 100x 100 mm, die cast in aluminium, resistant to corrosive effect of salt and grit, fitted with lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm upto a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS 873 part 4:1973)	each	5,997

Source: JICA Study Team

(9) Locations Requiring Special Consideration

1) Hair-Pin Bends

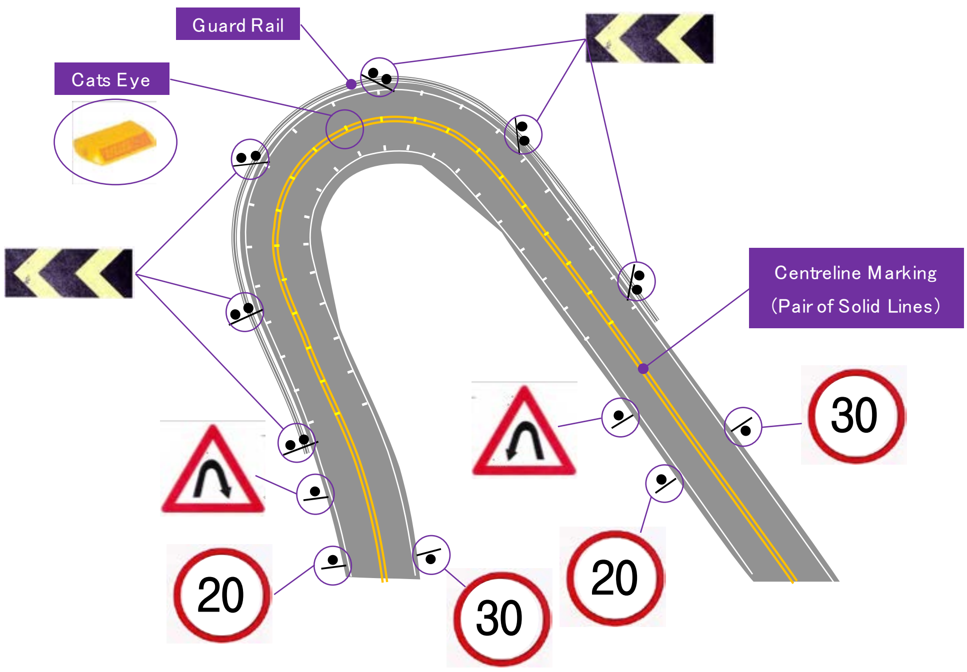
Since the target road is located in a mountainous region, hair-pin bends are unavoidable from the viewpoint of cost and environmental impact. Design speed of 20 km/h is applied for hair-pin bends, while design speed of 30 km/h is adopted in general. Small horizontal curves such as R20m-R25m are used in steep terrain to avoid large-scale earthwork and/or demolition of houses. At these sub-standard sections, securing traffic safety by applying combination of facilities shall be considered.

In hair-pin bends, it is difficult to secure overtaking sight distance and thus, the section shall be designated as no-overtaking section. In order to inform this to drivers, the double centre line with marking of pair of solid lines is applied.

Cat's eyes to delineate road alignment are to be installed on the centre line and lane edges so that drivers will be able to identify the direction he should go before entering into the curve.

Furthermore, traffic signs and guardrails shall be properly equipped to avoid hazardous accidents.

Figure 8.3-19 shows an example of combined traffic safety facilities to be installed at hair-pin bends.



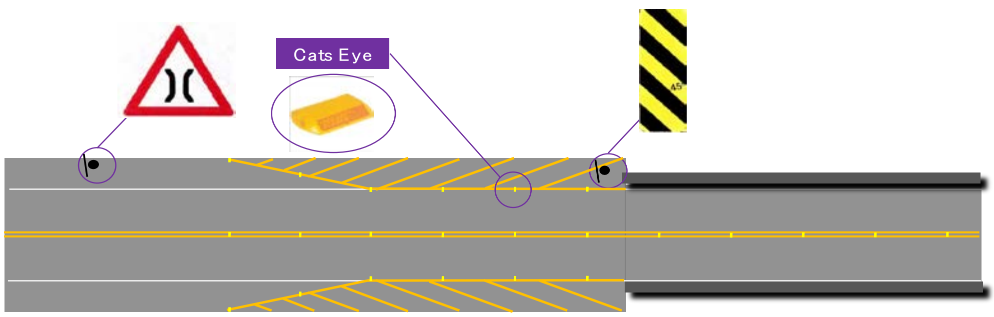
Source: JICA Study Team

Figure 8.3-19 Traffic Safety Facilities to be Installed at Hair-Pin Bends

2) Bridges with Narrow Width

In the locations where the existing bridges are to be utilized with rehabilitation works, the carriageway width becomes narrower than that of earthwork sections due to the difference in shoulder width. It is, therefore, proposed to install facilities that notify drivers of the decrease in carriageway width and existence of concrete curb.

