Government of India
Ministry of Road Transport and Highways

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

INTERIM REPORT 4

(Volume 2: Preliminary Design of NH54 Bypass)

August 2016

Japan International Cooperation Agency (JICA)

Survey Team constituted by

NIPPON KOEI CO., LTD.

NIPPON KOEI INDIA PVT. LTD.

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The information related to bidding has been deleted.

Abbreviations

AADT	- Average Annual Daily Traffic
AASHTO	- American Association of State Highway and Transportation Officials
AC	- Asphalt Concrete
ADT	- Average Daily Traffic
AIDS	- Acquired Immunodeficiency Syndrome
BOD	- Biochemical Oxygen Demand
BOT	- Built Operation Transfer
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
EMP	- Environmental Mitigation Plan
EPC	- Engineering, Procurement, and Construction
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
HDM4	- Highway Development & Management 4
HIV	- Human Immunodeficiency Virus
HQ	- Headquarter
IEE	- Initial Environmental Examination
INR	- Indian Rupee
IRC	- Indian Road Congress
IS	- Indian Standard
IUNC	- International Union for Conservation of Nature
JICA	- Japan International Cooperation Agency
JRSO	- Japan Road Structure Ordinance
JST	- JICA Study Team
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
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
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
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
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

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The remarkable economic growth of India located in South Asia is known to the world widely today. Well progress of development of infrastructures in transport sector with strengthening the connection between major cities makes this economic growth. Especially, road is one of most important mode to deal with most of the domestic transportation activities along with mode of railway, because road transportation constitute 85% of passenger and 60% of freight each. However, in mountainous areas, strengthening of traffic infrastructures has not processed smoothly due to financial and technical issues, while the reinforcement of the main highways in the plain area has been processed with acceleration of economic growth of India.

Particularly, only 28.5% (63.4% is average in whole country) of the road in North-East state is paved road and only 53% of national highway has more than 2-lane road. This is because the North-East state is located far from mainland of India as well as access road to reach the border of neighbor countries is undeveloped, Government of India (hereinafter referred to as "GOI") does not approve the agreement to make transportation with neighboring countries available except particular countries to avoid security risk. Furthermore, the area of North-East state has severe natural conditions such as steep mountainous geography (most of the state is located in hilly area) and high rainfall area (more than 10,000mm rainfall per year was recorded in Mizoram especially). Therefore, it is key issue how we prevent or reduce the road closer caused by natural disaster to achieve the economic growth in this state.

GOI raises "Special Accelerated Road Development Programme for North-East" committed in "Twelfth Five Years Plan (from April, 2012 to March, 2017)" to cope with above mentioned problems by improvement of national highways connected between major cities within the North-East state.

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

JICA Study Team examined applicability of the 11 projects for Yen Loan scheme and prioritized the 11 projects. NH54 and NH51 are selected as first priority sections and preliminary design for NH54 and NH51 are carried out. As for preliminary design of NH54, widening sections and bypasses sections are included and preliminary design of the bypass sections on NH54 is carried out in this study due to inadequate bypass study in DPRs.

1.2 Objectives of the Study

The major objectives of this Study are:

- To examine procurement and construction method, implementation schedule, social and environmental conditions, project cost, and feasibility of four bypass routes plan on NH54.

1.3 Study Area and Contents of Request

Target sections of this study are four bypasses on NH54 as shown in エラー! 参照元が見つかりません。.

Table 1.3-1 Additional Scope of Four Bypasses

No.	Name	Position of Bypasses (k.p.)	Length
1	Chhiahtlang Bypass	Start near 96.945km、End near 99.185km	Approx. 3km
2	Serchhip Bypass	Start near 104.430km、End near 114.170km	Approx.12.4km
3	Hnathial Bypass	Start near 169.550km、End near 178.550km	Approx.6.8km
4	Lawngtlai Bypass	Start near 472.000km、End near 478.850km	Approx.2.0km
Total			Approx.24.2km

Source: JICA Study Team

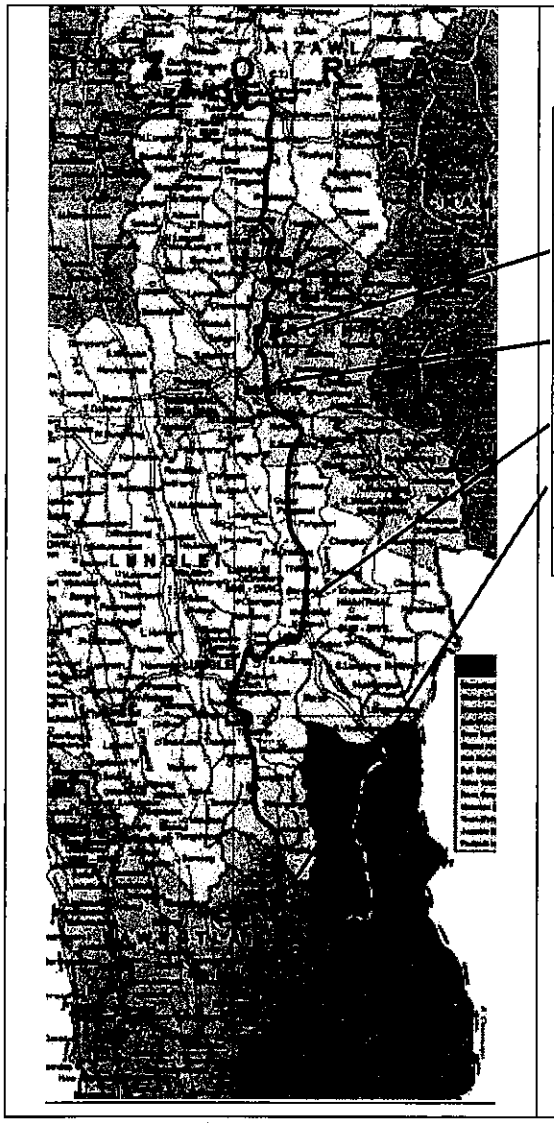
CHAPTER 2 TRAFFIC SURVEY, ANALYSIS AND FORECAST

2.1 General

The traffic likely to use the proposed by-passes (4 in numbers) has been estimated through conducting traffic surveys, and the same has been projected till the year 2040. At present, due to non-availability of by-passes at these 4 locations, the 'through' traffic (i.e., the vehicles that do not stop in the city/ town, but passes through it), has to pass through congested city/ town areas, thereby increasing the vehicular congestion levels of these cities/ towns.

The number & type of vehicles expected to use the proposed by-passes have been estimated through traffic surveys conducted in the month of February 2016. These traffic estimates were projected by using the standard "demand elasticity" approach, as is done for similar studies in India. The traffic estimates of 2016 are projected for the horizon years 2020, 2025, 2030, 2035 and 2040.

The proposed by-pass sections included in the present study are set out in Figure 2.1-1. There are 4 bypasses in total, adding up to 24.2 km. The longest by-pass (12.4 km) is proposed for Serchhip town.



Site	Coordinates at B.P./ E.P. side		Tentative Alignment Length
	Lat.	Long.	
1. Chhiahtlang bypass	23°23'31.36"N 23°22'53.20"N	92°50'30.11"E 92°50'22.22"E	3.0 km
2. Serchhip bypass	23°20'50.76"N 23°17'24.04"N	92°50'57.17"E 92°51'41.78"E	12.4 km
3. Hnathial bypass	22°59'06.90"N 22°56'00.06"N	92°55'29.90"E 92°55'29.28"E	6.8 km
4. Lawngtlai bypass	22°31'04.79"N 22°30'29.10"N	92°53'14.90"E 92°53'23.29"E	2.0 km
		Total	**24.2km**

Source: JICA Study Team

Figure 2.1-1 Study Road (by pass) Sections

2.2 Traffic Survey Methodology

For estimating the bye-pass traffic for each of the 4 identified cities/ towns on NH-54, the following two surveys were conducted at strategically selected locations (at two locations, one for the vehicles entering the town and other for vehicles leaving the town) on both sides of the road for each selected cities/ towns (Please refer Figure 2.2-1).

- Classified Vehicle Count Survey (CVCS); and
- Number Plate Survey (NPS)

The objective of both the above mentioned surveys is to estimate the number of vehicles that would divert to the proposed by-passes. It may be mentioned that generally CVCS is done for determining the traffic volume at a location, but can be structured by organizing two close-by & consecutive CVCSs for the same time-period in a day to obtain "through traffic" that can possibly get diverted to by-passes. Similarly, the "through traffic" can also be estimated by NPS by matching the registration number of vehicles, intercepted at two locations (for the same traffic flow direction) on either side of the city.

Thus both the surveys have been made to serve the same purpose. The results of these surveys were compared and analyzed, and the representative one was considered.

The two surveys were conducted on the same day at the same locations and for equal time period. However, in CVCS all the vehicles were covered, and for NPS it was on sample basis.

2.2.1 Classified Vehicle Count Survey

The CVCS was conducted for one day at two locations, one on each side (North and South) of the city/ town to capture vehicle movement in one direction (please refer Figure 2.2-1). Likewise, same arrangement was done to caption vehicle moment in other (opposite) direction. The "through traffic" for each direction was determined through the method described below:

(a) The frequency for vehicle counts was reduced to 15 minutes from the normal 60 min/ 30 min considered for such surveys (on the assumption that considering the city/ town sizes, 15 min would be adequate and appropriate for a "through vehicle" to cross the city)

(b) For each 15 minutes traffic counts in each direction of traffic flows (vehicles entering & leaving city in each direction) the following steps were carried out:

(i) All entries with zero counts in either or both locations (at city entry and exit) were deleted;

(ii) After above deletion, in the remaining vehicle count data, in case of difference in vehicle counts at entry and exit locations, the lower value of count was considered, otherwise for no difference in count the common count was considered.

Based on the method described above, the "through vehicles" were estimated for each of the two directions for a city, and then summed up to get the total "through vehicles". These "through vehicles" are the expected traffic that would divert to the proposed by-pass.

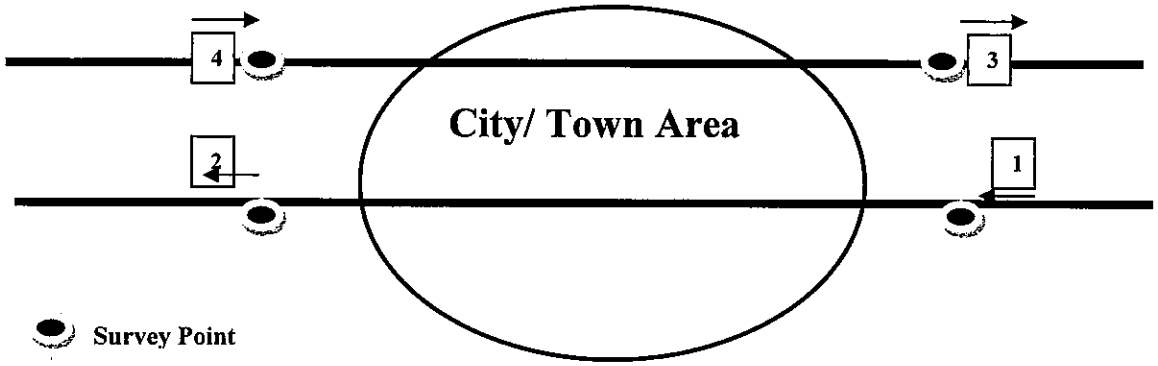
2.2.2 Number Plate Survey

Along with the CVCS, one day Number Plate Survey was conducted by noting down vehicle registration number for each category of vehicles, at every 15 minutes frequency. The NPS is an alternate for O-D survey, where by the vehicle registration number recorded at the two survey points located on the same side of the road (for example survey location 1 & 2 in Figure 2.2-1) when gets matched, then it means that the vehicle has crossed the city, i.e., it is a "through vehicle" and therefore can be considered as bye-pass traffic.

By doing simultaneously Number Plate Survey and Classified Vehicle Count Survey at the same locations, the percentage of "through vehicles" for each category of vehicle is estimated on the basis of

NPS data. These percentages are applied to the total vehicle count for each category of vehicle to arrive at the total expected "through vehicles".

The limitation for NPS is that it is sample based, whereby the two samples collected at both the entry as well as at exit locations are matched to obtain the common registration numbers. Thus it becomes a probabilistic event for vehicles with same registration number to get included in the two samples. Also, the sample is collected by noting down the registration number of moving vehicles, may result in a wrong entry.



Source: JICA Study Team

Figure 2.2-1 Typical Survey Points Locations for Classified Traffic Count Survey and Number Plate Survey

2.3 Traffic Estimates

As a step towards estimating the traffic expected to shift to by-pass, the CVCS and NPS were carried out simultaneously at two locations (one at the entry & other at exit points close to the city/town) of each of the 4 cities/ towns proposed for construction of by-pass. The following Table 2.3-1 shows the survey dates & chainage of each of the 4 by-pass cities/ towns.

Table 2.3-1 Traffic Survey Dates

Bye-Pass Name	By-pass Start & End Chainage	Traffic Survey Date
Chhiahtlang By-Pass (By-pass No.1)	Km 96.945 to Km 98.185	15.02.2016
Serchhip By-Pass (By-pass No.2)	Km 104.430 to Km 114.170	25.02.2016
Hnathial By-Pass (By-pass No.3)	Km 169.550 to Km 178.550	22.02.2016
Lawnglai By-Pass (By-pass No.4)	Km 472.000 to Km 478.850	18.02.2016

Source: JICA Study Team

The CVCS is the basis for estimating the daily traffic (vehicle counts for 24 hrs) at the survey locations, corresponding to each of the by-pass. The daily traffic as compiled from the CVCS data is set out in Table 2.3-2. It gives vehicle-wise count figures done at the entry points (to the city/ town) for traffic bound for North as well as South directions.

Table 2.3-2 Daily Traffic at By-pass Locations

Bye-Pass Name	Cars/ Jeep/ Taxi	Mini Bus	Bus	Three Wheeler	Two Wheeler	LCV	Trucks	PCU
Chhiahtlang By-Pass (By-pass No. 1)								
North Direction	134	0	4	20	172	23	16	335
South Direction	112	0	4	6	45	38	8	234
Total	**246**	**0**	**8**	**26**	**217**	**61**	**24**	**569**
Serchhip By-Pass (By-pass No. 2)								
North Direction	128	1	1	44	123	42	22	367

Bye-Pass Name	Cars/ Jeep/ Taxi	Mini Bus	Bus	Three Wheeler	Two Wheeler	LCV	Trucks	PCU
South Direction	154	3	2	34	83	21	12	308
Total	**282**	**4**	**3**	**78**	**206**	**63**	**34**	**675**
Hnathial By-Pass (By-pass No. 3)								
North Direction	71	3	1	12	86	23	14	210
South Direction	62	0	0	12	42	9	11	142
Total	**133**	**3**	**1**	**24**	**128**	**32**	**25**	**352**
Lawnglai By-Pass (By-pass No. 4)								
North Direction	101	0	4	20	44	20	18	239
South Direction	113	0	7	27	50	27	23	295
Total	214	0	10	47	94	47	42	**534**

Source: Traffic Survey conducted during February 2016 by JICA Study Team

2.4 Traffic Projection Methodology

The traffic projections have been carried out by 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 for traffic growth rate estimation has been carried out by the Consultants using the Vehicle Registration method and elasticity approach mentioned in the IRC: 108-1996, using the following form:

Table 2.4-1 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

2.4.1 Registered Vehicles

In absence of the traffic count figures data series for the project road sections, the Registered Vehicle data series (year 2007 to 2012) was used as a surrogate for traffic volume. The state – level registered vehicle data is presented in Table 2.4-2 for Mizoram State.

Table 2.4-2 Registered Vehicles – Mizoram State

State	Two Wheeler	Autos Rickshaw	Cars / Jeep Taxi	Bus	Truck	LCV
2007	27776	1758	20870	907	3000	2566
2008	30062	1931	22367	954	3167	2981
2009	32267	2105	23551	1003	3343	3397

State	Two Wheeler	Autos Rickshaw	Cars / Jeep Taxi	Bus	Truck	LCV
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%

Source: NEC, Shillong

2.4.2 Economic Indicators

Net State Domestic Product (NSDP) at constant prices has been used as independent variable for estimating the elasticity of the goods vehicles such as trucks, LCVs etc. The Per Capita Income (PCI) data was used as independent variables for estimating elasticity for passenger vehicles, such as cars, buses, two wheelers etc. The data series of NSDP & PCI at constant prices is presented in Table 2.4-3.

Table 2.4-3 NSDP & PCI (at Constant Prices)

Year	NSDP (Mn. INR)	PCI (INR)
2004-05	23996	24662
2005-06	25773	25826
2006-07	26927	26308
2007-08	29885	28467
2008-09	34370	31921
2009-10	38320	34699
2010-11	45389	40072
2011-12	44053	37921

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

2.4.3 Traffic Demand Elasticity

Considering the data series on Registered Vehicle and NSDP/ PCI, the elasticity estimates and its projections for the vehicle categories are given in Table 2.4-4.

Table 2.4-4 Vehicle-wise Demand Elasticity Values

Year/ Period	2014 - 17	2017 - 20	2020 - 25	2025-30	2030 -40
NSDP Growth Rate (%)	7.91%	7.11%	6.40%	6.08%	5.78%
Population Growth Rate (%)	2.03%	1.62%	1.46%	1.31%	1.25%
PCI Growth Rate (%)	5.88%	5.51%	4.97%	4.80%	4.57%
Elasticity w.r.t PCI					
Two Wheeler, ($y = 1.766x - 7.831$, $R^2 = 0.902$)	1.59	1.43	1.29	1.16	1.05
Autos Rickshaw , ($y = 1.299x - 5.834$, $R^2 = 0.875$)	1.24	1.17	1.11	1.11	1.11
Cars / Jeep Taxi, ($y = 1.425x - 4.741$, $R^2 = 0.809$)	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
Elasticity w.r.t NSDP					
Truck. ($y = 0.584x + 2.031$, $R^2 = 0.875$)	0.73	0.83	0.96	0.96	0.96
LCV, ($y = 1.475x - 7.219$, $R^2 = 0.904$)	1.32	1.19	1.07	1.02	0.97

Source: JICA Study Team

2.5 Traffic Projections

As explained earlier, the existing traffic at the bye-pass locations were estimated through the traffic survey. In addition to this, traffic is expected due to commencement of Kaladan project (explained below) and due to induced effect (combined impact of overall improvement of NH54, construction of by-passes and Kakadan project).

Traffic projections have been made by using methodology elaborated in earlier section of this chapter. The growth rates for the horizon year up to 2040 are set out in Table 2.5-1.

Table 2.5-1 Vehicle-wise Future Traffic Growth Rates

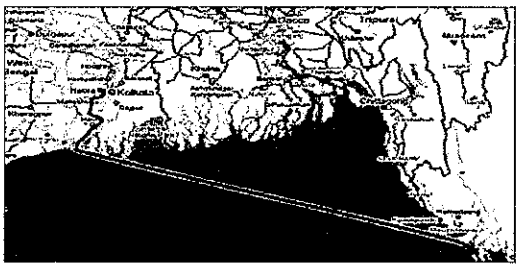
Year/ Period	2014 - 17	2017 -20	2020 - 25	2025-30	2030 - 40
Two Wheeler	11.58%	9.65%	7.97%	6.96%	6.08%
Three Wheelers	9.43%	8.20%	7.08%	6.74%	6.40%
Cars / Jeep Taxi	10.12%	8.80%	7.60%	7.24%	6.87%
Bus	7.60%	6.83%	6.15%	5.84%	5.55%
Truck	5.73%	5.93%	6.14%	5.83%	5.54%
LCV	15.72%	18.08%	6.86%	6.19%	5.59%

Source: JICA Study Team

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 Kaladan project, it is expected that a part of the traffic entering North-East Region (NER) from Kokrajhar (West Bengal side) shall get re-routed, and enter NER via NH54 (Mizoram).

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 2.5-1 Kaladan Multi Modal Transit Transport Project

In one of the earlier studies (Preparatory Study for Road Network Improvement in North-East States India Volume-I, 2015), JST considered the traffic on NH54 due to Kaladan project as set out in Table 2.5-2. The same has been also adopted for the present study.

Table 2.5-2 Traffic on Account of Kaladan Project

Vehicle Type	Traffic in 2020
Two Wheeler	196
Autos Rick	13
Cars / Jeep Taxi	373
Bus	20
Mini Bus	16
Trucks	53
LCV	255

Source: JICA Study Team

In addition to the above traffic stream, an induced traffic of 10% (by the 2020) has been considered due

to the expected combined impact of improvement of NH54, construction of bye-passes and opening of Kaladan project.

The total traffic thus arrived at by combining the existing traffic, Kaladan traffic and the induced traffic, was projected by using the future growth rates for the horizon years – 2020, 2025, 2030, 2035 & 2040 (Table 2.5-3).

Table 2.5-3 Traffic Projections (Daily Traffic)

Year	Cars/ Jeep/ Taxi	Bus	3 Wheeler	2 Wheeler	LCV	2 Axle	Total	PCU
Chhiahtlang By-Pass (By-pass No. 1)								
2020	349	10	36	319	116	30	861	841
2025	1103	66	74	808	543	118	2713	2861
2030	1565	87	103	1132	734	157	3777	3950
2035	2181	115	140	1520	963	206	5125	5333
2040	3041	150	191	2042	1264	270	6957	7206
Serchhip By-Pass (By-pass No. 2)								
2020	400	9	108	303	120	43	983	995
2025	1184	64	186	782	549	137	2902	3099
2030	1680	85	257	1095	742	182	4040	4280
2035	2342	111	351	1471	973	238	5486	5782
2040	3264	146	478	1976	1277	312	7454	7818
Hnathial By-Pass (By-pass No. 3)								
2020	189	5	33	188	61	31	508	517
2025	849	58	70	597	459	120	2153	2352
2030	1204	77	97	836	619	160	2993	3241
2035	1679	101	132	1123	813	209	4056	4368
2040	2340	132	180	1509	1067	274	5501	5891
Lawnglai By-Pass (By-pass No. 4)								
2020	303	13	65	139	90	52	662	769
2025	1031	70	119	517	502	151	2391	2737
2030	1462	93	165	724	678	201	3323	3770
2035	2038	121	225	973	890	263	4511	5085
2040	2841	159	307	1307	1169	345	6127	6864

Source: JICA Study Team

2.6 Bye-pass Traffic

Adopting the methodology described earlier in Section 2.2 of this chapter, the vehicle-wise diversion, in percentage terms, for the 4 by-passes were estimated through analysis of CVCS and NPS data. It was found that the percentage diversion estimated by using CVCS data was more consistent than NPS data. Therefore, to obtain the diverted traffic (traffic that is expected to use the by-passes), the percentage diversion values (vehicle-wise) based on CVCS data, presented in Table 2.6-1, were applied to the total traffic projections given in the previous table. The bye-pass traffic projections are set out in Table 2.6-2.

Table 2.6-1 Percentage Traffic Diversion to By-pass

By-Pass	Cars/ Jeep/ Taxi	Bus	Three Wheeler	Two Wheeler	LCV	Truck
Chhiahtlang By-Pass (By-pass No. 1)	67%	25%	15%	43%	46%	25%
Serchhip By-Pass (By-pass No. 2)	63%	-	55%	50%	51%	41%
Hnathial By-Pass (By-pass No. 3)	41%	-	25%	49%	25%	28%
Lawnglai By-Pass (By-pass No. 4)	66%	10%	56%	46%	35%	44%

Source: Traffic Survey by JICA Study Team

Table 2.6-2 Daily Traffic - Divert to By-passes

By - pass	Cars / Jeep Taxi	Bus	Three Wheeler	Two Wheeler	LCV	Truck	Total	PCU
Chhiahtlang By-Pass (By-pass No. 1)								
2020	349	10	36	319	116	30	861	841
2021	555	13	9	258	191	22	1048	1084
2025	744	16	11	350	249	28	1400	1437
2030	1056	22	16	490	337	37	1957	1998
2035	1472	29	22	659	442	48	2671	2716
2040	2052	38	29	885	580	63	3647	3695
Serchhip By-Pass (By-pass No. 2)								
2020	400	9	108	303	120	43	983	995
2021	555	0	78	288	214	45	1179	1233
2025	743	0	102	391	279	58	1573	1632
2030	1054	0	142	548	377	76	2197	2264
2035	1470	0	193	736	494	100	2993	3073
2040	2049	0	264	988	649	131	4081	4173
Hnathial By-Pass (By-pass No. 3)								
2020	189	5	33	188	61	31	508	517
2021	398	0	29	220	179	40	865	924
2025	533	0	38	299	233	51	1153	1222
2030	756	0	53	418	315	67	1609	1691
2035	1054	0	73	562	413	88	2188	2290
2040	1469	0	99	754	542	115	2979	3103
Lawnglai By-Pass (By-pass No. 4)								
2020	303	13	65	139	90	52	662	769
2021	483	0	50	190	196	50	969	1072
2025	647	0	66	259	255	64	1290	1416
2030	918	0	91	362	345	84	1800	1960
2035	1279	0	124	487	452	111	2453	2657
2040	1783	0	169	654	594	145	3344	3604

Source: JICA Study Team

CHAPTER 3 ECONOMIC ANALYSIS

3.1 General

The project cost and benefits have been estimated for the project analysis period of 30 years, including 2.5 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 net present value (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 (Yr. 2016) prices are used for economic evaluation. Since the project costs such as capital, vehicle, consumables, etc., are based on the market prices, these costs have been converted into economic costs by applying appropriate factors established for resource costs. For this, all the costs 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 equipments. 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.

3.2 By-passes & Corresponding Road Sections

Table 3.2-1 presents the length of the 4 by-passes and the corresponding road section length of NH54 (i.e., the start and end points of the existing road sections that meet the start and end point of the by-pass). The lengths of the by-passes and the road section lengths are inputs for economic analysis.

Table 3.2-1 Bypass Length & Equivalent Length of Corresponding Road Sections

Bye-Pass Name	By-pass Start & End Chainage	By-pass Length after design	Equivalent Length of Corresponding NH-54 Road Sectios
Chhiahtlang By-Pass (By-pass No.1)	Km 96.945 to Km 98.185	2.57km	1.24 Km
Serchhip By-Pass (By-pass No.2)	Km 104.430 to Km 114.170	11.80km	9.74 Km
Hnathial By-Pass (By-pass No.3)	Km 169.550 to Km 178.550	7.02km	9.00 Km
Lawnglai By-Pass (By-pass No.4)	Km 472.000 to Km 478.850	2.63km	6.85 Km

Source: JICA Study Team

The features of the road sections corresponding to the 4 by-passes are set out in Table 3.2-2.

Table 3.2-2 Features of Road Sections Corresponding to 4 By-passes

By-Pass Reference	Applicable Existing Road Section of NH 54	Lane Configuration	Shoulder Width (Mt)	Terrain	Wt. Avg. IRI
No.1	Km 55- Km125	3.75 (SL)	0.5 (UP)	Steep	5.00
No.2	Km 55- Km125	3.75 (SL)	0.5 (UP)	Steep	5.00
No.3	Km 125 - Km	3.75 (SL)	0.4 (UP)	Steep	6.20
No.4	Km 250 – and beyond	3.75 (SL)	0.45 (UP)	Steep	9.10

Source: JICA Study Team

3.3 Vehicle Fleet Data Inputs

Vehicle fleet data is used for estimating the operating cost of the vehicles. The inputs relate to vehicle cost, cost of tire, fuel prices, maintenance labor cost, and crew cost, etc., details on vehicle specification and performance. These input costs are given in Table 3.3-1. All the cost items are at economic cost, estimated on the basis of the method described earlier in this chapter.

Table 3.3-1 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)	420	54	139	924	651	1008	1117	680	454
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)	3.26	0.77	1.01	9.19	9.19	9.19	9.19	5.88	9.19
Fuel Per/Lt. (Rs.)	38.63	38.63	38.63	39.75	39.75	39.75	39.75	39.75	39.75
Maint. Labor (Rs. per hr.)	105	63	105	189	157.5	189	210	157.5	210
Crew Wages (Rs. per hr)	16.8	0	14.7	67.2	40.95	37.8	43.05	28.35	0
Annual Overhead (Rs 000)	21	0	10.5	42	31.5	31.5	42	31.5	10.5
Interest Rate (%)	12	12	12	12	12	12	12	12	12
Pass. Time Value* (Rs. per/hr.)	80.06	64.04	64.04	53.7	53.7	0	0	0	0
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

3.4 Project Cost

The cost estimates for the 4 by-passes were prepared by JST. It may be noted that the proposed construction works is only applicable for construction of new by-passes ('with' the project cases), and are not applicable for the base case alternative ('without' the project case).

The first year of construction period is considered as Yr. 2019, with the construction period lasting for 2.5 years (i.e., up to Yr. 2021). The opening year of traffic operations is expected to be Yr. 2021. The construction is expected to be completed in a phased manner as indicated as follows.

Table 3.4-1 Investment Schedule for Construction

Construction Year	Percentage Investment
2019	30%
2020	40%
2021	30%

Source: JICA Study Team

3.5 Maintenance Standards and Capital Costs

The maintenance (annual and periodic) cost has been taken separately for the base case alternative (do-nothing\ do-minimum) and the project alternatives. While the maintenance cost for '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 JST.

The capital costs (at market prices) for the 4 by-passes are presented in Table 3.5-1.

Table 3.5-1 Capital Cost of By-passes at 2016 Economic Prices

By-pass No.	By-pass Name	Capital Cost at Market Prices (2016) in Rs Million			
		2019	2020	2021	Total
1.0	Chhiahtlang By-Pass	195.85	261.13	195.85	652.83
2.0	Serchhip By-Pass	867.47	1,156.63	867.47	2,891.57

By-pass No.	By-pass Name	Capital Cost at Market Prices (2016) in Rs Million			
		2019	2020	2021	Total
3.0	Hnathial By-Pass	507.79	677.05	507.79	1,692.62
4.0	Lawnglai By-Pass	273.32	364.42	273.32	911.06

Source: Study Team

The capital cost of the whole about 350 Km of project section of NH54 mainline is INR 40,661 million.

3.6 Economic Evaluation

The economic analysis based on the method elaborated above, allowed the Study Team to obtain the economic indicators for each of the by-passes. The economic indicators such as economic internal rate of return (EIRR) is important for judging the economic feasibility of projects. The results of economic analysis are set out in Table 3.6-1.

Table 3.6-1 Results of Economic Analysis of By-passes

NH54 Section + By-pass Name	EIRR (%)
NH54 Main Road Section + Chhiahtlang By-Pass No.1	13.21%
NH54 Main Road Section + Serchhip By-Pass No.2	12.07%
NH54 Main Road Section + Hnathial By-Pass No. 3	12.77%
NH54 Main Road Section + Lawnglai By-Pass No. 4	13.17%
NH54 Main Road Section + All By-passes	10.96%

Source: Study Team

CHAPTER 4 ALTERNATIVE ROUTE STUDY

4.1 Objectives of Alternative Route Study

The scope of bypasses in the DPR was not clearly mentioned. The alignments of the four bypasses in DPR were given tentatively without much description of profile and detailed cross sections, especially for Chhiahtlang and Serchhip Bypasses. Therefore, JICA Study Team conducted Alternative Route Study for these four bypasses before conducting detailed topographic survey for preliminary design.

Based on the results of the Alternative Route Study, which included detailed examination of the routes on site by the team members, optimum route for each bypass is established.

4.2 Scope of Alternative Route Study

The scope of Alternative Route Study is to conduct site investigation for several conceivable alternative routes for each bypass and find the optimum route based on the alignment study from initial wide area digital terrain model prepared by photogrammetry method using satellite images.

4.3 References from DPR Study and Preliminary Review

4.3.1 General

The list of four bypasses proposed in the DPR of NH54 is given in Table 4.3-1.

Table 4.3-1 Scope of Four Bypasses

No.	Name	Position of Bypasses (k.p.)	Length
1	Chhiahtlang Bypass	Start near 96.945km、End near 99.185km	Approx. 3km
2	Serchhip Bypass	Start near 104.430km、End near 114.170km	Approx.12.4km
3	Hnathial Bypass	Start near 169.550km、End near 178.550km	Approx.6.8km
4	Lawngtlai Bypass	Start near 472.000km、End near 478.850km	Approx.2.0km
Total			Approx.24.2km

Source: JICA Study Team

Preliminary review of four bypasses by JST was conducted initially by desk.

4.3.2 Chhiahtlang Bypass

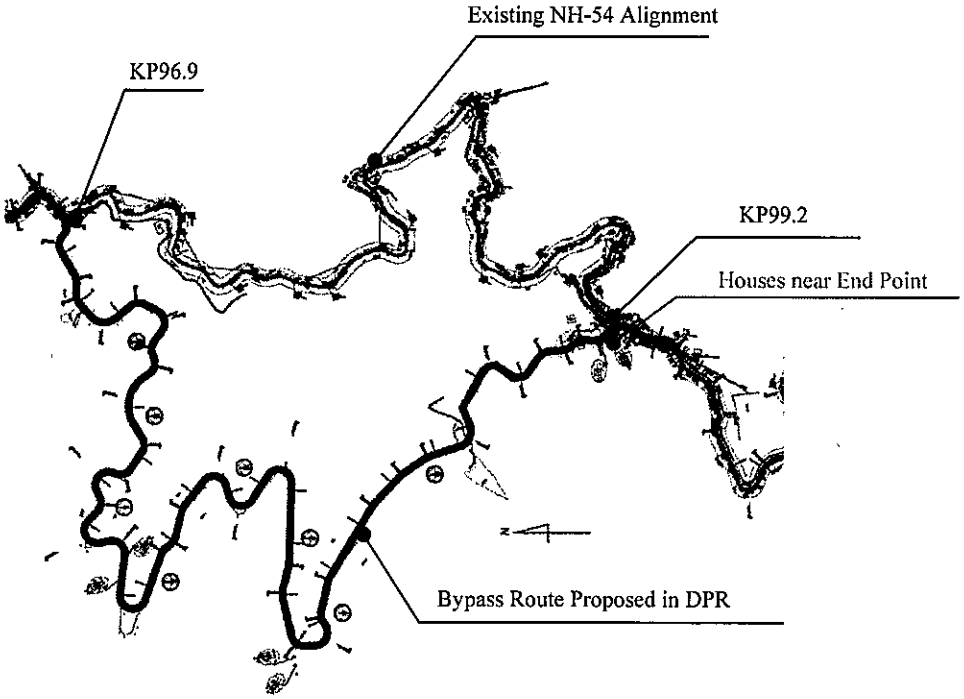
The layout of Chhiahtlang Bypass proposed in DPR is given in Figure 4.3-1.

It is confirmed that there exists a national park in eastern part of Chhiahtlang. Therefore, JST recommends to follow the bypass route proposed in DPR which passes through western side of the existing NH54. The bypass route stars near existing KP96.9 and ends near KP99.2 with an approximate length of about 3km. Based on the initial desk study JST observed some residences around the proposed end point, which needs to be confirmed during site investigation for verification and possible realignment.

4.3.3 Serchhip Bypass

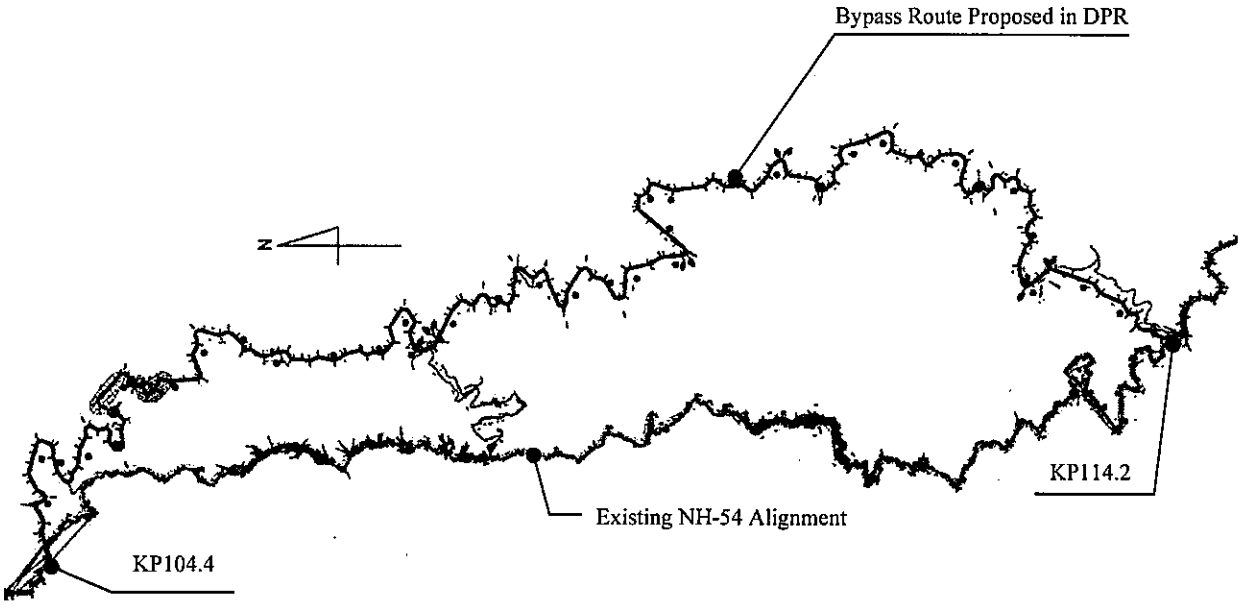
The layout of Serchhip Bypass proposed in DPR is given in Figure 4.3-2.

The bypass in DPR is proposed from the eastern side since much longer length would be required if western side is selected for bypass construction for Serchhip. Therefore, JST considers the eastern route proposed by DPR is appropriate. However, some residences were observed based on the available map in the area near the endpoint, which needs to be confirmed during site investigation.



Source: JICA Study Team

Figure 4.3-1 Chhiahtlang Bypass Route Proposed in DPR



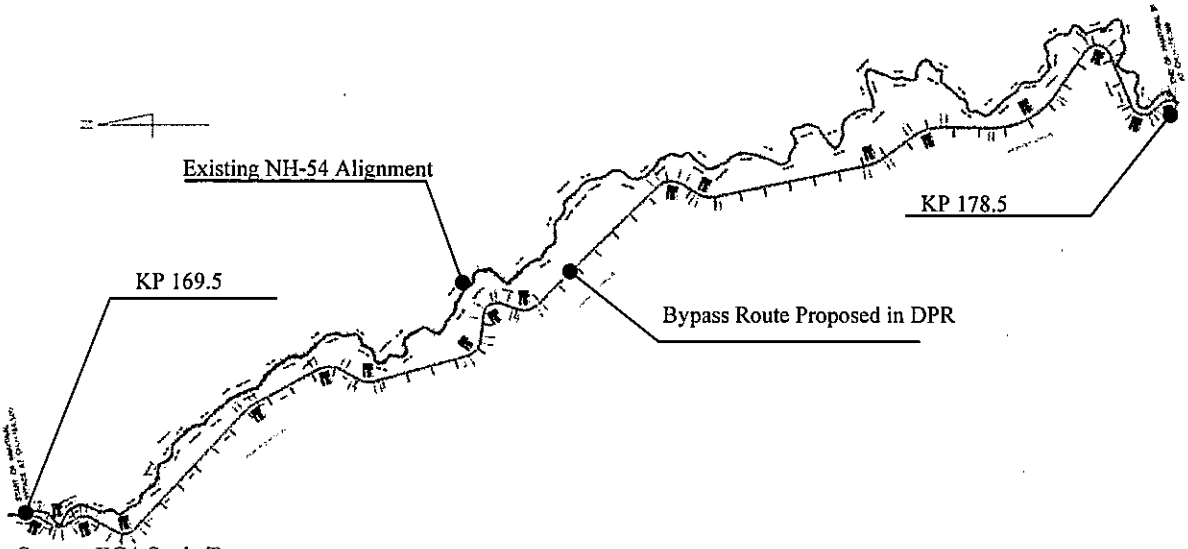
Source: JICA Study Team

Figure 4.3-2 Serchhip Bypass Route Proposed in DPR

4.3.4 Hnathial Bypass

The layout of Hnathial Bypass proposed in DPR is given in Figure 4.3-3.

The bypass in DPR is proposed from the western side of the existing NH54. In the eastern side of the existing NH54, the terrain is uphill near the end of bypass which makes it difficult to connect back to NH54. Therefore, the eastern side proposed in DPR seems appropriate. The bypass starts at existing KP169.5 and ends at KP178.5.



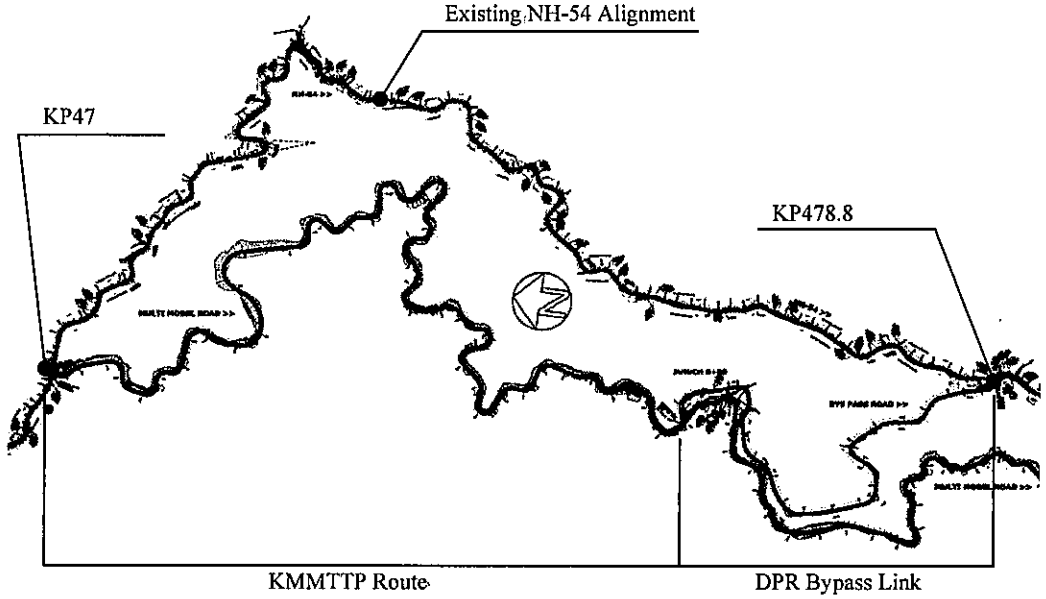
Source: JICA Study Team

Figure 4.3-3 Hnathial Bypass Route Proposed in DPR

4.3.5 Lawngtlai Bypass Link

The layout of Lawngtlai Bypass proposed in DPR is given in Figure 4.3-4.

In the Lawngtlai area, there is another road construction project which is the Kaladan Multi-Modal Transit Transport Project (KMMTTP), under construction, avoiding the route of urbanized area of Lawngtlai. Therefore, the beginning section of the bypass for Lawngtlai actually belongs to the KMMTTP project. However, the road under this project does not meet back to the NH54 at the other end. Therefore, a link road is proposed under the scope of this Project such that it connects back to NH54.



Source: JICA Study Team

Figure 4.3-4 Lawngtlai Bypass Link Proposed in DPR

4.4 Alternative Route Study

4.4.1 Data Used and Site Investigation

Wide area satellite images were used to produce digital terrain model with detailed contour lines by photogrammetry along all four bypass routes. At least two alternate horizontal alignments were designed based on the produced contour maps.

All the data were created in the same coordinate system of WGS-84 (World Geodetic System) with UTM (Universal Transverse Mercator) Zone of 46N (93degree E) for this reason.

Site investigations were carried out by 9 members of JICA Study Team to confirm design controls and other site conditions along the route corridor by walking along the proposed routes of all four bypasses. All the sections of bypasses were not accessible, but it was investigated from as close location as possible. The proposed alternative routes were investigation based on the handheld GPS for verification of correct location at site. A series of geo-tagged photographs along the routes were also recorded for verification of control points later during detailed analysis.

4.4.2 Major Features of Alternatives of Four Bypasses

Major general features of the alternatives in each bypass are summarized in Table 4.4-1.

Table 4.4-1 Major Features of Alternatives of Four Bypasses

No.	Name	Alternative Routes		
		Route	Length (km)	Major Features
1	Chhiahtlang Bypass	Alternate-1 (DPR)	2.584	Houses on valley side near end of bypass
		Alternate-2	2.578	Houses on hill side near end of bypass
2	Serchhip Bypass	Alternate-1 (DPR)	12.422	Follow lower side of hill, but relatively steep terrain. Straight alignment of the bridge near end section (longest bridge length at this location)
		Alternate-2	11.629	Follow upper side of hill than Alternative-1, which is relatively gentle. Straight alignment of the bridge near end section (moderate bridge length at this location)
		Alternate-3	11.708	Follow upper side of hill than Alternative-1, which is relatively gentle. Straight alignment of bridge near end section (shortest bridge length at this location) but longer approach to reduce bridge length
		Alternate-4	12.164	Follow upper side of hill than Alternative-1, which is relatively gentle. Curve bridge alignment to reduce bridge cost but end approach pass through difficult terrain condition.
3	Hnathial Bypass	Alternate-1 (DPR)	6.799	Follow upper side of hill but affects lots of houses
		Alternate-2	6.974	Follow lower side of hill to avoid houses
4	Lawngtlai Bypass	Alternate-1 (DPR)	1.870	Follow lower side of hill but passes through middle of landslide area
		Alternate-2	2.110	Follow upper side of hill avoiding landslide from upper side

Source: JICA Study Team

4.4.3 Alternatives and Control Points in Bypass-1 (Chhiahtlang Bypass)

The details are given in Figure of Appendix-1-1. Basically, the alignment is same as that of the DPR except for the short end section. Minor modifications were done to follow the contours. Major control points in this bypass are as follows;

1. Large cemetery area near Km0+200
   The DPR alignment passes along the existing road near the cemetery area at Km0+200. In order to pass the bypass route below the cemetery area, alternative to start the bypass alignment about 200m ahead was also checked. But the topographic condition was found to be very steep and this

alternative was abandoned.