Figure 8.3-20 shows an example of combined traffic safety facilities to be installed at narrow bridges.



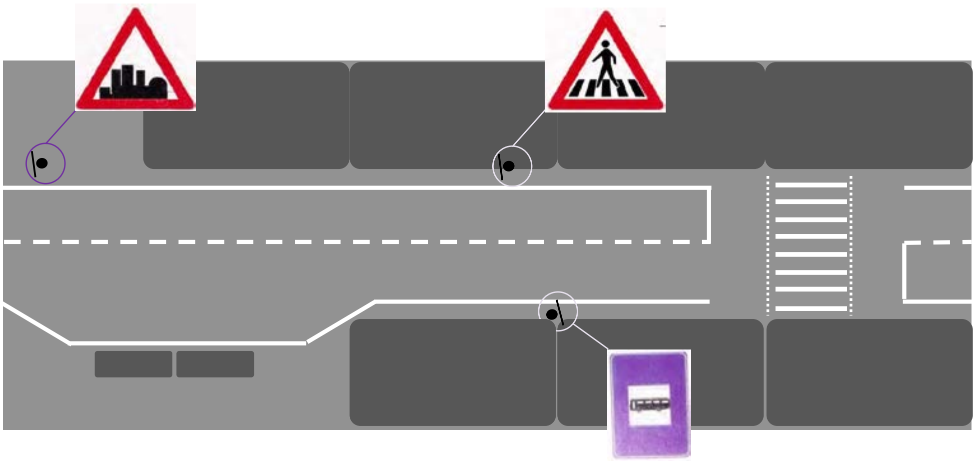
Source: JICA Study Team

Figure 8.3-20 Traffic Safety Facilities to be Installed at Narrow Bridges

3) Built-up Sections

In built-up sections, there are a lot of buildings, shops, or houses at roadside as well as pedestrians going along the sidewalk and crossing the road. Furthermore, more varied kinds of road facilities such as bus stops are necessary than in rural sections. Therefore, drivers have to handle much information on roads/traffic and decide their maneuvers in a short time at built-up areas. In order to assist road users in obtaining information, appropriate traffic signs and road markings shall be provided properly.

Figure 8.3-21shows an example of combined traffic safety facilities to be installed at built-up sections.



Source: JICA Study Team

Figure 8.3-21 Traffic Safety Facilities to be Installed at Built-up Sections

8.3.8 Road Appurtenances Plan

(1) Scope of Road Appurtenances

Road appurtenances are miscellaneous facilities for road users to take a rest and obtain road-related information as well as for road administrators to maintain their roads efficiently. In this study, considering the road function of rural roads and usage situation of the target roads, facilities listed in Table 8.3-31 are discussed for application to the project.

Table 8.3-31 Road Appurtenances to be Applied for NH51

No.	Item	Remarks / Related Code
1	Kilometer Stone	IRC8-1980, IRC26-1967
2	Boundary Stone	IRC25
3	Bus Bay	w/Bus Shed, IRC80-1981
4	Road Amenity	Public Toilet, Bazar Shed

Source: JICA Study Team

(2) Road Appurtenances Proposed in DPR

Table 8.3-32 summarizes road appurtenances that are considered being proposed in DPR.

Table 8.3-32 Road Appurtenances Proposed in DPR for NH51

ITEM	NH51
Kilometer Stone	To be provided. No detailed quantities are available in Report.
Boundary Stone	To be provided at ROW boundaries. No detailed quantities are available in Report.
Bus Bay	To be provided at 20 locations.
Road Amenity	To be provided. No detailed quantities are available in Report.
Truck Lay By	No information is available in Report.

Summarized by the JICA Study Team

(3) Approach for Road Appurtenances Plan

The objectives of the preparation of road appurtenances plan in this study are to confirm facilities proposed in DPR and to propose alternative plans where necessary. Furthermore, it will become part of the basis of the project cost estimate. However, since the documents are only partially available, some information is still missing as shown in Table 8.3-32.

In this study, every effort is made to consider facilities in similar manner as DPR in case where these are clear and reasonable. The quantities are estimated by assuming various conditions. It is therefore noted that further examination shall be made for the modification of DPR in accordance with on their design basis.

(4) Kilometer Stone

A kilometer stone is one of a series of numbered markers placed along a road or boundary at specific intervals. These are typically located at the side of the road. They are alternatively known as mile stones, mile markers or mileposts. Design of kilometer stones shall be made in accordance with IRC:8-1980.

Table 8.3-33 shows the estimated number of kilometer stones for the whole target road.

Table 8.3-33 Kilometer Stones Estimated for NH51

SOR No.	Item	Unit	Number
8.14	Kilometer Stone (Reinforced cement concrete M15grade kilometer stone of standard design as per IRC:8-1980, fixing in position including painting and printing)		
(i)	5th Kilometer Stone (Precast)	each	10
(ii)	Ordinary Kilometer Stone (Precast)	each	44
(iii)	Hectometer Stone (Precast)	each	216

Source: JICA Study Team

(5) Boundary Stone

Boundary stones are to be provided to establish the ROW and those shall be incorporated in the as-built drawings for future use. Design of boundary stones shall be made in accordance with IRC:25-1967.

Table 8.3-34 shows the estimated number of boundary stones for the whole target road.

Table 8.3-34 Boundary Stones Estimated for NH51

SOR No.	Item	Unit	Number
8.16	Boundary pillar (Reinforced cement concrete M15 grade boundary pillars of standard design as per IRC:25-1967, fixed in position including finishing and lettering but excluding painting)	each	1,080

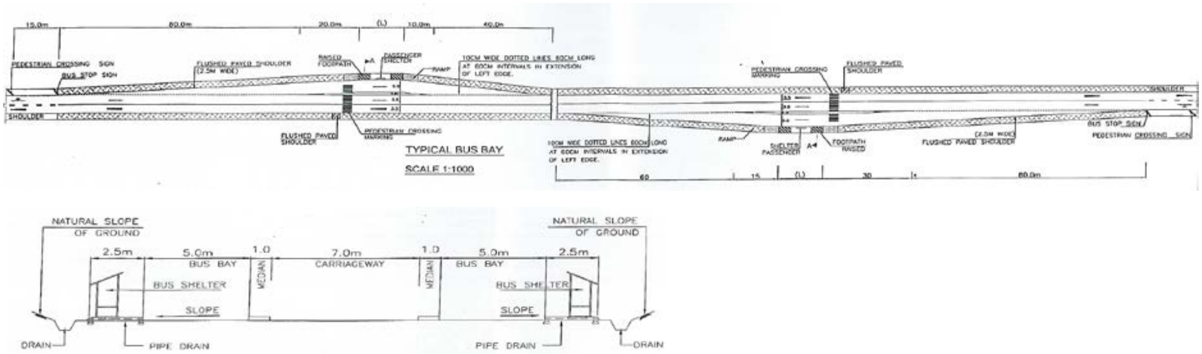
Source: JICA Study Team

(6) Bus Bay

Buses standing indiscriminately on the carriageway to drop or pick-up passengers can seriously affect capacity of the roadway, besides being a source of accidents. It is therefore desirable that on all busy non-urban highways, consideration should be given to the construction of bus lay-bys of suitable design at required locations to ensure orderly movement of the through traffic.

Since the target road is part of the national highway network with a function as important artery of the region, it is recommended to establish bus bays at appropriate locations.