2. Large cemetery area near Km2+100

   Another large cemetery area exists near Km2+100, where another existing road passes from the left of the cemetery. In order to avoid the cemetery area completely, relatively large hill cutting will be required on the left side, but there is no problem of slope stability.

3. Houses on both side of existing road at end section

   The bypass alignment ends utilizing the existing road at this section where houses exist on both sides of the existing road. Two alternatives, one passing from the hill side (Alternative-1) and the other passing from the valley side (Alternative-2) are considered to check the number of houses affected in each alternative.

   In order to avoid the houses in this stretch, another alternative was also checked at site such that the end of the bypass is extended for about 400m further south. But there exists large slope failure area and many houses are also located below the existing NH54, which will require relocation otherwise. Therefore, the alternative to extend the end point of the bypass was abandoned.

Table 4.4-2 Control Points in Bypass-1

Control Point	Site Photo
1. Large cemetery area near Km0+200	
2. Large cemetery area near Km2+100	

Control Point	Site Photo
3. Houses on both side of existing road at end section	

Source: JICA Study Team

4.4.4 Alternatives and Control Points in Bypass-2 (Serchhip Bypass)

The details are given in the Figure of Appendix-1-2. Four alternative routes were considered for this.

The initial section from Km0+000 to about Km9+700 has basically two alternatives. Alternative-1 (DPR alignment) passes through relatively lower side of the hill, but the slope condition is very steep at several locations. All other alternatives in this section have a common alignment which passes through relatively upper side of the hill with gentle slope conditions.

The end section after Km9+700 has four alternatives based on the location of the bridge crossing near Km10+500.

Three alternatives, Alternative-1, 2 and 3 pass the river at almost same location with a straight bridge alignment. Alternative-1 (DPR alignment) crosses the river at relatively higher elevation and hence the length of the bridge is longest for this alternative. Alternative-2 crosses the river at moderate elevation and the length of the bridge is also moderate among the three alternatives. The end approach section for this alternative has better alignment than other two alternatives. Alternative-3 is also basically similar to Alternative-2, but the bridge crossing was targeted at relatively lower elevation to reduce the length of the bridge as far as possible. But this resulted in higher length of end approach section and the alignment has more curvatures than Alternative 1 and 2.

The last alternative, Alternative-4 was studied to select different location of river crossing to further reduce the total length of the bridge and to construct the superstructure of the bridge at lower elevation with direct support system, which would result in lower bridge cost. The end approach section passes through the other side of the hill, which has very steep topographic conditions with several steep stream crossings. The end approach alignment is also poor and longest compared to all other alternatives.

In the DPR, the alignment was not modified to fine tune with the terrain, therefore, a large quantities of earthwork is resulted.

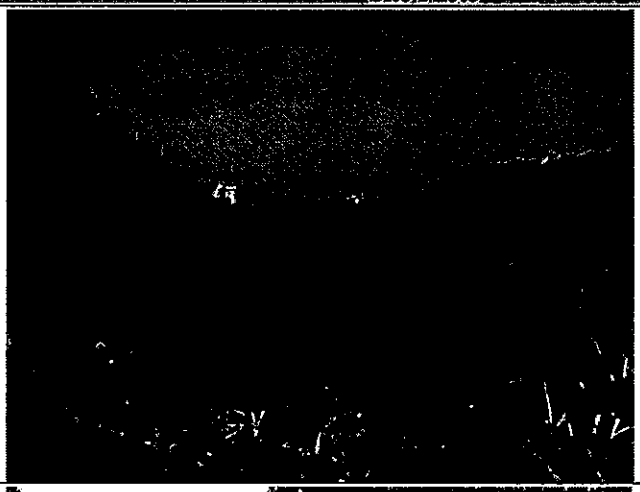
The major control points identified during site investigation are listed in Table 4.4-3.

Table 4.4-3 Major Control Points in Alternatives of Bypass-2

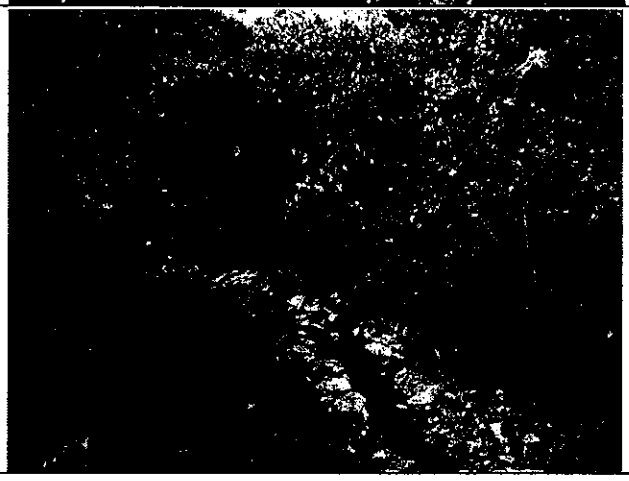
S.N.	Control Points	Description	Remarks
1	CP1	Saddle point on the hill	DPR alignment causes large cutting depth
2	CP2	Bridge in DPR	Avoided in Alternative-2, 3, 4
3	CP3	Steep slope in DPR	Steep slope in DPR is avoided by passing through CP4
4	CP4	Gentle slope in Alternative-2, 3, 4	
5	CP5	DPR alignment crossing Monument	Avoided in Alternative-2, 3, 4
6	CP6	Steep slope in DPR	Steep slope in DPR is avoided by passing through CP7
7	CP7	Gentle slope in Alternative-2, 3,4	
8	CP8	Steep slope in DPR	Steep slope in DPR is avoided by passing through CP9
9	CP9	Gentle slope in Alternative-2,3,4	
10	CP10	Bridge location in Alternative 1,2,3	Straight, but longer bridge
11	CP11	Alternative bridge location in Alternative-4	Lower bridge at curve
12	CP12	Houses affected by Alternative-4	Avoided in Alternative-2, 3, 4

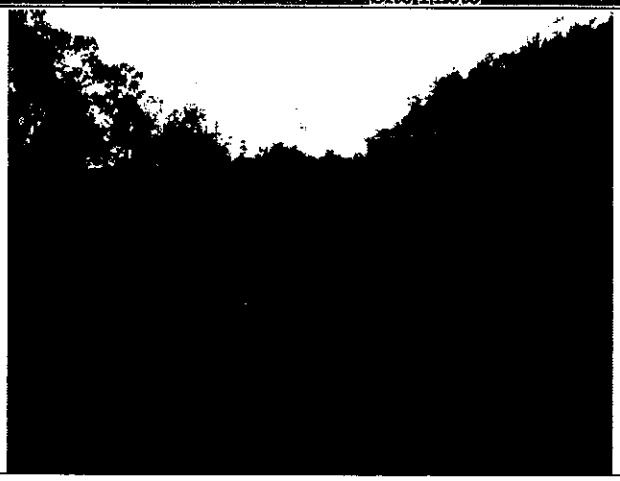
Source: JICA Study Team

Table 4.4-4 Control Points in Bypass-2

Control Point	Site Photo
CP1	
CP2	
CP3/CP4	

Control Point	Site Photo
CP5	
CP6	
CP7	

Control Point	Site Photo
CP8/CP9	
CP10	
CP11	

Control Point	Site Photo
CP12	

Source: JICA Study Team

4.4.5 Alternatives and Control Points in Bypass-3 (Hnathial Bypass)

The details are given in the Figure of Appendix-1-3. Two alternative routes were studied for this bypass.

Alternative-1 (DPR alignment) passes relatively along upper side of the hill, closer to the exiting NH54. Therefore, this alternative requires relocation of a large number of houses and a football ground as shown in the Figure of Appendix-3. Therefore, another alternative was studied, which passes relatively along lower side of the hill avoiding houses and the football ground.

In the DPR, the alignment was not modified to fine tune with the terrain, therefore, a large quantities of earthwork is resulted.

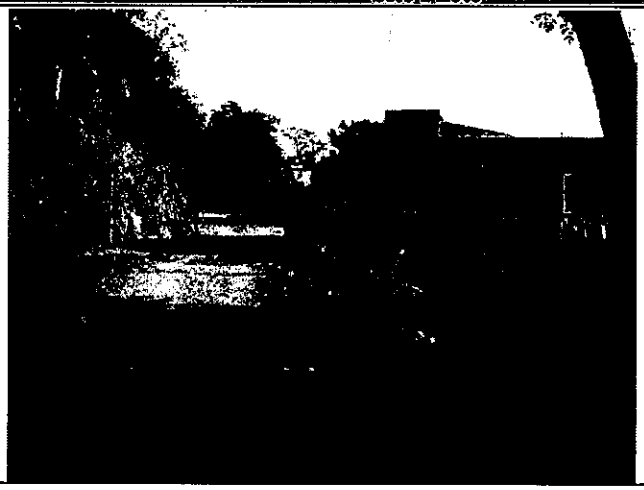
The major control points identified during site investigation are as listed in Table 4.4-5.

Table 4.4-5 Major Control Points in Alternatives of Bypass-3

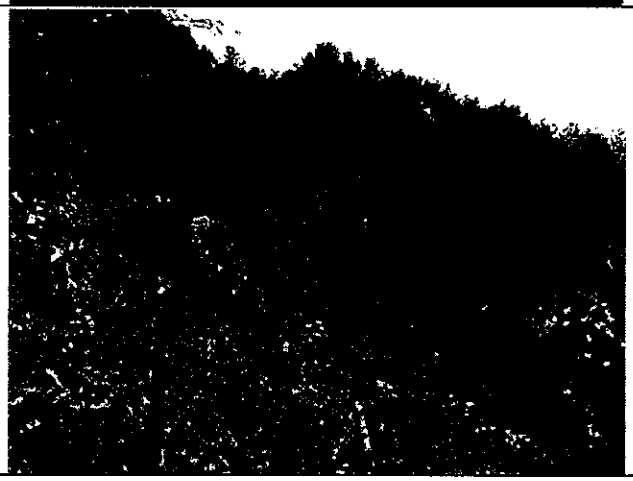
S.N.	Control Points	Description	Remarks
1	CP1	Houses affected in DPR	Avoided by alignment of Alternative-2
2	CP2	Houses affected in DPR	
3	CP3	Houses affected in DPR	
4	CP4	Houses affected in DPR	
5	CP5	Houses affected in DPR	
6	CP6	Football ground affected in DPR	
7	CP7	Excessive hill cutting	Excessive cutting due to straight alignment in DPR is avoided in Alternative-2 by applying curves with permissible radii

Source: JICA Study Team

Table 4.4-6 Control Points in Bypass-3

Control Point	Site Photo
CP1	

Control Point	Site Photo
CP2	
CP3	
CP4	

Control Point	Site Photo
CP5	
CP6	
CP7	

Source: JICA Study Team

4.4.6 Alternatives and Control Points in Bypass-4 (Lawngtlai Bypass Link)

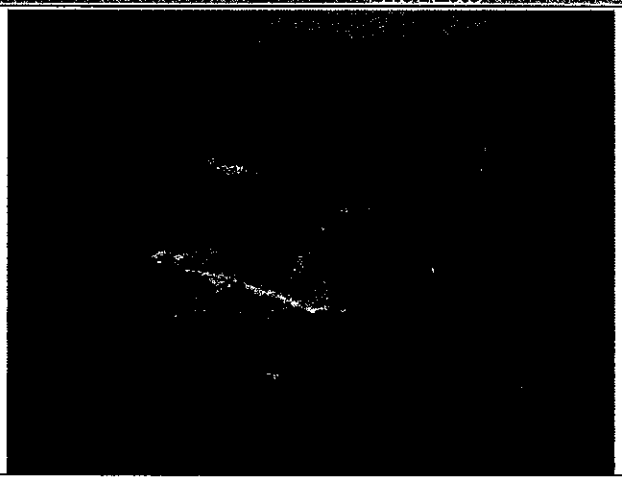
The details are given in the Figure of Appendix-1-4. Two alternative routes were studied for this bypass.

As mentioned in Section 4.3, the Lawngtlai Bypass would include a part of Kaladan Multi-Modal road in the initial section, which will not connect with NH54 in the south. Therefore, a link road is designed to connect from the Kaladan Multi-Modal road to the existing NH54 after the Lawngtali town so that it would serve as Lawngtlai Bypass for the traffic along NH54.

Major control point in this bypass is that Alternative-1 (DPR alignment) passes through the middle of

landslide area around Km1+100. Therefore, another alternative was studied so that it would pass through top avoiding the landslide area. In order to pass the alignment above the landslide area, yet maintaining the maximum vertical gradient of 7%, the alignment of Alternative-2 needs to start about 250m prior to the starting point of Alternative-1, making it longer in length.

Table 4.4-7 Control Points in Bypass-4

Control Point	Site Photo
landslide area around Km1+100	

Source: JICA Study Team

4.5 Results of Alternative Analysis

Alternative analysis was conducted to find the optimum route for each bypass with the following conditions;

1. The base case with Alternative-0 is also studied with the condition that the existing NH54 for the studied stretches are widened to 12m without bypass.
2. Geometric data of the alternative alignment (horizontal and vertical), environmental factors, spoil volume, houses to be compensated and total construction cost were used for the analysis.
3. In the analysis of Bypass-4 (Lawngtlai Bypass link), the base case of Alternative-0 is considered with the total length from where the Kaladan Multi-Modal Road starts before Lawngtlai town to the end of Bypass-4. Therefore, in Alternative-1 and Alternative-2, the total construction cost is inclusive of 4.4km of construction cost for the initial section of Kaladan Multi-Modal Road with assumed average cost of Rs.10 crore/km.

The details of the alternative analysis are given in Appendix-2. The summary of results with ranking on each item and overall ranking is given in Table 4.5-1.

Table 4.5-1 Summary Results of Alternative Analysis

Bypass No.	Bypass Name	Items for Analysis	Ranking for each Alternative				
			Alternate-0	Alternate-1	Alternate-2	Alternate-3	Alternate-4
1	Chhiahtlang Bypass	Geometry	3	1	1	--	--
		Spoil volume	1	3	2	--	--
		House compensation	3	1	1	--	--
		Construction cost	1	2	3	--	--
		OVERALL RANKING	**3**	**2**	**1**	--	--
2	Serchhip Bypass	Geometry	4	5	1	2	3
		Spoil volume	1	5	1	1	1
		House compensation	5	1	1	1	1
		Construction cost	1	5	2	4	3
		OVERALL RANKING	**5**	**4**	**1**	**2**	**3**
3	Hnathial Bypass	Geometry	3	1	2	--	--
		Spoil volume	1	3	1	--	--
		House compensation	3	2	1	--	--

Bypass No.	Bypass Name	Items for Analysis	Ranking for each Alternative				
			Alternate-0	Alternate-1	Alternate-2	Alternate-3	Alternate-4
		Construction cost	1	3	2	--	--
		OVERALL RANKING	**3**	**2**	**1**	--	--
4	Lawngtlai Bypass	Geometry	3	2	1	--	--
		Spoil volume	1	3	1	--	--
		House compensation	3	2	1	--	--
		Construction cost	1	3	2	--	--
		OVERALL RANKING	**3**	**2**	**1**	--	--

The highlighted cells are for the Optimum Route, which is Alternative-2 for each bypass.
Source: JICA Study Team

4.6 Conclusions

- Based on the results of the alternative analysis the conclusions are made as shown in Table 4.6-1.
- Detailed topographic survey will be conducted for the optimum routes for each bypass for preliminary design.

Table 4.6-1 Conclusions from Alternative Analysis

No.	Bypass Name	Route	Length (km)	Conclusion
1	Chhiahtlang Bypass	Alternate-0	2.200	Though Alternative-2 is ranked 1st in the analysis, both alternative routes are basically similar except the end section. Therefore, it will be further studied after detailed topographic survey results are available.
		Alternate-1	2.584	
		Alternate-2	2.578	
2	Serchhip Bypass	Alternate-0	9.700	Alternative-2 is selected as optimum route due to better alignment, less spoil volume and compensation of houses and least cost among 4 alternatives.
		Alternate-1	12.422	
		Alternate-2	11.629	
		Alternate-3	11.708	
		Alternate-4	12.164	
3	Hnathial Bypass	Alternate-0	10.000	Alternative-2 is selected as optimum route due to less spoil volume, compensation of houses and construction cost.
		Alternate-1	6.799	
		Alternate-2	6.794	
4	Lawngtlai Bypass	Alternate-0	5.800	Alternative-2 is selected as optimum route due to better alignment, less spoil volume, compensation of houses and construction cost.
		Alternate-1	6.270	
		Alternate-2	6.100	

Source: JICA Study Team

CHAPTER 5 PRELIMINARY DESIGN OF NH54 (BYPASS)

5.1 Natural Condition Surveys

5.1.1 Meteorological and Hydrological Surveys

(1) General
National Highway shall facilitate drainage system enough and properly to drain out rainy water fallen at road surface and flown from mountain upstream. Specially, hill road is suffered from large volume of crossing water flown from mountain slope. It is essential to protect the improved highway from such rainy water by appropriate arrangement of drainage facilities.
The hydrological study based on meteorological and topographical condition at project area is conducted.

(2) Meteorological condition
Mizoram has a mild climate, relatively cool in summer 20 to 29 °C and 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 254 centimeters per annum. In the capital Aizawl, rainfall is about 215 centimeters and in Lunglei, another major centre, about 350 centimeters. The state is in a region where cyclones and landslides can cause weather-related emergencies.
In addition, the rainfall intensity has being increased in the North-east state of India due to climate changes in recent as explained in Chapter 5.2.10

(3) Topographical condition
Mizoram has the most variegated hilly terrain in eastern part of India. The hills are steep and are 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 2210 meters.
The approximate evelation where NH54 bypass are planned are as shown below.

- Chhiahtlang (Bypass No.1) : 900m－930m
- Sercchip (Bypass No.2) : 810m－980m
- Hnathial (Bypass No.3) : 600m－720m
- Lawngtlai (Bypass No.4) : 750m－860m

(4) Hydrological study
a) Methodology
The hydrological study is conducted with referred on IRC:SP:13 "Guidelines for the design of small bridges and culverts" and IRC:SP42 "Guidelines of road drainage", which is well used technical standard for hydrological study in Indian highway design.
The analysis is conducted based on 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.

Ratinal 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)

b) Return period

The return period is described on IRC:SP42 as follows.

-For side drain for N.H. : 25 years (at valley points)

-For cross-drainage for N.H. : 25 years (up to 2m span) / : 50 years (2 to 6m span)

It is also suggested on IRC:SP42 that to assure the discharge not only for design flood but also for check flood in order to protect an area from prolonged inundation when a flood rarer that the design flood hits the area. A check flood is a flood having next higher commonly followed recurrence interval. The project highway locates at highly hill, the water flood may causes high risk of fatal accidental. Also increase of rainfall intensity in recent years, an application of 50 years for all drainage is not overestimate.

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

c) Rainfall Intensity

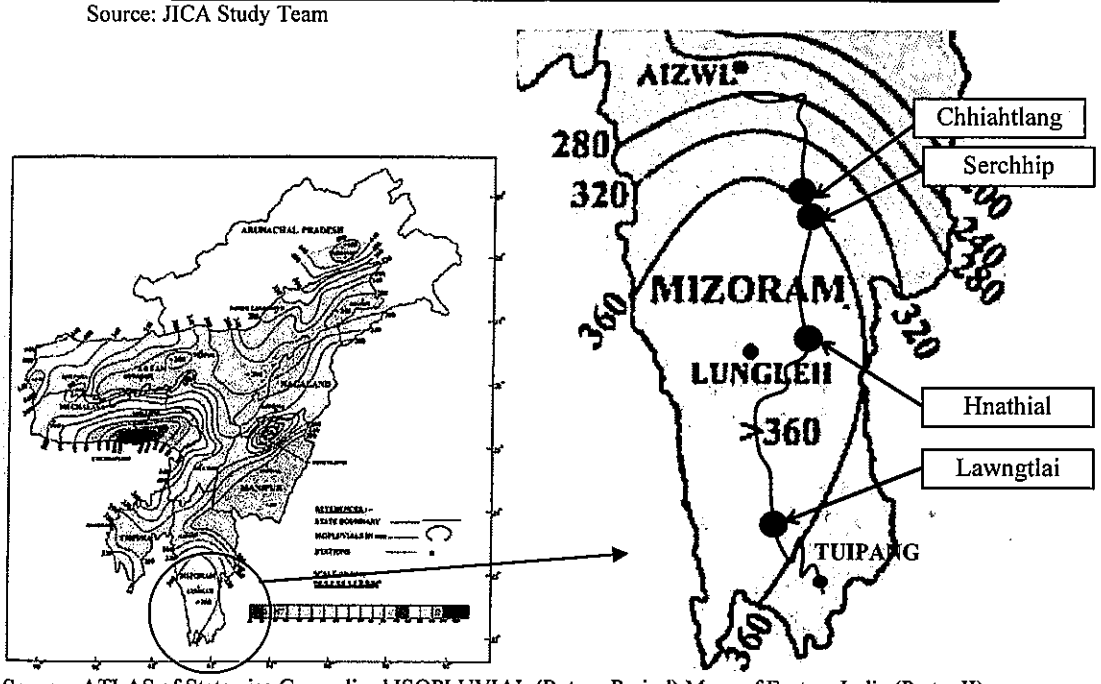
The rainfall intensity is based on the ATLAS of Statewise Generalised ISOPLUVIAL MAPs of Eastern India (Part-II), published by India Meteorological Department, Government of India. Location of NH54 and Bypass planning site is identified on the isopluvial map. The isopluvial map with the project location is shown in Figure 5.1-1. It is sectioned by range of rainfall intensity which value is read from higher edge of counter value.

Rainfall intensity for each sections in NH54 Bypass is shown in Table 5.1-1 .

Table 5.1-1 Rainfall intensity for each section in NH54 Bypass

Bypass No.	City	50Years- 24hours Rainfall intensity
Bypass No.1	Chhiahtlang	360mm/hr
Bypass No.2	Serchhip	360mm/hr
Bypass No.3	Hnathial	400mm/hr
Bypass No.4	Lawngtlai	400mm/hr

Source: JICA Study Team



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

Figure 5.1-1 Isopluvial map with project location for NH54 Bypass (For 50years)

d) Runoff coefficient

The guidance of runoff-coefficient is described on IRC:SP:13.

The topographical condition at project area on NH54 Bypass is wholly 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 is obtained by computation with satellite data and GIS software.

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

An example of catchment area map obtained by computation for NH54 bypass is shown in Figure 5.1-2.

Source: JICA Study Team

Figure 5.1-2 An example of catchment area map obtained by computation for NH54 bypass

(5) Discharge result

By hydrological study, discharge results for water crossing point with catchment area are obtained. The discharge summary for large discharge (Q>4m3/s) is summarized in Table 5.1-2 .

For all discharge result including small catchment area is shown in "cross-drainage list" prepared in Appendix.
It is noted that cross-drainage is planned not only for the location where crossing water is appeared on the hydrological computation but also the locations for satisfy the capacity of side ditches which drain out waters fallen down onto road surface and its surroundings. It is explained in chapter of Drainage Design.

Table 5.1-2 Discharge summary for large discharge (NH54 bypass)

Bypass	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	Discharge Q50 (m3/s)
Bypass1	1+280	41,975	312	88	4.71
Bypass2	4+580	384,785	1,165	175	29.19
	4+800	75,937	619	132	7.20
	5+340	40,228	314	103	4.57
	5+860	114,968	531	166	10.37
	6+380	168,303	629	190	14.44
	6+440	42,277	454	198	4.71
	7+040	405,915	1,314	221	30.53
	8+370	124,273	552	230	11.15
	8+475	40,113	323	171	4.58
	8+600	45,154	274	100	4.99
	9+410	326,132	1,014	278	25.88
	9+940	47,062	365	143	5.11
	11+490	35,862	331	164	4.24
Bypass3	0+420	45,242	341	127	5.38
	1+020	56,129	349	98	6.32
	1+830	42,631	292	115	5.16
	2+340	44,292	358	112	5.27
	2+740	75,719	353	158	8.10
	3+125	49,988	417	178	5.78
	3+540	35,038	393	179	4.46
	3+640	75,906	415	171	8.07
	3+820	58,008	428	198	6.49
	4+490	93,072	448	217	9.59
	4+905	42,283	336	156	5.13
	5+180	147,775	680	259	14.14
	5+220	118,156	572	222	11.67
	6+160	153,784	777	253	14.51
	6+220	69,882	480	262	7.54
	6+330	104,991	535	278	10.60
	6+350	33,941	357	124	4.36
Bypass4	0+170	31,591	224	125	4.02
	0+480	47,121	397	172	5.53
	0+850	36,572	224	125	4.65

Source: JICA Study Team

5.1.2 Topographic Survey

As discussed in Section 4.5.1, in the alternative route study, wide area satellite images were used to produce digital terrain model with detailed contour lines by photogrammetry along all four bypass routes. All the data were created in the same coordinate system of WGS-84 (World Geodetic System) with UTM (Universal Transverse Mercator) Zone of 46N (93 degree E).

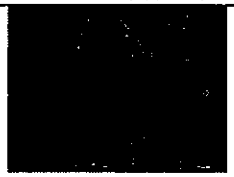
After the alternative analysis, detailed topographic survey was conducted for optimum routes of all four bypasses. The topographic survey plan is given in Table 5.1-3.

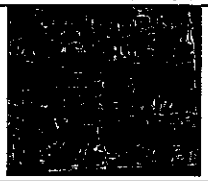
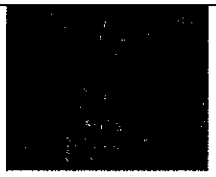
Table 5.1-3 Topographic Survey Plan

No.	Name	Length	GPS Control Survey	3D point Survey
1	Chhiahtlang Bypass	Approx. 3km	2 pairs	• Bypass length x 90m corridor
2	Serchhip Bypass	Approx.12.4km	3 pairs	
3	Hnathial Bypass	Approx.6.8km	3 pairs	
4	Lawngtlai Bypass	Approx.2.0km	2 pairs	

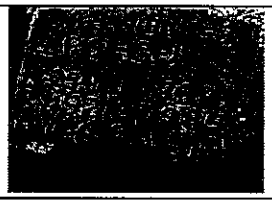
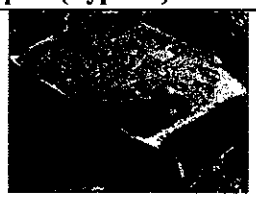
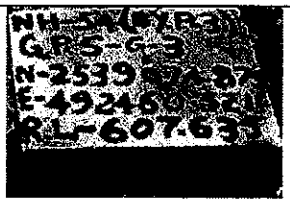
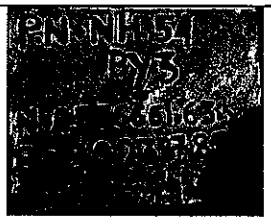
Source: JICA Study Team

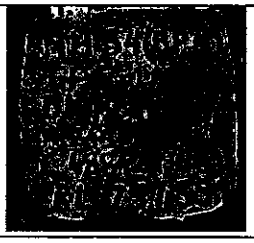
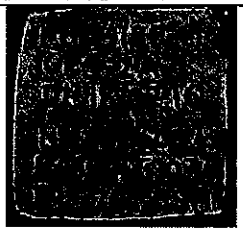
The GPS pillar for each bypass is given below;

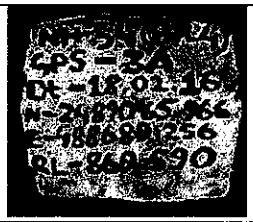
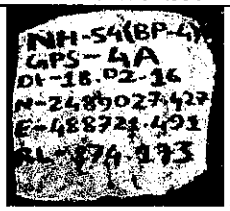
GPS Pillar for Chhiahtlang Bypass (Bypass1)	
	
UTM North-Zone_46 : 90E Northing : 2586780.297 Easting:484282.645 Elevation:901.238	UTM North-Zone_46 : 90E Northing : 2586781.389 Easting:484265.06 Elevation:903.143
	
UTM North-Zone_46 : 90E Northing : 2585897.915 Easting:484021.147 Elevation:928.596	UTM North-Zone_46 : 90E Northing : 2585874.484 Easting:484025.989 Elevation:919.587

GPS Pillar for Serchhip Bypass (Bypass2)	
	
UTM North-Zone_46 : 90E Northing : 2582007.356 Easting:484686.211 Elevation:876.290	UTM North-Zone_46 : 90E Northing : 2582000.032 Easting:484646.616 Elevation:869.256
	
UTM North-Zone_46 : 90E Northing : 2579354.177 Easting:486167.852 Elevation:869.263	UTM North-Zone_46 : 90E Northing : 2579322.216 Easting:486130.370 Elevation:876.226

GPS Pillar for Serchhip Bypass (Bypass2)	
	
UTM North-Zone_46 : 90E Northing : 2575742.556 Easting:485828.055 Elevation:861.718	UTM North-Zone_46 : 90E Northing : 2575677.915 Easting:485827.262 Elevation:865.605

GPS Pillar for Hnathial Bypass (Bypass3)	
	
UTM North-Zone_46 : 90E Northing : 2541613.323 Easting:492107.985 Elevation:660.514	UTM North-Zone_46 : 90E Northing : 2541575.894 Easting:492102.769 Elevation:661.444
	
UTM North-Zone_46 : 90E Northing : 2539074.875 Easting:492460.521 Elevation:607.635	UTM North-Zone_46 : 90E Northing : 2539039.231 Easting:492483.807 Elevation:608.153
	
PILL=G5 UTM North-Zone_46 : 90E Northing:2536661.635 Easting :492387.822 Elevation: 544.457	PILL=G6 UTM North-Zone_46 : 90E Northing :2536638.741 Easting: 492386.391 Elevation: 543.530

GPS Pillar for Lawngtlai Bypass (Bypass4)	
	
UTM North-Zone_46 : 90E	UTM North-Zone_46 : 90E

GPS Pillar for Lawngtlai Bypass (Bypass4)	
Northing : 2490510.310 Easting:488427.631 Elevation:757.394	Northing : 2490600.458 Easting:488465.034 Elevation:761.599
	
UTM North-Zone_46 : 90E Northing : 2489065.966 Easting:488689.256 Elevation:869.590	UTM North-Zone_46 : 90E Northing : 2489027.427 Easting:488721.491 Elevation:874.173

5.1.3 Geological Survey

(1) General

In order to clarify the geology and geological condition of NH54 Bypasses 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.

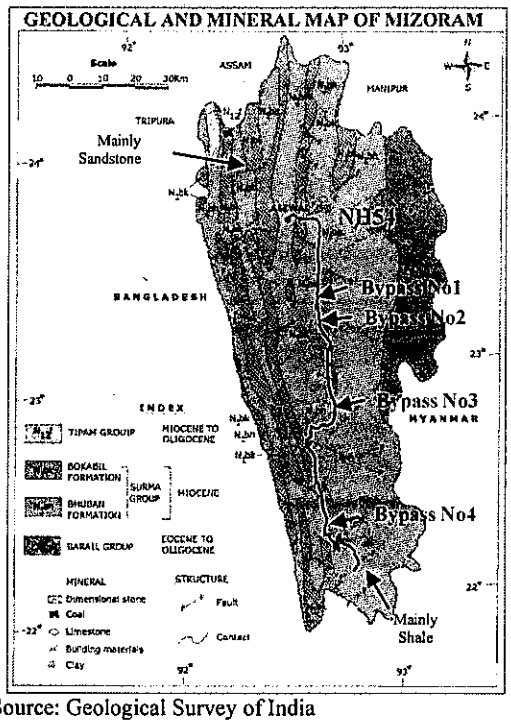
Before starting the site survey, JICA study team collected existing data and information on geological and topographical setting, earthquake occurrence, and landslide disaster in the study area. Although several organizations such as Mizoram Remote Sensing Application Centre and Geological Survey of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

(i) Geological and Topographical Setting

The North-East India is located on the north-east edge of the Himalayan orogenic belt resulted from Indo-Eurasian continental plate collision that took place during Cenozoic era, 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 predominately 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 meters to 2,157 meters, the highest point at Phawngpui. There are only a few and small patches of flat lands, which are mostly intermontane basins.

Figure 5.1-3 shows the geological map of the Mizoram state. According to this map, the geology along the national highway 54 consists of Bokabil formation and Bhuban formation of Surma groups. This lithology is as shown in Table 5.1-4.



Source: Geological Survey of India

Figure 5.1-3 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 Indian plate has been subducting below the Burmese plate. The sedimentary rocks such as shale distributing in the Mizoram state are very vulnerable to weathering, which is often causes collapsing and sliding along the bedding plane.

The topographical property of the state is characterized by approximately N-S trending steep, mostly anticlinal, parallel to sub-parallel hill ranges and narrow adjoining synclinal valleys with series of parallel hummocks or topographic highs.

Table 5.1-4 Lithology of Bokabil and Bhuban Formation

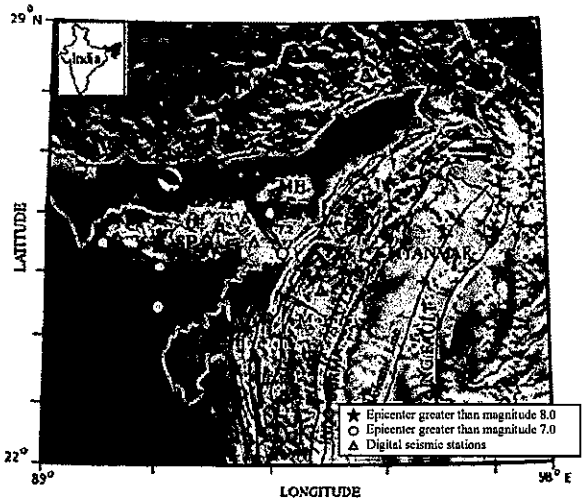
Formation	Lithology
Bokabil	Mainly argillaceous rocks represented by shale/siltstone and thinly bedded sandstone alternations with subordinate buff colored, fine to medium grained soft, friable sandstone
Upper Bhuban	Mainly arenaceous rocks which includes mainly thickly bedded, grey, khaki, buff colored fine to medium grained, at places friable, kaolinised sandstone with very fine grained sandstone, siltstone, shale (grey, olive green) interbands, with shell limestone as lensoidal bodies, conglomeratic at places, grey, very fine grained to fine grained, hard compact, calcareous sandstones
Middle Bhuban	Mainly argillaceous rocks which include grey, khaki shale, silty shale and siltstone/ shale interlaminations with grey, buff colored hard, compact, micaceous, fine to medium grained, thinly to moderately bedded sandstone with a few thick, grey, hard, very fine grained, micaceous sandstone bands
Lower Bhuban	Mainly arenaceous rocks which includes fine to very fine grained, compact, blue, ash, green colored, massive to well bedded sandstone exhibiting turbidite features and well laminated siltstone, olive green silty shale/shale interlaminations

Source: Geological Survey of India, Miscelleaneous Publication No. 30 Part IV, Vol 1(Part-2)

(ii) Seismologic Situation

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 north of Meghalaya and north-east of Arunachal Pradesh in 1897 and 1950 respectively as shown in Figure 5.1-4. And also earthquake with a magnitude of more than 7.0 on the Richter scale has occurred in and around the Meghalaya state along main tectonic faults.

On the other hand, earthquake is not frequent in the Mizoram states (Table 5.1-5). In the past, the biggest historic earthquake was magnitude 6.1 which occurred in Chittagong near the border with Bangladesh, and other earthquakes are a low magnitude from 4.0 to 5.7 on the Richter scale and comparatively low intensities from IV (Light) to VI (Strong) out of 12 levels in Indian earthquake intensity scales.



Source: Geological Survey of India

Figure 5.1-4 Epicenter Distribution Map

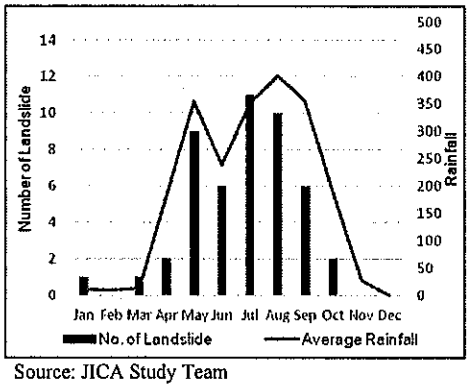
Table 5.1-5 Historical Earthquake in Mizoram

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

(iii) Past Landslide Disaster

JICA study team collected information on past landslide disaster in and around Mizoram states because the area is extremely high rainfall region and mountainous area. Figure 5.1-5 shows the number of landslide reported in newspapers and academic paper from 1992 to 2015 and plotted by month. In September 2014, a large landslide occurred near PWD office at Laipuitang in 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 in monsoon season from May to September.



Source: JICA Study Team

Figure 5.1-5 Landslide Frequency Distribution by Month

(2) Geological Investigation for Bridge Planning

Geological investigation for bridge planning was conducted for four locations which include candidate location during the bypass route comparison stage. Survey quantity for each location is summarized as shown in Table 5.1-6.

Table 5.1-6 Survey Quantity for Each Location

Location	Boring No.	Drilling length	SPT	Remarks
Bypass1	BV-01, BV-02	20m each	Conducted	
Bypass2(A)	BV-01, BV-02	20m each	Conducted	Bridge planned location
Bypass2(B)	BV-03, BV-04, BV-05	20m each	Conducted	Bridge planned location
Bypass3	BV-01, BV-02	20m each	Conducted	

Source: JICA Study Team

SPT result for two locations which is finally taken as bridge planned location is summarized as in Table 5.1-7.

Table 5.1-7 SPT Result for Bridge Planned Location

Location	Boring No.	Depth (m)	N-value
Bypass2(A)	BV-01	0.0 -	Not penetrated
	BV-02	0.0 -	Not penetrated
Bypass2(B)	BV-03	0.0 -	Not penetrated
	BV-04	0.0 - 0.5	44
		0.5 - 1.0	100
		1.0 -	Not penetrated
	BV-05	0.0 - 0.5	12
		0.5 - 1.0	45
		1.0 -	Not penetrated

Source: JICA Study Team

The bearing layer for bridge foundation of two locations is estimated as follows;

i) Bypass2 (A)

Surface soil is accumulated in 1.5m thickness below the ground surface. Under the depth, weakly weathered- rock is composed in 7-8m thickness. Because the layer cannot be penetrated by SPT, it is assumed as hard enough for bearing layer. Therefore, bearing layer for the foundation is estimated depth 1.5m below the ground surface.

ii) Bypass2 (B)

Surface soil is accumulated in 2m thickness below the ground surface. Under the depth, weakly weathered- rock is composed in 5-6m thickness for BV-03, and in 10-12m thickness for BV-04 and BV-05. Because the layer cannot be penetrated by SPT, it is assumed as hard enough for bearing layer. Therefore, bearing layer for the foundation is estimated depth 2m below the ground surface.

(3) Geological Survey for Landslide on No.4 Lawngtlai Bypass

The location and quantities of boring survey are shown in Figure 5.1-6 and Table 5.1-8 respectively. And photos of each drilling core are as shown in Figure 5.1-7

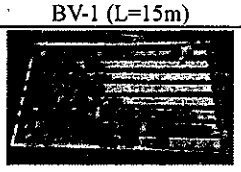
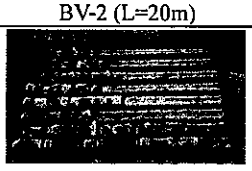
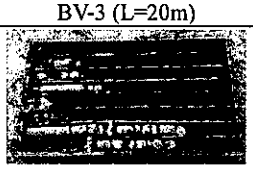
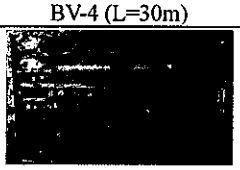
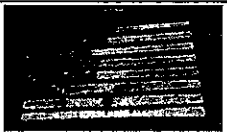
Source: JICA Study Team

Figure 5.1-6 Location of Boring Survey

Table 5.1-8 Quantity of Boring Survey

Boring No	Unit	Quantity	Note
BV-1	m	15	
BV-2	m	20	Water level observation (BV-2S:20m)
BV-3	m	20	
BV-4	m	30	

Source: JICA Study Team

BV-1 (L=15m)	BV-2 (L=20m)	BV-3 (L=20m)	BV-4 (L=30m)
 0-10m	 0-10m	 0-10m	 0-10m
 10-15m	 10-20m	 10-20m	 10-20m
			 10-20m

Source: JICA Study Team

Figure 5.1-7 Drilling Core

Location of the head and the lower end of landslide is judged as follows.

i) Location of the Head of Landslide

Obvious sliding cliff is observed. So, the location of the head of landslide is judged to be located at the

lower end of the sliding cliff.

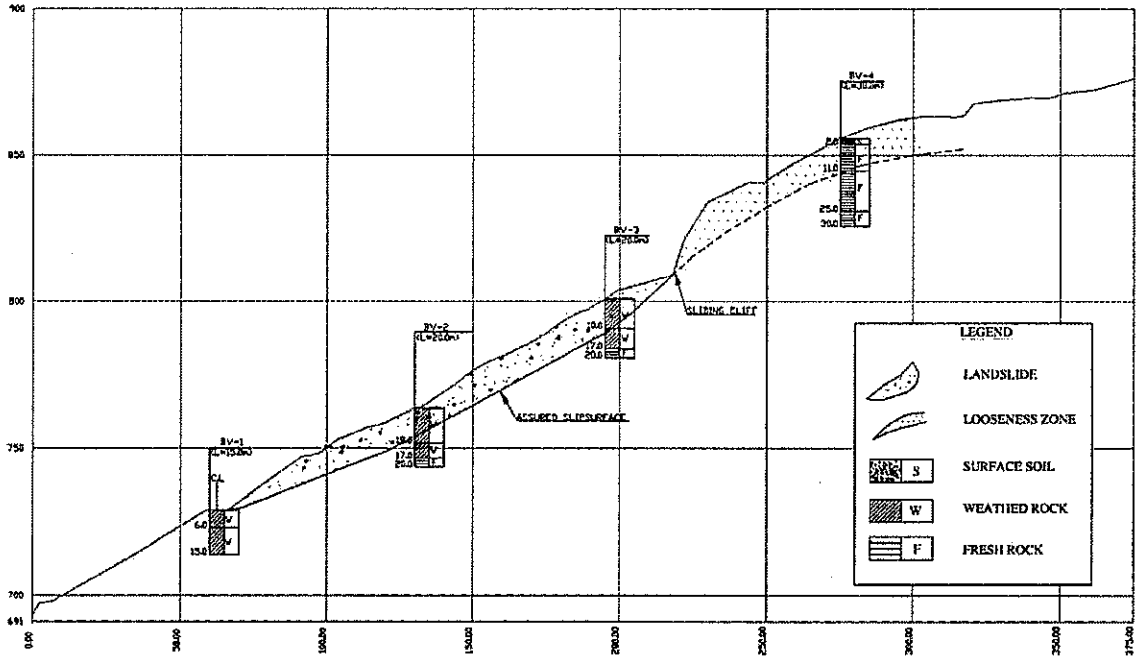
ii) Location of the Lower End of Landslide

Width of landslide is about 80 meters, so thickness of landslide is presumed to be empirically about 10 meters. There is no deformation on the road. Therefore, the location of the lower end of landslide is judged to be located at the lower end of the cutting slope of road. Figure 5.1-9 shows assumed landslide profile studied based on the survey result above.

Sliding Cliff | No Deformation on the road

Source: JICA Study Team

Figure 5.1-8 Head and Lower End of Landslide



Source: JICA Study Team

Figure 5.1-9 Assumed landslide Profile

5.1.4 Road Inventory Survey

(1) Outline of Road Inventory Survey

JICA Study Team conducted a road inventory survey along NH54 Bypasses in Mizoram 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

a) Target Road

JST conducted the road inventory survey along to the following national highway in Mizoram state.

- NH-54 Bypasses : 24.2 km (Mizoram State)

b) Measurement Items

1) Road Cross Section Element

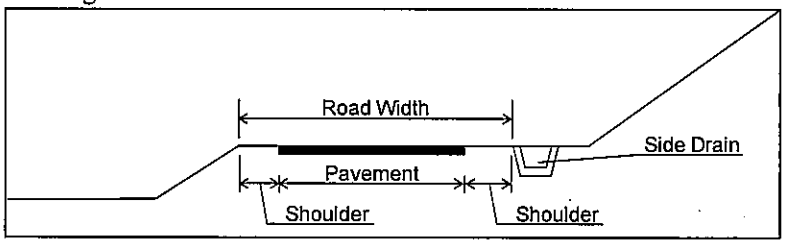
The following items were measured by measuring tape and visual observation at every 100 m sections or any locations where the target objects were found out.

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

The item of pavement condition is consisting of four categories, "Good", "Fair", "Poor" and "Bad". Each category was judged in the basis of following criteria

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

The road width was obtained at each 100m interval along target roads and the definition of road width is shown in Figure 5.1-10.



Source: JICA Study Team

Figure 5.1-10 Definition of Road Width

2) 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 out.

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

3) 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 out.

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

4) Social Infrastructure and Religious Object

The following items were recorded based on existing local information collected in advance and visual observation at any locations where the target objects of social infrastructure and religious object were found out. The distance from 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)

5) 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 objects of overhead utility line were found out. The distance from pavement edge to the objects was measured by measuring tape at each location.