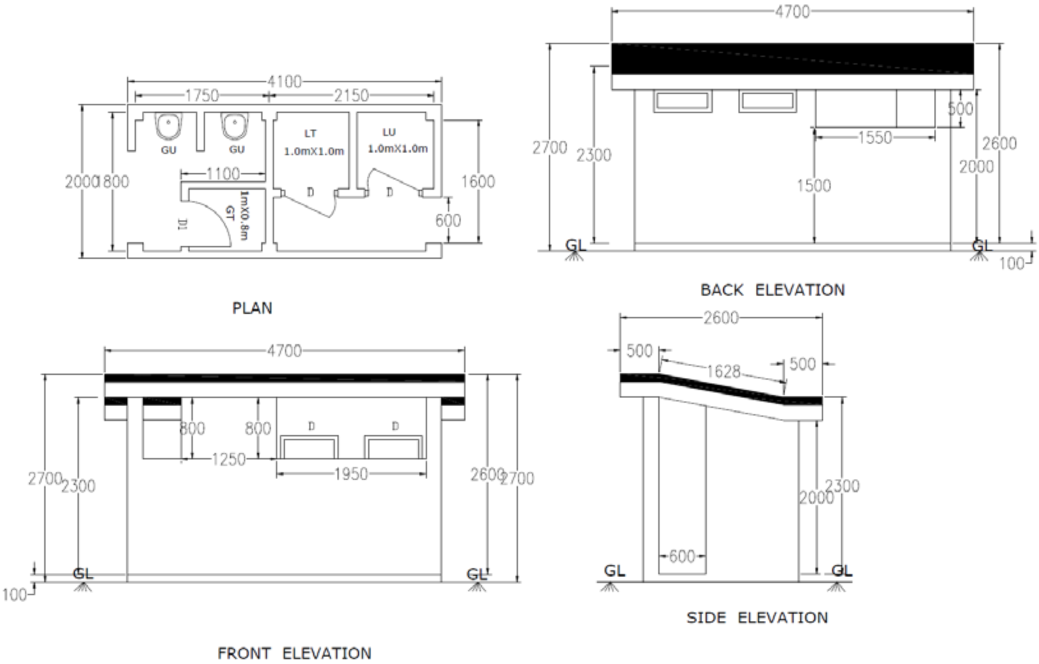
IRC:80-1981 stipulates general requirements for bus bays. DPR has applied the general layout suggested in that standard. This study also follows the recommendations of IRC and assumes the application of the general plan shown in Figure 8.3-22.



Source: Detailed Project Report for National Highway No.51

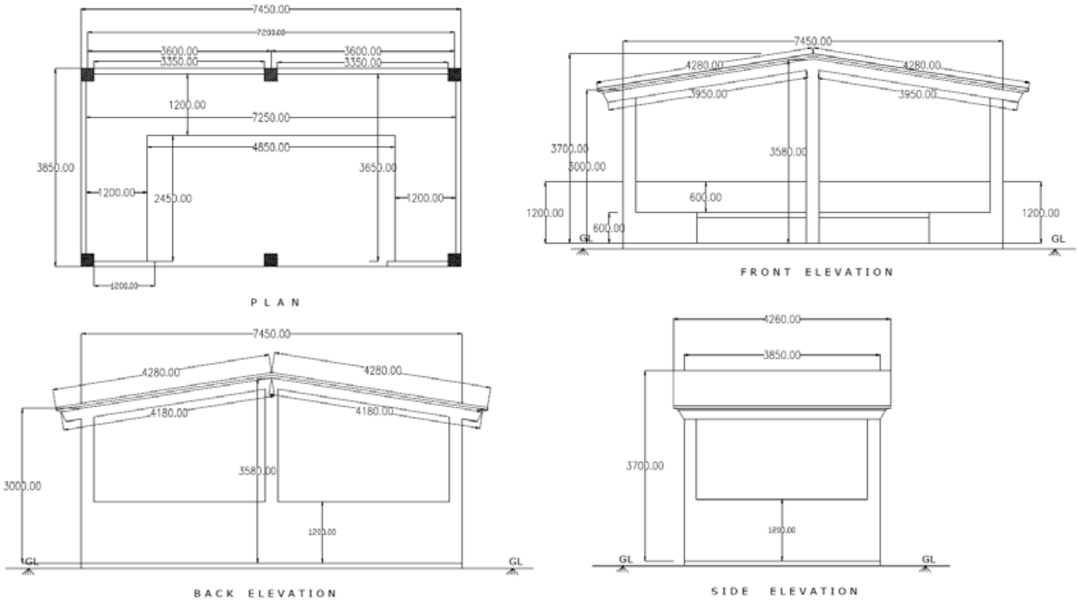
Figure 8.3-22 General Layout for Bus Bays

Road amenities for tourists to use the road comfortably shall be developed at suitable intervals. It is therefore suggested to equip road amenities including public toilets and bazaar sheds at bus bays. Figure 8.3-23 and Figure 8.3-24 present general view of public toilet and bazaar shed proposed in DPR.