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

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

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

- Water Supply Line
- Optical Fiber Cable Line

7) Bridge (Width, Length)

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

(3) Summary of Results

a) Road Cross Section Element

1) Road Width (Pavement & Shoulder)

Figure 5.1-11 shows the result of road width inventory data.

- No.1 Chhiahtlang Bypass

  Existing road sections given around 4m to 5.5m width with pavement which is mostly poor condition exist beginning and ending short sections of the bypass. Shoulder of 2m in total is given only beginning side of the bypass.

- No.2 Serchhip Bypass

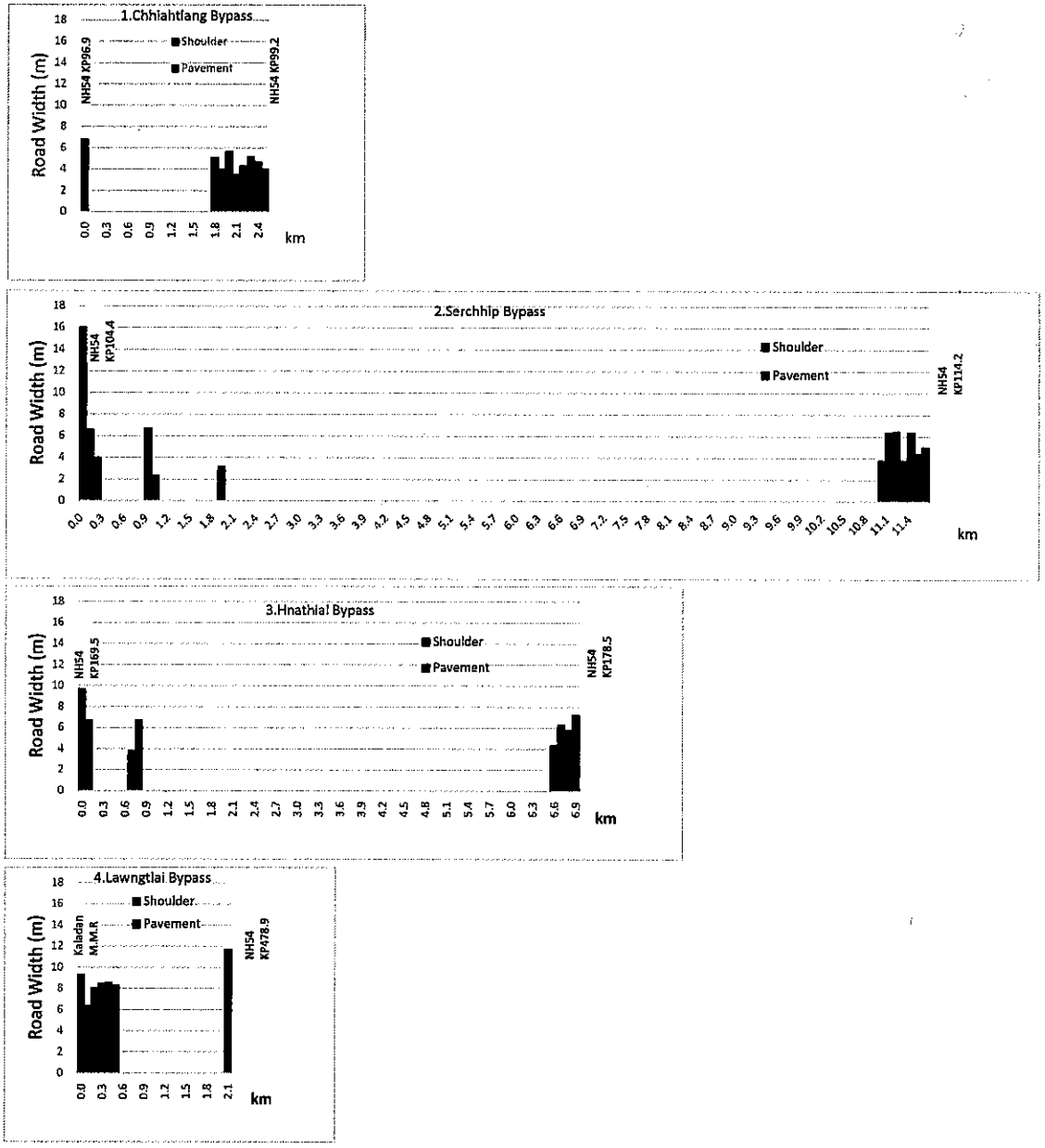
  Existing road sections given around 4m to 6m width with pavement which is poor condition exist beginning and ending short sections of the bypass. Shoulder of 2.5m in total is partially given ending side of the bypass. Section about 16m width in total is observed at beginning side of the bypass and this is wide intersecting point with NH 54 mainline.

- No.3 Hnathial Bypass

  Existing road sections given around 4m to 5m width with pavement which is mostly poor condition exist beginning and ending short sections of the bypass. Around 1.0m to 2.5m shoulder in total are partially given.

- No.4 Lawngtlai Bypass

  Existing road sections given around 4m width with pavement which is poor condition exist beginning short section of the bypass. Shoulder of 4m in total is given. Section about 12m width in total is observed at ending side of the bypass and this is wide intersecting point with NH 54 mainline.



Source: JICA Study Team

Figure 5.1-11 Road Width (Pavement & Shoulder)

2) Others

Figure 5.1-12 shows the result of other inventory survey items in road cross section elements.

- Topography

  The sections where one side is hill and the other side is valley occupied in almost whole sections of exixting road sections in four bypasses.

- Land Use

  Rural landuse is dominant in almost all sections. However, there are built-up area near beginning and ending short sections which is near to NH54 mainline.

- Pavement Condition

  Bad condition is mostly observed in bypass No. 1, 2, and 4. However, pavement

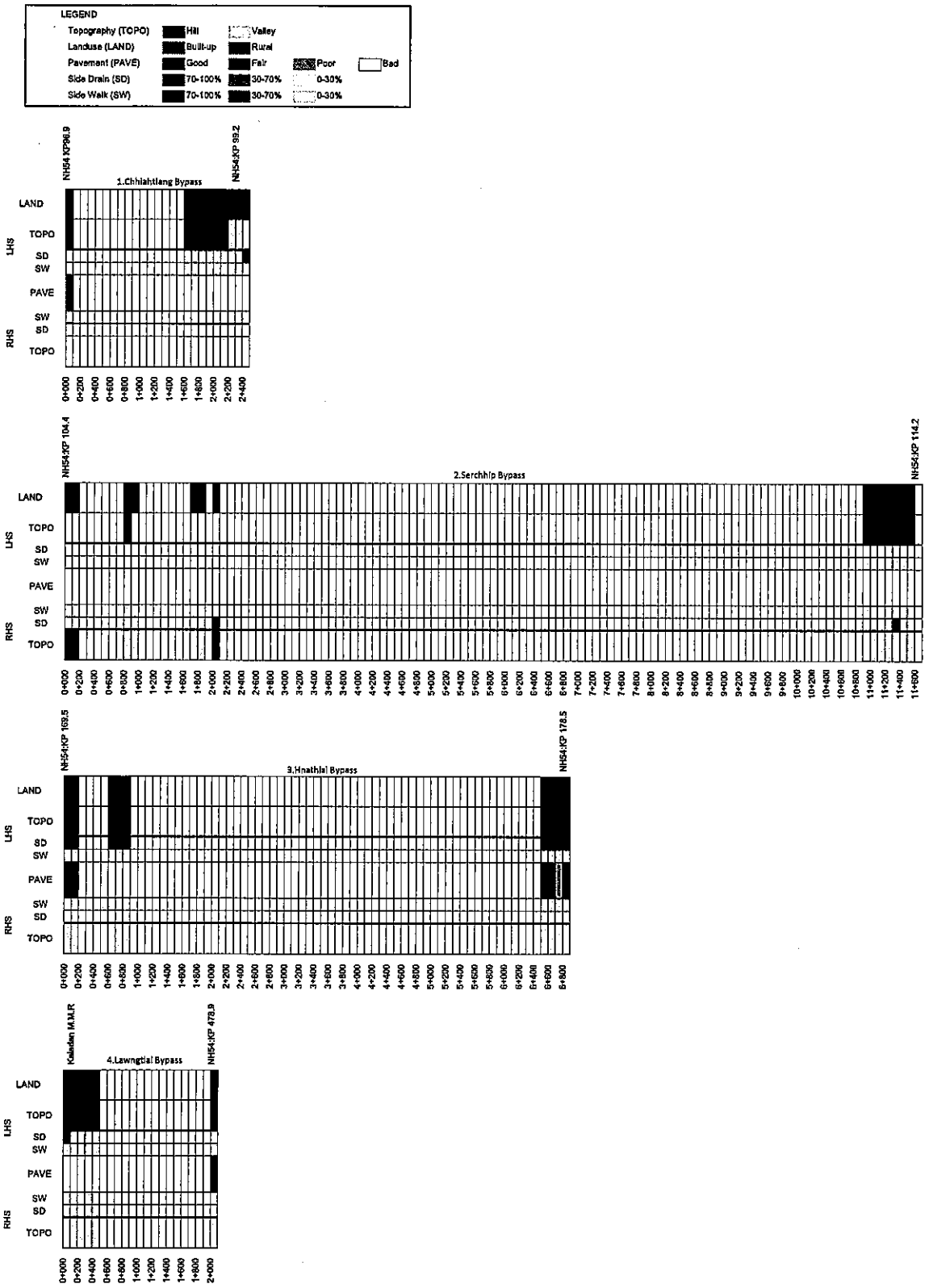
condition near intersection with NH54 in bypass No. 3 is mostly fair.

- Side Drain

  Installation of side drain on hill side of bypass No. 3 existing road section is more than 70%. On the other hand, only 0% to 30% side drain installation is observed on other existing road sections.

- Side Walk

  Side walk is not observed on existing road sections of all bypasses.



Source: JICA Study Team

Figure 5.1-12 Cross Sectional Elements and Pavement Condition of NH54

b) Cross Drain

Following table shows the result of cross drain inventory data. The average No. of cross drain was 0.5 No. per km due to short section length of existing road for all bypass length.

Table 5.1-9 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	1.Chhiahtlang Bypass	2.6	0	2	1	0	3	1.2
	2.Serchhip Bypass	11.8	0	2	0	0	2	0.2
	3.Hnathial Bypass	7.0	2	1	0	0	3	0.4
	4.Lawngtlai Bypass	2.6	3	0	1	0	4	1.5
	TOTAL	24.0	5	5	2	0	12	0.5

Source: JICA Study Team

c) Retaining Wall

In whole section along existing road on NH54 bypass, Masonry type was used.

Table 5.1-10 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	1.Chhiahtlang Bypass	2.6	48.3	0.0	48.3	0.0	0.0	0.0	48.3	0.0	48.3
	2.Serchhip Bypass	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.Hnathial Bypass	7.0	0.0	0.0	0.0	52.5	0.0	52.5	52.5	0.0	52.5
	4.Lawngtlai Bypass	2.6	0.0	0.0	0.0	229.9	0.0	229.9	229.9	0.0	229.9
	TOTAL	24.0	48.3	0.0	48.3	282.4	0.0	282.4	330.7	0.0	330.7

Source: JICA Study Team

d) Guardrail

Only bypass No.3 existing road is installed small length of the guardrail.

Table 5.1-11 Result of Guardrail

Route	Section	Section Length (km)	Length of Guardrail (m)			
			Masonry	Parapet	Steel	TOTAL
NH54	1.Chhiahtlang Bypass	2.6	0.0	0.0	0.0	0.0
	2.Serchhip Bypass	11.8	0.0	0.0	0.0	0.0
	3.Hnathial Bypass	7.0	0.3	21.0	0.0	21.3
	4.Lawngtlai Bypass	2.6	0.0	0.0	0.0	0.0
	TOTAL	24.0	0.3	21.0	0.0	21.3

Source: JICA Study Team

e) Social Infrastructure

Installation of Urinal / Toilet is observed in bypass No. 1, 2, and 4.

Table 5.1-12 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	1.Chhiahtlang Bypass	2.6	0	0	5	0	1	1
	2.Serchhip Bypass	11.8	0	1	1	0	0	0
	3.Hnathial Bypass	7.0	0	0	0	0	0	0
	4.Lawngtlai Bypass	2.6	0	0	4	0	0	0
	TOTAL	24.0	0	1	10	0	1	1

Source: JICA Study Team

f) Religious Object

A church is observed on bypass No. 2.

Table 5.1-13 Result of Religious Object

Route	Section	Section Length (km)	No. of Religious Object					
			Church	Mosque	Mandir	Memorial Stone	Grave	Monument/Statue
NH54	1.Chhiahtlang Bypass	2.6	0	0	0	0	1	0
	2.Serchhip Bypass	11.8	1	0	0	1	0	0
	3.Hnathial Bypass	7.0	0	0	0	0	0	0
	4.Lawngtlai Bypass	2.6	0	0	0	0	0	0
	TOTAL	24.0	1	0	0	1	1	0

Source: JICA Study Team

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

The No. of crossing or close passing utilities' line was counted as shown the table below.
Electric distribution line is mostly found in three bypasses.
Telecommunication line is found in bypass No. 1 and 2.
Water supply line is found in bypass No. 1 and 3.
OFC line is not observed.

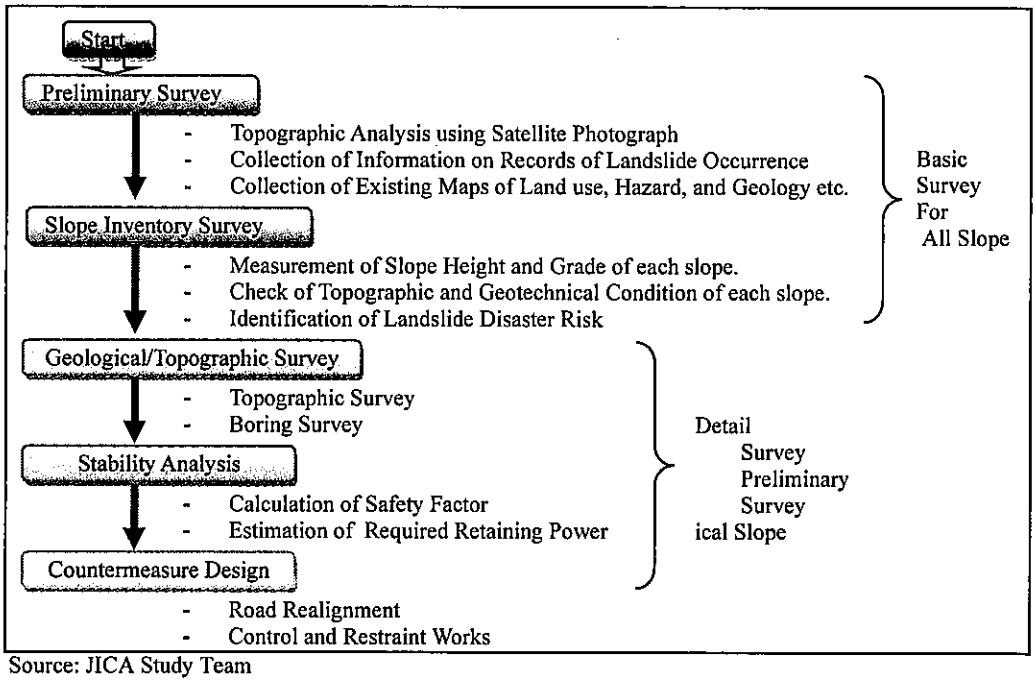
Table 5.1-14 Result of Public Utilities

Route	Section	Section Length (km)	No. of Neighboring Public Utilities (Location of Crossing / Close Passage)				
			Electric Line		Telecommunication Line	Water Supply	OFC
			Distribution	Transmission			
NH54	1.Chhiahtlang Bypass	2.6	7	0	1	1	0
	2.Serchhip Bypass	11.8	4	0	1	0	0
	3.Hnathial Bypass	7.0	1	0	0	3	0
	4.Lawngtlai Bypass	2.6	0	0	0	0	0
	TOTAL	24.0	12	0	2	4	0

Source: JICA Study Team

5.1.5 Slope Inventory Survey

The slope inventory survey was conducted for the purpose of slope disaster prevention against the planned Bypass. Observation of outcrops is very important for the evaluation of slope cutting. Therefore, the survey was done using the outcrops along the current road near the planned Bypass route. Because the slope along the planned route is covered by the vegetation, so no outcrop can be found. Figure 5.1-13 shows the flowchart of slope study.



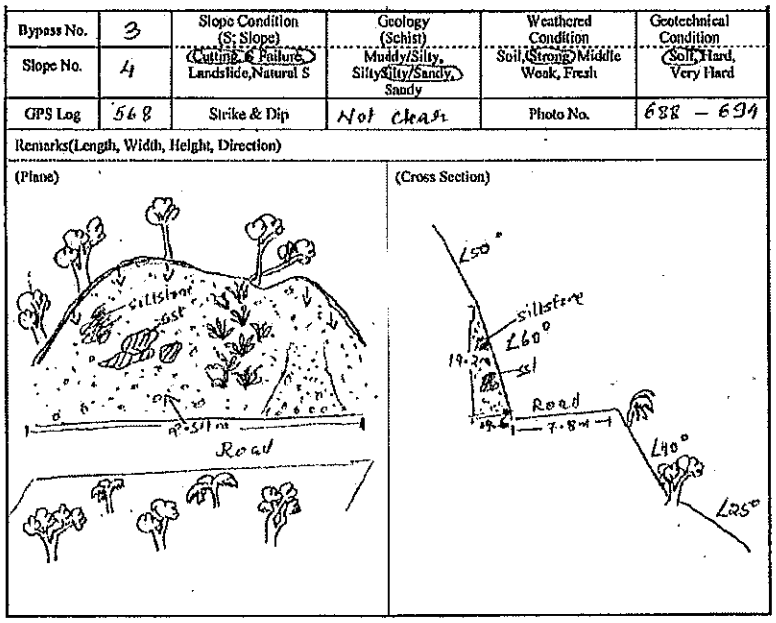
Source: JICA Study Team

Figure 5.1-13 Flowchart of Slope Prevention Study

(1) Survey Method and Site Location

(i) Survey Method

Inventory survey was conducted using the inventory sheet as shown in Figure 5.1-14. And the results were made up in the list. The details of the results are attached in Appendix.



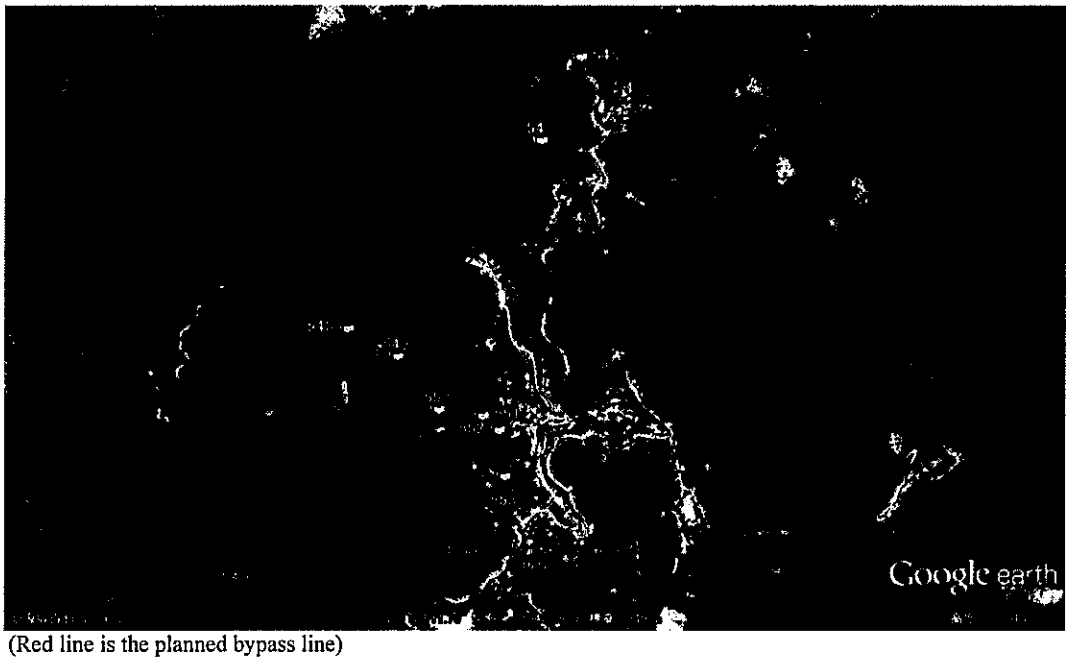
Source: JICA Study Team

Figure 5.1-14 Example of Inventory Sheet

(ii) Bypass No1

Figure 5.1-15 shows planned Bypass route and inventory survey sites. Table 5.1-15 shows the survey result list.

Siltstone and sandstone are mainly distributed as bedrock in this area. Weathered condition of bedrock is strong to middle, so cracked rocks are observed along the cutting slope. Color of the rock is brownish color by weathering. As a whole, self-standing of the cutting slope is good. Therefore the slope failure is hardly seen along the road. But if the height of cutting is high, there is a possibility of slope failure. On the other hand, a hard rock of sandstone was observed characteristically at the No8 site.



(Red line is the planned bypass line)
Source: JICA Study Team

Figure 5.1-15 Location of survey sites

Table 5.1-15 Slope inventory list (Bypass No1)

Slope No.	Location GPS Log	Geology	Weathered Condition	Geotechnical Condition	Strike			Dip		Disaster Risk (due to slope cutting)
1	545	Muddy/Silty	Middle(Cracky)	Soft	N	75°	W	20°	N	Slope Failure
2	547	Muddy/Silty	Soil/Strong	Soft	—		—			Slope Failure
3	548	Silty Sand	Strong(cracky)	Soft	—		—			Slope Failure
4	549	Silty Sand	Middle(Cracky)	Soft	N	60°	E	50°	S	Slope Failure
5	550	Silty Sand	Middle(Cracky)	Soft	N	50°	W	55°	S	Slope Failure
6	551	Silty Sand	Middle(Cracky)	Hard	—		—			Slope Failure
7	552	Silty Sand	Fresh	Hard	N	15°	W	65°	S	Slope Failure
8	553	Siltstone/Sandstone	Strong and Weak	V. Hard and Soft	N	30°	E	42°	S	Slope Failure

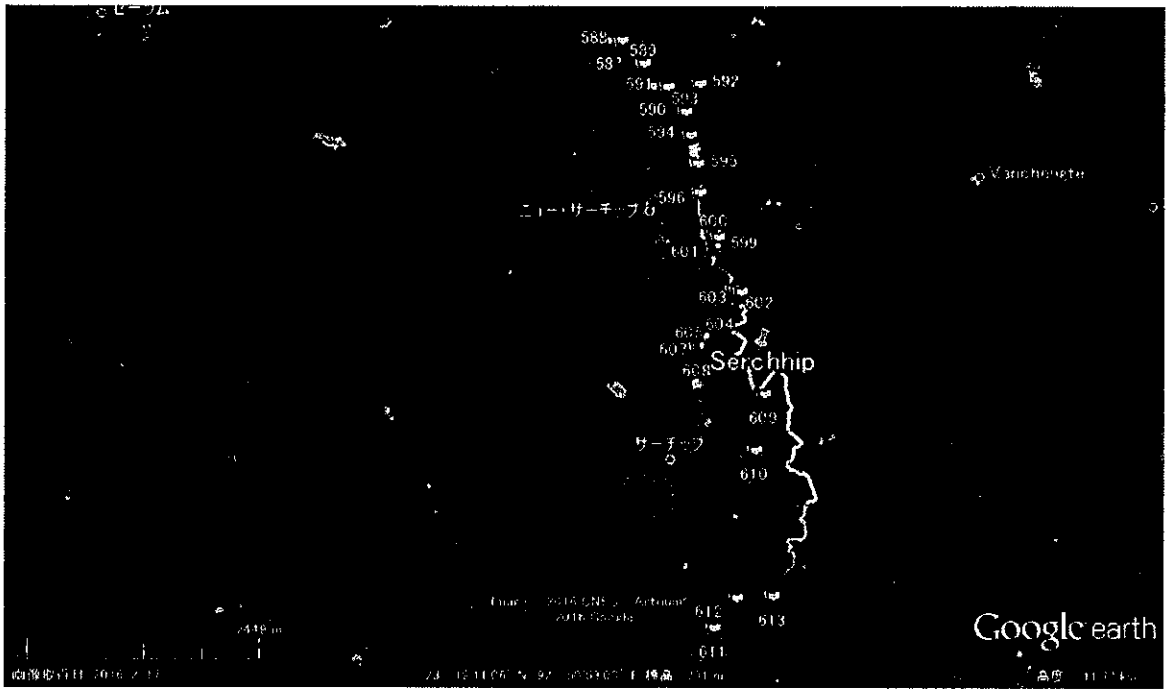
Source: JICA Study Team

(iii) Bypass No2

Figure 5.1-16 shows planned Bypass route and inventory survey sites. Table 5.1-16 shows the survey result list.

Siltstone and sandstone are mainly distributed as bedrock in this area. Weathered condition of bedrock is mainly strong to middle, so cracked rocks are observed along the cutting slope. Also the sediment with rock is observed in places. This sediment is thought to be a strong weathered rock which has been weathered at the present location as mentioned in the following section. Color of the rock is brownish color by weathering.

As a whole, self-standing of the cutting slope is good. But small slope failures are observed locally. On the other hand, the middle weathered rocks are observed around the ridge as shown in No6 to No10. Probably, the strong weathered rocks on the middle weathered rocks, which look like the sediment, are thought to have almost flowed out in the past. A part of the strong weathered rocks can be seen on the middle weathered rocks in No7 site. If the height of cutting is high, the weathered rocks have a possibility of slope failure.



(Red, yellow and green lines are the planned bypass lines)
Source: JICA Study Team

Figure 5.1-16 Location of survey sites

Table 5.1-16 Slope inventory list (Bypass No2)

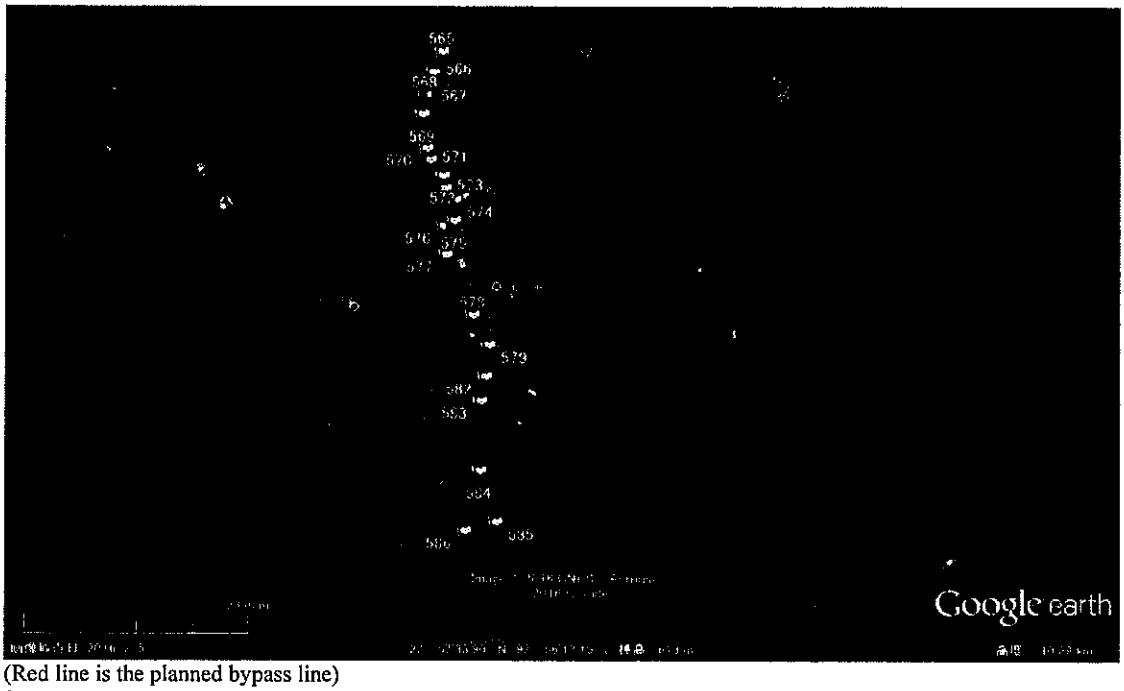
Slope No.	Location GPS Log	Geology	Weathered Condition	Geotechnical Condition	Strike			Dip		Disaster Risk (due to slope cutting)
1	587	Muddy/Silty	Middle(Cracky)	Soft	N	50°	E	10°	S	Slope Failure
2	588	Muddy/Silty	Middle	Soft	N	30°	W	60°	S	Slope Failure
3	589	Silty/Sandy	Middle	Soft	N	60°	E	45°	N	Slope Failure
4	590	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure
5	591	Silty/Sandy	Strong	Soft	N	18°	E	18°	S	Slope Failure(Exist)
6	592	Silty/Sandy	Soil/Middle	Soft	—		—		—	Slope Failure
7	593	Silty/Sandy	Strong	Soft	N	25°	E	38°	S	Slope Failure
8	594	Silty/Sandy	Middle	Soft	N	10°	E	40°	N	Slope Failure
9	595	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure
10	596	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure(Exist)
11	599	Silty/Sandy	Strong	Hard	N	10°	E	64°	S	Slope Failure(Exist)
12	600	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure
13	601	Sandy	Weak(Little cracky)	Soft/Hard	—		—		—	—
14	602	Silty/Sandy	Strong	Soft/Hard	—		—		—	Slope Failure(Exist)
15	603	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure
16	604	Silty/Sandy	Strong	Soft/Hard	—		—		—	Slope Failure
17	605	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure
18	606	Silty/Sandy	Strong	Soft	N	15°	W	63°	N	Slope Failure
19	607	Silty/Sandy	Strong	Hard	N	32°	W	74°	N	Slope Failure(Exist)
20	608	Silty/Sandy	Strong	Soft	N	25°	W	20°	N	Slope Failure
21	609	Silty/Sandy	Weak	Soft/Hard	—		—		—	—
22	610	Silty/Sandy	Soil/Weak	Soft	—		—		—	—
23	611	Silty/Sandy	Middle	Soft	—		—		—	Slope Failure
24	612	Silty/Sandy	Soil/Middle	Soft	—		—		—	Slope Failure
25	613	Silty/Sandy	Middle	Soft/Hard	—		—		—	Slope Failure

Source: JICA Study Team

(iv) Bypass No3

Figure 5.1-17 shows planned Bypass route and inventory survey sites. Table 5.1-17 shows the survey result list.

Siltstone and sandstone are mainly distributed as bedrock in this area. Weathered condition of bedrock is strong to middle, so cracked rocks are observed along the cutting slope. Also the sediment with rock is observed in places. This sediment is thought to be a strong weathered rock which has been weathered at the present location as mentioned in the following section. Color of the rock is brownish color by weathering. As a whole, self-standing of the cutting slope is good. But as seen in No4, No5, No8, No9, No13, No16 and No20, along the road, small slope failures are observed locally. Therefore, if the height of cutting is high, these weathered rocks have a possibility of slope failure.



(Red line is the planned bypass line)
Source: JICA Study Team

Figure 5.1-17 Location of survey sites

Table 5.1-17 Slope inventory list (Bypass No3)

Slope No.	Location GPS Log	Geology	Weathered Condition	Geotechnical Condition	Strike			Dip		Disaster Risk (due to slope cutting)
1	565	Muddy/Silty	Middle	Soft	—		—		—	Slope Failure
2	566	Muddy/Silty	Middle	Soft	—		—		—	Slope Failure
3	567	Sandy	Soil/Middle	Soft	—		—		—	Slope Failure
4	568	Silty/ Sandy	Strong	Soft	—		—		—	Slope Failure
5	569	Muddy/Silty	Middle	Soft	—		—		—	Slope Failure
6	570	Muddy/Silty	Middle	Soft	—		—		—	Slope Failure
7	571	Muddy/Silty	Middle	Soft	—		—		—	Slope Failure
8	572	Muddy/Silty	Soil/Strong	Soft	—		—		—	Slope Failure
9	573	Muddy/Silty	Soil/Strong	Soft	—		—		—	Slope Failure
10	574	Silty/ Sandy	Middle	Soft	—		—		—	Slope Failure
11	575	Silty/ Sandy	Middle	Hard	N	10°	E	27°	S	Slope Failure
12	576	Silty/ Sandy	Soil/Middle	Soft	—		—		—	Slope Failure
13	577	Silty/ Sandy	Soil/Middle	Soft	—		—		—	Slope Failure(Exist)
14	578	Silty/ Sandy	Soil/Strong	Soft	N	30°	W	30°	S	Slope Failure
15	579	Silty/ Sandy	Strong	Soft	—		—		—	Slope Failure(Exist)
16	582	Silty/ Sandy	Soil/Middle	Soft	—		—		—	Slope Failure(Exist)
17	583	Silty/ Sandy	Soil/Middle	Soft/Hard	—		—		—	Slope Failure
18	584	Silty/ Sandy	Soil/Strong	Soft	—		—		—	Slope Failure
19	585	Silty/ Sandy	Strong	Soft/Hard	—		—		—	Slope Failure
20	586	Muddy/Silty	Strong	Soft	—		—		—	Slope Failure

Source: JICA Study Team

(v) Bypass No4

Figure 5.1-18 shows planned Bypass route and inventory survey sites. Table 5.1-18 shows the survey result list. This area has the geological characteristics which are different from those of the other three areas. The characteristics are as follows;

- Weathering condition of bedrock which had got a lot of stress is remarkable compared to the other bypass areas. Therefore this area has characteristics which the slope failure and the landslide are easy to occur.
- The active landslide which was due to cutting was observed along the road (No7). And this landslide is considerably unstable at present.
- The brownish sediment which was formed by the slope failure in the past is distributed on the slope (No10).

Actually, the sediment deposition which has a variation history is distributed on the slope along the bypass No4. This condition is obviously different from the other three areas (No1-No3).
Probably, the landslide of No7 is thought to be originally the old one, because the disturbed outcrop is observed at the sliding cliff as mentioned in the following section.

(Red line is the planned bypass line)
Source: JICA Study Team

Figure 5.1-18 Location of survey sites

Table 5.1-18 Slope inventory list (Bypass No4)

Slope No.	Location GPS Log	Geology	Weathered Condition	Geotechnical Condition	Strike			Dip		Disaster Risk (due to slope cutting)
1	554	Sandy	Strong/Fresh	Hard	N	30°	E	30°	S	Slope Failure(Exist)
2	555	Silty Sand	Strong/Fresh	Soft	—		—		—	Slope Failure(Exist)
3	556	Silty Sand	Strong/Fresh	Soft	—		—		—	Slope Failure(Exist)
4	557	Silty Sand	Strong	Soft	—		—		—	Slope Failure
5	558	Silty Sand	Strong	Soft	—		—		—	Slope Failure
6	559	Silty Sand	Strong	Soft	N	20°	W	48°	N	Slope Failure
7	563	Silty Sand	Strong	Soft	—		—		—	Landslide(Mass Movement)(Exist)
8	560	Silty Sand	Strong	Soft/Hard	N	25°	E	40°	N	Slope Failure
9	561	Silty Sand	Strong	Soft	—		—		—	Slope Failure(Exist)
10	562	Muddy/Sandy	Strong	Soft	—		—		—	Slope Failure(Exist)

Source: JICA Study Team

(2) Topographic Dissection and Weathered Condition

Mizoram area consists of the fold structure formed by the plate collision. This stress is thought to have made remarkable weathering and vulnerable geology in the Mizoram area.

The mountains which consist of vulnerable geology were eroded in the Quaternary. At the result, the present stable topography is thought to have been formed through the topographic dissection (Figure 5.1-19).

The uplift of Mizoram area is thought to be a little compared to that of Himaraya area in the northern India. That is presumed to be one of the factors that the stable topography was formed in this area.

Source: JICA Study Team

Figure 5.1-19 Stable Topographical Condition (Hnathial)

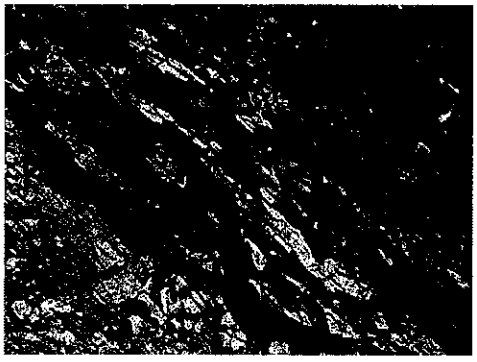
Generally, fresh rock changes to weathered rock by mechanical and chemical weathering.

Weathered rock condition can be defined here as follows;

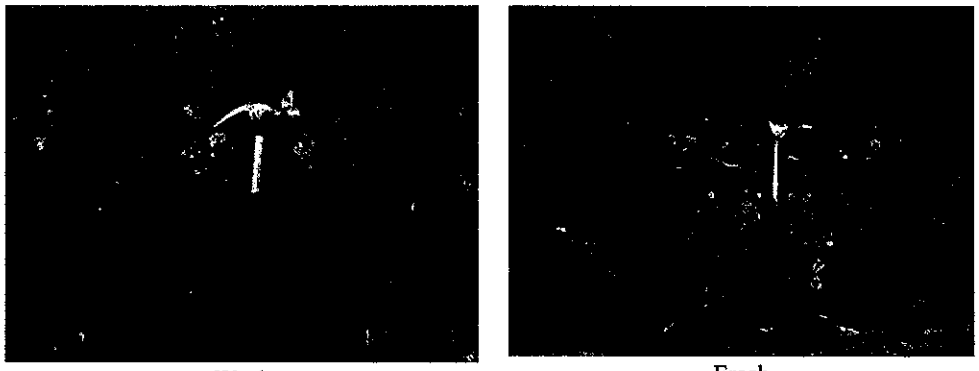
- Fresh rock : Color shows grayish color of original rock color
- Weak weathered rock : Color shows grayish color, but the surface of layers is brownish one
- Middle weathered rock : Color shows grayish - brownish color, there are a lot of joints
- Strong weathered rock : Color shows brownish color, rock condition is very soft and a part of rocks change to sediment

Figure 5.1-20 shows the example of the weathered rocks.

Strong



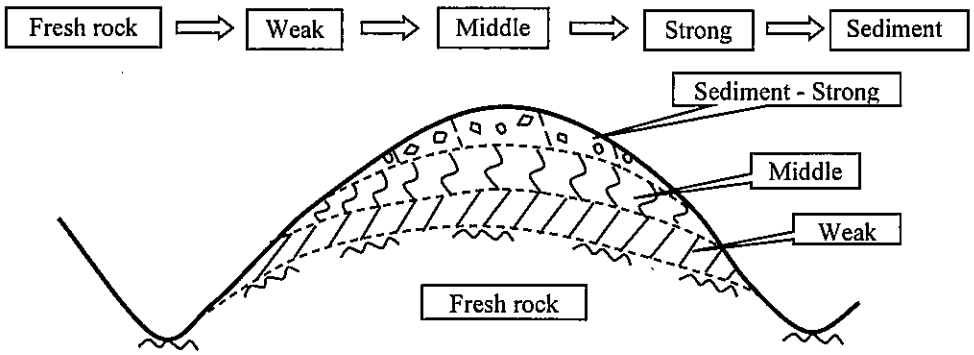
Middle



Weak　　Fresh

Figure 5.1-20 Example of Weathered Rocks

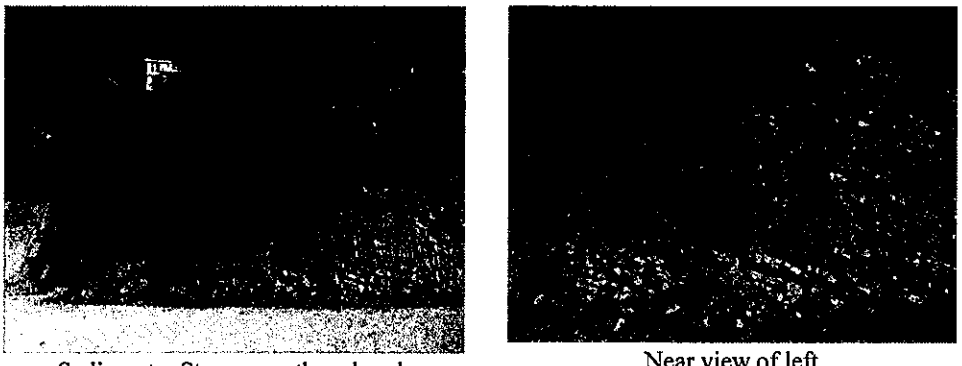
According to the inventory survey, the weathering structure of mountain is presumed to be the basic type shown in Figure 5.1-21 .



Source: JICA Study Team

Figure 5.1-21 Weathering Process and Structure of the Mountain

Figure 5.1-22 shows the examples of outcrop.



Sediment – Strong weathered rock　　Near view of left

Fresh rock in the valley

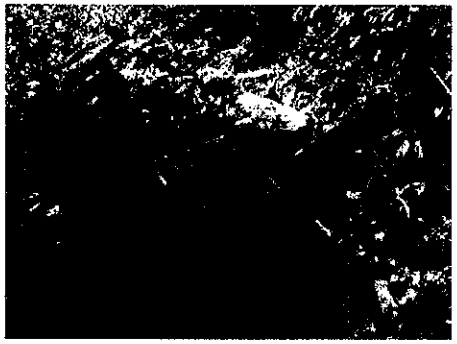
Fresh rock on the riverbed

Source: JICA Study Team

Figure 5.1-22 Example of Outcrop

But, there are cases that the hard rock like sandstone is distributed on or below the ridge as shown in Figure 5.1-23. This condition is thought to be formed by the reason that the soft rock on the hard rock was eroded for a long time as shown in Figure 5.1-24.

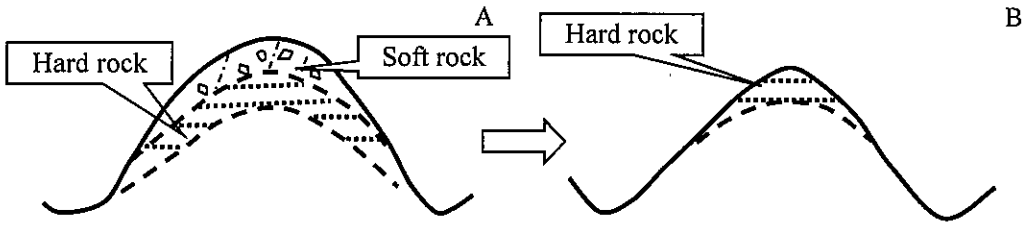
Sandstone on the ridge



Sandstone near the ridge

Source: JICA Study Team

Figure 5.1-23 Hard sandstone distributed on or blow the ridge



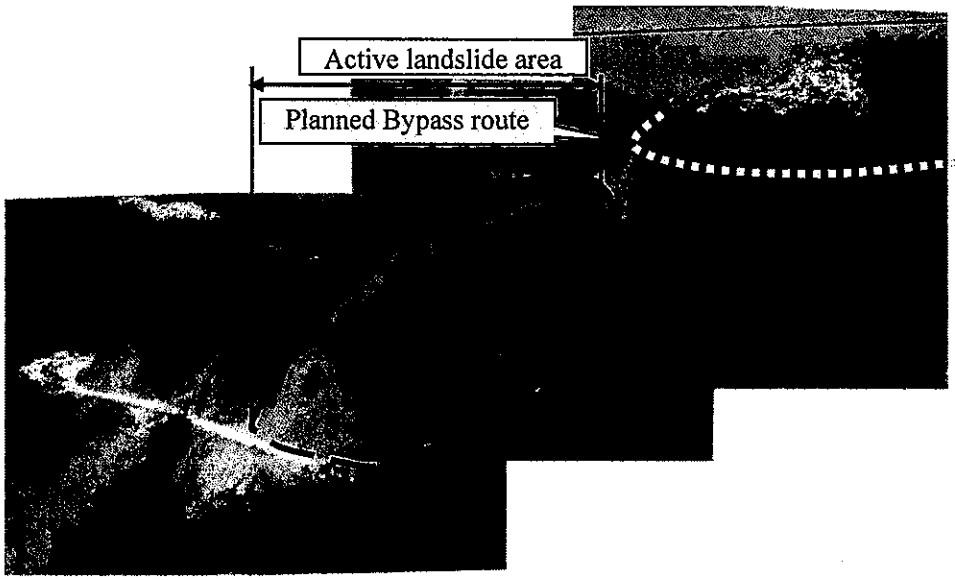
Source: JICA Study Team

Figure 5.1-24 Distribution of hard rock and formation of ridge

(3) Occurrence of Landslide by Cutting

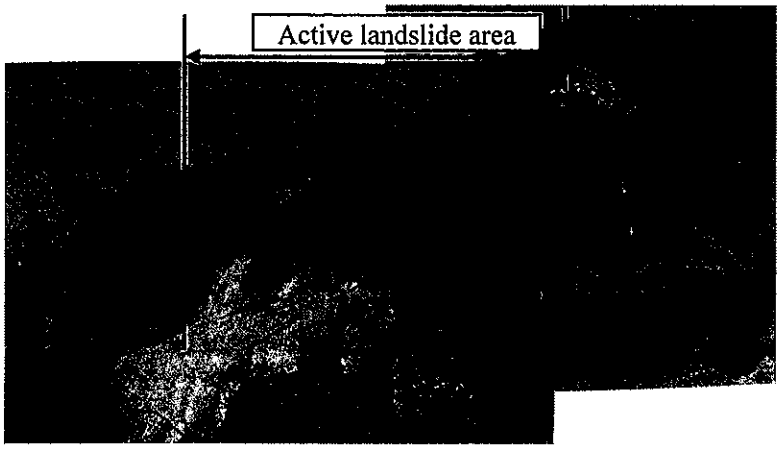
The large slope failures and the landslide are seen along the current road near the planned Bypass No4. Especially, the Bypass route is planned on the head of the landslide which is very active as shown in Figure 5.1-25.

The outcrop of the sliding cliff located at the head of landslide consists of the disturbed materials as shown in Figure 5.1-26 E/F. Scale of the active landslide is presumed to be the scale shown in Table 5.1-19 based on the geological survey. Figure 5.1-27 shows the landslide cross section presumed based on the geological survey.

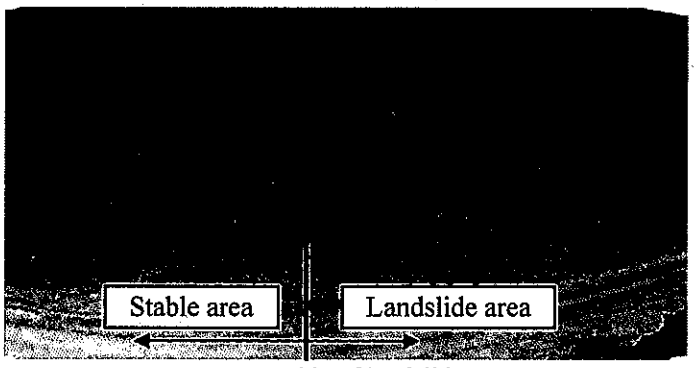


Source: JICA Study Team

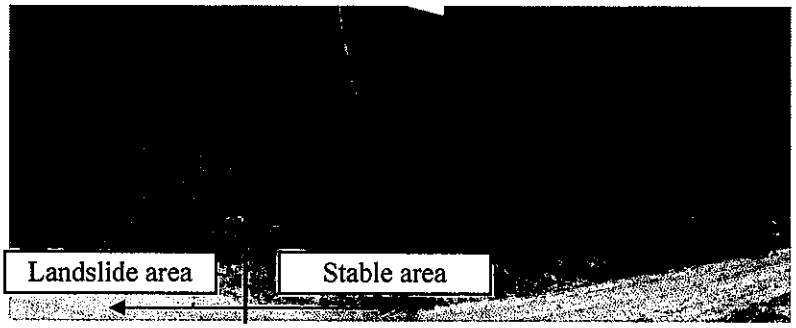
Figure 5.1-25 Landslide formed by cutting and planned route



A : Full view of landslide



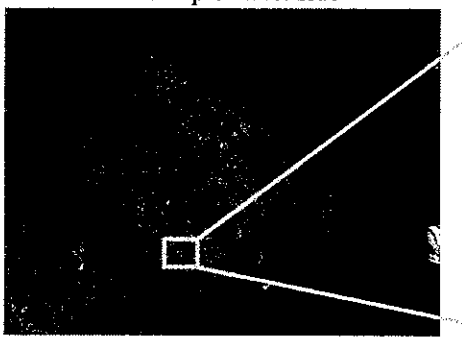
West side of landslide



B : East side of landslide

C : Scarp of west side

D : Sliding cliff



E : Sliding cliff

F : Near view (Disturbed materials)

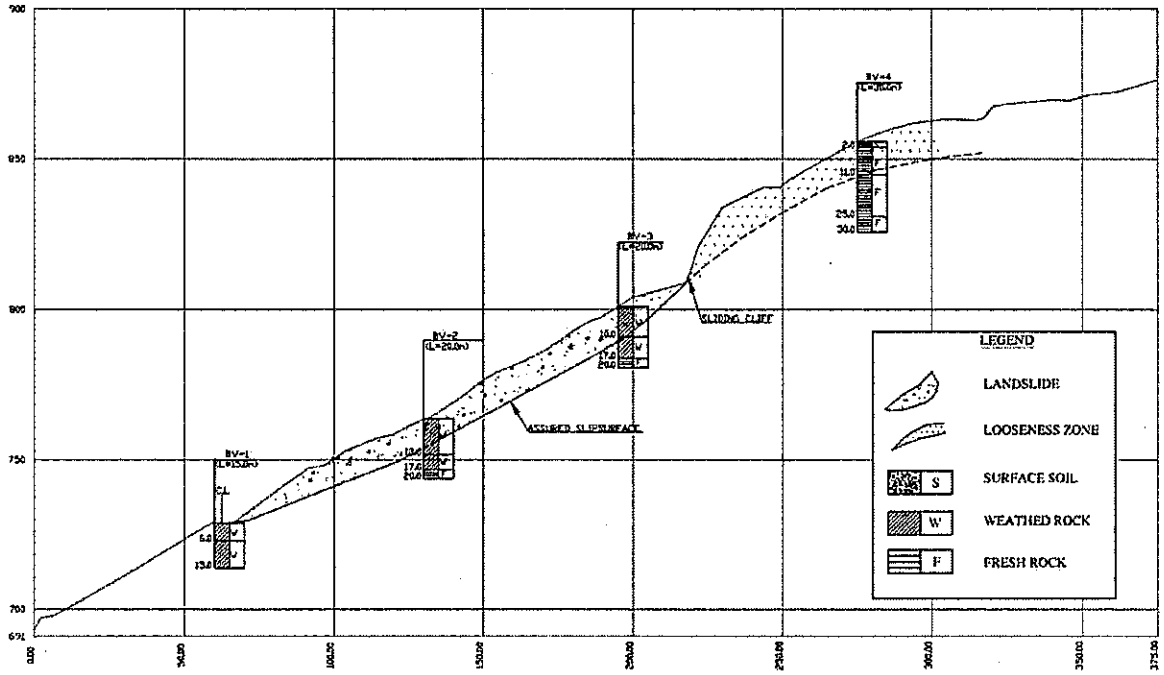
Source: JICA Study Team

Figure 5.1-26 Geological condition of Landslide

Table 5.1-19 Scale of Landslide

Item	Unit	Scale
Width	m	100
Length	m	150
Depth	m	10

Source: JICA Study Team



Source: JICA Study Team

Figure 5.1-27 Presumed Cross Section of landslide

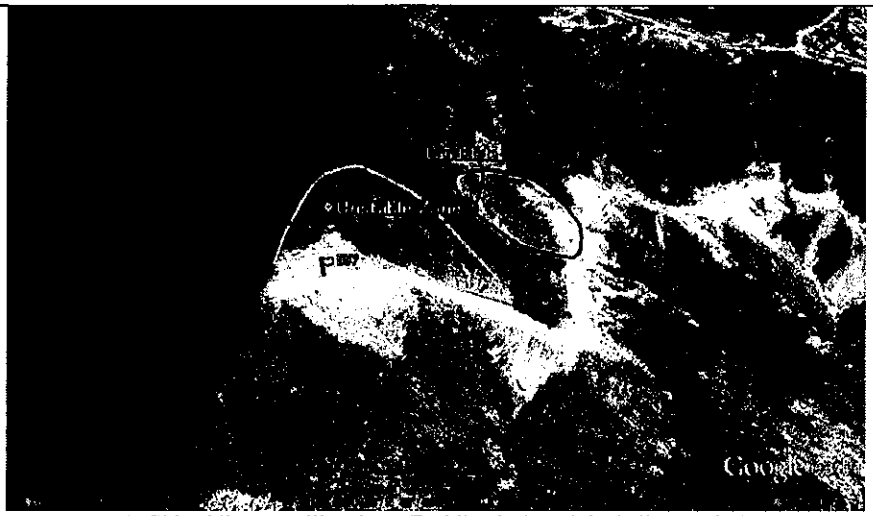
(4) Another unstable slope along Bypass No4

There is another unstable zone along Bypass No4 besides the landslide. The slope is distributed around the survey point No4 (GPS log 557). Source: JICA Study Team

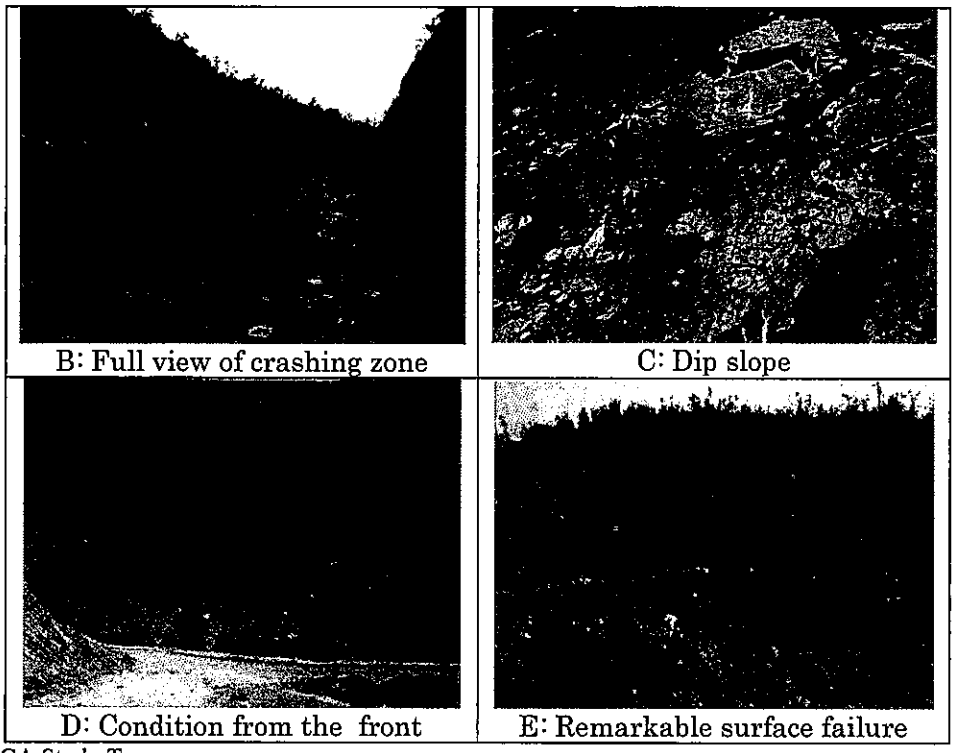
Figure 5.1-28 shows the current condition of the slope. The weathered area such as fracture zone is distributed along the current road (M/M road). Geotechnical structure shows dip slope in this section. Therefore, the road alignment is desired to avoid this unstable area and to go through the upper side of this area. Provably, it is assumed to be difficult to sustain the foundation of road. The red line in

Source: JICA Study Team

Figure 5.1-28 (A) is the original alignment plan which goes through the unstable slope and the landslide.



A: Side oblique satellite photo (Red line is the original aliment plan)



Source: JICA Study Team

Figure 5.1-28 Current condition of unstable slope

5.2 Preliminary Design

5.2.1 Review of DPR

Review of road design for the bypasses is given in Chapter 4.3.

5.2.2 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 following Design Policies are established;

- There were differences in design concept in each bypass in 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 bypasses as well as the improvement of NH54.

- Design of alignment shall be based on a policy with a balance between application of minimum design standard and the terrain condition, so that balanced cut and fill is resulted as far as possible reducing the disposal volume.
- Alignment shall be designed with a concept to minimize the relocation of houses.
- 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 5.2-1 .

Table 5.2-1 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)	12.0 (10.0)	() for exceptional sections only
		Carriageway Width (m)	2 x 3.5	
		Outer Shoulder Paved Width (m)	2 x 1.5 (0.9)	
		Outer Shoulder Earthen Width (m)	2 x 1.0 (0.6)	
		Crossfall of Roadway (%)	2.5	
		Slope of Earthworks		
		Fill	V : H = 1:1.75	
		Cut (soil)	V : H = 1:1.2	Varies
		Cut (rock)	V : H = 1:0.2-0.5	Varies
5	Sight Dist.	Stopping Sight Distance, SSD (m)	30 (45)	() 40km/h
		Intermediate Sight Distance, ISD (m)	60 (90)	() 40km/h
		Overtaking Sight Distance, OSD (m)	(165)	() 40km/h
6	Horizontal Alignment	Horizontal Curve		
		Absolute Minimum Radius of Horizontal Curve (m)	30	
		Ruling Minimum Radius of Horizontal Curve (m)	50	
		Widening of Carriageway on Horizontal Curves		
		Widening for Absolute Minimum Radius (21m-40m)	1.5	
		Widening for Ruling Minimum Radius (41m-60m)	1.2	
		Superelevation (Se)		
		Maximum Se for Absolute Minimum Radius (%)	7.0	
		Superelevation Runoff Rate	1/60	
		Transition Curve		
		Minimum Length for Absolute Minimum Radius (m)	30	
		Minimum Length for Ruling Minimum Radius (m)	20	
7	Vertical Alignment	Vertical Gradient		
		Ruling Gradient (%)	6.0	
		Critical length of continuous Ruling Gradient (m)	2000	120m rise in 2km for steep
		Limiting Gradient (%)	7.0	
		Exceptional Gradient (%)	8.0	
		Critical Length for Exceptional Gradient (m)	100	
		Minimum Gradient for Drainage (%)	0.5	Cut sections with lined side
		Vertical Curve		
		Minimum Length of Vertical Curve (m)	15	
		Minimum Radius of Summit (Crest) Curve (m)		
		Absolute Minimum Radius (m)	205	From SSD
		Minimum Radius (m)	375	From ISD
		Desirable Minimum Radius (m)	1500	From OSD
		Minimum Radius of Valley (Sag) Curve (m)		
		Absolute Minimum Radius (m)	355	

Source: JICA Study Team

(3) Horizontal Alignment Design

Total length of each bypass is given in Table 5.2-2.

Table 5.2-2 Total Length of each Bypass

SN	Bypass	Length (m)	Remarks
1	Bypass1	2,572.851	Start and end locations are similar to DPR
2	Bypass2	11,805.031	Start and end locations are similar to DPR
3	Bypass3	7,025.157	Start and end locations are similar to DPR
4	Bypass4	2,635.921	Start location is about 450m before DPR, but end location is similar to DPR

Source: JICA Study Team

The details of applied horizontal curvature in each bypass are given in Table 5.2-3. Minimum radius applied satisfies for minimum design speed of 30km/h

Table 5.2-3 Application Rates of Minimum Radius in each Section of NH54

Bypass		R<30	R=30	30<R≤50	R>50	Remarks
Bypass1	No	0	12	6	7	
	(%)	0%	48%	24%	28%	
Bypass2	No	0	45	53	44	
	(%)	0.0%	31.7%	37.3%	31.0%	
Bypass3	No	0	27	33	11	
	(%)	0.0%	38.0%	46.5%	15.5%	
Bypass4	No	0	13	7	11	
	(%)	0.0%	41.9%	22.6%	35.5%	

Source: JICA Study Team

The quantities of excavation and spoil volume are given for each bypass in Table 5.2-4, with the percentage of spoil volume in relation to the excavation volume.

Table 5.2-4 Excavation and Spoil Volume for the Bypasses

SN	Bypass	Excavation Volume (m^3)	Spoil Volume (m^3)
1	Bypass1	120,193	89,987 (74.9%)
2	Bypass2	711,152	555,682 (78.1%)
3	Bypass3	360,654	289,997 (80.4%)
4	Bypass4	241,385	179,248 (74.2%)

Source: JICA Study Team

(5) Vertical Alignment Design

- Minimum gradient is design as 0.5% at cut sections for drainage
- The Ruling Gradient is designed as 6% as per the Design Standard given in Section 5.2.2.
- The Limiting Gradient is 7% at difficult locations
- The exceptional Gradient is 8%, but has not been applied in any of the bypasses.

The length of designed vertical profile grade range is given in Table 5.2-5 in percentage of the total length of each Section.

Table 5.2-5 Summary of Designed Vertical Profiles

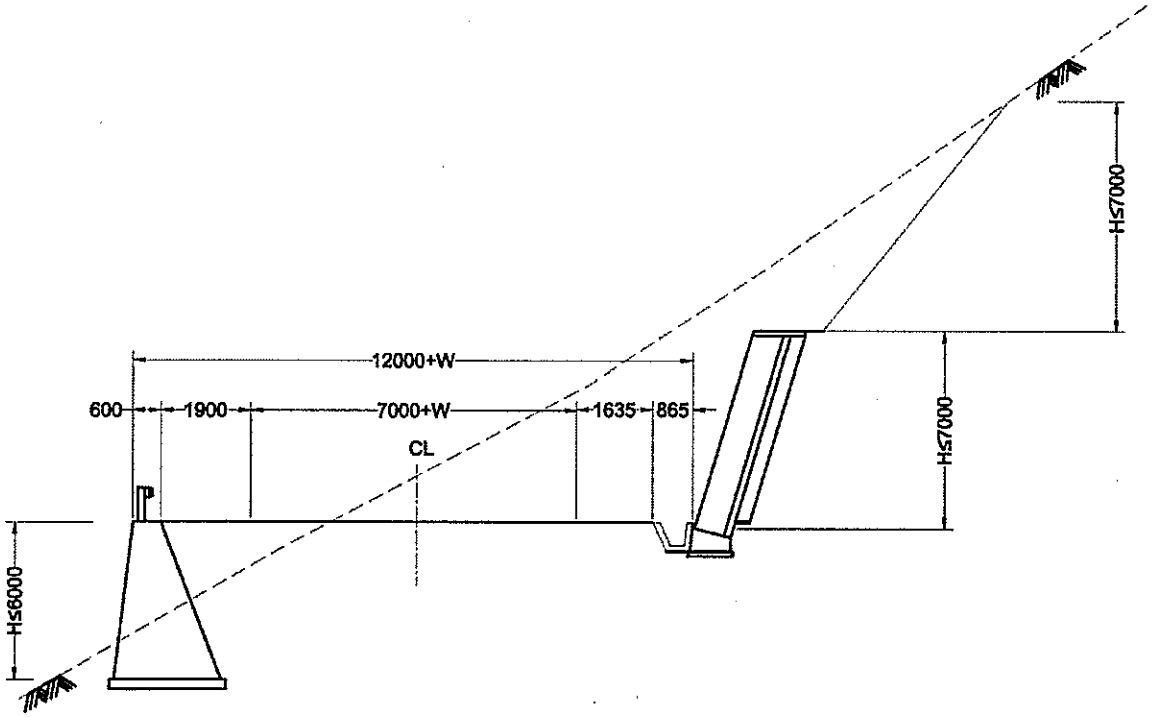
SN	Bypass	Vertical Grade Range								
		0.5%	0.5%-1%	1%-2%	2%-3%	3%-4%	4%-5%	5%-6%	6%-7%	7%-8%
1	Bypass1	13.1%	4.9%	0.0%	31.3%	0.0%	12.1%	38.6%	0.0%	0.0%
2	Bypass2	0.0%	4.3%	21.0%	12.3%	19.4%	11.1%	17.4%	14.5%	0.0%
3	Bypass3	8.9%	7.6%	15.0%	27.9%	16.8%	5.1%	11.0%	7.7%	0.0%
4	Bypass4	2.7%	31.2%	0.0%	0.0%	41.9%	9.8%	9.6%	4.7%	0.0%

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 lengths of 0%, 14.5%, 7.7% and 4.7% for Bypass1, Bypass2, Bypass3 and Bypass4 respectively.

(6) Typical Cross Section

The typical cross section is given in Source: JICA Study Team
Figure 5.2-1 for balanced cut and fill design.



Source: JICA Study Team

Figure 5.2-1 Typical Cross Section for balanced cut/fill design

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

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

(5) Final Alignment in Bypass 4

As discussed in Section 4.5 (Alternative Route Study), Bypass4 (Lawngtlai Bypass) starts from the Kaladan Multi-Modal Road, which is under construction at present. Major control point in this bypass is the landslide area around Km1+100 (DPR chainage). DPR alignment passes through the middle of the landslide area and therefore, another alternative was selected in the Alternative Route Study which passes through the top of the landslide area.

During the Alternative Route Study, the applied topographic data was developed from wide area satellite images and not the actual ground survey, which had lesser degree of accuracy. Moreover, since the Kaladan Multi Modal Road (MM Road) is under construction, its exact location and elevations were not known during the Alternative Route Study.

After the Alternative Route Study, detailed topographic survey was conducted. The completed section of MM Road at the take off point of Bypass4 was also surveyed. The designed alignment and profile data of MM Road was also transferred to the same coordinate system as that of the detailed topographic survey. The design data for the realignment of a local road (Lawngtlai to Bungtlang) passing through Bypass4 as well as the MM Road was also obtained and transferred to the same coordinate system.

Based on these data, it was observed that cutting of more than 70m height will be required at the take off point of Bypass4 for a length of about 200m. In order to minimize the cutting, two alternatives were further studied. The first alternative considered raising of profile of MM Road for a length of about 500m at the take off point of Bypass4 and the second alternative considered shifting of MM Road alignment for a length of about 200m to valley side at the take off point, which is also required for junction development between Bypass4 and MM Road.

The issue was discussed with Chief Engineer of PWD Mizoram in presence of the Manager (Projects) – Mizoram of NHIDCL and the DPR Consultant and Consultant of MM Road. It was concluded that the alternative which considers shifting of MM Road alignment for a length of about 200m is more suitable. PWD was also of the view that since MM Road is ongoing, the design cannot be changed at present and such modification shall be done during the implementation of the bypass.

5.2.3 Bridges and Structures Design

(1) General

NH54 bypass route is planned passing through mountainous area. In order to cross over valleys among mountains, cross structures such as bridge and culvert are required.

Specially, bridge is needed at locations where the distance between planned road level and ground level is high, or catchment area of rainy water is large.

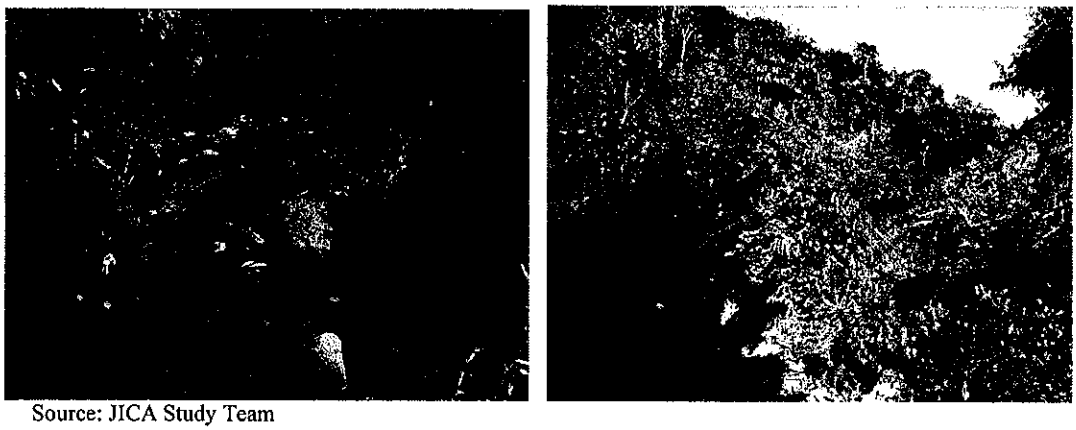
Hence, bridge is planned at two location of Serchhip bypass.

Serchhip bypass at km 4+530

- It locates at about 4.5km from beginning point of serchhip bypass.
- The route crosses the valley as curve section of horizontal alignment.
- Minor bride is enough because crossing length on valley is comparably short.
- Water flow is confirmed when site investigation was conducted in January 2016.
- Some boulders and rocks are appeared above the ground in river bed.
- Vegitations and shrubs are flourished at around site.

Serchhip bypass at km 10+800

- It locates at about 10.8km from beginning point, 0.8km from end point of serchhip bypass.
- The route crosses the valley as straight section of horizontal alignment.
- Major bride is required because crossing length on valley is comparably large.
- Water flow is confirmed when site investigation was conducted in January 2016.
- Some boulders and rocks are appeared above the ground in river bed.
- Vegetation, shrubs and trees are flourished at around site.



Source: JICA Study Team

Figure 5.2-2(Left) Site view at 4+530 in Serchhip bypass / (Right) Site view at 10+800 in Serchhip bypass

(2) Design standard

The design is based on the IRC standard in principal. For detailed design stage, it shall be designed based on IRC standard as far as applicable.

Major codes and typical drawings regarding to bridge design is summarized in Table 5.2-6. Also, the codes for road design are to be referred.

But not limited to;

Table 5.2-6 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 account for the regional and project characteristic. Major load conditions are as follows.

- Live load: IRC Class 70R Loading (Accordance with IRC:6 Clause201)
- Live load combination: One lane of Class 70R OR Two lanes of Class A (Accordance with IRC:6

Clause 204.3)
- Impact load: (Accordance with IRC: 6 Clause 208)
- Temperature load: +5 to +40 degree (Accordance with IRC:6 Clause215)
- Seismic load: Zone-V, Important Factor: 1.5 (Accordance with IRC:6 Clause219)

For other load conditions also be determined in accordance with IRC standards.

(3) Planning for Major bridge

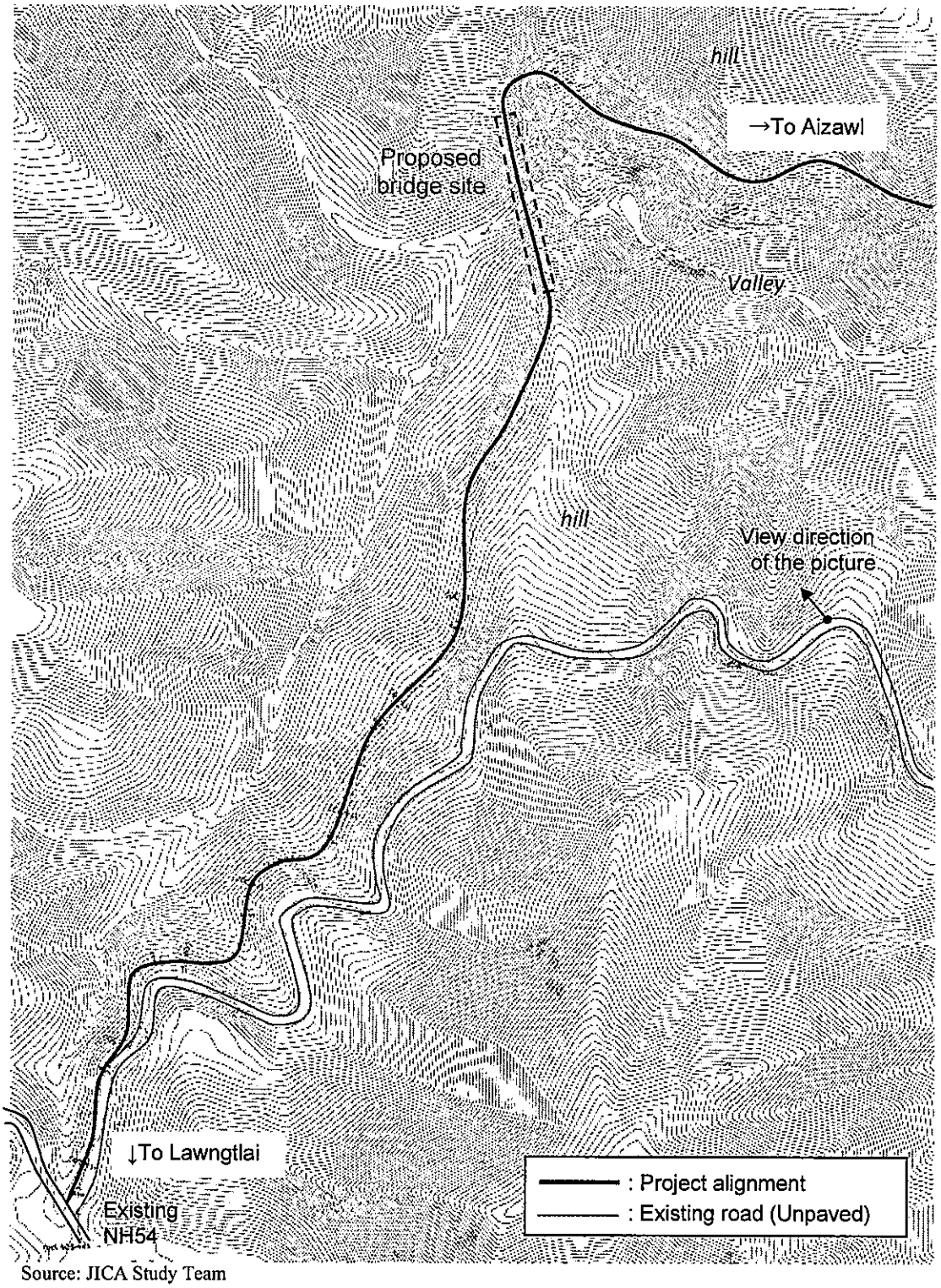
A major bridge is planned for crossing over the valley at 10.8km from beginning point of Serchhip bypass. For the selection of bridge type, appropriate bridge type should be selected with considering the condition of 140m length and valley terrain at the site.

Steel arch type is frequently applied in valley terrain in mountain area. It doesn't require pier construction at deep valley point by an arch rib built on rigid ground at both slopes. Manufacture of steel arch member in factory enable to be comparably short construction period. The valley terrain and shape of arch rib is well harmonized and makes good landscape.

As alternative type from PC type bridge, T-type rigid frame bridge which is frequently used to similar scales is compared. A table for comparison of bridge type is summarized in Table 5.2-7. Because steel arch type is superior to total evaluation, upper-deck type steel arch bridge (RC slab + Steel Arch + RC slab) is proposed.

Source: JICA Study Team

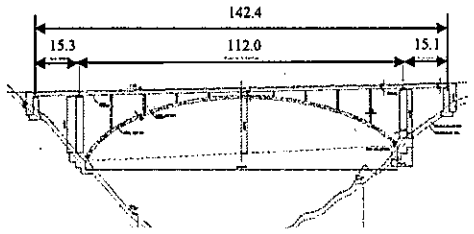
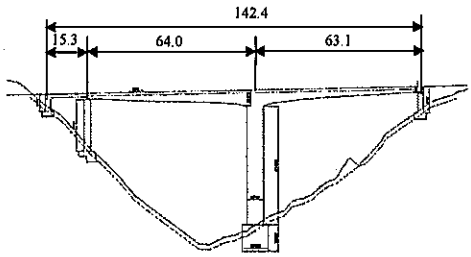
Figure 5.2-3 Location of major bridge planned (km 10.8, View from E.P. side)



Source: JICA Study Team

Figure 5.2-4 Location map of major bridge (km10.8) on Serchhip bypass

Table 5.2-7 Comparison of structural type of major bridge

	Upper-deck type steel arch bridge (RC slab + Steel arch + RC slab)	T-type rigid frame PC BOX bridge (RC slab + T-typ rigid frame BOX)
Layout		
Abstract	Steel arch type is frequently applied in valley terrain in mountain area. Long span is provided by arch effect of rib which supported on rigid ground. It can be built by cable erection method with cable crane facilities and temporary steel tower.	PC Canti-lever type is applied on condition where bent support is un-suitable due to high location. The girder is built by cantilever method with mobile work machine from pier head constructed.
Construction cost ratio	1.00	0.85
	- It is supposed that an oversea's contractor such as Japan is procured. A part of equipment and staff may need to be imported.	- It is well familiar method in India. All material, equipment, staff will be procured from domestic.
Construction period	1.5 year	2 year
	- The sub-structural work can be proceeded during a manufacturing 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.	- The canti-lever work is mobilized after the pier head completed. Hence, the construction period takes comparably large. - The concrete work is more influenced by weather condition. It has a risk of huge delay.
Landscape	good	poor
	- The arch bridge is generally considered to be good landscape. The valley terrain and shape of arch rib is well harmonized.	- Due to large dimension of main pier and BOX girder, the bridge looks so artificial and heavy.
Construction condition	good	poor
	-It can be built by cable erection method from existing road side. -Steel member is manufactured in factory so that the it provides well quality control.	- Material and equipment need to be transported to the pier construction point at slope bottom with construction road. - Large concrete work at site in long period need more notification to control quality.
Environmental aspect	good	poor
	-An effect for natural environment can be minimized because site works are comparably short.	-A construction road to access to pier bottom at slope bottom is needed. -Due to largeness of structure, traffic of concrete mixer truck will be frequent.
Evaluation	O	-

Source: JICA Study Team

Geographical and Geological condition

- The bridge length becomes 142.4m between two abutments. The height from ground level to road surface level at around steel arch center is 55m in approximate. The elevation difference between road levels at both abutment is 3m in approximate. Vertical gradient of road on the bridge is 2.0%.
- Boring survey was conducted at three points around the bridge planned location. SPT results either un-penetration or about 50 of N-value in depth of 2m. Hence, each foundation under arch-rib, pier and abutment can be designed as spread foundation and to be reached to depth 2m.

Outline of bridge plan

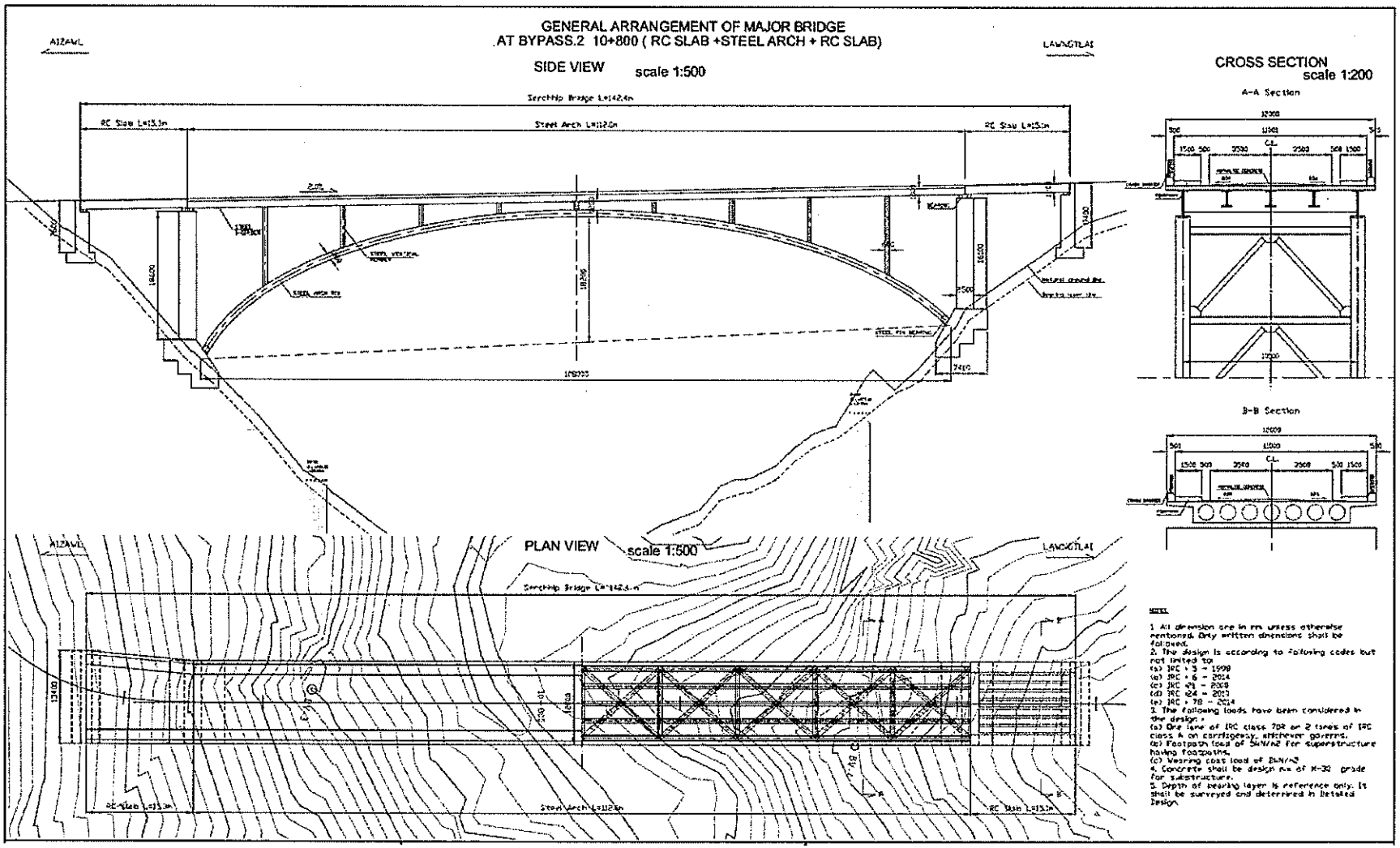
- Total width of the bridge is 12m in accordance with IRC standard. For provision of passenger walking space, footpath of 1.5m width is provided at both side.
- Crash barrier needs to be facilitated due to high location bridge.

For design stage

- Design condition shall be based on latest IRC standard. Live load class is to be IRC Class 70R.
- The area of North east region has experienced several large earthquakes in past. The area is categorized Zone-V in seismic zone classification. It requires seismic design based on IRC standard taking account of characteristic of steel arch structure.
- It is an option to add the application of weathering steel, which is known as effective to reduce a total cost of initial cost plus life cycle cost. Japanese manufacturer provides such innovative technology.

For construction stage

- Member of steel arch will be manufactured in factory and transported to the construction site.
- The steel arch will be erected by the cable erection method with cable crane and temporary steel tower facilitated at the site.



Source: JICA Study Team

Figure 5.2-5 General view of Major Bridge

(4) Planning for Minor bridge

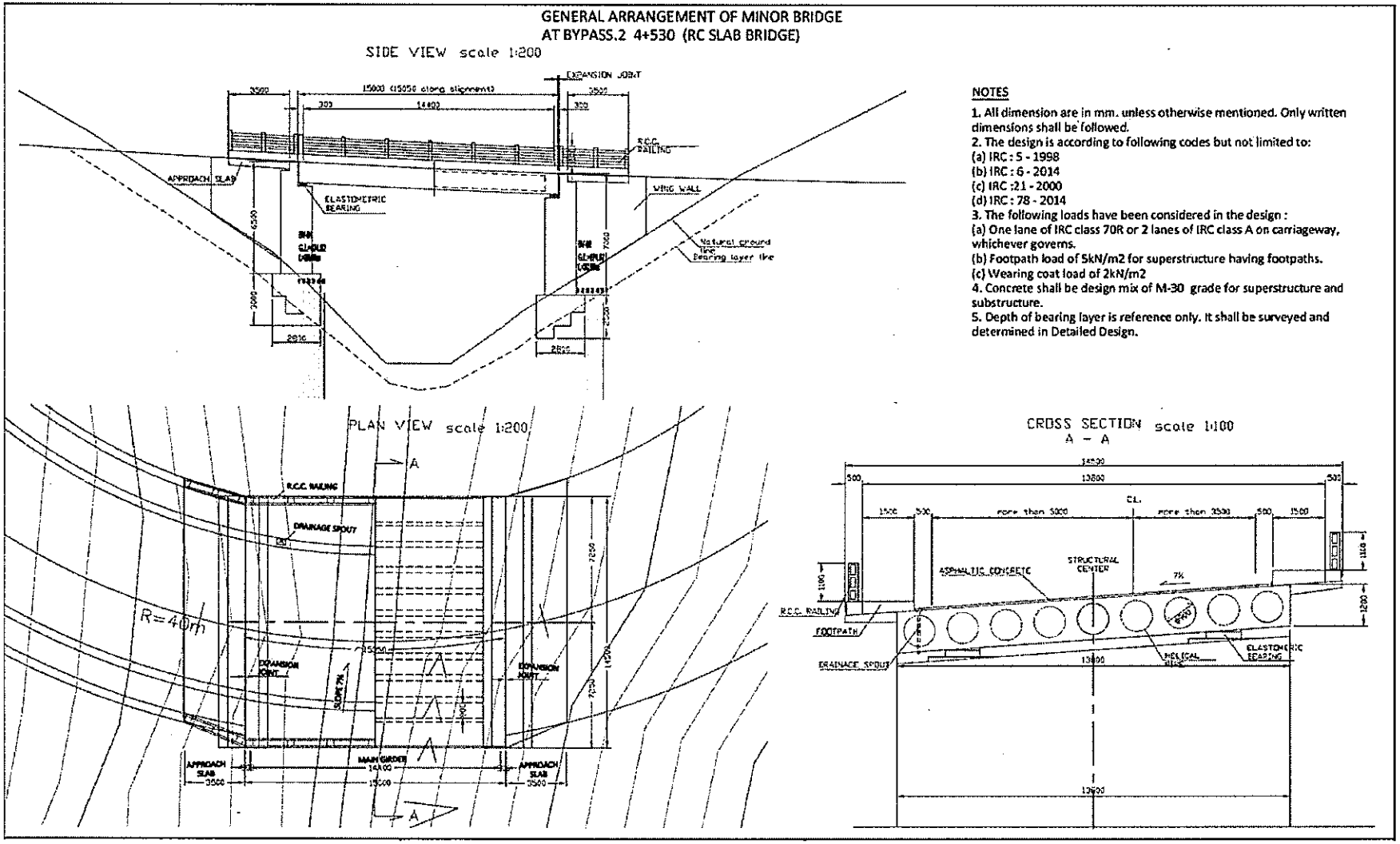
Minor bridge is proposed for Serchhip bypass as shown in table below.

Table 5.2-8 Plan of Minor Bridge at Serchhip bypass

Location	Bridge type	Outline
Serchhip bypass Km 4+530	RC slab bridge (Hollow slab)	Bridge length : L=15m Total width : W=12m Foundation : Spread foundation

Source: JICA Study Team

- Total width of the bridge is 12m in accordance with IRC standard. For provision of passenger walking space, footpath of 1.5m width is provided at both side.
- Boring survey was conducted at two points around the bridge planned location. SPT results un-penetration in depth of 1.5m. Hence, each foundation under arch-rib, pier and abutment can be designed as spread foundation and to be reached to depth 1.5m.
- Because the bridge is composed from RC member only, concrete work with mixer at site is supposed. The superstructure concrete will be by cast in-situ on the support.
- Due to increase of flown water in rainy season, construction work in dry season is recommended.



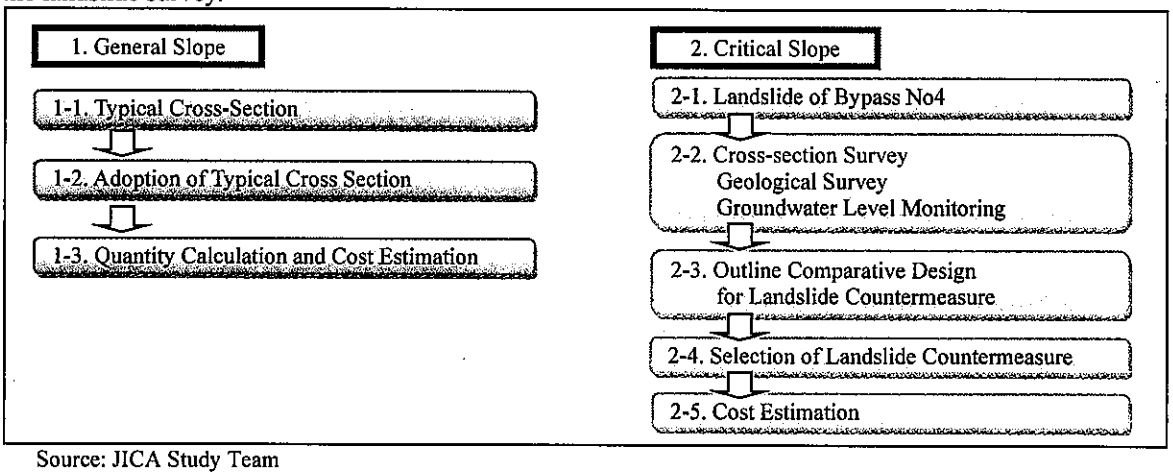
Source: JICA Study Team

Figure 5.2-6 General view of Minor Bridge

5.2.4 Earth Work / Slope Protection / Land Slide Prevention Design

1) Methodology

Figure 5.2-7 shows flow of the methodology of planning for earth work, slope protection, and landslide prevention works. Based on the slope inventory survey as mentioned above, slopes along the road were evaluated about their stability. Also, the landslide prevention works of Bypass No4 were studied based on the landslide survey.