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 8.3-23 General View of Public Toilet



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 8.3-24 General View of Bazaar Shed

Proposed locations of bus bays for NH51 are presented in Table 8.3-35.

Table 8.3-35 Proposed Bus Bay Locations for NH51

No.	Location	Distance from Babadam (km)	Section Length (km)
1	Babadam	-	
2	Champarea	0.2	0.2
3	Ganol	1	0.6
4	Rongan Hiran	4	3
5	Dap. of Agriculture Rongkhon	6	3
6	Tura	8	2
7	Dadaungiri	19	10
8	Rubber	19	0.2
9	Purakashya	26	7
10	Chokpot	30	4
11	Moropgre	41	12
12	Rengsipara	47	6
13	Rendapara	48	0.8
14	Megupara	55	7
15	Purakhasia	56	0.9
16	Dalu	57	1

Source: JICA Study Team

Notwithstanding the foregoing, considering that DPR proposes installing 20 bus bays for NH51, the cost estimate of bus bays and road amenities is made for 20 locations in this study.

8.3.9 Preliminary Study of Spoil Bank

(1) General

Concerning the result of the preliminary design of NH51 by the JICA Study Team, the necessary volume of spoil bank has been calculated as shown in Table 8.3-36 below. For NH51, at least about 268,000 cu.m capacity is required to deal with not only balance of cut and fill but also replacement of soils for soil stabilization.

Table 8.3-36 Required Volume for Spoil Bank

Highway No.	Sec.	Item	Unit	Volume of Generated Soil	Coefficient of Compation	Volume of Compacted Soil	Required Volume of Spoil Bank
				Cu.m		Cu.m	Cu.m
NH51	1	Cut Soil	cu.m	41,840	0.9	37,656	37,656
		Fill Soil	cu.m			0	
	2	Cut Soil	cu.m	77,562	0.9	69,806	29,177
		Fill Soil	cu.m			40,629	
	3	Removed Soil for Replacement	cu.m			201,600	201,600
	Total						268,433

Source: JICA Study Team

(2) Conditions of Spoil Bank Selection

The JICA Study Team examined the criteria to identify target locations where seems to have sufficient and necessary conditions for spoil bank construction. The following are assumed conditions for suitable locations for spoil banks.

❖ To find a suitable place at every 5-km length along NH51 with following conditions:
- Ground shape with concavity topography;
- Less ground gradient than 22° which is assumed as the average angle of spoil bank slope with necessary steps;
- No built-up area; and
- No national sanctuary area.

❖ To be able to construct the spoil bank in less than 30-m height.

(3) Result of Examination for Spoil Bank Locations

In accordance with above assumed conditions, nine locations in the 51-km stretch of NH51 has been totally identified for spoil bank construction having about 342 cu.m capacities. Below Table 8.2-36 shows the list of spoil banks with their stationing and capacities.

Table 8.3-37 List of Spoil Banks

No.	Section	Sta.	Capacity of Spoil Bank
			Cu.m
1	Sta. 85-94	88+000	47,120
2	STA.101-143	105+805	4,620
3		110+000	86,190
4		110+550	58,260
5		119+340	16,856
6		124+800	77,440
7		130+800	15,526
8		135+420	22,806
9		139+100	12,883
Total in NH-51			341,701

Source: JICA Study Team

8.4 Consideration of Climate Change Adaptation

As mentioned in Section 7.3, the increase of frequency and intensity of heavy rains is related to climate change. In NH51, the increase of annual rainfall is predicted to be 5% to 10% for the period of 2021 to 2050.

The design policy for each item mentioned in Section 8.3 takes into consideration adaptation measures for climate change. With the increase in rainfall frequency and intensity, river water and groundwater levels are expected to be high, and cause inundation and damage to the road facilities. Therefore, the JICA Study Team checks spring water points carefully and planned subsurface drainage where necessary. Furthermore, flood marks were checked in the site reconnaissance and interview survey for the disaster countermeasure design.

Table 8.4-1 shows adaptation measures for climate change that were taken into consideration in this road design.