Source: JICA Study Team

Figure 5.2-7 Flowchart of Plan for Slope Protection Work

2) Proposed Design Policy and Design Criteria

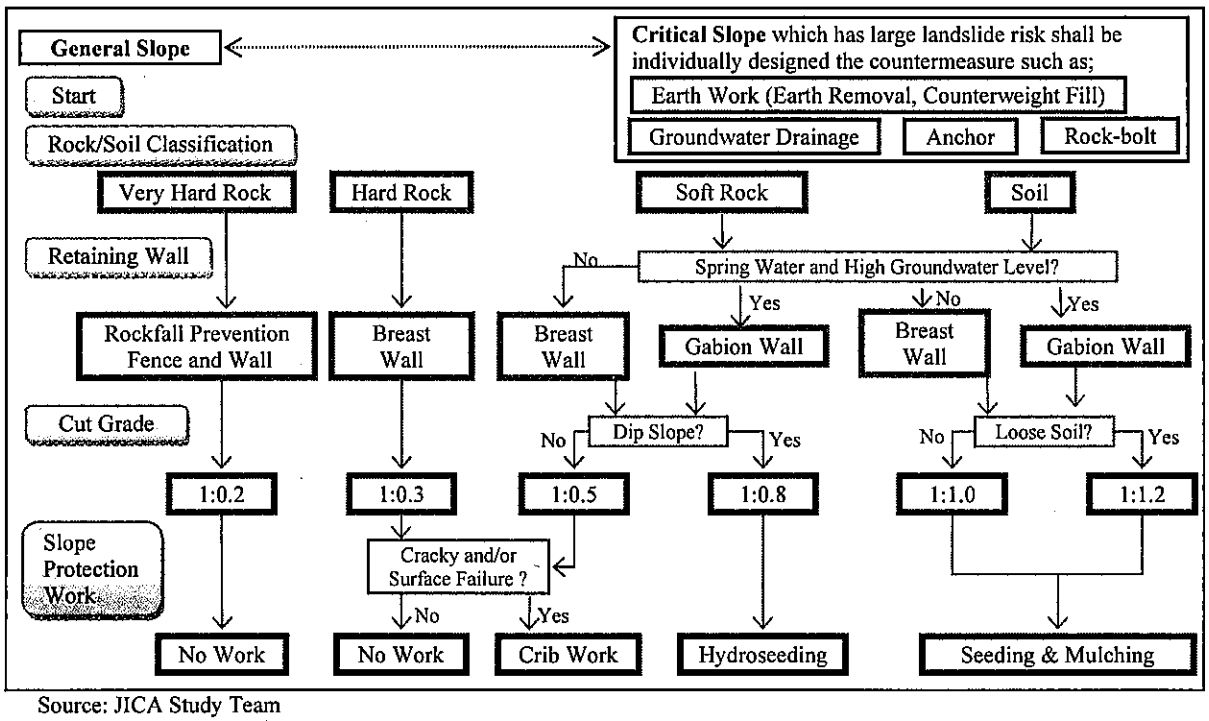
Against the general slopes, slope protection work, retaining wall, and grade of cut/embankment slope shall be planned according to the natural condition including geology, geotechnics, and topography of each slope based on the following design criteria mentioned below.

- A stable cut slope of soil and soft rock shall be covered with vegetation works in consideration of harmonization with species of local vegetation.
- An unstable slope and an unsuitable slope for the vegetation works shall be adopted slope protection works.
- Height of one step of cut slope shall be maximum 7m. When the height of slope exceeds 7m, a berm with 1.5m wide shall be set between each slopes.
- Total height of cut slope shall be maximum 20m basically considering economy, workability and safety.
- In case of a large slope, to prevent a large cutting, slope gradient shall be adopted steeper one than stable using slope protection works.
- Breast wall shall be built on the toe of cut slope to prevent small collapse and to maintain the side ditch.
- Slope protection works shall be selected among general construction method in India and Japan.
- Landslide area shall be avoided basically by road alignment as much as possible.
- If road alignment pass through the landslide area, landslide countermeasure such as groundwater drainage works, counterweight fill work, earth removal works and anchor work shall be examined for slope stabilization.

Figure 5.2-8 shows the flowchart of selection of slope prevention works such as retaining wall types, cut gradient and slope protection works for cut slope. The critical slope which is expected to give huge damage to the road shall be individually surveyed and designed its countermeasures e.g. earth work including landslide removal and counterweight fill, groundwater drainage, anchor work, and rock-bolt work, etc.

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 design of slope protection works. We improved the criteria of earth works such as cut and embankment based on the

actual geotechnical condition at the site. Because the manual is not enough for determination of dimension, specification of materials, and quantity of anchor work and reinforced earth wall, we designed them utilizing the Japanese technical guideline for road works published by Japan Road Association. Table 5.2-9 presents the result of the review of IRC regarding design of slope protection work.



Source: JICA Study Team

Figure 5.2-8 Flowchart of Selection of Slope Protection Work for Cut Slope

Table 5.2-9 Review of IRC for Slope Protection Design

Item	Clause		JICA Study Team Evaluation
Earth Work			
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 (6-11m) that the team propose 1.5m wide following Japanese guidelines.
Embankment	-	A	Not shown in the Hill Road Manual. Utilized the design criteria in Rural Road Manual (SP:20-2002).
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	Not shown the exact dimension 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 doesn't mention about panel material of the front slope.
	SR 7.6.	B	SR shows the basic formulas of internal stability. It doesn't show the typical soil and tensile coefficient of embankment and reinforce 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 & 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			

Item	Clause	JICA Study Team Evaluation	
Groundwater Drainage	IRC: 11.6.2(c)	C	Specification in IRC is not effective for large landslide, is 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.	B	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	Similarly to counterweight fill, SR suggests to reduce of soil amount at the top of 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 the anchor wall and practical example, however, doesn't 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 the rock-bolt. Design method including specification, length, and alignment of the rock-bolt is not explained in SR.

Source: JICA Study Team

Evaluation A: Applicable to design
B: Necessary to add detailed design criteria for detail design
C: No description, necessary to be introduced

3) Design of Earth Work

1) Cut Slope

Cut grade of slope above the retaining walls along the road shall be decided based on geological and geotechnical condition of slope. Table 5.2-10 shows design criteria of cut grades for each rock and soil classification comparing those in IRC. Because there are many slope failure 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 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 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 m3 (less than 3m width and less than 1m depth) on the cut slope. In case that larger landslide is concerned, landslide countermeasure such as anchor and rock-bolt works need to be planned individually in the countermeasure design for the critical slopes.

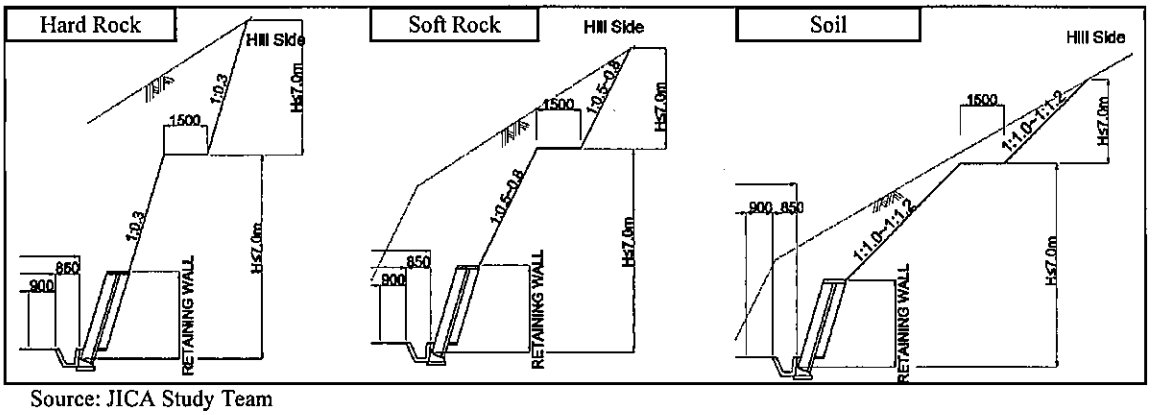
For prevention of erosion and surface failure and also for landscape improvement, most of cut slope shall be covered by hydroseeding work or seeding and mulching, and will be greened. The thickness of the sprayed hydroseeding shall be varied from 3 to 7 cm depending on the geotechnical condition. The cut slope of soft rock which is cut with 1:0.8 is applied 5cm thick hydroseeding. Seeding and mulching is applied for soil cut slope. As very hard or hard rock slope consists of intact bed rock 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. Figure 5.2-9 shows typical cross section of cut slope.

Table 5.2-10 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 5.2-9 Typical Cross Section of Cut Slope

In this study, rock and soil classification on each planned bypass route by cutting is set as shown in Table 5.2-11 based on the slope inventory survey.

Table 5.2-11 Rock and Soil Classification by Cutting

(%)

Classification	Bypass No1	Bypass No2	Bypass No3	Bypass No4
Common soil	20	20	30	10
Soft rock	80	75	70	80
Hard rock	-	5	-	10

2) Embankment on the Valley Side

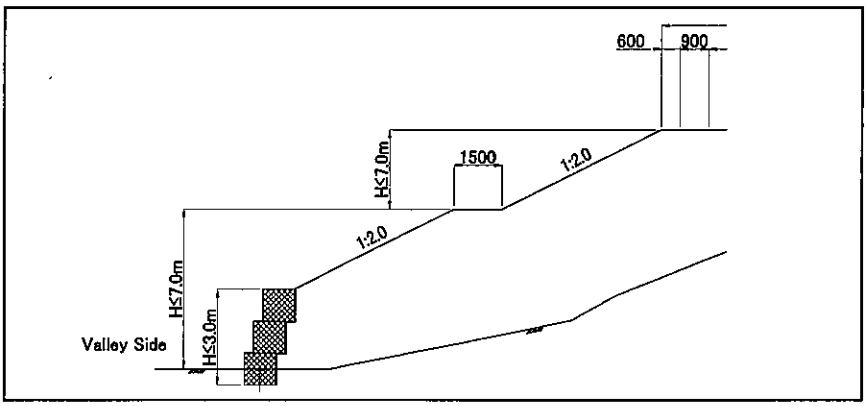
Slope grade of embankment slope is generally decided based on the embankment material and total slope height. Because generated soil by cutting is expected to utilize as embankment material in this project, the embankment material is composed of gravelly soil derived from sandstone and shale. The slope gradient of embankment is proposed as shown in Table 5.2-12. In order to prevent surface failure on the embankment slope, retaining wall such as gabion wall shall be built on the toe of slope. And turfing shall be implemented on the embankment slope for prevention of erosion and landscape improvement. Figure 5.2-10 shows typical cross section of embankment slope.

Table 5.2-12 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 (Sodding)
			5 ~ 20 m	**1:2.0**	Turfing (Sodding)

*IRC: 36-1970

Source: JICA Study Team



Source: JICA Study Team

Figure 5.2-10 Typical Cross Section of Embankment Slope

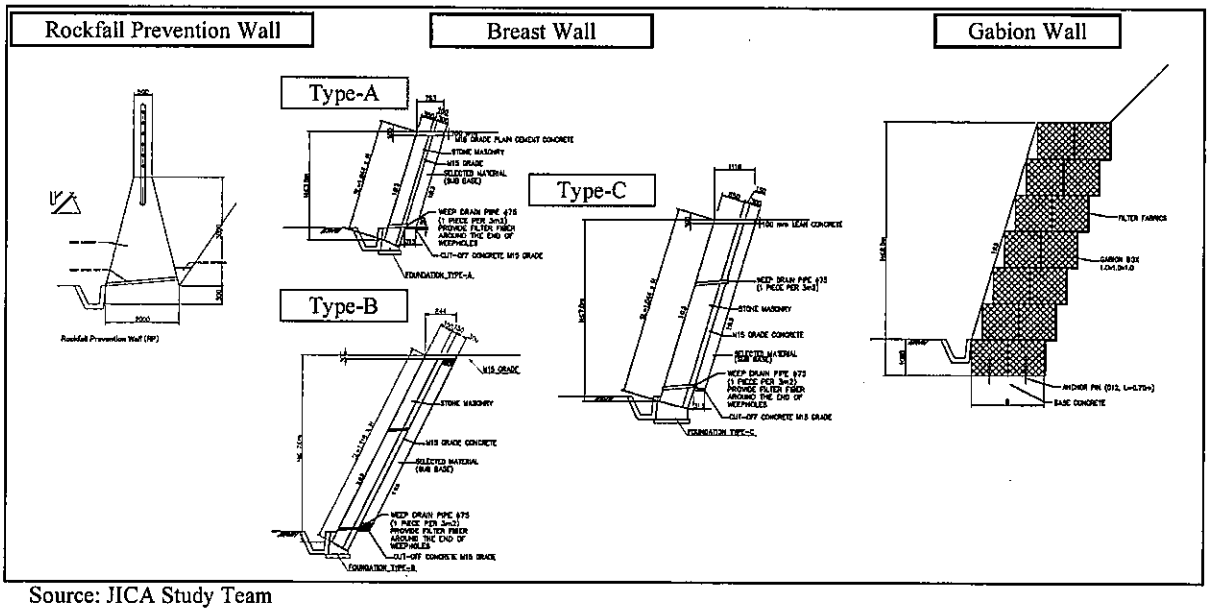
4) Retaining Wall

Retaining walls shall be built on the toe of almost all slopes on hill side along the road in order to prevent a small slope failure on the first step of cutting and to maintain the side ditch. Table 5.2-13 shows design criteria of the retaining wall. The type of the retaining wall should be changed to reduce the amount of cutting considering slope height. Namely, a large retaining wall type with 65 cm thickness should be applied for higher slope. On the other hand, a small one with 35 cm thickness should be applied for other lower slope. Gabion wall, which has high permeability, should be adopted against the slope where the spring water is found and groundwater level is presumed to be high. In steep slope consisted of very hard rock strata, gravity-type retaining wall with a rock fall prevention fence should be built at the toe of cut slope to protect the road. Figure 5.2-11 shows typical cross section of retaining wall.

Table 5.2-13 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 5.2-11 Typical Cross Section of Retaining Walls

5) Embankment Structure

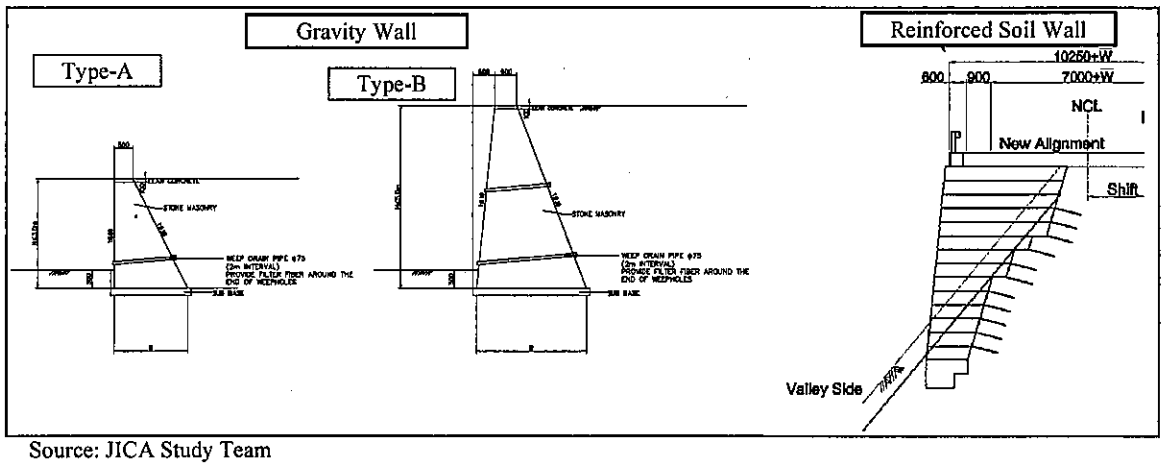
Retaining walls are built in front of the road embankment with the road widening on valley side,. Type of retaining wall should be selected depending on slope topography on valley side. For gentle and low valley slope which is gentler than 30 degree, gravity wall is frequently used for soil retaining. Because the gravity walls which has vertical or very steep grade on front slope need to excavate largely behind the wall in construction, it is necessary to pay attention to ensure the present traffic while construction. Steep and high slope need the reinforced earth wall which can be built more than 20m in height. Table 5.2-14 shows design

criteria of embankment structure. Also, Figure 5.2-12 shows typical cross section of retaining walls.

Table 5.2-14 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 degree
Reinforced Earth Wall		5 ~ 20 m	**1:0.1**	High and Steep Slope

Source: JICA Study Team

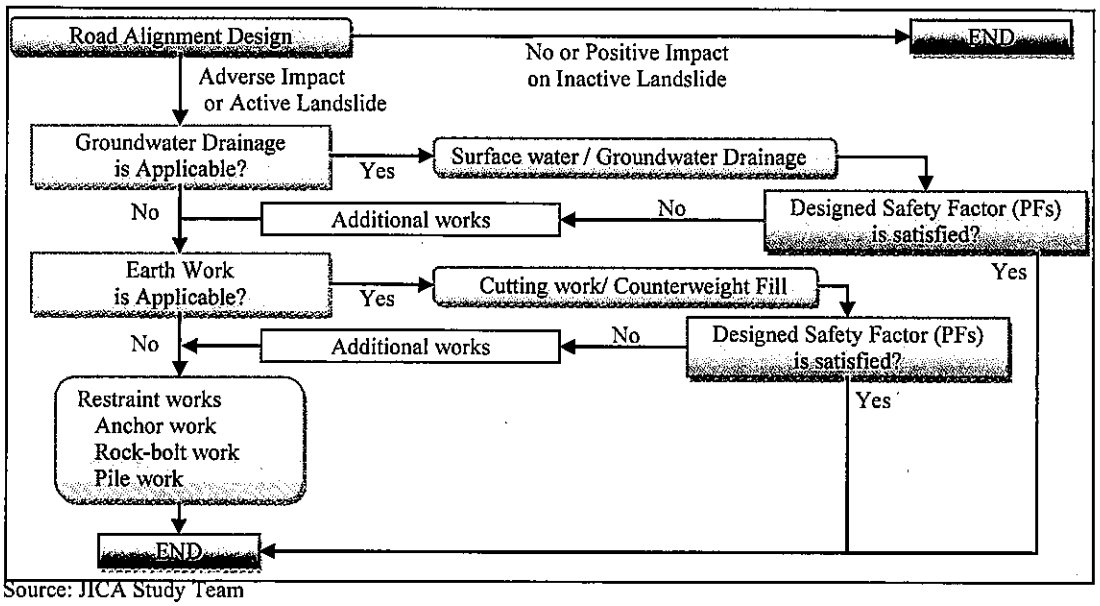


Source: JICA Study Team

Figure 5.2-12 Typical Cross Section of Retaining Walls for Embankment

6) Landslide Prevention Design

Basically, design of road alignment have to be planned not to promote the landslide movement. But, unavoidably if the road alignment goes through the landslide, landslide prevention measures have to planned and designed for the landslide. Figure 5.2-13 shows flowchart of selection of the landslide prevention measures. In terms of the landslide which is active or is concerned to be destabilized by cutting or banking, landslide countermeasure is required. The landslide prevention measures are mainly divided into three types; namely groundwater drainage work, earth work 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 earth work. But they are often constrained by topographical, geotechnical, and groundwater condition. On the other hand, restraint work which prevents the landslide movement by force is generally expensive, but their technique can be adopted as permanent countermeasure. Therefore, restrain works shall be introduced by combination of groundwater drainage works and earth works considering the cost reduction of the countermeasures.



Source: JICA Study Team

Figure 5.2-13 Flowchart of Landslide Prevention Measure

In terms of the landslide of Bypass No4, road alignment was eventually reviewed because the landslide is assumed to be very active. The planned alignment was adopted the alignment which goes through the upper slope of the landslide. Therefore, prevention measures against the main unit of landslide are not conducted as shown in Figure 5.2-14. But, the looseness zone is assumed to be distributed on the upper slope of the landslide, so a proper scale prevention measure against the lower part of the planned road is required to prevent expansion of the slope failure.

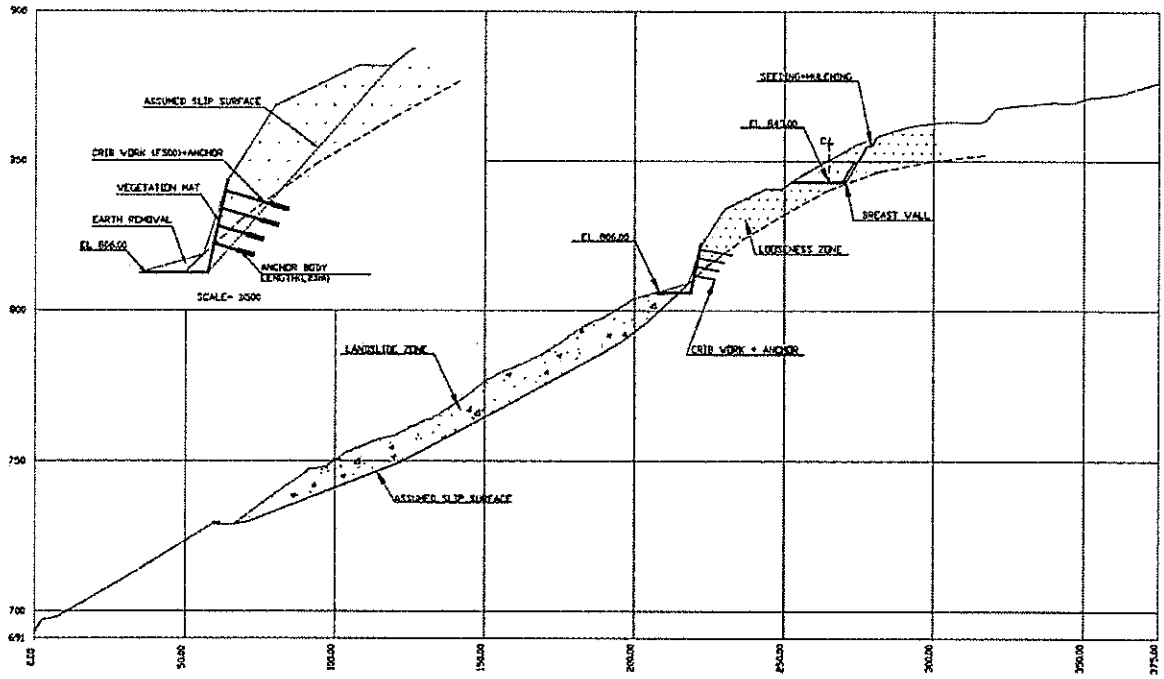


Figure 5.2-14 Countermeasure for Looseness Zone

5.2.5 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 5.2-15 and pavement design for NH54 bypass is applied same pavement composition with NH54.

Table 5.2-15 Pavement Composition 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

Source: JICA Study Team

5.2.6 Drainage Design

(1) General

It is required to facilitate culvert or side ditch on road for drain water surrounding or upstream of road to downstream properly. Specially, hill road is always suffered from large volume of water fallen from mountain slope towards to the road. It is quite important to protect the road by arranging cross drainage appropriately to satisfy the discharge from crossing water.

The new drainage system is designed by based on hydrological calculation result. Based on obtained location of water crossing and water discharge, dimension and locations for drainage system are determined. For cross drainage structure, appropriate culvert type is selected by taking account of economy, construction workability, and maintenance ability.

(2) Design standard

The design is based on the IRC standard in principal. For detailed design stage, it shall be designed based on IRC standard.

Major codes regarding to drainage design is referred to bridge design. The additional codes and typical drawings for drainage design is as follows.

Table 5.2-16 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

(3) New drainage design

(a) Cross drainage structure

The structural type of cross drainage is classified as pipe culvert, BOX culver and slab culvert.

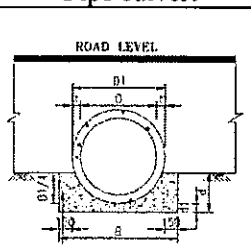
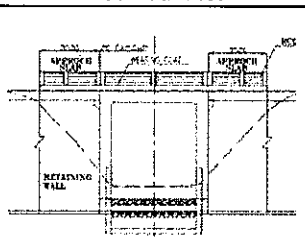
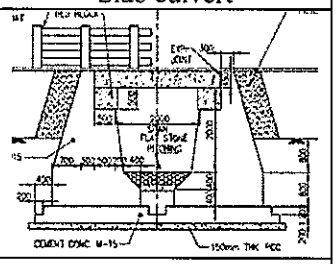
Pipe culvert is most appropriate structure where the water discharge is comparably small. It has advantage for economy, provision of quality because of precast manufacturing for RC pipes.

BOX culvert is appropriate where the water discharge is more than pipe capacity. Because BOX culvert is composed from all RC structure, it is reliable to keep durability and construction quality more than slab culvert which is composed from slab plate and masonry abutment.

In such reason, BOX culvert was applied to World Bank Road which is neighbor of NH54 constructed few years before.

Each type of culverts is compared in table below.

Table 5.2-17 Comparison for 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 comparable large. The size is determined to satisfy the water discharge obtained by hydrological calculation.

The contents of pipe culvert and BOX culvert is explained below.

- Culvert length from inlet to outlet is 12m which is same as the road width in general section. However, it shall be widened to match with widening in curve section.
- General arrangement of pipe culvert for straight section is planned as Figure 5.2-16. Also, pipe culvert for curved section is planned as Figure 5.2-17. However, it is noted that actual details such as culvert length, inlet and outlet structures shall be determined in implementation stage in order to satisfy for matching road width with widening, and topographical condition in each location.
- BOX culvert is based on the IRC standard drawings. Approach slab is needed for approach part. RC railing is needed at kerb at both side. The inner dimension of BOX culverts is arranged between 2mx2m to 4mx4m to satisfy the discharge in each location. However, the dimension shall also be taken account of topographical condition in each location in detailed design.
- Pipe culvert is type of NP4 based on IRC:13. It is based on the standard of IS458: Precast concrete pipes. The size of diameter 1.2m is planned to arrange to fit to satisfy the capacity for discharge.
- At inlet of the culvert, catch pit is provided. For the section of excavation at slope side, the chute is provided.
- At 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.

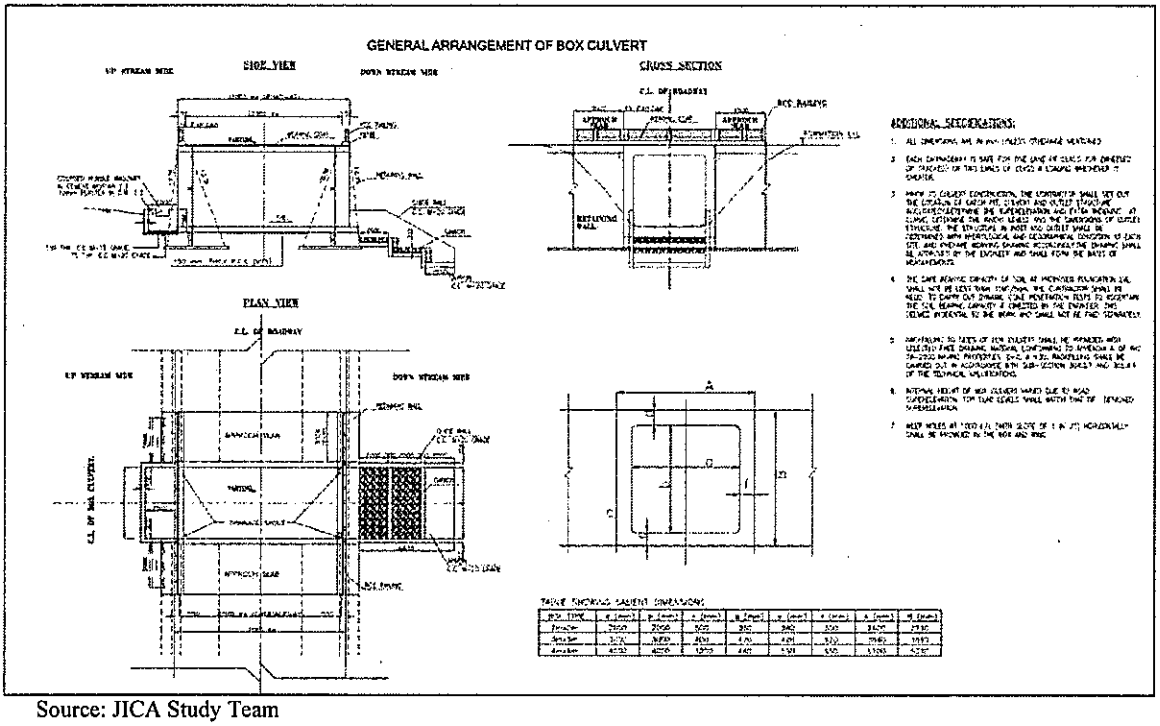
The capacity for each size of culverts to be applied in NH54 bypass is summarized in Table 5.2-18.

Table 5.2-18 Capacity for each size of culverts

	Size	A(m2)	n	i (%)	Capacity (m3)	Applied condition
Pipe culvert	φ1.2m	1.028	0.013	5.0	4.17	Flowing full condition
BOX culvert	2mx2m	4.000	0.033	5.0	15.88	Flowing full condition
	3mx3m	9.000	0.033	5.0	36.19	Flowing full condition
	4mx4m	12.400	0.033	5.0	95.71	Open section with vertical clearance of 0.9m

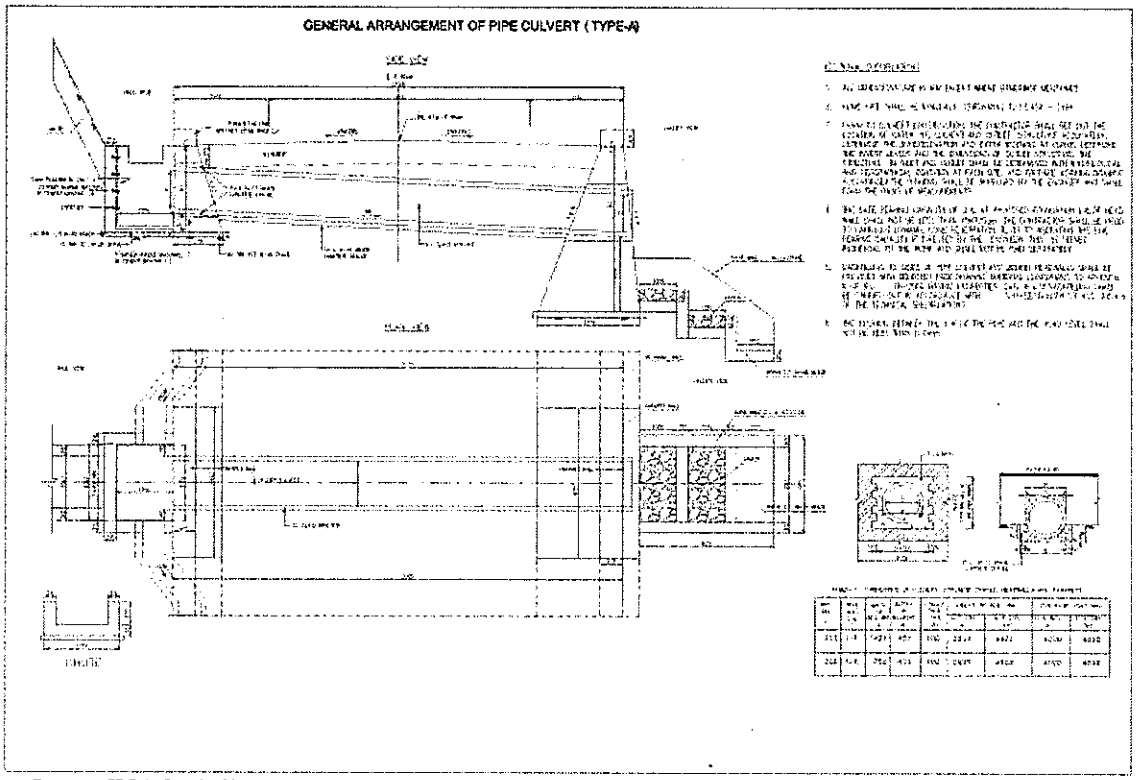
Source: JICA Study Team

General arrangement plan for BOX culvert and Pipe culvert is shown in figure below.



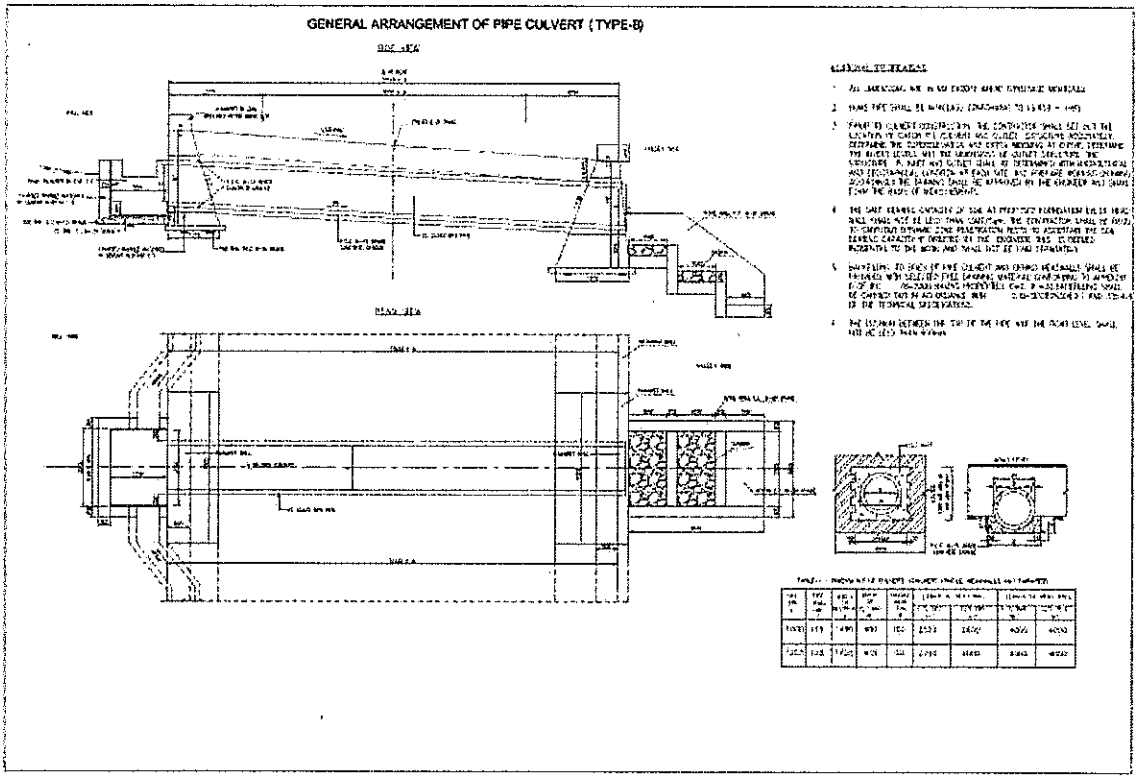
Source: JICA Study Team

Figure 5.2-15 General arrangement plan for BOX culvert



Source: JICA Study Team

Figure 5.2-16 General arrangement plan for pipe culvert (Type-A)

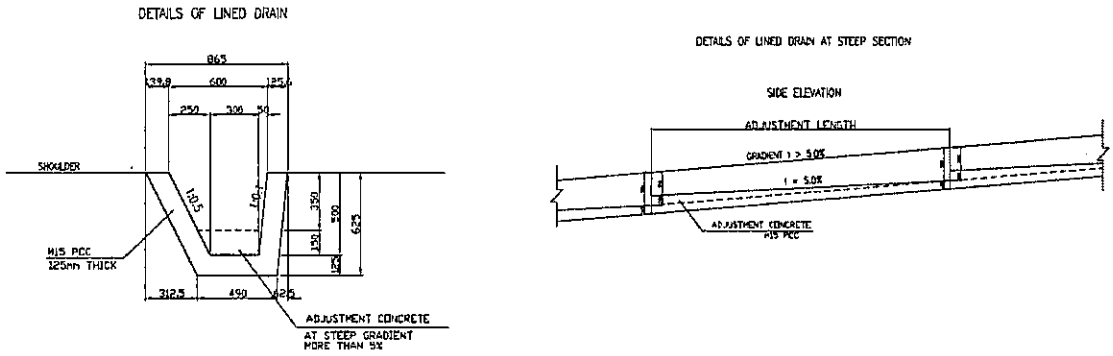


Source: JICA Study Team

Figure 5.2-17 General arrangement plan for pipe culvert (Type-B)

(b) Side ditch structure

The side ditch on road is designed as concrete lined ditch for all section of cut side.
General arrangement plan for side ditch is shown in figure below.



Source: JICA Study Team

Figure 5.2-18 General arrangement plan for side ditch

(c) Drainage arrangement plan

The cross drainage arrangement is planned with following policy.

(i) The cross-drainage which has capable dimension for the estimated discharge or pipe culvert 1.2m in minimum is arranged at the location where the crossing water estimated by hydrological map computation.

(ii) Side ditch capacity is not satisfied if an interval between cross-drainages is too long. Hence, a pipe culvert 1.2m is planned to complement the long interval to shorten to 300m in maximum.

The quantity of each culvert is summarized in Table 5.2-19.
Here, a ratio between type-A and type-B for pipe culvert quantity is estimated as 0.4 : 0.6 for a conveniency.
The cross-drainage list for all of NH54 bypass is prepared in Appendix.

Table 5.2-19 Quantity for each culverts

	Bypass No.1	Bypass No.2	Bypass No.3	Bypass No.4
Pipe culvert 1.2m	19	78	40	13
(TYPE-A)	8	31	16	5
(TYPE-B)	11	47	24	8
BOX culvert 2x2m	1	8	12	6
BOX culvert 3x3m	0	2	5	0
BOX culvert 4x4m	0	3	0	0
Total	20	91	57	19

Source: JICA Study Team

5.2.7 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, facilities listed in Table 5.2-20 are discussed for application to the Project.

Table 5.2-20 Traffic Safety Facilities to be Applied for NH54 Bypass

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	Guard Rail	
5	Street Furniture (Blinker, Road Stud/Cats Eye)	MoRTH's Research Project R-63

Source: JICA Study Team

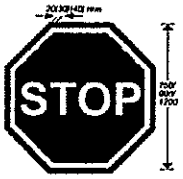
(2) Traffic Sign

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.

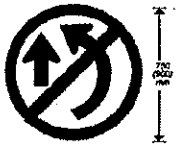
Figure 5.2-19 shows some of typical traffic signs to be installed for the target roads.

Mandatory/Regulatory Signs



Stop

Give Way



No Overtaking

No Parking

Cautionary/Warning Signs

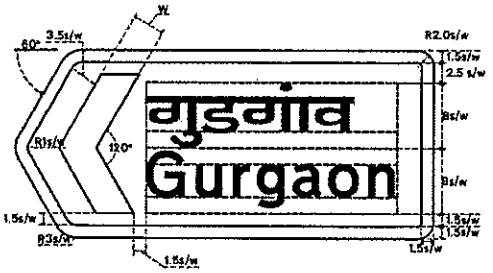
Hair-Pin Bend

Side Road

Narrow Road Ahead

Narrow Bridge Ahead

Informatory/Guide Sings



Flag Type Direction Sign

Toilet

Source: IRC: 67-2012 Code of Practice for Road Signs (Third Revision)

Figure 5.2-19 Typical Traffic Signs

In this study, the traffic signs are suggested as Table 5.2-21 in accordance with IRC: 67-2012.

Table 5.2-21 Suggestion of Traffic Signs for NH54 Bypass

Item	Type of Traffic Signs	Location of Installation
90 cm equilateral triangle	 T-Intersection Major Road Ahead  Side Road	- Installation at front side of intersection and side road
90 cm equilateral triangle	 Reverse Bend  Hand Curve	- Installation at front side of reverse bend and hand curve
90 cm equilateral triangle	 Narrow Bridge Ahead	- Installation at front side of bridge
60 cm circular	 Maximum Speed Limit	- Installation at start and end point of bypass - Installation every 2 km
80 cm x 60 cm rectangular	 Flag Type Direction Sign	- Installation at front side of intersection

Source: IRC: 67-2012 Code of Practice for Road Signs (Third Recision)

In this Study, as a result, the number of traffic signs are estimated as shown in Table 5.2-22.

Table 5.2-22 Traffic Signs Estimated for NH54 Bypass

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
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	19	70	28	20
(ii)	60 cm equilateral triangle	Each	0	0	0	0
(iii)	60 cm circular	Each	4	12	8	4
(iv)	80 cm x 60 cm rectangular	Each	9	8	8	12
(v)	60 cm x 45 cm rectangular	Each	0	0	0	0
(vi)	60 cm x 60 cm square	Each	0	0	0	0

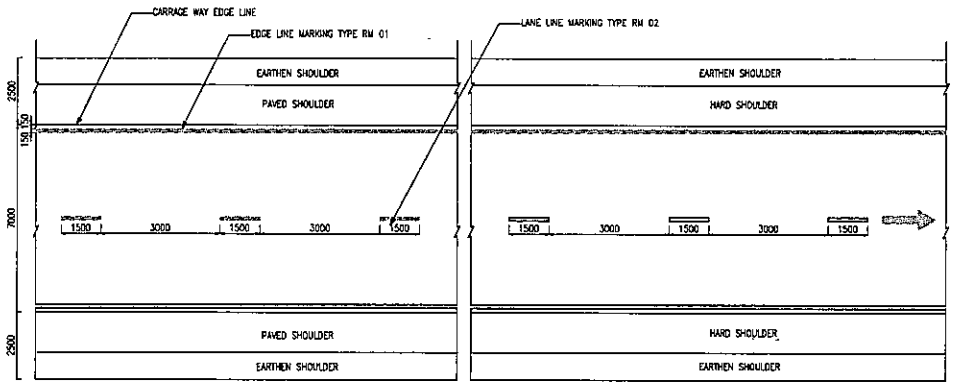
Source: JICA Study Team

(3) Road Marking

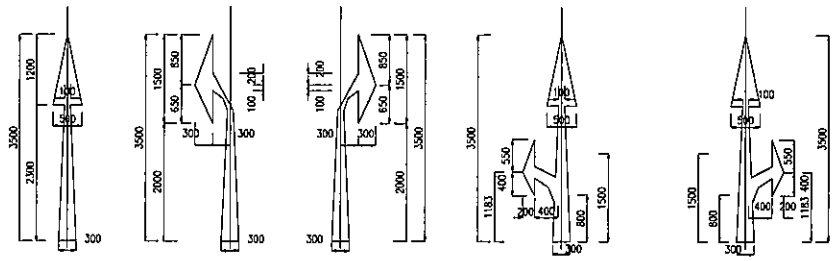
Road markings perform important functions of guiding and controlling traffic on roads. They serve as a psychological barrier and signify the delineation of traffic hazards for safe movement of traffic. Traffic markings also channelize, ensure smooth and orderly flow of traffic. Therefore, suitable road markings shall be provided on roads in accordance with IRC: 35-1997.

Figure 5.2-20 shows some of typical road markings to be provided for the target roads.

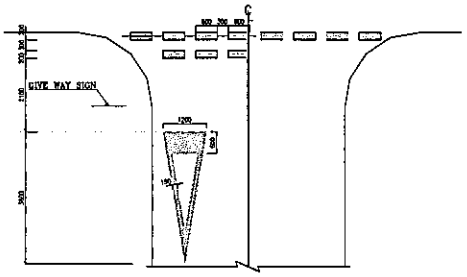
Typical Layout of Road Marking



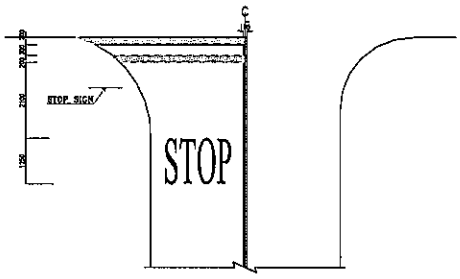
Route Directional Arrows



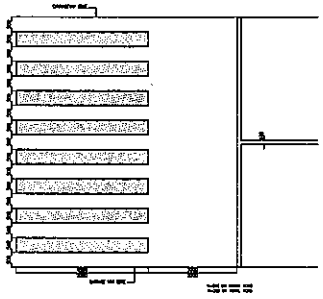
Access Road (Give Way)



Access Road (Stop)



Pedestrian Crossing



Source: Detailed Project Report for National Highway No.54 Section-2

Figure 5.2-20 Typical Road Markings

Road markings for NH54 are proposed as shown in Table 5.2-23 in DPR.

Table 5.2-23 Road Markings proposed in DPR for NH54

Item	NH54-S1	NH54-S2	NH54-S3
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)

Summarized by JICA Study Team

In this Study, road markings shown in Table 5.2-24 are considered for the NH54 Bypass based on unit quantity per kilometer of 250 sqm which is adopted in DPR.

Table 5.2-24 Road Markings Estimated for NH54 Bypass

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
			L=2.573km	L=11.805km	L=7.025km	L=2.636km
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	643	2,951	1,756	659

Source: JICA Study Team

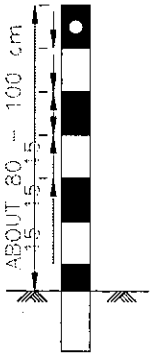
(4) Road Delineator

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 condition of heavy rain, fog or snow. IRC: 79-1981 stipulates the standards for the post type delineators with retro-reflective units.

Figure 5.2-21 shows typical type of road delineator with circular retro-reflector.

In this Study, road delineators are suggested as follows in accordance with IRC: 79-1981.

- Road embankments exceeding 3 m in height.
- Spacing on straight section is 70 m from each other.
- Spacing on horizontal curve section is as shown in Table 5.2-25.



Source: Detailed Project Report for National Highway No.54 Section-2

Figure 5.2-21 Typical Road Delineator

Table 5.2-25 Recommended Spacing for Roadway Indicators on Horizontal Curves

Radius of curve (meters)	Spacing on curve, S (meters)
30	6
50	8
100	12
200	20
300	25
400	30
500	35
600	38
700	42
800	45
900	48
1000	50

Source: IRC: 79-1981 Recommended Practice for Road Delineators

Road delineators for NH54 Bypass are estimated as shown in Table 5.2-26.

Table 5.2-26 Road Delineators Estimated for NH54 Bypass

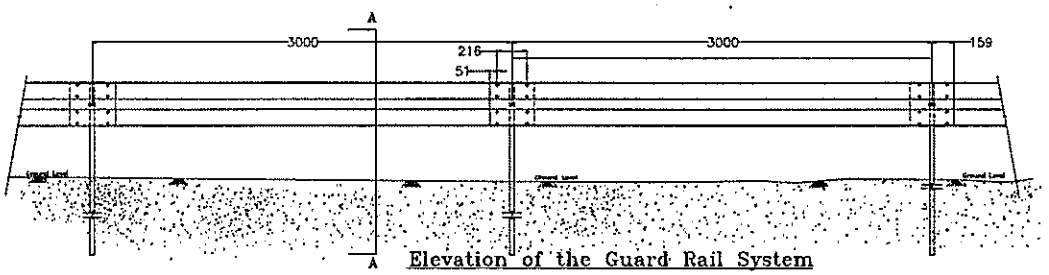
SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
8.15	Road Delineators (Supplying and installation of delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 15 cm wide stripes, fitted with 80 x 100 mm rectangular or 75 mm dia circular	each	132	1,155	801	181

Source: JICA Study Team

(5) Guard Rail

DPR adopts single "W" type steel guard rails for selected locations including valley side of curves, high embankment sections, approaches to bridges and built-up areas.

Figure 5.2-22 shows typical single "W" type of guard rail.



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 5.2-22 Typical Guard Rail

In this Study, the length of guard rails is considered based on the drawings of each Bypass. The length of guard rails is estimated as shown in Table 5.2-27.

Table 5.2-27 Guard Rails Estimated for NH54 Bypass

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
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	1,200	3,150	1,200	1,250

Source: JICA Study Team

(6) 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 center 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, street furniture are suggested to install at center and both side of road of location as follows. Space of street furniture is 2 m from each other.

- Sharp outer curve
- Near houses
- Section in parallel with other road
- Center and both side

Street furniture are estimated as shown in Table 5.2-28.

Table 5.2-28 Street Furniture Estimated for NH54

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
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	1,650	7,200	3,600	1,650

Source: JICA Study Team

5.2.8 Road Appurtenances Plan

(1) Scope of Road Appurtenances

Road appurtenances are miscellaneous facilities for road administrators to maintain their roads efficiently. In this Study, facilities listed in Table 5.2-29 are suggested for NH54 Bypass.

Table 5.2-29 Road Appurtenances for NH54 Bypass

No.	Item	Remarks / Related Code
1	Kilometer Stone	IRC8-1980, IRC26-1967
2	Boundary Stone	IRC25

Source: JICA Study Team

(2) 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 5.2-30 shows estimated number of kilometer stones for the NH54 Bypass.

Table 5.2-30 Kilometer Stones Estimated for NH54 Bypass

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
			L=2.573km	L=11.805km	L=7.025km	L=2.636km
8.14	Kilo Metre Stone (Reinforced cement concrete M15grade kilometre stone of standard design as per IRC: 8-1980, fixing in position including painting and printing etc)	sqm				
(i)	5th Kilometre Stone (Precast)	each	0	2	1	0
(ii)	Ordinary Kilometre Stone (Precast)	each	2	9	6	2
(iii)	Hectometer Stone (Precast)	each	10	48	28	11

Source: JICA Study Team

(3) 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 5.2-31 summarizes boundary stones of NH54 proposed in DPR.

Table 5.2-31 Boundary Stones proposed in DPR for NH54

Item	NH54-S1	NH54-S2	NH54-S3
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)

Summarized by JICA Study Team

In this Study, boundary stones shown in Table 5.2-32 are considered for the NH54 Bypass based on unit quantity per kilometer of 20.02 which is adopted in DPR.

Table 5.2-32 Boundary Stones Estimated for NH54 Bypass

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
			L=2.573km	L=11.805km	L=7.025km	L=2.636km
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	52	236	141	53

Source: JICA Study Team

5.2.9 Preliminary Study of Spoil Bank

(1) General

Concerning the result of preliminary design for NH-54 Bypass, the necessary volume of spoil bank has been calculated as shown Table 5.2-33.

Table 5.2-33 Required Volume for Spoil Bank

Bypass Name	Item	Volume of Generated Soil	Coefficient of Compaction	Volume of Compacted Soil	Required Volume of Spoil Bank
		Cu.m		Cu.m	Cu.m
Chhiahtlang Bypass	Cut Soil	127,499	0.9	114,749	77,238
	Fill Soil			37,511	
Serchhip Bypass	Cut Soil	743,768	0.9	669,391	481,306
	Fill Soil			188,085	
Hnahthial Bypass	Cut Soil	379,505	0.9	341,555	252,047
	Fill Soil			89,508	
Lawngtlai Bypass	Cut Soil	247,013	0.9	222,312	154,547
	Fill Soil			67,765	

Source: JICA Study Team

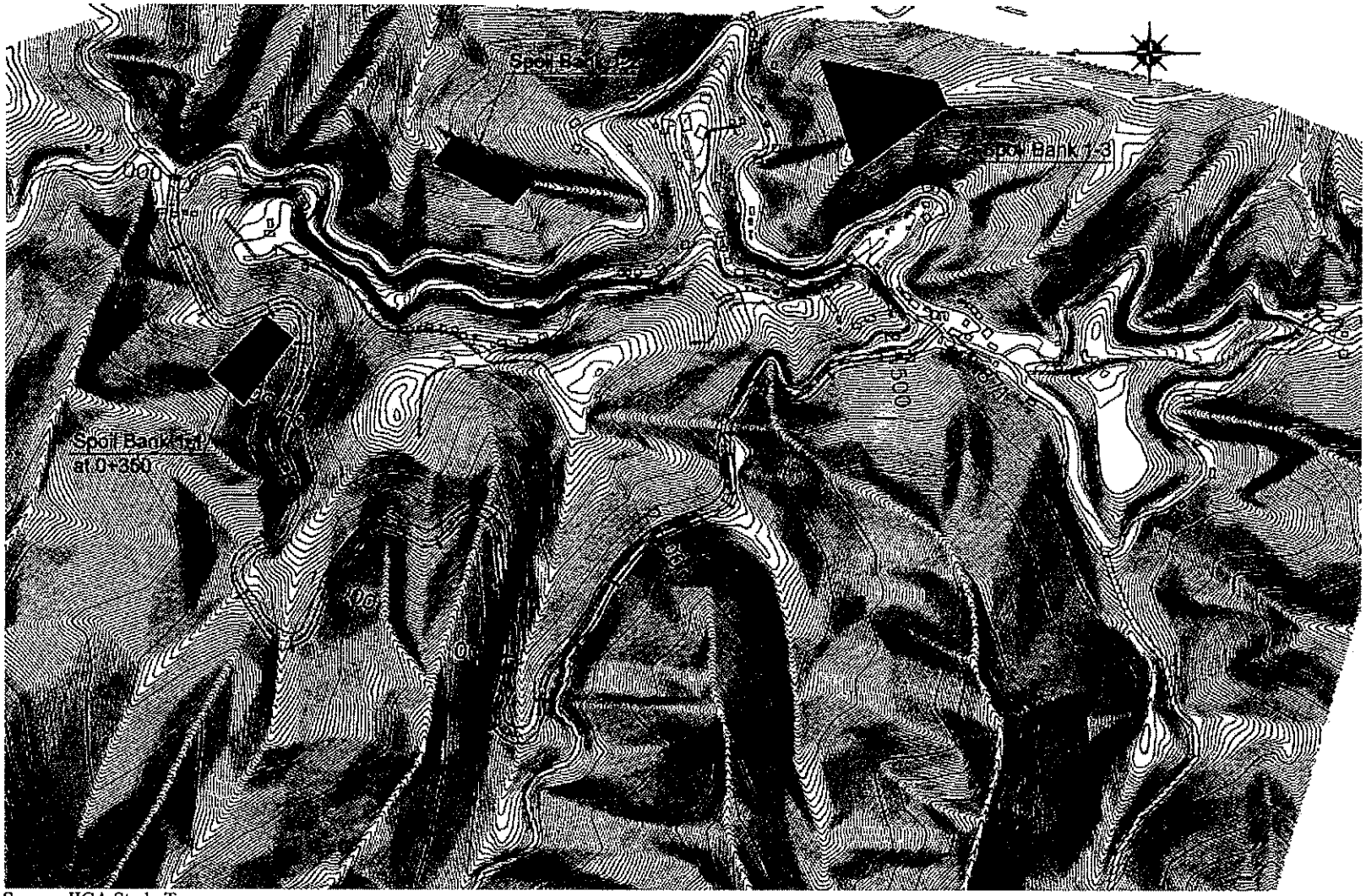
(2) Condition of Spoil Bank Selection

JICA Study Team has examined to identify target locations where seems to have sufficient and required conditions for spoil bank construction. Followings are assumed conditions for suitable locations for that.

- ❖ To find out suitable place along NH-54 Bypass with following condition;
  - Ground shape with concavity topography
  - Less ground gradient than 22 degree 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 in less than 30m height

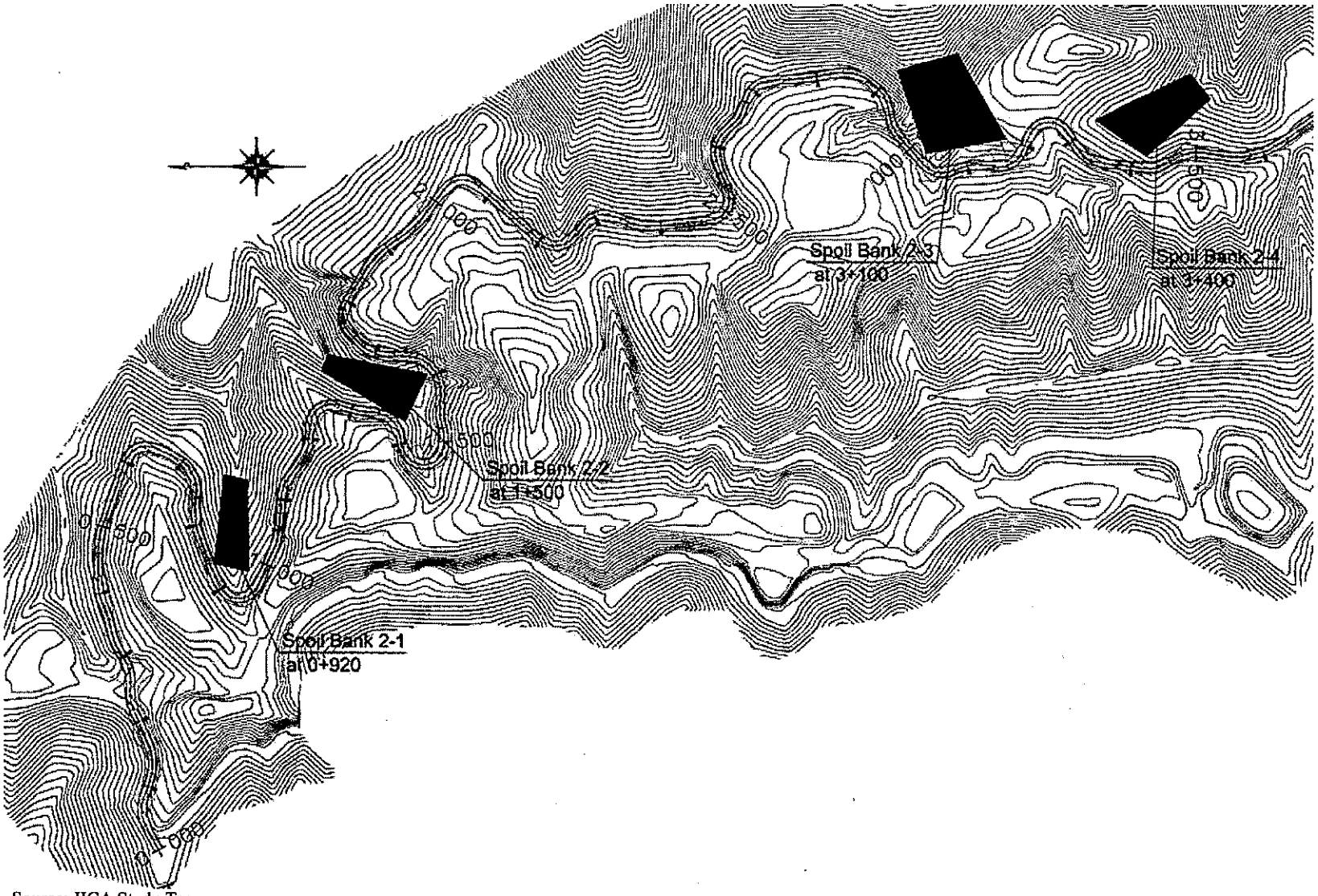
(3) Result of Examination for Spoil Bank Location

In accordance with above assumed conditions, locations of spoil bank are selected as Figure 5.2-23 to Figure 5.2-32 and capacities of spoil bank are calculated as shown in Table 5.2-34 and Table 5.2-35.



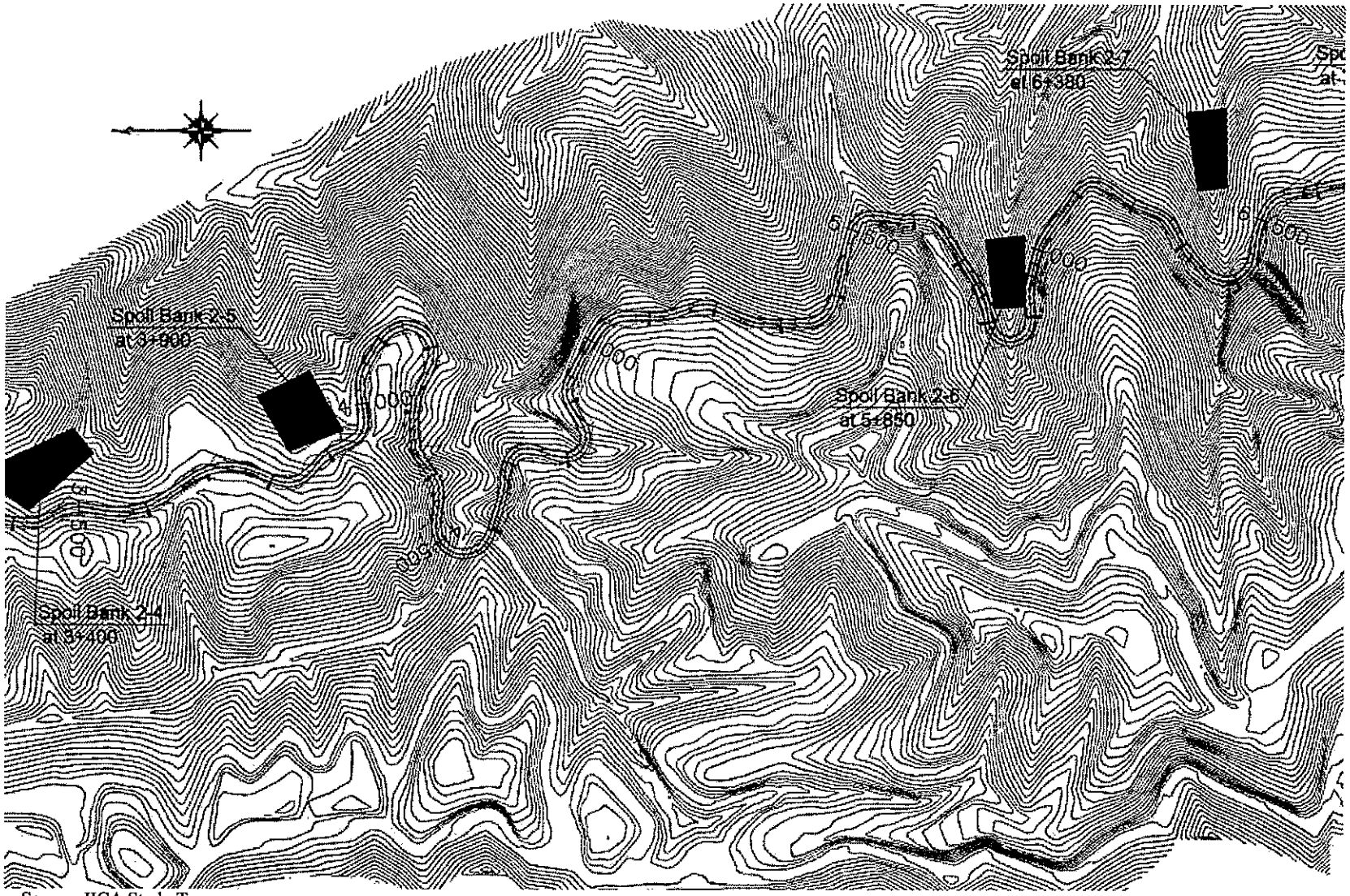
Source: JICA Study Team

Figure 5.2-23 Plan for Locations of Spoil Bank (Chhiahtlang Bypass)



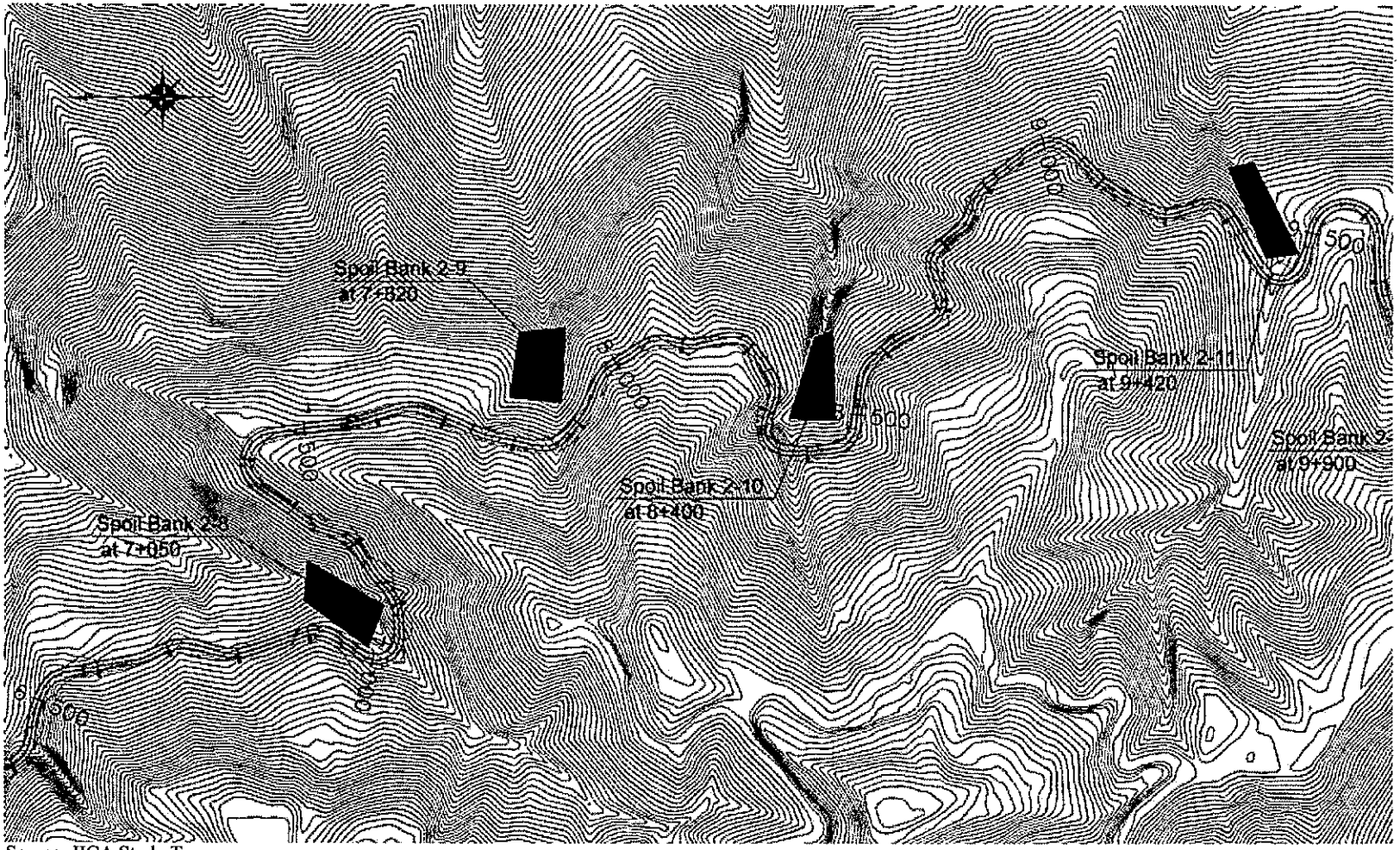
Source: JICA Study Team

Figure 5.2-24 Plan for Locations of Spoil Bank (Serchhip Bypass) -1/4



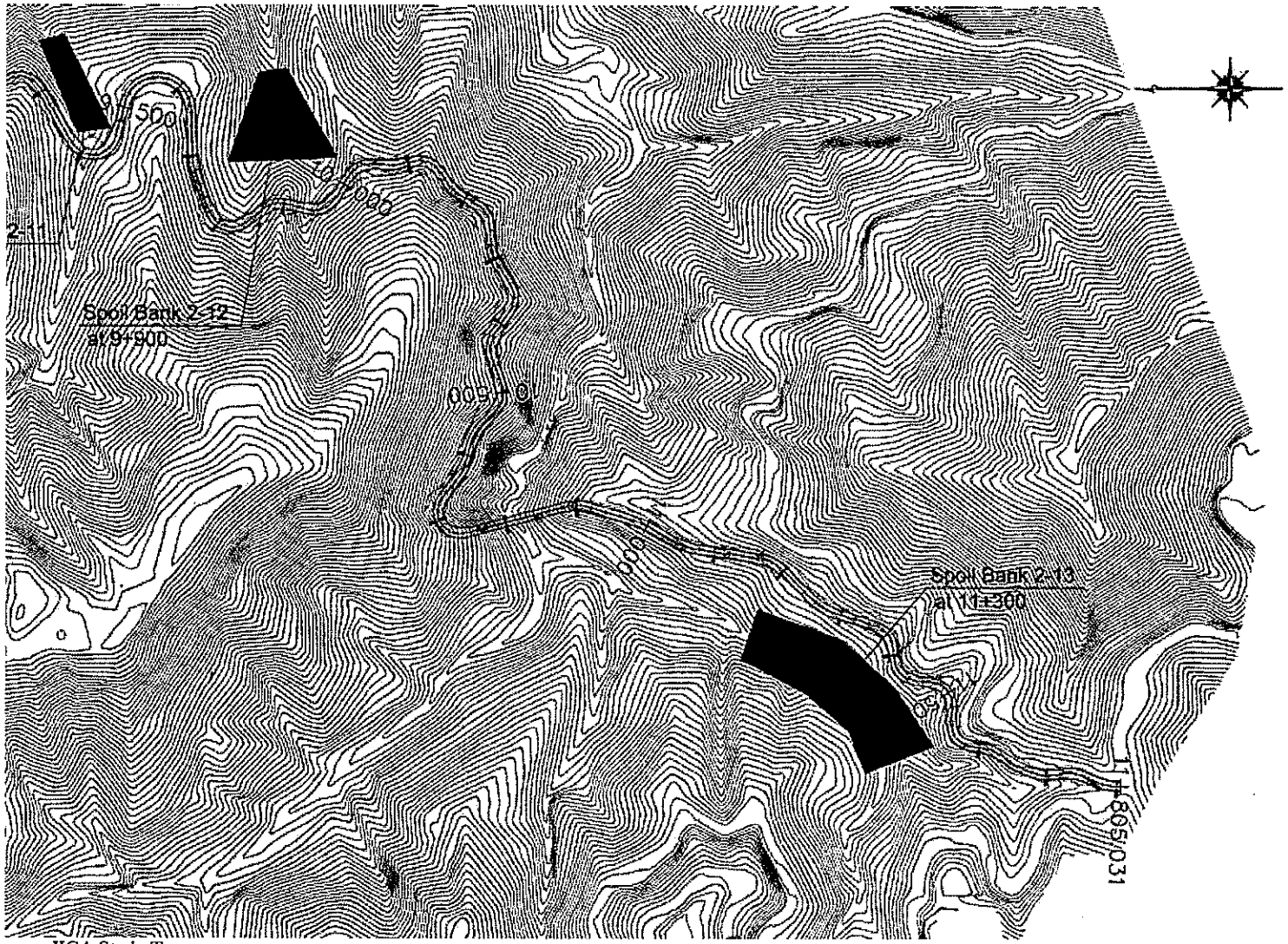
Source: JICA Study Team

Figure 5.2-25 Plan for Locations of Spoil Bank (Serchhip Bypass) -2/4



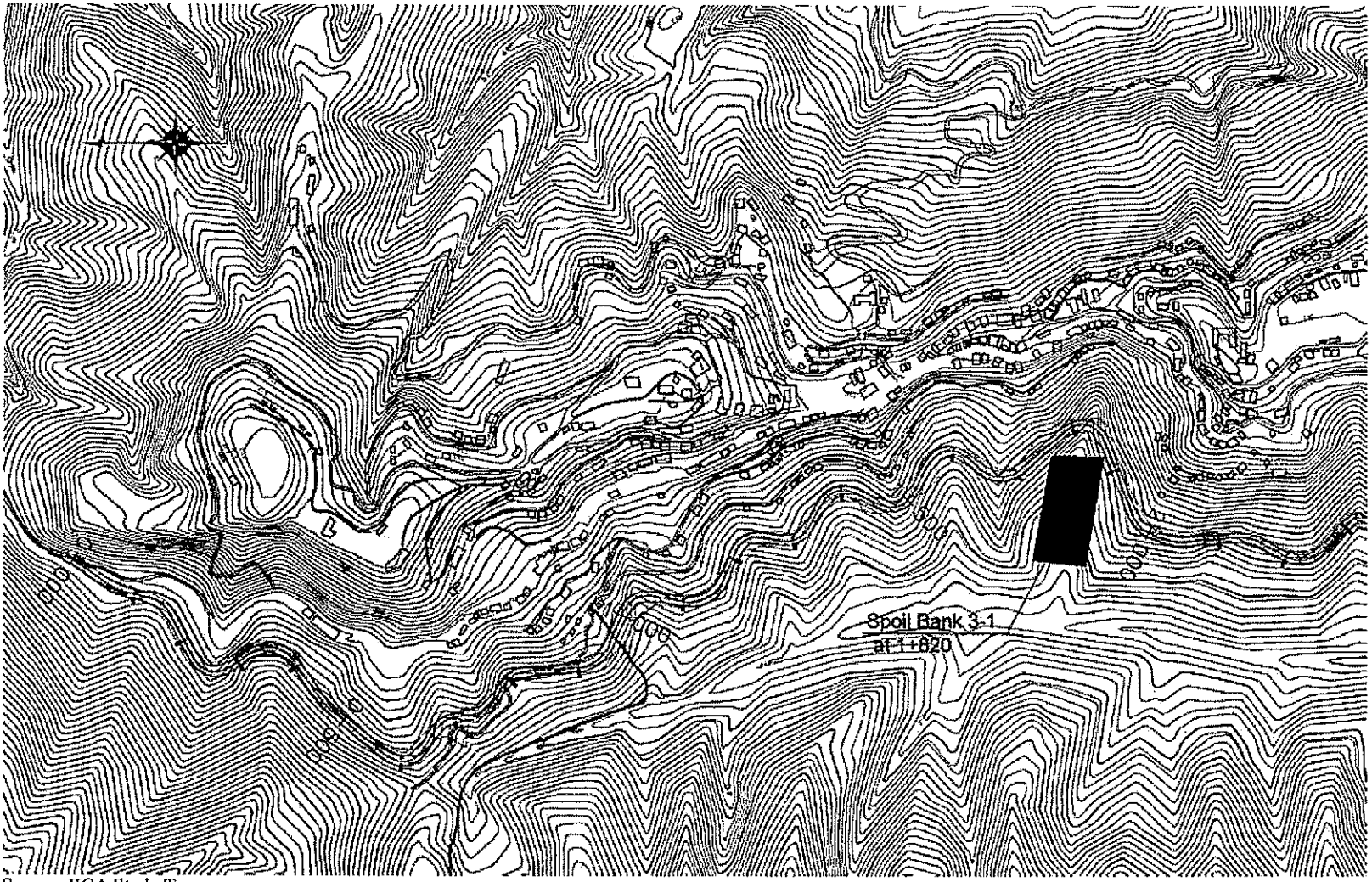
Source: JICA Study Team

Figure 5.2-26 Plan for Locations of Spoil Bank (Serchhip Bypass) -3/4



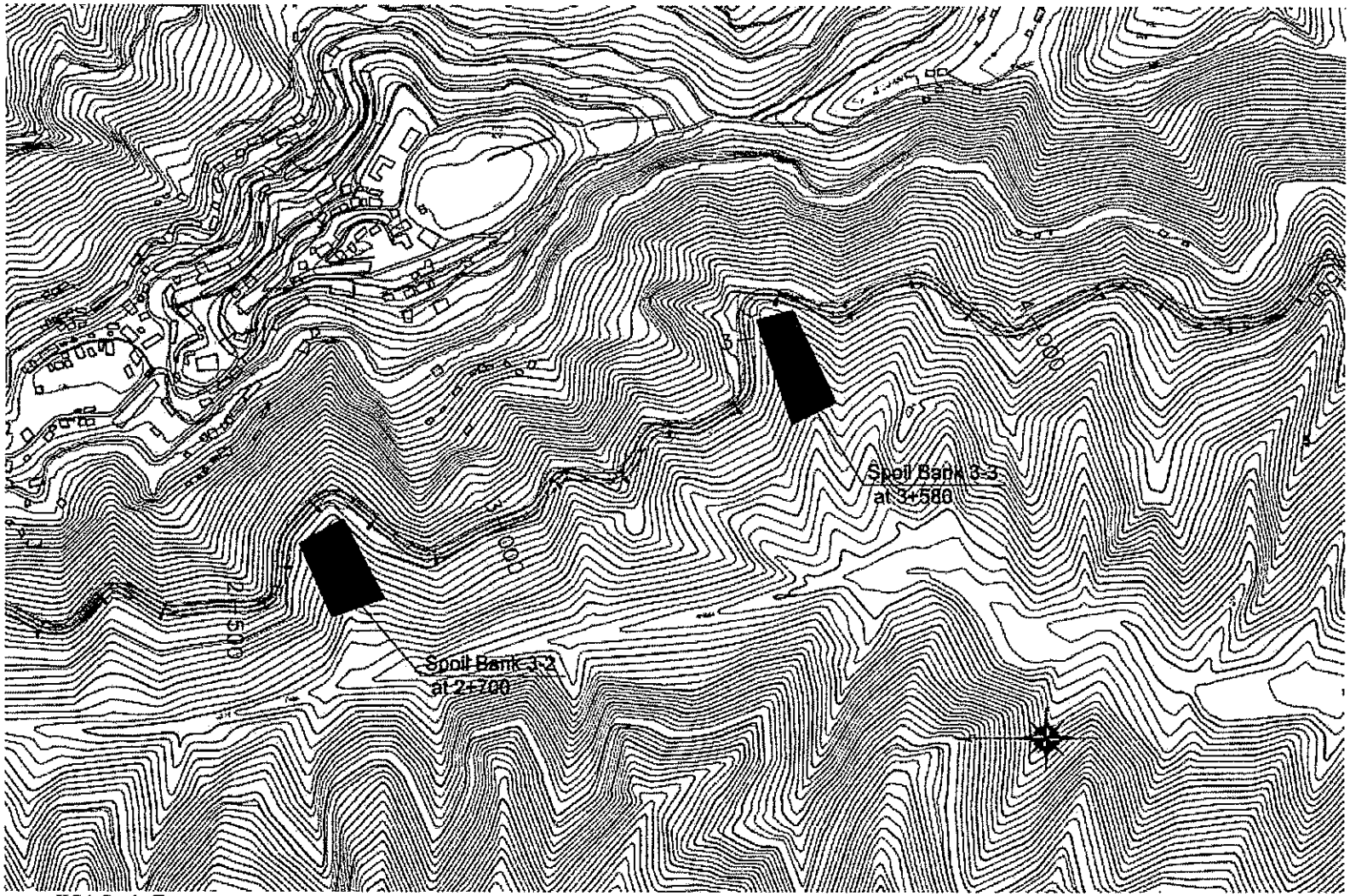
Source: JICA Study Team

Figure 5.2-27 Plan for Locations of Spoil Bank (Serchhip Bypass) -4/4



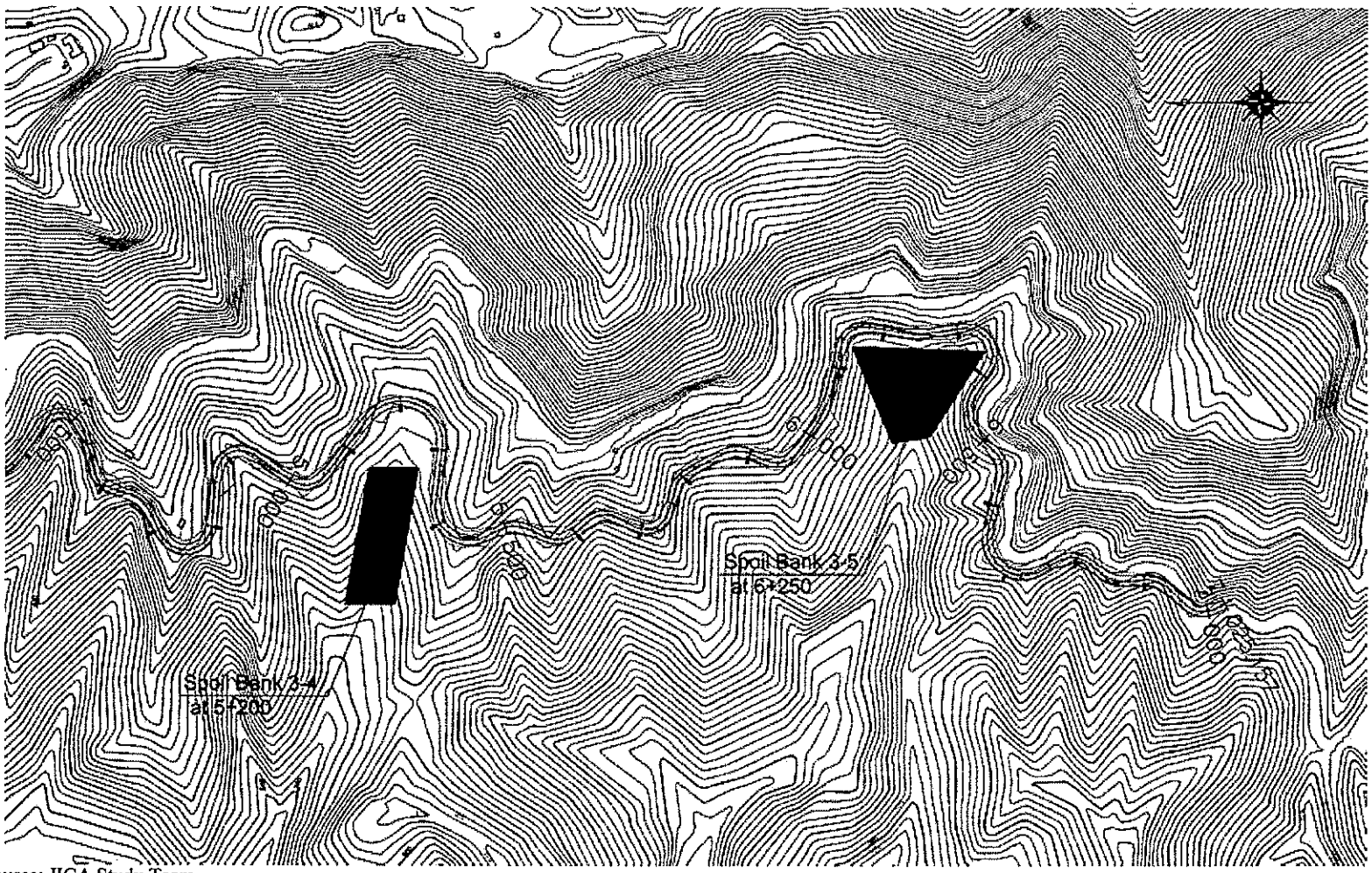
Source: JICA Study Team

Figure 5.2-28 Plan for Locations of Spoil Bank (Hnathial Bypass) -1/3



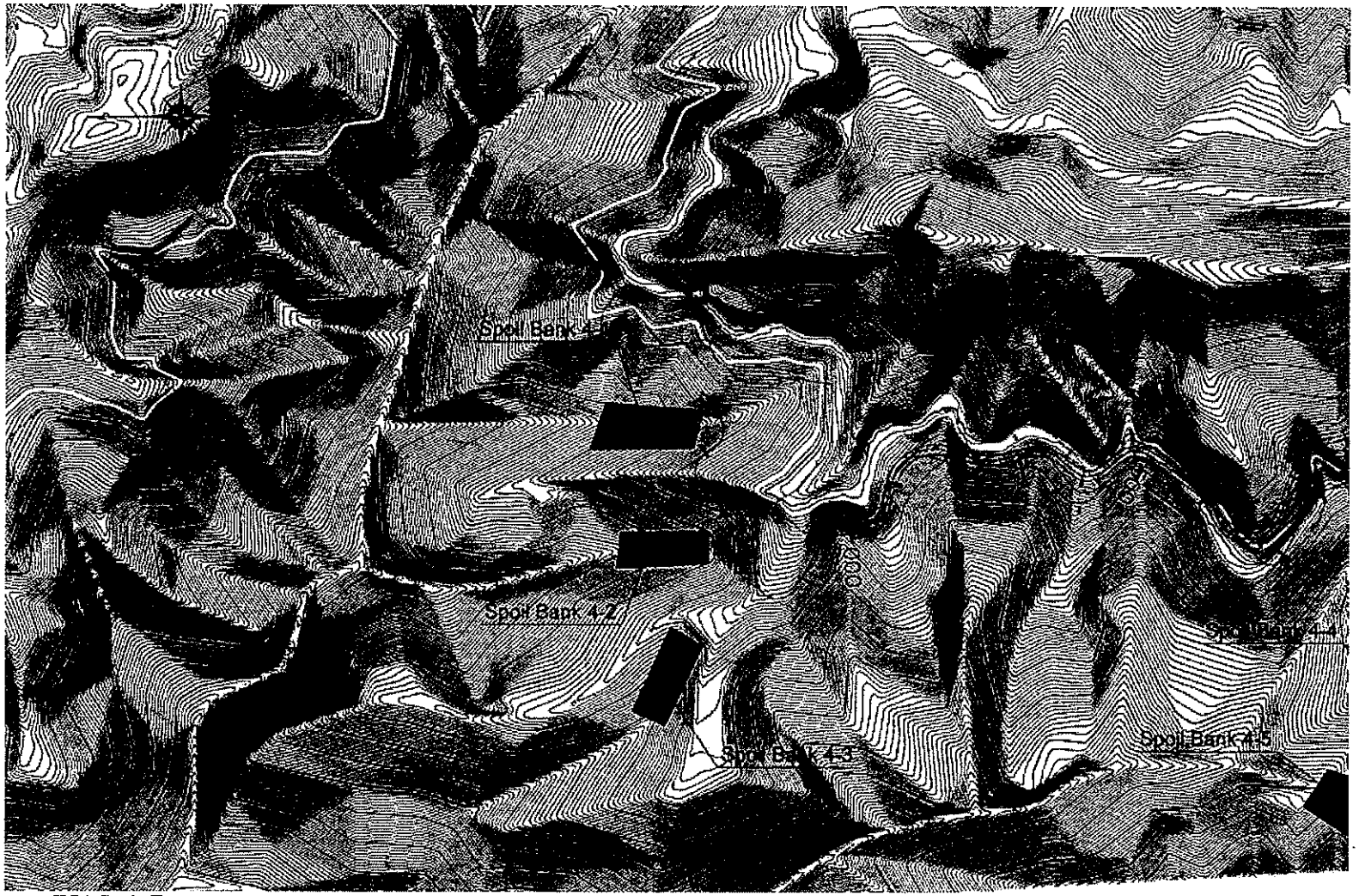
Source: JICA Study Team

Figure 5.2-29 Plan for Locations of Spoil Bank (Hnathial Bypass) -2/3



Source: JICA Study Team

Figure 5.2-30 Plan for Locations of Spoil Bank (Hnathial Bypass) -3/3



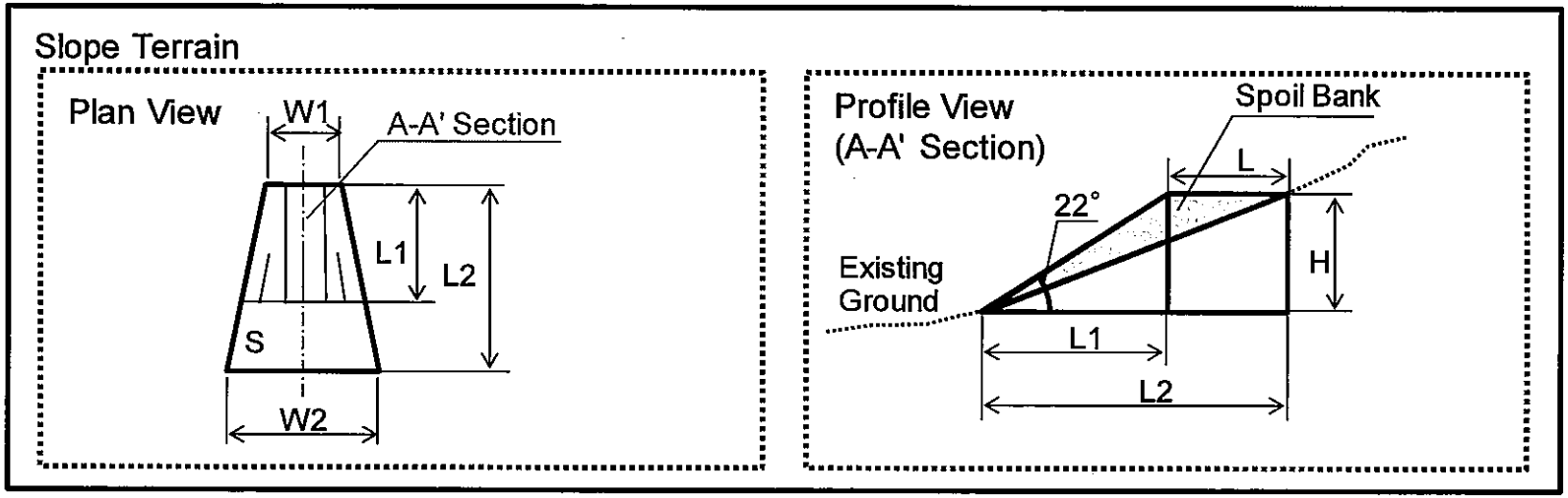
Source: JICA Study Team

Figure 5.2-31 Plan for Locations of Spoil Bank (Lawngtlai Bypass) -1/2

Source: JICA Study Team

Figure 5.2-32 Plan for Locations of Spoil Bank (Lawngtlai Bypass) -2/2

Table 5.2-34 Capacities of Spoil Bank-1/2



Bypass Name	Sl. No.	STA.	H	L2	W1	W2	L1 =H/tan22	L=L2-L1	L/L2	S	V	D1	Volime of Spoil Bank	
													Plan	Require
			m	m	m	m	m	m	%	m2	m3	m	m3	m3
Chhiahtlang Bypass	1-1	0+350	30	101	55	43	74.3	26.7	26%	1,286	12,860	80.1	12,860	
	1-2	-	30	113	43	37	74.3	38.7	34%	1,536	15,360	80.1	15,360	
	1-3	-	30	132	145	32	74.3	57.7	43%	5,023	50,230	80.1	50,230	
												Total	78,450	77,238
Serchhip Bypass	2-1	0+920	30	130	35	50	74.3	55.7	42%	2,320	23,200	80.1	23,200	
	2-2	1+500	30	142	24	75	74.3	67.7	47%	3,303	33,030	80.1	33,030	
	2-3	3+100	30	133	90	117	74.3	58.7	44%	6,056	60,560	80.1	60,560	
	2-4	3+400	30	137	46	89	74.3	62.7	45%	4,161	41,610	80.1	41,610	
	2-5	3+900	30	94	83	82	74.3	19.7	20%	1,551	15,510	80.1	15,510	
	2-6	5+850	30	102	55	45	74.3	27.7	27%	1,377	13,770	80.1	13,770	
	2-7	6+380	30	113	57	42	74.3	38.7	34%	1,901	19,010	80.1	19,010	

Source: JICA Study Team

Table 5.2-35 Capacities of Spoil Bank-2/2

Bypass Name	Sl. No.	STA.	H	L2	W1	W2	L1 =H/tan22	L=L2-L1	L/L2	S	V	D1	Volime of Spoil Bank	
													Plan	Require
			m	m	m	m	m	m	%	m2	m3	m	m3	m3
Serchhip Bypass	2-8	7+050	30	113	53	59	74.3	38.7	34%	2,151	21,510	80.1	21,510	
	2-9	7+820	30	95	62	69	74.3	20.7	21%	1,306	13,060	80.1	13,060	
	2-10	8+400	30	116	26	62	74.3	41.7	35%	1,786	17,860	80.1	17,860	
	2-11	9+420	30	135	34	44	74.3	60.7	44%	2,316	23,160	80.1	23,160	
	2-12	9+900	30	120	38	146	74.3	45.7	38%	4,195	41,950	80.1	41,950	
	2-13	11+300	30	273	69	98	74.3	198.7	72%	16,412	164,120	80.1	164,120	
												Total	488,350	481,306
Hnathial Bypass														
	3-1	1+820	30	149	73	72	74.3	74.7	50%	5,401	54,010	80.1	54,010	
	3-2	2+700	30	117	76	69	74.3	42.7	36%	3,053	30,530	80.1	30,530	
	3-3	3+580	30	147	68	51	74.3	72.7	49%	4,285	42,850	80.1	42,850	
	3-4	5+200	30	186	67	66	74.3	111.7	60%	7,421	74,210	80.1	74,210	
	3-5	6+250	30	123	51	179	74.3	48.7	39%	5,516	55,160	80.1	55,160	
												Total	256,760	252,047
Lawngtlai Bypass														
	4-1	-	30	138	68	54	74.3	63.7	46%	3,872	38,720	80.1	38,720	
	4-2	-	30	123	49	43	74.3	48.7	39%	2,206	22,060	80.1	22,060	
	4-3	-	30	124	49	50	74.3	49.7	40%	2,455	24,550	80.1	24,550	
	4-4	-	30	118	36	64	74.3	43.7	37%	2,183	21,830	80.1	21,830	
	4-5	-	30	142	61	97	74.3	67.7	47%	5,272	52,720	80.1	52,720	
												Total	159,880	154,547

Source: JICA Study Team

5.2.10 Consideration of Climate Change Adaption

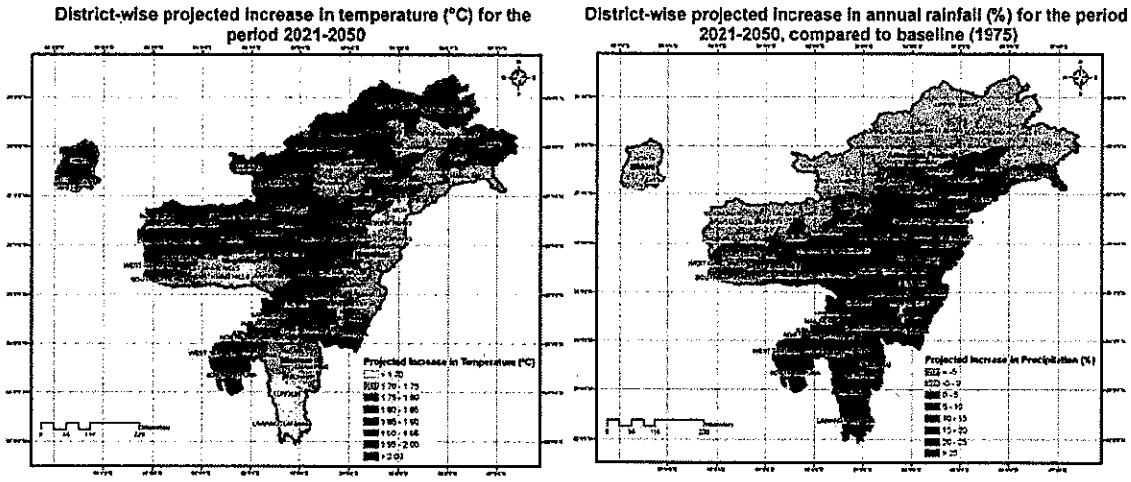
(1) Climate Change Situation in India

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 increase of frequency and intensity of cyclone, it will be necessary to improve and reinforce the road facilities.