Table 8.4-1 Adaptation Measures for Climate Change in NH51

Factor	Design Policy Considering Adaptation
Side Slope	· Retaining wall is built all along the road. · Slope protection work is constructed on some weathered and loosened slopes. · Cut slope is covered with vegetation to prevent erosion and collapse. · Replacement of subgrade and subsurface drainage are planned as countermeasures against sinking.
Embankment	· Drain filter is sandwiched in embankment. · Flood level is confirmed in site reconnaissance and interview survey near the river bank south of NH51.
Bridge and Drainage System	· Rainfall intensity is carefully determined based on the authorized data: ATLAS of Statewise Generalised Isopluvial Maps of Eastern India published by the Indian Meteorological Department. The isopluvial value from the higher edge of counter range is applied. · The capacity of all structures is determined to be capable for the discharge of 50 years return period.
Pavement	· Superelevation is installed properly. · Pavement material is examined not to rise over 60 °C on the surface.
Road Signage	· Wind load and visibility is taken into consideration.

Source: JICA Study Team

CHAPTER 9 PRELIMINARY PROJECT COST ESTIMATE

9.1 NH54

9.1.1 Outline of the Project

(1) Objectives of the Project

NH54 is a national highway with total length of 381 km connecting Aizawl and Tuipang in Mizoram State. It stretches along the mountain ridges in most sections and the average altitude of the road varies from 700 m to 900 m. The existing carriageway width is 5.5 m in the extent of the 55 km from Aizawl and 3.75 m in the remaining section of 326 km.

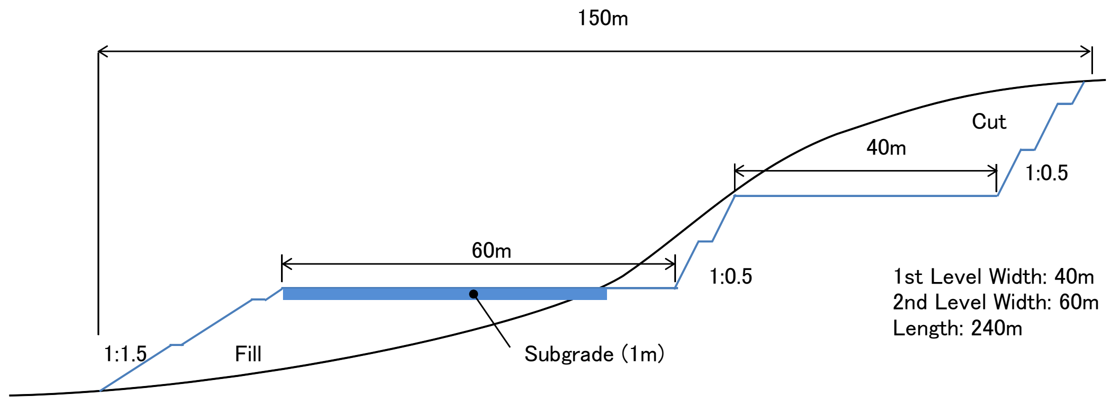
The objective of the project is to secure stable, efficient, and safe traffic through improvement of the existing NH54, including road widening with appropriate slope protection, and installation of pavement, drainage, and other road facilities.

(2) Construction Package

The package plan of the project is examined based on project scale and etc..

9.1.2 Construction Plan

Mobilization of machine, material, workers, and preparation of main camp and plant yard are scheduled to implement during six months from beginning of the construction period. Figure 9.1-1 shows typical configuration of the camp site.



Source: JICA Study Team

Figure 9.1-1 Typical Configuration of the Main Camp

The construction yard (main camp) shall be developed along the project road. Required area for the yard is estimated to be 2.4ha (1.4ha for camp and 1ha for plants and stock yard) based on past practices. Major buildings to be constructed in the yard are Consultant's and Contractor's offices, staff quarters, staff lounge, canteen, laboratory, general warehouse, cement storage, workshop, medical room, and security guard's house. Since the project road is located in the mountainous terrain and usable flat land is limited in the neighboring area, land development is required. In case assuming the topography is as illustrated in Figure 9.1-1, cut and fill volume is estimated to be 120 thousand m3 and 110 thousand m3, respectively. Furthermore, subgrade (1m layer below the construction level) preparation of 10 thousand m3 is required.