Multi-sector mitigation strategies for climate change are proposed in India's Intended Nationally Determined Contribution submitted to United Nations Framework Convention on Climate Change. Safe, Smart and Sustainable Green Transportation Network is proposed as mitigation strategy on transportation sector and green highways (plantation & maintenance) policy to develop 140,000 km long "tree-line" with plantation along both sides of national highways is proposed as road sector measure.

In the North-East states in India, North East Climate Change Adaptation Programme has been carried out by KfW Development Bank and adaptation against the climate change is examined together with Ministry of Development of North-East Region. The Project Document in the programme mentioned the prediction of impact of the 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.
- According to the rainfall data for a period of 1901-2007, the annual mean precipitation has increased by 51 cm in 100years.
- The projected increase in annual rainfall is high in the central and east part of the states (see Figure 5.2-33 right). Especially, rainfall increase in rainy season (June-September) is expected to be significant in the eastern part including Mizoram state.
- Extreme rainfall events of 100-150mm per day and greater than 150 mm are predicted to increase with around 20% and 38% respectively.



Source: North East Climate Change Adaptation Programme

Figure 5.2-33 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 NH54. As presented in Figure 5.2-33, increase of annual rainfall is predicted 5-15% in NH54 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 5.2-36.

Table 5.2-36 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) Adaption Measure

The design policy of each item mentioned in clause 5.2 takes into consideration adaptation measures to the 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 because of fallen debris from the slope, that has caused heavy damage on the pavement. Therefore, the retaining wall and slope protection work are planned all along the road in this study.

Table 5.2-37 shows adaptation measures for climate change taken into consideration in this road design.

Road closure has frequently occurred on NH54 during rainy season since there are no appropriate slope protection measures on road side of NH54. It is expected that the adaption measures for side slope shown in Table 5.2-37 will drastically reduce the road closure caused by slope failure.

Table 5.2-37 Adaption 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 & 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	- Super elevation is installed properly. - Pavement material is examined not to rise over 60 °C on the surface.
Road Sign	- Wind load and visibility is taken into consideration.

Source: JICA Study Team

June 2016.

CHAPTER 8 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 Legal and Regulatory Framework Related to Environmental and Social Considerations

8.1.1 Requirement of EIA under Indian Regulations

As per MOEF EIA Notification dated 14.09.2006 (as amended in August 2013), any highway project falls under Category A if the project entails *i) New National Highways; and ii) Expansion of National Highways greater than 100km involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on re-alignments and bypasses*. The proposed bypasses do not trigger these requirements and therefore, the project does not require environmental clearance from MOEF[1].

On the other hand, the project has been classified as Category A as per JICA's Environmental and Social Guidelines, for which a full EIA study is required. Based on this backdrop, an EIA study has been carried out as per JICA's guidelines. The project also results involuntary resettlement of 20 households (133 persons) for which a Resettlement Action Plan has been prepared.

8.1.2 Requirements of Clearance and Permits

As discussed earlier, Environmental Clearance is not required for this project as the scale of widening and land acquisition for this project is not significant enough not trigger the requirement. However, the forest clearance permit will have to be obtained prior to the commencement of construction activity, as per the requirement of the Forest Act. According to the discussions held with Department of Environment and Forests, the application will be processed at various Forest Department offices at Division, State and Central Government level depending on forest land requirement for non-forest purposes. Part 1 of the application format has to be filled in by NHIDCL, the project proponent while Part 2 of the application will be cleared by the Forest Division. Part 3 will be cleared at State Environment and Forest Department while Part 4 (at Nodal Officer under Forest Conservation Act) and Part 5 (Secretary of Department of Environment and Forest at Government of Meghalaya) will clear them before forwarding it to Ministry of Environment and Forest in Delhi for appraising and issuing Forest Clearance.

Also, various clearance will be required for setting up hot-mix plants, batching plants, etc., under the Air and the Water Acts. Clearance from the State Department of Mining is required for establishing quarries. Clearance from the Sate Ground Water Boards/Authorities is required for establishment of new tube-wells/bore-holes in case they are required during construction work. Also, the provisions as laid down in the Factories Act, 1948, Labor Act, 1988 and the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 with respect to hygiene and health during the construction stage would apply for this project. With limited possibility, the provisions of the Hazardous Wastes (Management and Handling) Rules, 1989 and the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 may also apply during the construction and the operation periods. The applicability of environmental and other relevant rules and acts is shown in Table 8.1-1 Requirements of Environment-Related ClearanceTable 8.1-1.

Table 8.1-1 Requirements of Environment-Related Clearance

No.	Activity	Statute	Requirement	Competent Authority	Responsible Agency for Obtaining Clearance	Time Required

1 The project requires NOC (Consent-for-Establishment and Consent-for-Operation) from the respective State Pollution Control Board, which will be discussed in more detail Chapter 3.

Pre-Construction Stage (Responsibility: MORTH)						
2	Road-side tree cutting and clearing forest	Forest Conservation Act1980 & MOEF Letter Dt.18.02.1998	Permission for Road-side tree cutting	State and Central Government	MORTH	2-3 months
3	Filling of Roadside water bodies (ponds and borrow pits)	State Fisheries Policy Draft Wetlands (Conservation & Management) Rules, 2008	Permission for filling of water bodies	State Irrigation Department State Fisheries Department State Wetlands Conservation Committee	MORT&H	2-3 months
Construction Stage (Responsibility: Contractor)						
1	Establishing stone crusher, hot mix plant, wet mix plant and Diesel Generator Sets	Water Act of 1974, Air Act of 1981, Noise Rules of 2000 and Environmental Protection Action of 1986 and as Amended	Consent-forest abolishment	States Pollution Control Boards for respective section	Contractor	4-6 months
2	Operating stone crusher, hot mix plant, wet mix plant and Diesel Generator Sets	Water Act of 1974, Air Act of 1981, Noise Rules of 2000 and Environmental Protection Action of 1986 and as Amended	Consent-for operation	States Pollution Control Boards for respective section	Contractor	4-6 months
3	Use and storage of explosive for quarry blasting work	India Explosive Act 1984	Explosive licence for use and storage	Chief Controller of Explosives	Contractor	2-3 months
4	Storage of fueloil, lubricants, diesel etc. at construction camp	Manufacture storage and Import of Hazardous Chemical Rules 1989	Permission for storage of hazardous chemical	States Pollution Control Boards for respective section and or Local Authority (DC)	Contractor	4-6 months
5	Quarry Operation	State Minor Mineral Concession Rules, The Mines Act of1952, Indian Explosive Act of1984, Air Act of1981 and WaterAct of 1974	Quarry Lease Deed and Quarry License	State Department of Mines and Geology	Contractor	4-6 months
6	Extraction of ground water	Ground Water Rules of 2002	Permission for extraction of ground water foruse in road construction activities	State Ground Water Board	Contractor	4-6 months
7	Engagement of labor	Labor Act	Labor license	Labor Commissioner	Contractor	2-3 months

Source: JICA Study Team

8.1.3 Institutional Setup

The environmental regulations, legislation, policy guidelines and control that may impact this project, are the responsibility of a variety of government agencies. In all, following agencies would play important roles in this project.

(1) Ministry of Environment and Forests (MOEF)

The primary responsibility for administration and implementation of the Government of India's (GOI) policy with respect to environmental management, conservation, ecologically sustainable development and pollution control rests with the Ministry of Environment and Forests (MOEF). Established in 1985, the MOEF is the agency primarily responsible for the review and approval of EIAs pursuant to GOI legislation.

(2) MOEF Regional Offices

The Ministry of Environment and Forests (MOEF) has set up regional offices, with each region having an office. The office that cover North Eastern zone including Mizoram is located at Shillong, Meghalaya. This office is responsible for collecting and furnishing information relating to EIA of projects, pollution control measures, methodology and status, legal and enforcement measures and environmental protection in special conservation areas such as wetlands, mangroves and biological reserves.

(3) Central Pollution Control Board (CPCB)

Statutory authority attached to the MOEF and located in New Delhi, the main responsibilities include inter alia the following:

- Planning and implementing water and air pollution programs;
- Advising the Central Government on water and air pollution programs;
- Setting air and water standards; and
- Coordinating the various State Pollution Control Boards.

The role of the CPCB, (for this project) will only be in an advisory capacity while the project shall adhere to the norms and standards set up by the Mizoram State Pollution Control Board (MSPCB).

(4) Departments of Environment and Forests (DOEF)

They perform the functions similar to the MOEF at the state level.

(5) Mizoram State Pollution Control Board (M-SPCB)

The M-SPCB has the mandate for environmental management at the state level, with emphasis on air and water quality. The board is responsible for:

- Planning and executing state-level air and water initiatives;
- Advising state government on air, water and industry issues;
- Establishing standards based on National Minimum Standards;
- Enforcing and monitoring of all activities within the State under the Air Act, the Water act and the Cess Act, etc.;
- Conducting and organizing public hearings for projects as defined by the various Acts and as stipulated by the Amendment (April 1997) to the EIA Act; and,
- Issuing No-objection Certificates (NOC) for industrial development defined in such a way as to include road projects as the Third National Highway Project.

(6) Mizoram State Forest Department

The Mizoram State Forest Department is responsible for the protection and managing the forest designated areas within the state. The Forest Department works out Forest Working Plans for the various forest divisions to manage and protect the forest resources. These plans form the basis for managing the forest resources and for chalking out specific plans and policies with respect to the

conservation, protection and development of the forest areas. The Forest department will be responsible for granting clearances for forest areas that need to be cleared for the project, according to the provisions of the Forest (Conservation) Act, 1980.

8.2 Legal and Regulatory Framework for Land Acquisition

8.2.1 Key Policies and Legislations

The Land Acquisition Act of 1894 has so far served as the base policy document on which the state government passes resolution to acquire land for different projects. This act is superseded by a new act (Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation, and Resettlement Act, 2013), which took effect on January 1, 2014. However, the State Government of Mizoram issued a notification (No. H. 11018/8/2010-REV, dated January 5, 2015) stating that the new act will not be used in Mizoram on the ground that being under the sixth schedule of the Constitution, the land within the state belongs to individuals and not to the government. The government is in the process of developing its own rule. The Mizoram (Land Acquisition, Rehabilitation, and Resettlement) Act 2016 generally follows the LARR 2013 but there are differences in terms of the additional benefits to rural area and solatium to be added to the compensation. In keeping view of the requirement under JICA Guidelines, the resettlement policy and entitlement proposed in a RAP report will be adopted in this project. Other applicable acts, notifications, and policies relevant in the context of the project are summarized below.

Table 8.2-1 Applicable Acts and Policies

No.	Acts, Notifications, Policies	Relevance and Applicability to the Project
1	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR 2013)	Provides for enhanced compensation and assistances measures and adopts a more consultative and participatory approach in dealing with the Project Affected Persons (PAPs). The Act took effect in January 2014, however, State of Meghalaya opposes to the provisions on the ground that being under the Sixth Schedule of the Constitution, land in the State belongs to the individuals and not the Government.
2	Mizoram (Land Acquisition, Rehabilitation and Resettlement) Act 2016	Generally follows the policies and provisions in LARR 2013, but differs in the amount of extra compensation paid for land acquisition in rural area and paymenet of solatium.
3	National Rehabilitation & Resettlement Policy, 2007 ((NRRP 2007)	Provides limited benefits to affected family (an ex-gratia payment of not less than Rs. 20,000/- and in case land-holder becoming landless or small or marginal farmer in such cases other rehabilitation benefits as applicable.
4	The National Tribal Policy, 2006	Provides an environment conducive to the preservation of traditional and customary systems and regime of rights and concessions enjoyed by different ST communities.
5	The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006	Provides for recognition of forest rights to Scheduled Tribes in occupation of the forest land prior to 13.12.2005 and to other traditional forest dwellers who are in occupation of the forest land for at least 3 generations i.e. 75 years, up to maximum of 4 hectares. These rights are heritable but not alienable or transferable.

6	The Right to Information Act, 2005	Provides for setting out the practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, the constitution of a Central Information Commission and State Information Commissions and for matters connected therewith or incidental thereto.
7	World Bank OP 4.12 – Involuntary Resettlement	The project requires additional land area for widening and strengthening, junction improvements, realignments, safety provisions, etc. It will also affect structures mainly used for residences, business units, cattle sheds and livelihood of people. Some of them are without any valid pass/permit. All affected under the project, irrespective of a valid pass/permit shall be supported under the project to improve their quality of life or at least restore to pre-project standards.
8	OP 4.10 – Indigenous Peoples	Over 90% of the population in the State belongs to Tribal community, and almost all affected households belong to ST. While a separate IPP report is not prepared, the issues discussed in RAP takes into account this fact and address issues related to indigenous peoples in the RAP. The project shall ensure broad community support for the project based on free prior and informed consultation.
9	JICA Guidelines for Environmental and Social Considerations	See 8.2.2 below

Source: JICA Study Team

8.2.2 Key gaps between LARR 2013 and JICA Guidelines

The following table summarizes key deviations between the two sets of legal and policy frameworks i.e. JICA policies and the existing Indian policies relevant to this project. The table also makes recommendations for measures to plug these gaps.

Table 8.2-2 Key Gaps between JICA Guidelines and Indian Regulations

Sl. No.	JICA Guidelines (2010)	Provisions in LARR 2013 and NRRP	Provisions in Mizoram Act 2016	Gaps Between JICA's Guidelines and Indian Policies	Proposed Gap Filling Measures
1	Involuntary resettlement should be avoided wherever possible.	Stated aim to minimize large scale displacement. Encourages projects to be set up on waste land, degraded land, Un-irrigated land. (NRRP 2007, #1.4, Chap 1)	--	No	-
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	If unavoidable, Govt. to consider different alternatives to minimize displacement, total land acquired and total agricultural land acquired for non agricultural use (NRRP 2007, #1.4, Chap 1), LARR has provision for compensation for losses incurred.	Provisions for compensating loss are included.	No	-
3	People who must be settled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	Provisions made for R&R benefits to all; but subject to condition that non titleholders must be residing or drawing livelihood in the affected area for a period not less than 3 years preceding date of declaration of the affected area. (NRRP, #3.1.b.iii)	Government will carry out social impact assessment to identify the scope of impact, which will inform the design of Rehabilitation Plan. Also, the Collector shall consider the impac of resettlement (change of residence or place of business) and provide reasonable expenses incidental to such change	Yes, Non titleholders need to be residing continuously or drawing livelihood from the affected area for a period not less than 3 years preceding the date of declaration. Both LARR and Mizoram Act are silent on compensation rights of Non Titleholders for loss of land (illegally occupied), structures. R&R benefits such as housing improvement, development benefits, loss of crops, trees, transitional support etc to be provided only if residing/ drawing livelihood for a continuous 3 year period in the area, preceding declaration of 'affected area'	Recognize claims of Non Title holders (as identified by census survey and irrespective of their residing period status) and in respect of – - Compensation for structures, trees - Structure transfer assistance - Structure reconstruction assistance - Shifting assistance for residential house owner - Tenant shifting allowance Assistance to be provided at par with similar R&R support extended to titleholder familiar

Sl. No.	JICA Guidelines (2010)	Provisions in LARR 2013 and NRRP	Provisions in Mizoram Act 2016	Gaps Between JICA's Guidelines and Indian Policies	Proposed Gap Filling Measures
4	Compensation must be based on the full replacement cost as much as possible	Compensation made on market rate as determined or recognized by state. Also, 100% of solatium is added to the final award.	Compensation made on market rate as determined by the Collector. Collector may add solatium to final compensation amount.	Yes, Market rate as calculated by government is usually far below the actual prevailing market rates. Solatium may serve as gap-filling tool, but in Mizo Act, the provision of solatium is not mandatory.	Compensation to be provided at full replacement cost based on prevailing market rates and additional allowances
5	Compensation and other kinds of assistance must be provided prior to displacement	Provisions exist in NRRP	--		-
6	For projects that entails large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	Requirement for RAP is mentioned subject to number of displaced exceeding 400 families in plains or 200 in hilly/tribal areas or Desert Development Programme (DDP) blocks.	--	Yes, numerical condition (400 in plain area, 200 in tribal, hilly or DDP blocks) attached. JICA requires RAP to be prepared for project involving large-scale resettlement.	Abbreviated RAP is prepared for this project.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	Specific mention provided in NRRP	--	No	-
8	When consultation held, explanation must be given in a form, manner, and language that are understandable to the affected people	Provision made	--	No	-
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement	Specified	Government carries out social impat assessment and prepares rehabilitation program in consultation with community	No	-

Sl. No.	JICA Guidelines (2010)	Provisions in LARR 2013 and NRRP	Provisions in Mizoram Act 2016	Gaps Between JICA's Guidelines and Indian Policies	Proposed Gap Filling Measures
	action plans				
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities	Specified	Process/procedures of lodging objection is specified	Yes, R&R Committee to be set up only if in the project area more 400 families (in plains) or 200 in tibal/hilly areas are to be displaced	- Two-tier GRM to be set up. - R&R implementing NGO/Consultant will be stationed in each project affected district and facilitate and inform PAHs about GRM and its processes.
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefit.	Specified under NRRP for identification of all affected persons	--	No	-
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under la), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no	Specified- R&R benefits to non titleholders provisioned by subject to them residing/ drawing livelihood for period not less than 3 years in the project affected area (from the date formal declaration)	--	Yes, Non titleholders if residing or drawing livelihood for a period less than 3 years are not eligible for R&R benefits	- All non-titleholders (as identified on the date of census survey) will also be eligible for R&R benefits

Sl. No.	JICA Guidelines (2010)	Provisions in LARR 2013 and NRRP	Provisions in Mizoram Act 2016	Gaps Between JICA's Guidelines and Indian Policies	Proposed Gap Filling Measures
	recognizable legal right to the land they are occupying				
13	Preference should be given to land –based resettlement strategies for displaced persons whose livelihoods are land-based.	Specified	--	No	-
14	Provide support for the transition period (between displacement and livelihood restoration)	Specified	Specified	Yes, no such benefits provision for non titleholder residing/drawing livelihood for a period less than 3 years	- Transition benefits to be provided to all non titleholders (displaced and livelihoods impacted) who have been identified as per census survey.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.	Mentioned for vulnerable groups as defined under NRRP. Specific mention of additional provisions for SC and ST community mentioned under #7.21 of the NRRP. Requirement of a separate tribal development plan to be prepared if number of tribal displaced families exceeds 200 families.	--	No	- Additional assistance will be provided to vulnerable groups as specified in A-RAP. -

Source: JICA Study Tea

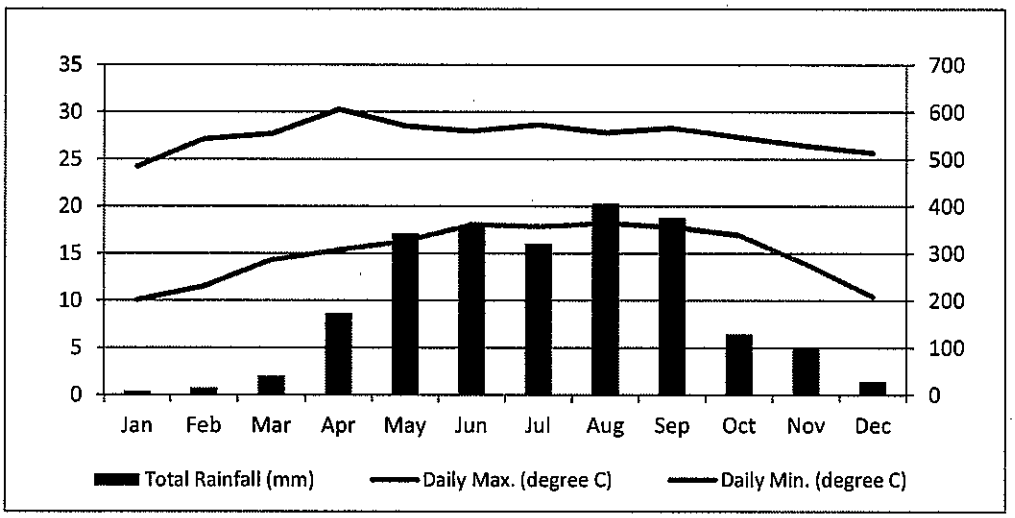
8.3 Environmental and Social Baseline

Existing environment and socio-economic conditions against which likely environmental and social impacts of the project has been analyzed. The baseline data presented below have been collected by monitoring surveys as well as literature reviews and interactions with local people and government officials at various levels.

8.3.1 Natural Environment

(1) Climate

Mizoram has a mild climate, relatively cool in summer 20 to 29 °C (68 to 84 °F)[2] and winter temperatures range from 7 to 22 °C. The region is influenced by monsoon, 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 2540 mm per annum.



Source: Meteorological Data of Mizoram 2015

Figure 8.3-1 Monthly rainfall and daily max/min temperature in Aizawl (average between 2011 and 2015)

Annual rainfall in three reporting centers near the proposed bypass is presented below. Lawngtlai (BP4) area tends to have lower rainfall compared to other areas.

Table 8.3-1 Annual Rainfall in Project Area (2011-2015)

Report Center	Annual Rainfall in mm				
	2011	2012	2013	2014	2015
Serchhip (for BP1 and 2)	1940.3	1784.8	1725.9	1811	2214.7
Hnathial (BP3)	1924.3	2105.1	2046.3	1720.3	1942
Lawngtlai (BP4)	NA	887.7	1768.9	1541.3	1673.4

Source: Meteorological Data of Mizoram 2015

2 This is the long-term average. However, 2015 was exceptionally hot year with temperature of 30°C or more was recorded in 10 out of 12 months. Between 2011 and 2014, temperature over 30°C was recorded only twice.

(2) Topography, Geology, and Soil

The North-East India is located on the north-east edge of the Himalayan orogenic belt resulted from Indo-Eurasian continental plate collision that took place during Cenozoic era, 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.

The Geology of Mizoram consists of a repetitive succession of Neogene (Tertiary) arenaceous and argillaceous sediments occurring in a series of approximately North- south trending longitudinal plunging anticlines and synclines. The topography of the area is often a good indication of lithology and argillaceous groups of rocks occur in relatively lower altitudes as compared to arenaceous rocks. The parent materials are predominantly shales and siltstone, with a reasonable percentage of day minerals. As the rocks are relatively impermeable, the dry months provide opportunity of desiccation of the upper topsoil creating some weak bond by geo-chemical processes (laterisation, limonisation, or sometimes kaolinisation). The common rocks found are sandstone, shale, silt, stone, clay stones and slates. The rock system is weak and unstable prone to frequent seismic influence. See section 5.1.3 for details of the geological survey and survey for seismic condition of the area.

Soil texture, in general, varies from sandy loams, clayey loams to clay. Although the soils are mature, profuse rainy spells in the region coupled with the high gradients have accelerated the problem of leaching of the loose soils. These soils are highly porous with low water holding capacity and this is the main cause of the low water table in Mizoram. The soils of Mizoram are deficient in potassium, phosphorous, nitrogen and humus. The traditional jhum cultivation has adversely affected the productivity. Although superficial greenery is observed owing to the profuse rainfall, the tract is actually in the process of fast degradation. The pH of these soils is acidic to neutral due to excessive leaching. The soil structure of the project area is summarized below.

Table 8.3-2 Soil Structures in Project Area

District	Soil pH	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potash (Kg/ha)
Serchhip	5.53	264	12	277
Lunglei	5.38	251	10	147
Lawngtlai	5.95	229	16	221

Source: Soil Information System

(3) Flora and Fauna

Mizoram is the highest forest cover state in the India, having about 90 % of the total geographical area is under forest (India State Forest Report FSI, 2013). Mizoram is a hilly region receiving heavy rainfall with soil characteristics conducive for luxuriant growth. Flora and fauna assessment were carried out for all the three districts that the targeted section of NH54 by-passes through.

Floral/ Vegetation assessment carried out through quadrate methods; for trees 10mx10m, for shrubs 5mx5m and for Herbs 1m x1m square shaped quadrats were used. Quadrates were laid randomly in the corridors upside and downside of the road. All species in the quadrats were recorded & ecological parameters such as density and frequency were calculated. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. The flola and fauna survey was carried out twice, during the dry season (from February to March 2016) and the rainy season (from May to July 2016).

1) Flora

The major areas are under tropical semi-evergreen forests and sub-tropical forests. The vegetation consists of trees, shrubs, herbs and climbers. The forest exhibits a clear zonation consisting of different species of trees.

(i) The tropical wet evergreen with tall dense trees.
(ii) The tropical, semi-evergreen with deciduous species.
(iii) The Montane sub-tropical with broad leaved evergreen species

During the field study the undergrowth is dense with herbaceous plants. Evergreen and diverse forests are also present in the middle and lower canopies. Musa spp. are also common in the slopes. Ferns, palms orchids, bryophytes and orchids are also fairly common in the study area. Due to traditional practice of jhumming cultivation, large areas of forests are being converted into barren land. However, the department environment and forest is taking steps to regenerate the forest area either naturally and/or artificially through plantation. In most parts these plantations consists of teakwood trees.

Jhumming and shifting cultivation is the principal method of cultivation and majority of the rural population is engaged in cultivation. In jhum cultivation the vegetation are cut and allowed to dry. After some days the forests are burnt and the area is cleared for cultivation. Many tree species are destroyed during the process but bamboo regrows as soon as favorable temperature and seasonal monsoon arrive. Therefore, in abandoned jhum land the first plant to grow is bamboo. Some important associates found growing along with bamboos are Emblica officinalis, Litsea monopetala, Pterospermum acerifolium, Terminalia myriocarpa, Caryota mitis, Artocartus chama, Duabanga grandiflora, Albizia procera, Gmelina arborea, Syzygium species.

Maize, wheat, palms and oil seeds, pulses, peas, ginger, groundnut, papaya, pineapple, cash crops like tapioca and vegetables like potato, tomato and beans are grown in the study area. A small patch of tea plantation was also found in the study area of Chhiathlang (BP1).

No endangered or vulnerable floral species have been spotted during the field surveys. The floral diversity recorded during the field study and secondary data collected from the Environment and Forest Department, Mizoram are listed in the Table below. The common name, local name, IUCN red list category and IWPA category (wherever applicable) and field observation are included in the Appendix 6.

2) Fauna

Being part of India-Burma biodiversity hotspot, Mizoram is known for its rich biodiversity. Meanwhile, no pristine ecosystem remains in the areas along NH54, the main road network of the State, due to human activities. As such, there are significant differences in the level of biodiversity and richness of flora/faunal community between in the area the proximity of NH54 and in Natural Park and Protected Areas of the State. The interviews with local people and officials suggested that large and precious species cannot be found in the area near the human settlement, which was confirmed in the field study in both dry and monsoon seasons (see Appendix 7 for the list of species spotted in the field surevy). Meanwhile, one "Vulnerable" species as per IUCN Red List, Slow Loris, has been found in the project area during the field survey in Phase I.

(4) Protected Area

There are a total of 10 protected area (National Park, Wildlife Sanctuary, and Tiger Reserve) in Mizoram, but the proposed bypasses do not traverse or border with any of them.

Source: Department of Environment and Forests, Government of Mizoram

Figure 8.3-2 Protected Area in Mizoram

According to the discussion with the official in State Environment and Forest Department, three Wildlife Sanctuaries, namely Tawi, Khawnglung and Ngengpui are located near the proposed bypasses Tawi WLS is located about 12 km north west of BP1 and 20 km north of BP2. Khawnglung WLS is located about 13 km east of BP3 and Ngengpui WLS is locared about 11 km south west of BP4. While no direct impacts to these WLSs are expected due to this project, their baseline condition and the list of key species in each WLS is shown below, against which, potential indirect impact can be monitored.

A. Tawi Wildlife Sanctuary

The Tawi Wildlife Sanctuary is located between 23°29'N – 23°34'North and 92°54'E- 92°59' East, approx. 180 km from Aizawl, and its covering area is 35.75 km^2. This sanctuary provides shelter and protection of five rare and endangered species of wildlife mentioned in the Red Data Book of IUCN.

Table 8.3-3 Summary of Tawi Wildlife Sanctuary

No.	Item	Description	
1	Location	Approx. 180 km East of Aizawl (between 23°29'N – 23°34'North and 92°54'E-92°59' East)*)	
2	Area	35.75 km^2 *)	
3	Principal Species	Flora	- *Quercus species* - *Betula species* - *Wild orchids* - A few clumps of *Chimnobambusa collasa* etc.
		Fauna	- Clouded Leopard (Threatened) - Leopard Cat (Endangered) - Hoolock Gibbon (Endangered) - Serow (Threatened) etc.

Note: *) Finally notified in 2001 vide Government of Mizoram letter No.B.12012/1/91-FST Dt. 16th Nov/2001
Source: "Review Management Plan of Tawi Wildlife Sanctuary Mizoram for the period (2006-2007 to 2015-2016)", Wildlife Wing Environment & Forest Department Government of Mizoram

B. Khawnglung Wildlife Sanctuary

The Khawnglung Wildlife Sanctuary is located between 23°04'N – 23°10'North and 92°55'E-92°59' East, approx. 140 km south from Aizawl, and its covering area is approx. 35 km^2. The Sanctuary is situated at Lunglei District, under the Development Block of Hnathial and carved out from Thenzawl Forest Division.

Table 8.3-4 Summary of Khawnglung Wildlife Sanctuary

No.	Item	Description	
1	Location	Between 23°04'08''N – 23°10'11''North and 92°55'11''E- 92°59'23'' East	
2	Area	35 km^2	
3	Principal Species	Flora	(No significant survey has been implemented)
		Fauna	- Hoolock Gibbon - Rhesus Macaque - Assamese macaque - Stump Tailed Macaque - Phayre's Leaf Monkey - Capped Langur - Leopard - Clouded leopard - Himalayan black bear - Malayan sun bear - Sambar - Barking deer - Serow etc.

Source: "Review Management Plan of Khawnglung Wildlife Sanctuary Mizoram for the period (2008-2017)", Wildlife Division, Aizawl

C. Ngengpui Wildlife Sanctuary

The Ngengpui Wildlife Sanctuary is located between 22°21'N – 22°30'North and 92°44'E-92°50' East, approx. 280 km south of Aizawl and 39 km west of Lawngtlai. This area is under Lawngtlai District and under Lawngtlai Rural development Block within Lai Autonomous District Council. Its covering area is approx. 110 km2, notified as Wildlife Sanctuary in 1997 vide Govt. Notification No. B. 12012/4/01-FST dt 22.7.1997. Ngengpui Wildlife Sanctuary is very rich in biodiversity. The forest type of this area is Tropical Wet Evergreen Forest and Semi-evergreen Forest, and there are a number of medical plants. Regarding the fauna, Elephant, Gaur and other mammals can be found, also this area is one of the important bird areas (IBAs) in India from A1 (Globally threatened species) and A2 (Restricted range species).

Table 8.3-5 Summary of Ngengpui Wildlife Sanctuary

No.	Item	Description	
1	Location	Geographical coordinate 22°21'18"– 22°30'01" N and 92°44'30"- 92°50'37"E, It is close to Indo-Myanmar & Indo Bangladesh border.	
2	Area	110 km^2	
3	Principal Species	Flora	- *Raulfia serpentine* - *Bergenia ciliate* - *Ardisia macrocapa* - *Cautraya gracillis* - *Gardenis caronania* - *Rajanda longifolia* - *Zingiber purphotium* - Orchids etc.
		Fauna	- Elephant - Gaur - Serow - Sambar - Barking Deer - Leopard - Clouded Leopard (Threatened) - Marble Cat - Golden Cat - Leopard Cat - Hoolock Gibbon - Phayre's Leaf Monkey - Pig tailed macaques - Stump Tailed Macaques - Himalayan Black Bear - Malayan Sun Bear - Capped Langur - Slow Loris etc.

Source: "Review Management Plan of Ngenpui Wildlife Sanctuary Mizoram for the period (2010 - 2020)", Under CSS : Integrated Development off Wildlife Habitats.

No reserve forest will be affected by the project. However, the project runs through open forest, jhum land (shifting cultivation) and abandoned jhum area. Given that the forest and forest produces play an important role in local livelihood, efforts are needed to minimize deforestation and to disturbance during construction stage.

(5) Hydrology

The hydrological study is conducted based on IRC:SP:13 "Guidelines for the design of small bridges and culverts" which is well used technical standard for hydrological study in Indian highway design. The analysis is presented in Chapter 5.1 of this report.

(6) Mineral Resources

Being a hilly state, Mizoram is rich in minerals. The figures on production of stone and sand are shown below. The stone and sand production is mainly concentrated in Aizawl, and in Mamit, Kolasib and Lunglei districts. Mizoram has mineral deposits of shell limestone, siltstone, clay mineral, coal seam, oil and gas. Building-quality stones are exported to Bangladesh. Numerous natural water springs in Mizoram also offers potential for manufacturing mineral water.

Table 8.3-6 Number of Quarry Permit Issued and Mineral Production

Year	No. of Quarry Permit Issued	Production form Quarry (Stone) (Cu.M)	Rs. in Lakhs	Sand Production (Cu.m)	Rs. in Lakhs

Year	No. of Quarry Permit Issued	Production form Quarry (Stone) (Cu.M)	Rs. in Lakhs	Sand Production (Cu.m)	Rs. in Lakhs
2005-2006	191	NA	NA	NA	NA
2006-2007	164	NA	NA	NA	NA
2007-2008	33	312797.083	37.54	36176.54	18.09
2008-2009	78	418208.316	50.19	118585.26	59.29
2009-2010	48	261488.330	31.38	62611.40	31.31
2010-2011	97	212937.325	85.18	136303.94	68.15

Source: Statistical Abstract of Mizoram 2011

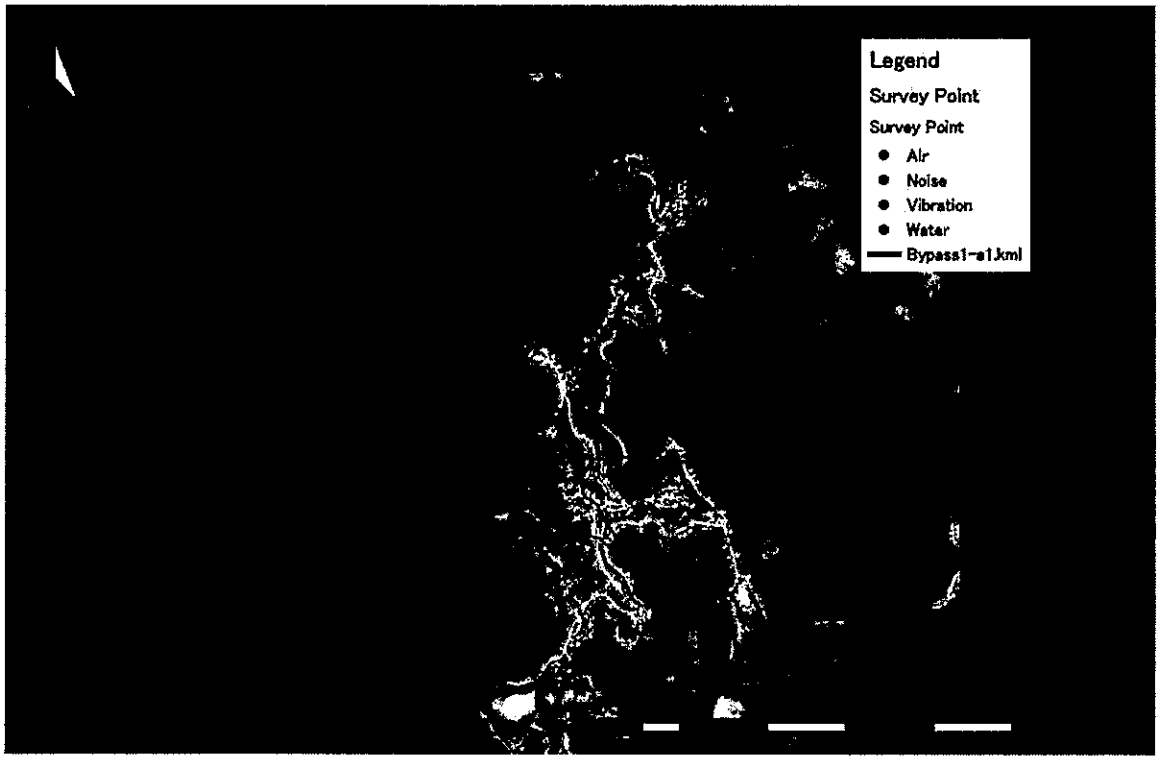
Table 8.3-7 District-wise Number of Quarry Permit Issued and Mineral Production, 2010-11

District	No. of Quarry Permit Issued	Production form Quarry (Stone) (Cu.M)	Rs. in Lakh)	Sand Production (Cu.m)	Rs. in Lakh
Mamit	4	11087.50	4.43	1980.00	0.99
Kolasib	6	11594.90	4.64	11312.20	5.66
Aizawl	28	171776.725	68.71	67189.04	33.59
Champhai	15	4913.95	1.97	29825.70	14.91
Serchhip	8	4799.70	1.92	5435.00	2.72
Lunglei	31	8294.55	3.32	20562.00	10.28
Lawngtlai	5	470	0.19	-	-
Saiha	-	-	-	-	-
Total	**97**	**212937.325**	**85.18**	**136303.94**	**68.15**

Note: Districts where the proposed bypasses are located are highlighted.
Source: Statistical Abstract of Mizoram 2011

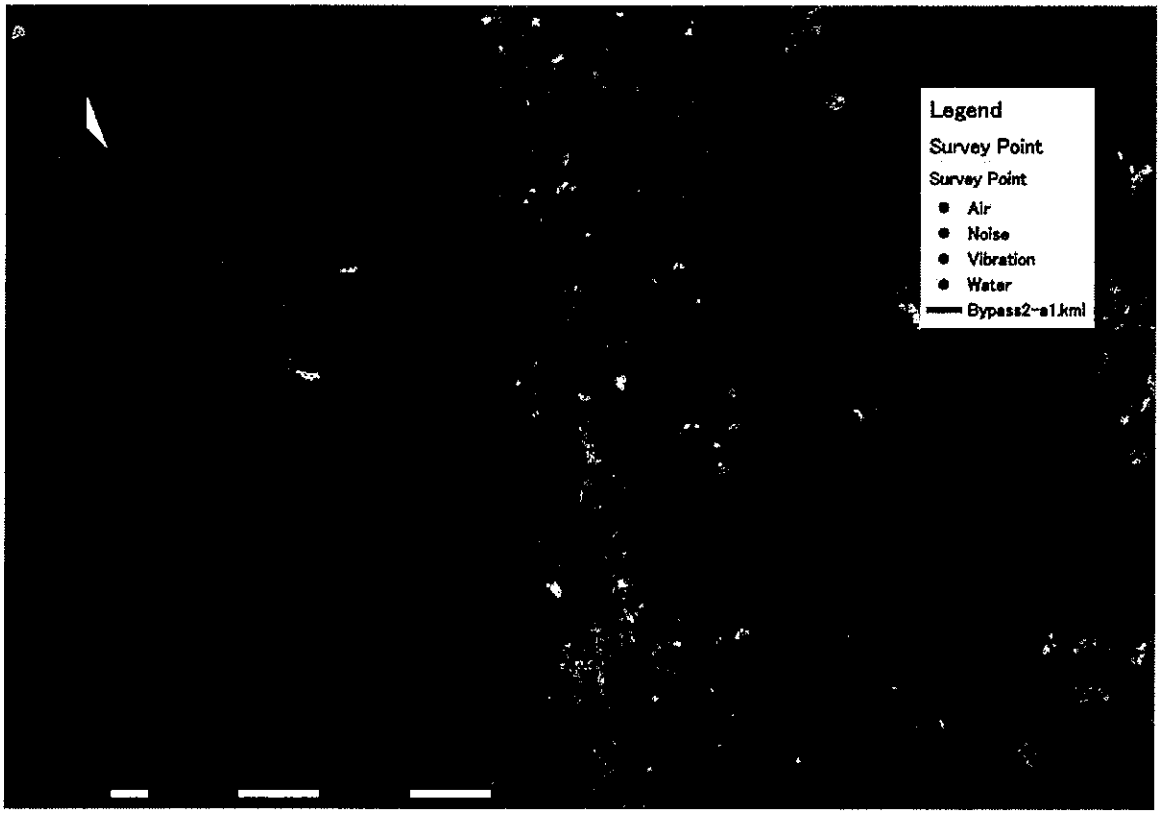
8.3.2 Living Environment

The survey points for Air Quality, Water Quality, Noise and Vibration is shown below.