9.1.3 Applied Laws, Regulations, and Guidelines

Preliminary project cost was estimated making reference to the following documents:

1) Specifications for Road and Bridge Works (Fifth Revision), Ministry of Road Transport and Highways
2) Schedule of Rates (SOR) 2014 for National Highways and State Roads, Government of Mizoram

9.1.4 Preliminary Project Cost Estimate

(1) Conditions of Construction Cost Estimate

Unit costs set out based on the SOR 2014 were applied to most work items. Besides, unit costs derived from experience in foreign countries were employed for some specific items considering the possibility of participation of international contractors. These items are:

1) Crib Work (F300)
2) Crib Work (F500)
3) Non-frame
4) Anchor Work
5) Rock-bolt Work

Price escalation from 2014 up to the time of bidding was estimated to be 5% and was added to the construction cost.

(2) Abstract of Cost Estimate

The abstract of the cost estimate for the project is prepared.

9.2 NH51

9.2.1 Outline of the Project

(1) Objectives of the Project

NH51 is a national highway with total length of 54 km connecting Tura and Dalu in Meghalaya State. It passes rolling terrain in most sections and the average altitude of the road varies from 110 m to 260 m. The existing carriageway width is 3.75 m.

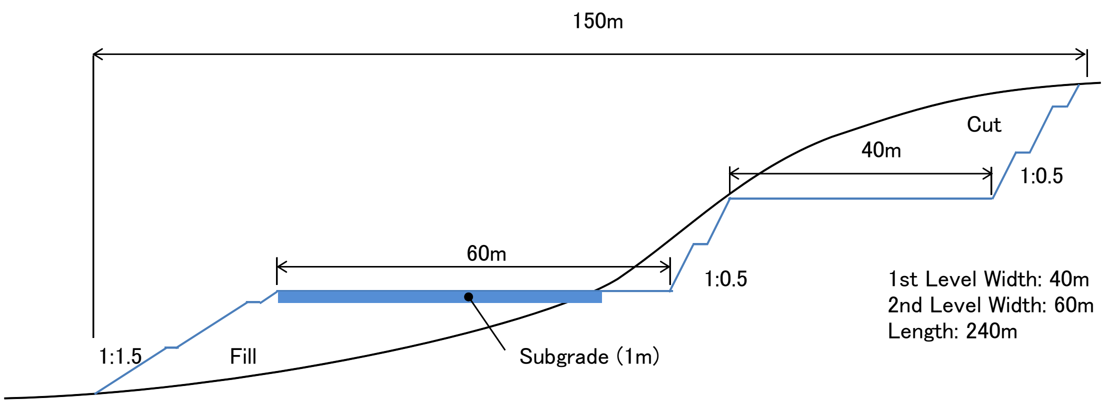
The objective of the project is to secure stable, efficient, and safe traffic through improvement of the existing NH51, including road widening with appropriate slope protections and installation of pavement, drainage, and other road facilities.

(2) Construction Package

The package plan of the project is examined based on project scale and etc..

9.2.2 Construction Plan

Mobilization of machine, material, workers, and preparation of main camp and plant yard are scheduled to implement during three months from beginning of the construction period. Figure 9.2-1 shows typical configuration of the camp site.



Source: JICA Study Team

Figure 9.2-1 Typical Configuration of the Main Camp

The construction yard (main camp) shall be developed along the project road. Required area for the yard is estimated to be 2.4ha (1.4ha for camp and 1ha for plants and stock yard) based on past practices. Major buildings to be constructed in the yard are Consultant's and Contractor's offices, staff quarters, staff lounge, canteen, laboratory, general warehouse, cement storage, workshop, medical room, and security guard's house. Since the project road is located in the mountainous terrain and usable flat land is limited in the neighboring area, land development is required. In case assuming the topography is as illustrated in Figure 9.2-1, cut and fill volume is estimated to be 120 thousand m3 and 110 thousand m3, respectively. Furthermore, subgrade (1m layer below the construction level) preparation of 10 thousand m3 is required.

9.2.3 Applied Laws, Regulations, and Guidelines

Preliminary project cost was estimated making reference to the following documents:

1) Specifications for Road and Bridge Works (Fifth Revision), Ministry of Road Transport and Highways
2) Schedule of Rates (SOR) 2014 for National Highways and State Roads, Government of Meghalaya

9.2.4 Preliminary Project Cost Estimate

(1) Conditions of Construction Cost Estimate

Unit costs set out based on the SOR 2014 were applied. Price escalation from 2014 up to the time of bidding was estimated to be 5% and was added to the construction cost.

(2) Abstract of Cost Estimate

The abstract of the cost estimate for the project is prepared.