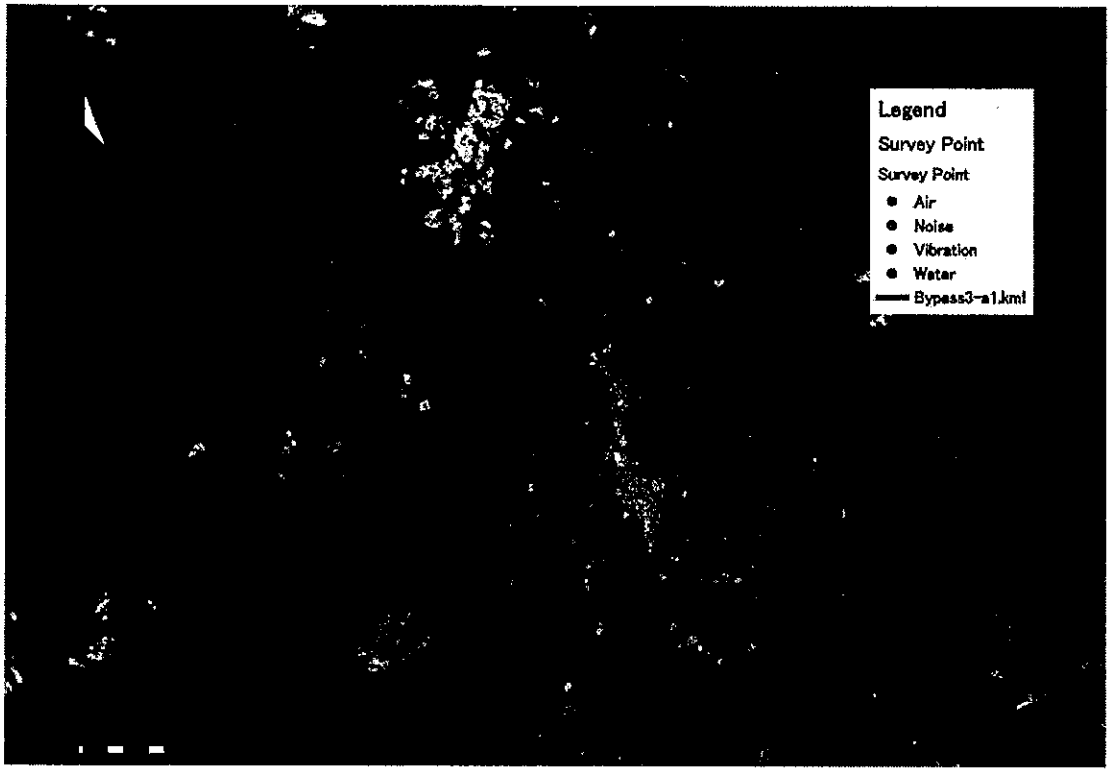
Source: JICA Study Team

Figure 8.3-3 Survey Points for Chhiathlang Bypass (BP1)



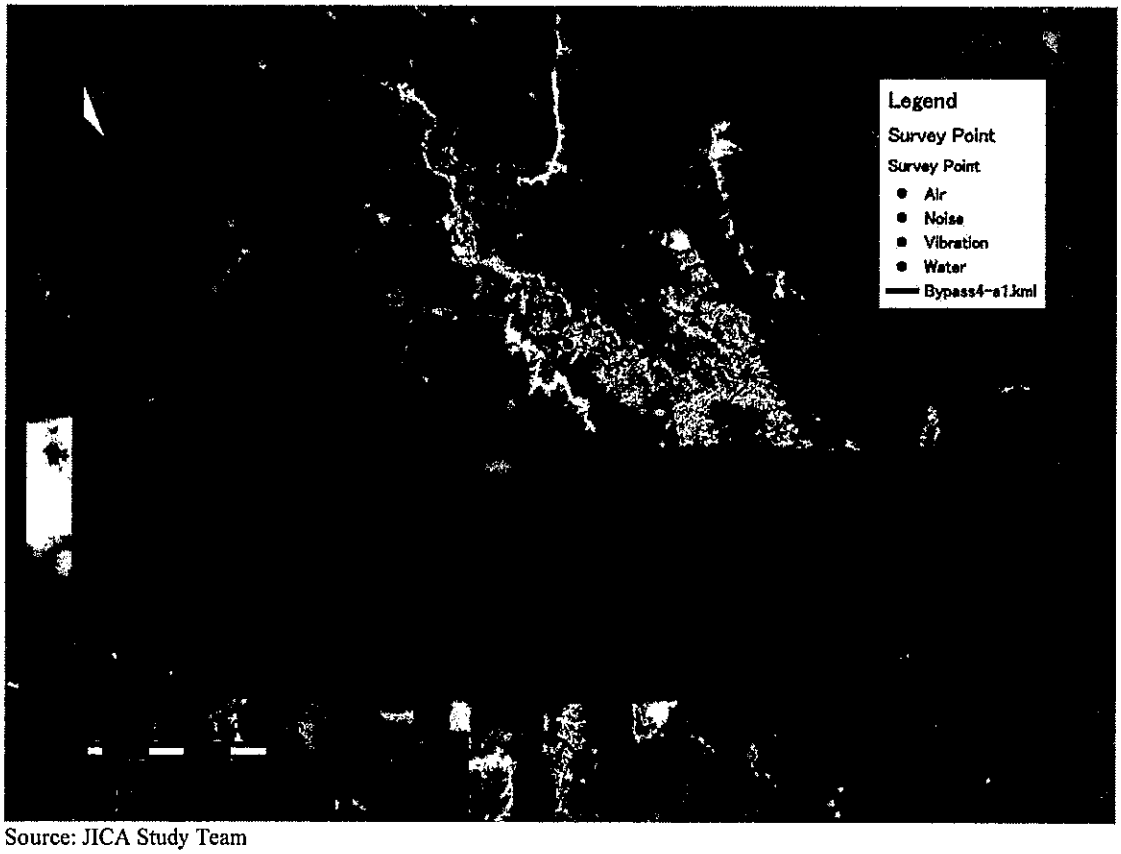
Source: JICA Study Team

Figure 8.3-4 Survey Points for Serchhip Bypass (BP2)



Source: JICA Study Team

Figure 8.3-5 Survey Points for Hnathial Bypass (BP3)



Source: JICA Study Team

Figure 8.3-6 Survey Points for Lawngtlai Bypass (BP4)

The sections below present the summary of monitoring study. The detailed results of the study in both dry and monsoon seasons for each bypass is presented in Appendix 7.

(1) Air Quality

Ambient air quality of the study area was monitored in the pre monsoon/dry season and monsoon season to get an idea of baseline air quality scenario. The NAAQS Monitoring & Analysis Guidelines Volume-I, CPCB was followed for collection and analysis of ambient air samples.

The ambient air quality monitoring (AAQM) stations were selected in the study areas of each by-pass. In Lawngtlai and Chhiahtlang two stations (start point and end point) were selected. Three points (start point, midpoint and end point) were selected as AAQM stations in Hnathial and Serchhip. The AAQM stations were based on the accessibility and availability of electricity.

Polltech $PM_{2.5}$ & PM_{10} ADS Fine Dust Sampler and Ecotech AAS Sampler with gaseous sampling attachment were used for ambient air quality monitoring. The results of PM_{10}, $PM_{2.5}$, SO_2, NO_x and lead concentration measurements during the study period are presented in the tables below. On the basis of tabulated data it can be inferred that the concentrations of the measured parameters complies the limits of the National Ambient Air Quality Standards, CPCB notification dated 18th November, 2009.

Table 8.3-8 National Ambient Air Quality Standards

Parameters	Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
Time Weighted Average Annual	60	40	50	40	0.5

Source: Central Pollution Control Board Notification, New Delhi the 18th Nov'2009

(i) Chhiathlang (Bypass One)

Two ambient air quality stations were selected in the Chhiathlang bypass (near start point and end point) and the results are enumerated below.

A) PM_{10}: The concentration of PM_{10} at the AAQM station in Chhiathlang ranged from 36 µg/Nm^3 to 52 µg/Nm^3 in the dry season, and ranged from 27 µg/Nm^3 to 34 µg/Nm^3 in the monsoon season.

B) PM2.5: The concentration of $PM_{2.5}$ at the AAQM station ranged from 17 µg/Nm^3 to 32 µg/Nm^3 in the dry season, and ranged from 15 µg/Nm^3 20 µg/Nm^3 in the monsoon season

C) Sulphur Dioxide (SO_2)

The concentration of SO_2 ranged from 6 µg/Nm^3 to 12 µg/Nm^3 in the dry season, and ranged from <5 µg/Nm^3 to 7 µg/Nm^3 in the monsoon season.

D) Nitrogen Oxide (NOx)

The concentration of NOx ranged from 12 µg/Nm^3 to 18 µg/Nm^3 in the dry season, and ranged from 7 µg/Nm^3 to 11 µg/Nm^3 in the monsoon season.

E) Lead

The concentration of lead in ambient air was <0.01 µg/Nm^3 for both the locations and both seasons.

(ii) Serchhip (Bypass Two)

Three ambient air quality stations were selected in the Serchhip bypass (near start point, mid-point and end point) and the results are enumerated below.

A) PM_{10}: The concentration of PM_{10} at the AAQM station in Serchhip ranged from 50 $\mu g/Nm^3$ to 56 $\mu g/Nm^3$ in the dry season, and ranged from 31 $\mu g/Nm^3$ to 38 $\mu g/Nm^3$ in the monsoon season.
B) $PM_{2.5}$: The concentration of $PM_{2.5}$ at the AAQM station ranged from 26 $\mu g/Nm^3$ to 35 $\mu g/Nm^3$ in the dry season, and ranged from 20 $\mu g/Nm^3$ to 27 $\mu g/Nm^3$ in the monsoon season.
C) Sulphur Dioxide (SO_2): The concentration of SO_2 ranged from 7 $\mu g/Nm^3$ to 12 $\mu g/Nm^3$ in the dry season, and ranged from <5 $\mu g/Nm^3$ to 9 $\mu g/Nm^3$ in the monsoon season.
D) Nitrogen Oxide (NOx): The concentration of NOx ranged from 12 $\mu g/Nm^3$ to 17 $\mu g/Nm^3$ in the dry season, and ranged from 8 $\mu g/Nm^3$ to 14 $\mu g/Nm^3$ in the monsoon season
E) Lead: The concentration of lead in ambient air was <0.01 $\mu g/Nm^3$ for both the locations and both seasons.

(iii) Hnathial (Bypass Three)

Three ambient air quality stations were selected in the Hnathial bypass (near start point, mid-point and end point) and the results are enumerated below.

A) PM_{10}: The concentration of PM_{10} at the AAQM station in Hnathial ranged from 37 $\mu g/Nm^3$ to 52 $\mu g/Nm^3$ in the dry season, and ranged from 29 $\mu g/Nm^3$ to 34 $\mu g/Nm^3$ in the monsoon season.
B) $PM_{2.5}$: The concentration of $PM_{2.5}$ at the AAQM station ranged from 18 $\mu g/Nm^3$ to 32 $\mu g/Nm^3$ in the dry season, and ranged from 15 $\mu g/Nm^3$ to 22 $\mu g/Nm^3$ in the monsoon season.
C) Sulphur Dioxide (SO_2): The concentration of SO_2 ranged from 6 $\mu g/Nm^3$ to 9 $\mu g/Nm^3$ in the dry season, and ranged from 6 $\mu g/Nm^3$ to 8 $\mu g/Nm^3$ in the monsoon season.
D) Nitrogen Oxide (NOx): The concentration of NOx ranged from 12 $\mu g/Nm^3$ to 16 $\mu g/Nm^3$ in the dry season, and ranged from 9 $\mu g/Nm^3$ to 14 $\mu g/Nm^3$ in the monsoon season.
E) Lead: The concentration of lead in ambient air was <0.01 $\mu g/Nm^3$ for both the locations and both seasons.

(iv) Lawngtlai (Bypass Four)

Two ambient air quality stations were selected in the Lawngtlai bypass (near start point and end point) and the results are enumerated below.

A) PM_{10}: The concentration of PM_{10} concentration at the AAQM station in Lawngtlai ranged from 55 $\mu g/Nm^3$ to 62 $\mu g/Nm^3$ in the dry season. The PM_{10} concentration at AOC Veng, Lawngtlai crossed the permissible limit of 60 $\mu g/Nm^3$ during the monitoring period of 22/02/2016 to 23/02/2016. This may be due to the dry season, vehicular movement and construction activities going on in the particular location. On the other hand, the concentration of PM_{10} ranged from 29 $\mu g/Nm^3$ to 35 $\mu g/Nm^3$ in the monsoon season.
B) $PM_{2.5}$: The concentration of $PM_{2.5}$ at the AAQM station ranged from 32 $\mu g/Nm^3$ to 41 $\mu g/Nm^3$ in the dry season, and ranged from 18 $\mu g/Nm^3$ to 23 $\mu g/Nm^3$ in the monsoon season.
C) Sulphur Dioxide (SO_2): The concentration of SO_2 ranged from 7 $\mu g/Nm^3$ to 9 $\mu g/Nm^3$ in the dry season, and ranged from 6 $\mu g/Nm^3$ to 8 $\mu g/Nm^3$ in the monsoon season.
D) Nitrogen Oxide (NOx): The concentration of NOx ranged from 13 $\mu g/Nm^3$ to 16 $\mu g/Nm^3$ in the dry season, and ranged from 9 $\mu g/Nm^3$ to 14 $\mu g/Nm^3$ in the monsoon season.
E) Lead: The concentration of lead in ambient air was <0.01 $\mu g/Nm^3$ for both the locations and both seasons.

(2) Ground and Surface Water Quality

Under natural conditions, the water quality reflects environmental conditions to a great extent. Hydro-geochemical factors influence color, odour, taste, temperature and the degree of mineralization of water derived from surface run off, springs, etc. Besides, human settlements, overall land use, morphology of the basin area, seasonal distribution of rainfall and winds, disposal of industrial effluents and sewage, etc. contribute a great deal in determining the quality of water. The quality of ground water is influenced by surface and sub-surface environmental conditions. The quantity and quality of water entering the underground regime is another important parameter which influences

ground water quality. Rainfall absorbs atmospheric pollutants during its descent through the atmosphere.

The collected water sample was analyzed for selected physical and chemical parameters. The analyzed parameters of the physico-chemical properties of the water samples meet desirable limits as per IS 10500:2012. The odor, taste and smell are acceptable for all areas. Oil and grease and fluoride were below detectable limit. Hardness of water, determined by the dissolved salts calcium and magnesium, was found to be in the range from 18 to 56 mg/l. The water of the samples analyzed can be classified as soft water (Durfer and Backer classification of Hardness). The total dissolved solid (TDS) of water represents the amount of soluble inorganic substances in the water source. The TDS of the water samples varied from a minimum of 80 mg/l to 510 mg/l. The iron content of the water samples was lower in the surface water sample as compared to the ground water samples. The concentration of the trace metals and soluble inorganics like sulphate and nitrate analyzed was within the permissible limits as per IS 10500:2012.

(i) Chhiathlang (Bypass One)

One surface water sample, three ground water sample and one sample from community water tank were collected from different locations of Chiahtlang. The pH ranged from 6.7 to 7.4 in the dry season and from 6.4 to 7.9 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water was lower than the ambient temperature and ranged from 19°C to 20.1°C in the dry season and 25.1°C to 27°C in the monsoon season. The physico-chemical parameters analyzed were within the limits as per IS 10500:2012. The presence of total coliform was detected in the community water tank (Chiahtlang Sample 1) and surface water sample (Chiahtlang Sample 5).

(ii) Serchhip (Bypass Two)

Two surface water samples, one ground water sample and one sample from community water tank were collected from different locations of Serchhip. The pH ranged from 7.4 to 7.7 in the dry season and 7.2 to 8.3 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water ranged from 19.2°C to 20.1°C in the dry season and 26.1°C to 27.6°C in the monsoon season. Most of the physico-chemical parameters tested was well within the limits as per IS 10500:2012. Total coliform was detected in the samples collected from community water tank (Serchhip Sample 1) and surface water (Serchhip Sample 1 and Serchhip Sample 4).

(iii) Hnathial (Bypass Three)

One surface water sample and three samples from community water tank were collected from different locations of Hnanthial. The pH ranged from 6.8 to 7.7 in the dry season and 6.3 to 8.2 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water was lower than the ambient temperature and ranged from 18.1°C to 19°C in the dry season and 26.6°C to 27°C in the monsoon season in the community tanks. The physico-chemical parameters analysed were within the limits as per IS 10500:2012. There was presence of total coliform in the surface water sample (Hnanthial Sample 1) and in one of the community water tank ((Hnanthial Sample 2).

(iv) Lawngtlai (Bypass Four)

Three ground water samples and one surface water sample was collected from different locations of Lawngtlai. The pH ranged from 6.7 to 7.3 in the dry season and from 6.5 to 7.8 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water was slightly lower than the ambient temperature ranging from 18.6°C to 20.5°C in the dry season and 26.5°C to 27.8°C in the monsoon season. Most of the physico-chemical parameters tested was within the limits as per IS 10500:2012. The surface water sample (Lawngtlai Sample 4) showed the presence of total coliform.

(3) Noise and Vibration

1) Noise

Noise can be defined as an unwanted sound. It interferes with speech and hearing and if intense enough can damage hearing or is otherwise annoying. The definition of noise as unwanted sound implies that it has an adverse effect on human beings and their environment. Noise can also disturb natural wildlife and ecological system.

Ministry of Environment, Forest and Climate Change has notified the ambient standards in respect of noise and these standards are given in the table below. To understand the noise environment in the study area, a noise survey was conducted using Lutron SLM 4013. The sound levels in the study area are given in the tables below. The ambient standards in respect of noise both for Leq_{day} and Leq_{night} with respect to noise applicable for Commercial Area were considered in the present study.

Table 8.3-9 Ambient Standard for Noise

Area Code	Category of Area	Leq. Limits in dB(A)	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note: 1. Day time is reckoned in between 6:00 a.m and 10:00 p.m. 2. Night time is reckoned is between 10:00 p.m and 6.00 a.m. 3. Silence Zone is defined as areas upto 100 m around such premises as hospitals, educational, institutions and Courts. The Silence Zones are to be declared by the competent authority.

Source: Pollution Control Acts, Rules and Notifications Issued Thereunder, Central Pollution Control Board, Delhi, May, 1998.

(i) Chhiathlang (Bypass One)

In the dry season, the maximum Leq was 61.5 and minimum was 54.7 during day time. During night time the maximum and minimum Leq are 47.8 and 43.0 respectively. In the monsoon season, the maximum Leq was 63.2 and minimum was 55.3 during day time. During night time the maximum and minimum Leq are 47.2 and 42.9 respectively. In both seasons, the ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change.

(ii) Serchhip (Bypass Two)

In the dry season, the maximum Leq was 64.5 and minimum was 61.7 during day time, and the maximum and minimum Leq are 52.7 and 49.6 during night time. The ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change. In the monsoon season, the maximum Leq was 72.1 and minimum was 59.5 during day time. During night time the maximum and minimum Leq are 53.1 and 42.1 respectively. The sampling locations are in the commercial area with activity during the daytime so the ambient sound level are found to be higher.

(iii) Hnathial (Bypass Three)

In the dry season, the maximum Leq was 62.1 and minimum was 55.3 during day time. During night time the maximum and minimum Leq are 53.4 and 43.2 respectively. The ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change. In the monsoon season, the maximum Leq was 68.7 and minimum was 59.2 during day time. During night time the maximum and minimum Leq are 48.4 and 40.2 respectively. The sampling locations are in the commercial area with activity during the daytime so the ambient sound level are found to be higher.

(iv) Lawngtlai (Bypass Four)

In the dry season, the maximum Leq was 65.4 and minimum was 61.5 during day time, and the maximum and minimum Leq are 56.8 and 48.2 during night time. Since the study point (start and end point of the area) was near busy commercial area the ambient sound level are slightly higher at

Lawngtlai 2 AOC Veng during daytime and night time. In the monsoon season, the maximum Leq was 68.4 and minimum was 56.3 during day time. During night time the maximum and minimum Leq are 54.5 and 43.4 respectively. Since the study point (start and end point of the area) was near busy commercial area the ambient sound level are slightly higher at Lawngtlai 2 AOC Veng during daytime and night time.

2) **Vibration**

Vibration Survey was implemented at two points (the start point and the end point) for every bypass area and the summary of the results of two seasons are as follows.

(i) Chhiathlang (Bypass One)

In the dry season, the maximum vibration is 1.95 mm/sec (rms). On the other hand, in the monsoon season, the maximum vibration is 1.88 mm/sec (rms).

(ii) Serchhip (Bypass Two)

In the dry season, the maximum vibration is 2.35 mm/sec (rms). On the other hand, in the monsoon season, the maximum vibration is 2.12 mm/sec (rms).

(iii) Hnathial (Bypass Three)

In the dry season, the maximum vibration is 1.60 mm/sec (rms). On the other hand, in the monsoon season, the maximum vibration is 1.92 mm/sec (rms).

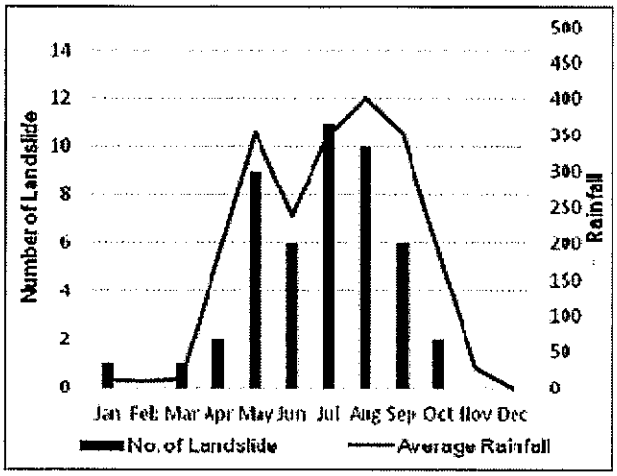
(iv) Lawngtlai (Bypass Four)

In the dry season, the maximum vibration is 1.85 mm/sec (rms). On the other hand, in the monsoon season, the maximum vibration is 1.98 mm/sec (rms).

(4) Hazards

With the inherently weak geology of fractured rock, the steep, unstable slopes are further weakened by water flows during monsoons and result in landslides. Deforestation due to felling of trees for timber, animal fodder and removal of vegetation for jhum cultivation are also contributing to soil erosions and destabilization of slopes.

In addition to the field identification of landslide, information on past landslide disaster in and around Mizoram states has been collected to ascertain the trend of natural hazard in area. The number of landslide reported in newspapers and academic paper from 1992 to 2015 is summarized in Figure below, which clearly indicates elevated risk of landslide in monsoon season. In September 2014, a large landslide occurred near PWD office at Laipuitang in Aizawl and killed 17 people and destroyed 15 structures including PWD office buildings. These disasters often cause severe disruption in the lifeline, which deprive the local population along NH54 of supply of essential commodities.



Source: JICA Study Team

Figure 8.3-7 Frequency of Landslide in Mizoram

8.3.3 Socio-Economic Conditions

(1) Mizo People

Mizoram name derived from Mi (Peoples), Zo (Hills) & Ram (Land) thus Mizoram implies '*land of the hilly peoples*'. The meaning itself shows social structure of the Mizoram state. The Mizos are broadly divided into 5 major tribes and 11 minor tribes. The 5 major tribes are Lushai, Ralte, Hmar, Paite and Pawi. Mizo is the official language and most widely used language for verbal interactions, but English being important for education, administration, formalities and governance, is also widely used. The Duhlian dialect, also known as the Lusei, was the first language of Mizoram and has come to be known as Mizo language. All the tribes still have their own unique dialects which are slightly different from the dominant Mizo (Duhlian), but they can understand each other without problems. As per 2011 census, total population of Mizoram is 1,097,206. The Lushai tribes constituted the majority of the Mizo population. Population density of Mizoram is 52 per km^2. The literacy rate in Mizoram is 91.3% as per 2011 census. District-wise and Tribe-wise population of Mizoram is shown below. Out of 8 districts, districts where four bypasses are located are highlighted in below table.

Table 8.3-10 District-wise Population and Literacy Rate

District	Population			Density (per Sq Km)	Sex Ratio	Literacy %
	Male	Female	Total			
Mamit	44,567	41,190	85,757	28	924	60
Kolasib	42,456	40,598	83,054	60	956	94.54
Aizawl	201,072	202,982	404,054	113	1009	98.50
Champhai	63,299	62,071	125,370	39	981	93.51
Serchhip	32,824	32,051	64,875	46	976	98.76
Lunglei	79,252	74,842	154,094	34	944	89.40
Lawngtlai	60,379	57,065	117,444	46	945	66.41
Saiha	28,490	27,876	56,366	40	978	88.41
Total	**552,339**	**538,675**	**1,091,014**	**52**	**875**	**91.85**

Source: 2011 Census

The population of four towns where the bypasses are located is shown below.

Table 8.3-11 Population of Bypass Area

Town	No. of Household	No. of Population
Chhiathlang	815	4,071
Serchhip	4,085	21,158
Hnathial	1,548	7,187
Lawngtlai	3,910	20,830

Source: 2011 Census

The Mizo ancestors had no written language and the British missionaries, F.W. Savidge and J.H. Lorrain, created the Mizo alphabets based on the Roman scripts. The majority of the Mizo people are Christian. The major Christian denominations are Presbyterian, Baptist, United Pentecostal Church, Roman Catholic, the Salvation Army, Congregational Church of India (Maraland), Seventh-day Adventist, among others. There are other religions like Buddhism, Hinduism, Muslim and Sikh. There are few people who practice Judaism claiming to be one of the lost Judaic tribe group Bnei Menashe and a modernized traditional Mizo religion called Hnam sakhua, which put a particular emphasis on Mizo culture and seeks to revive traditional Mizo values. There are also few tribal religions such as Lalchhungkua, Lalhnam and Nunna Lalchhungkua.

(2) Mizo Economy

As per the data available, the Net State Domestic Product (NSDP) for the year 2012-13 was about Rs 7,556 Crores, and the Per Capita Income (PCI) during the same period was Rs. 63,413. It has also been observed that during the period 2004-05 to 2012-13 the economy of the state grew at a compound annual growth rate of 9.3%, with Primary Sector growing at 7.6%, Secondary Sector at 7.9% and the Tertiary Sector at 10.3%. During the same period the per capita income of the state grew at 6.8%.

Table 8.3-12 Economic Growth of Mizoram

Sector	CAGR (2004-05 to 2012-13)
Agriculture & Allied – P (Primary Sector)	7.64%
Industry - S (Secondary Sector)	7.87%
Services – T (Tertiary Sector))	10.30%
NSDP (Net State Domestic Product)	9.30%
PCI (Per Capita Income)	6.77%

Note: CAGR – Compound Annual Growth Rate

The main occupation of the people is agriculture. About 80% of the population are agriculturist. Rice is the main crop of Mizoram and besides rice, maize, potato, ginger, tumeric, black pepper, chilies and a variety of fruits are grown. In Mizoram, the ownership of land is vested with the government, which issues periodic pattas to individual cultivators. The Village Council distributes the plots of land among the villagers for cultivation every year. The agricultural system practiced is of the primitive type of 'jhum' or 'slash and burn', a practice that has been regarded as detrimental to the top layer of the soil, rendering it to become loose and soft and susceptible to frequent soil erosion. The government is attempting to bring about a change to the practice of 'jhum' by introducing 'terrace cultivation' which is ideal for the hill slope. The main horticulture crops are fruit crops like Mandarin orange, banana, passion fruit, grapes, hatkora, pineapple, papaya, etc. and flowers like anthurium, orchid, rose and other subsidiary seasonal flowers. Anthurium is being sent for sale to places to major cities like Kolkata, Delhi, Mumbai and Hyderabad. People have also started extensive cultivation of oil palm, medicinal and aromatic plants.

Demographic and socio-economic profile of project affected households are discussed in Section 8.11.2.

8.4 Analysis of Alternatives

8.4.1 Analysis of Alternative for Widening and Improvement of NH54

The analysis of alterntives has been carried out in two stages. First, alternatives for widening of NH54 between Aizawl and Tuipang was carried out during the feasibility study in Phase I. The scope for alternative was limited due to hilly nature of the terrain and the nature of the project, which essentially aims to improve and widen existing road. In developing a proposed preliminary road design, three concepts of alternatives have been as shown below.

Table 8.4-1 Concepts of Alternatives

No.	Option	Contents
0	Zero-Option (without project)	Existing road and slope conditions will persist. Poor pavement condition will lead to more vehicular emissions with detrimental impacts on health and ecosystem. Also, continuation of uncontrolled encroachment will increase the risk of traffic accident in built-up areas. Poor road network continues to be a bottleneck of economic development and also undermine positive benefits of ongoing Kaladan Multimodal Transport Project, which provides additional network from Mizoram to Haldia/Kolkata ports through NH54 and Kaladan River in Myanmar.
1	Applying the same design standard across the whole stretch based on the IRC	The same standard for widening/improvement will be applied across the whole stretch irrespective to geological condition and socio-economic conditions. While the positive impact of widening is significant, the project will trigger significantly more resettlement compared with option 2. Also, geometric improvement of many hair-pin curves will trigger more cutting and filling, increasing impacts on forest and leads to higher project implementation cost. The number of traffic accident will also increase due to the increased speed of vehicles passing through built-up areas.
2	Selective widening considering social impacts	The level of widening will be minimized in heavily built-up area to reduce the scale of resettlement. This option is desirable from socio-economic point of view, but the positive impact in terms of improvement of the road network in the region may be slightly limited compared with option 1.
3	New bypass to avoid densely built-up areas	A new bypass will be constructed in densely built-up areas to avoid resettlement. The option will minimize the scale of resettlement, but the impact on forest and agricultural land (jhum) will be significant as the new road will be constructed in open forest. The bypass will be required in the longer-term to accommodate project increase in traffic demand in the future, but its environmental impact as well as economic feasibility will have to be studied in more details.

Source: JICA Study Team

The illustrative images of widening concepts are shown below.

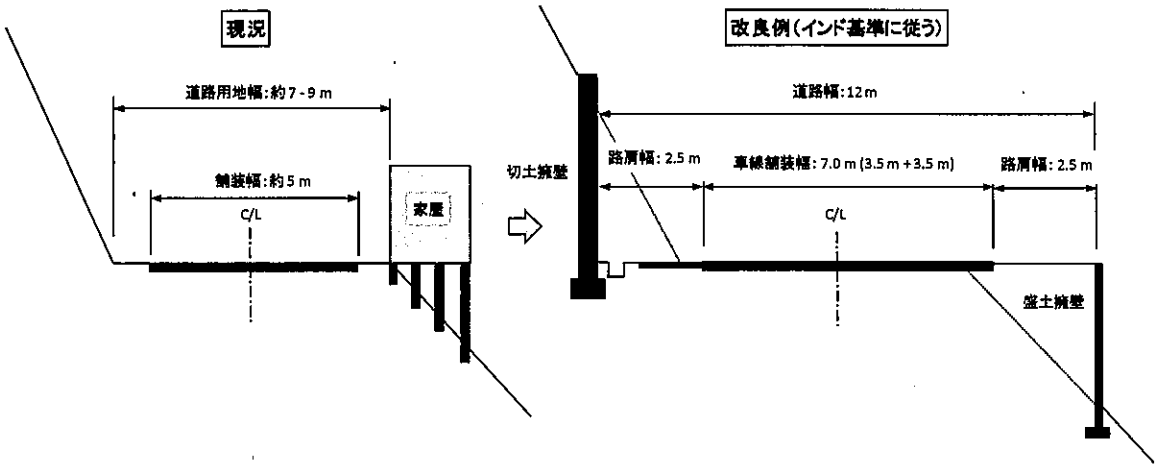


Figure 8.4-1 Alternative One (Widening based on IRC Standard)

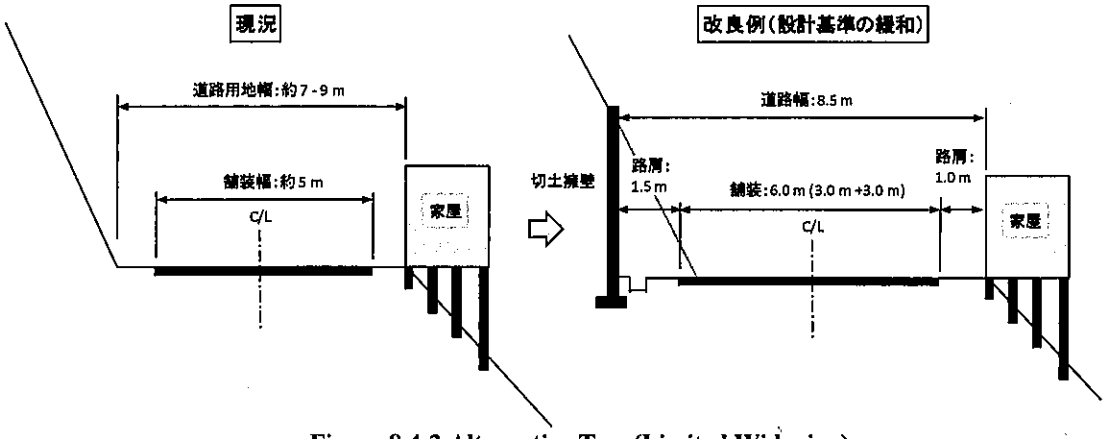


Figure 8.4-2 Alternative Two (Limited Widening)

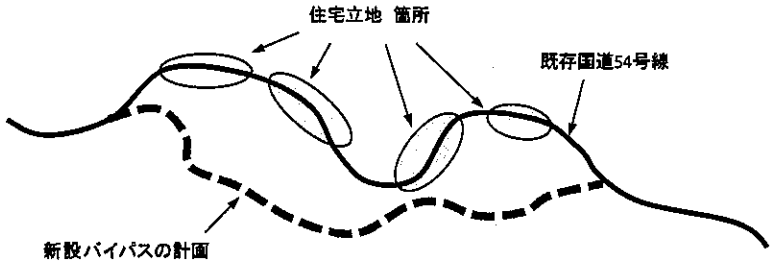


Figure 8.4-3 Alternative Three (New Bypass)

A comparison of three options is provided in below.

Table 8.4-2 Review of Alternatives

Alternative	Zero Option	One	Two	Three
General Objective	No project. Continue business as usual without intervention.	Follow Indian standard and ensure road capacity will be sufficient over the long-run	Minimize the scale of resettlement	Avoid resettlement
Resettlement	N/A	× Trigger significant resettlement. Preliminary assessment suggest that expansion beyond 15m can result in resettlement of more than 5,000 households.	△ ROW 12m will be adopted in general, except for hair pin curves. Impact will be reduced compared with Option One. 1,937 households will be affected in total.	◎ Minimum impact, but create negative impact on natural environment
Impact on natural environment	△ No immediate impact, but slope failure and soil erosion without proper management will eventually degrade natural environment	◎ Limited impact as the engineering work will be limited in the side of existing road	◎ Limited impact as the engineering work will be limited in the side of existing road	× A more detailed analysis is needed to assess potential impact for new bypass to be constructed in open forest
Social Impact	△ No immediate impact, but frequent slope failure and landslide will hamper the movement of goods and people along NH54.	○ Widening will create a positive impact but greater traffic volume in major towns/villages result in traffic jams, which may offset some positive impacts.	○ Widening will create a positive impact but greater traffic volume in major towns/villages result in traffic jams, which may offset some positive impacts.	◎ The positive impact will be biggest as the road is widened without causing traffic jam in major towns.
Pollution	× No immediate impact, but poor road and growing level of congestion will lead to elevated pollution level in the long-run, particularly in	○ The option leads to least level of congestion and thus least to relatively small increase in vehicular emissions.	△ More congestion will be expected compared with option one, but still leads to better situation compared with without project scenario.	◎ Traffic will not pass through densely built up area and thus the health impact associated with greater vehicular emission

Alternative	Zero Option	One	Two	Three
	built-up area			will be minimized.
Traffic Safety	× Likely to deteriorate further as no safety measures will be implemented.	○ Proper safety measures inc. traffic signs will be required as the speed of vehicles passing through built-up area is likely to increase.	○ Proper safety measures inc. traffic signs will be required as the speed of vehicles passing through built-up area is likely to increase.	◎ The traffic does not pass through densely built-up area and thus the risk of accident will be reduced.
Construction cost	N/A	△ Require significant cost associated with land acquisition and resettlement.	◎ The cost associated with land acquisition and resettlement will be less than option one.	× While the cost associated with resettlement will be least among three options, cost of constructing new bypass will be significant.
Overall Evaluation (Ranking in bracket)	**4** Given the vulnerability of existing road against landslide and the importance as the key infrastructure in the state, it is not recommended to keep the condition as it is.	**3** The option will trigger significant resettlement. Given the limited availability of open and flat land, preparation of new resettlement site will be necessary.	**1** The scale of widening is compromised in some areas, but this level of widening will be sufficient for caring existing and projected traffic volume in mid-terms.	**2** The scale of resettlement will be minimum, but the high cost associated with bypass construction will undermine economic viability of the project.

Note: ◎: most desirable, best among the option; ○: desirable but better option is available; △: other option is preferable; × should be avoided

Source: JICA Study Team

Option two has been identified as the most viable option for this project. However, considerable expectation for new bypasses has been observed during consultation meetings, particularly from residents in large village in which widening is likely to trigger significant resettlement. After a review of likely resettlement impact, future traffic volume and economic viability of the project in the long-term, and feasibility from engineering g point of view, four major villages with over 4,000 population, namely: Chhiahtlang, Serchhip, Hnathial and Lawngtlai, have been selected for bypass construction.

8.4.2 Analysis of Alternative for NH54 Bypasses

The analysis of alternatives for four bypasses that have been identified the feasibility study for widening and improvement of NH54. As discussed in Section 4.1, a total of 10 alternative routes have been studied for the project (two alternative routes for BP1, 3 and 4, and four alternative routes for BP2). In this stage, the altenrtive have been assessed based on 1) likely environmental and social impacts, including the volume of surplus soil and distance from protected area; 2) risk of natural diasters; 3) the length of bypass and 4) construction cost.

Table 8.4-3 Conclusions from Alternative Analysis

No.	Bypass Name	Route	Length (km)	Conclusion
1	Chhiahtlang Bypass	Alternate-0	2.200	Though Alternative-2 is ranked 1st in the analysis, both alternative routes are basically similar except the end section. Therefore, it will be further studied after detailed topographic survey results are available.
		Alternate-1	2.584	
		Alternate-2	2.578	
2	Serchhip Bypass	Alternate-0	9.700	Alternative-2 is selected as optimum route due to better alignment, less spoil volume and compensation of houses and least cost among 4 alternatives.
		Alternate-1	12.422	
		Alternate-2	11.629	
		Alternate-3	11.708	
		Alternate-4	12.164	
3	Hnathial Bypass	Alternate-0	10.000	Alternative-2 is selected as optimum route due to less spoil volume, compensation of houses and construction cost.
		Alternate-1	6.799	
		Alternate-2	6.794	
4	Lawngtlai Bypass	Alternate-0	5.800	Alternative-2 is selected as optimum route due to better alignment, less spoil volume, compensation of houses and construction cost.
		Alternate-1	6.270	
		Alternate-2	6.100	

Source: JICA Study Team

(1) Scale of Invluntary Resettlement (Bypass One)

Bypass one passes through the existing community road near the ending point. As the image below shows, widening both sides of the community road will result in demolishment of house and other structures in both sides. Widening of valley side only (Alternative 2) will result in resettlement of 19 households while widening of both sides are likely to result in resettlement of over 35 households. For other bypasses, no significant differences have been identified in terms of involuntary resettlement.

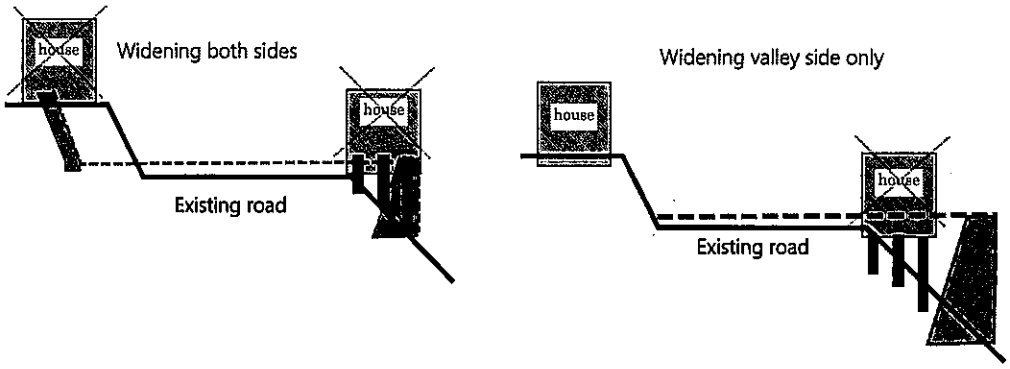


Figure 8.4-4 Widening in Community Road section

8.5 Scoping of Environmental and Social Impacts

8.5.1 Procedure of Scoping

In order to assess the likely significant environmental and social impacts, potential environmental and social impacts of the project were preliminary identified based on the project description and overall environmental and social conditions in and around project area. The assessment also builds on the feasibility study of widening of NH54 between Aizawl and Tuipang, which was carried out in 2015. The impacts of pollution, natural environment and social environment, health and safety, emergency risk, and others were classified as A to D in accordance with the following criteria, assuming no specific measures toward the impacts are taken:

A-: Significant negative impact A+: Significant positive impact
B-: Some negative impact B+: Some positive impact
C: Impacts are not clear, need more investigation
D: No impact or impacts are negligible, no further study required

8.5.2 Results of Scoping

Results of the scoping for environmental and social impact assessment are shown in Table 6.1. Scoping was conducted toward the construction of four bypasses. A separate description is added where likely environmental and social impact are considerably different across different bypasses. The positive and negative impacts associated with the proposed project vary temporally and therefore, impacts were evaluated for three different stages, which are: pre-construction; construction; and operation. In the table below, they are referred to as P, C and O respectively.

Table 8.5-1 Scoping Matrix for NH54 Bypass Construction

Sl.	Item	Scoping Result			Rational of Assessment
		P	C	O	
Natural Environment					
1.1	Climate/ Meteorological Phenomena	D	D	D	P: No impact is expected as no engineering work is carried out at this stage.
					C/O: The impacts on micro-climate and micro meteorological phenomena are negligible because the project-related structures will not disturb wind path.

1.2	Topography	D	A-	D	P: No impact is expected as no engineering work is carried out at this stage.
					C: Changes in topographic conditions are expected due to the requirement of cutting filling work. Balancing the volume of cutting and filling is recommended to minimize the volume of spoil soil.
					O: Topographic condition will be stable after the completion of construction work which include slope protection and slope stabilization.
1.3	Geology	D	D	D	P/C/O: No impact is expected as the project does not alter geological condition of the area.
1.4	Soil Erosion	D	A-	B+/B-	P: No impact is expected as no engineering work is carried out at this stage.
					C: Soil erosion is expected particularly during the monsoon period. Construction work should avoid the monsoon period.
					O: Poor condition of drainage causes soil erosion in existing road. The project is expected to improve the condition and thus reduce the risk of soil erosion, but measures for slope protection and stabilization and prevent soil erosion, particularly during the monsoon period, must be in place and regularly monitored.
1.5	Hydrology	D	B-	B-	P: No impact is expected as no engineering work is carried out at this stage.
					C: Construction work may cause minor, temporary impacts on hydrology.
					O: Cutting and/or filling may result in changes in local hydrology. New drainage and culvert will be installed, taking into account the likely water flow in the area.
1.6	Groundwater	D	D	D	P: No impact is expected as no engineering work is carried out at this stage.
					C: The project does not envision the use of groundwater and thus no impact is expected.
					O: No impact is expected during the operation stage.
1.7	Ecosystem, Flora, Fauna and Biodiversity	D	A-	B-	P: No impact is expected. No unique/endangered species have been identified during assessment.
					C: The project will not affect pristine ecosystem as the work will be carried out along the existing road. However, construction work will affect mountain ecosystem and local flora and fauna including jhum and plantation.
					O: Increases in traffic volume will have negative impact ecosystem and flora and fauna along the road.
1.8	Protected Areas/Forest	C	C	C	P/C: The bypasses do not traverse or border with national parks or protected forest. Meanwhile, potential indirect impacts on nearby protected area will need to be assessed continuously.
					O: Increases in emissions due to greater traffic volume will negatively affect forest and surrounding ecosystem. Monitoring shall be carried out to check the impact of increased emissions on forest/plantation and measures (e.g. additional plantation) shall be undertaken to mitigate negative impacts as necessary.
1.9	Coastal Zone	D	D	D	P/C/O: No impacts are expected, because the alignment is far away from the coastal zone and the planned alignment will not pass the tidelands and the mangrove forests which are peculiar to the coastal region.

1.10	Landscape	D	D	B+	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Changes in landscape during the construction work will be minor and temporary.
					O: Improved road network facilitates access to scenic places and tourist attractions, thereby positively contributing tourism in the region.
1.11	Natural Disaster	D	B-	B+	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Many areas of the road are prone to landslide and thus appropriate measures should be in place during the construction work to avoid accidents. Construction during the monsoon period is risky and should be avoided.
					O: Slope protection/stabilization measures and drainage are expected to significantly reduce the risk of natural disaster.
Living Environment (Pollution Control)					
2.1	Air Pollution	D	B-	B-	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Some negative impacts are expected due to operation of construction equipment and vehicles. One of these is the dust incidental to earthwork especially during the dry season.
					O: Air pollution is expected to increase due to increase traffic volume on the road. Relevant data (e.g. actual/projected traffic volume) shall be shared with relevant State authority so that mitigation measures can be developed.
2.2	Offensive Odor	D	D	D	P/C/O: No impact is expected as the project does not involve the use of chemical and other materials that may cause offensive odor.
2.3	Water Pollution	D	B-	B-	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Turbid water due to the earthworks and wastewater effluents from construction workers' camps/yards are expected to pollute the surrounding rivers/canals to some extent.
					O: Some impacts on water quality in surrounding water bodies are expected due to water discharge from road users and wastewater from maintenance activities.
2.4	Bottom Sediment Contamination	D	D	D	P/C: No impact is expected.
					O: Some wastewater will be generated from maintenance activities along the road, the impacts on bottom sediment from the wastewater will be negligible.
2.5	Soil Contamination	D	D	D	P: No impact is expected as no engineering activity will be carried out at this stage
					C: Impacts on soil from deposition of pollutants from construction materials in the construction site are expected to be small. Since there is no major industrial activity along the road, it is unlikely that soil along the road is already polluted.
					O: No impact is expected except for the risk of accidental spillage of oil and lubricant, which will be managed by proper safety measures.
2.6	Ground Subsidence	D	D	D	P/C/O: No impact is expected
2.7	Noise/ Vibration	D	B-	B-	P: No impact is expected.
					C: Noise and vibration are generated by operation of construction equipment and vehicles, although they are temporary. Construction schedule should take into account the location of schools, hospitals and religious facilities that require silence in part of the day.

					O: Noise and vibration level are likely to increase due to greater traffic volume along the road. Specific measures may be required to minimize impacts on schools, hospitals and religious facilities.
2.8	Sunshine Obstruction	D	D	D	P/C/O: No impact is expected.
2.9	Wastes/Hazardous Materials	D	B-	B-	P: No impact is expected. C: Waste from construction workers' camps are expected to be generated. Waste generated from construction and demolition work may include hazardous materials that must be treated before final disposal. O: Waste will be generated from road users and workers of maintenance works.
Social Environment					
3.1	Involuntary Resettlement	A-	D	D	P: Bypass construction is likely to result in involuntary resettlement of 20 households, majority of which will take place in BP1. Minimizing the resettlement should be the priority for road design. C: Resettlement will be completed before construction begins and thus no resettlement is expected during operation O: No impact is expected, as relocation will be completed before construction begins.
3.2	Land Use	A-	A-	D	P: Land acquisition and involuntary resettlement are likely to cause changes in existing land use pattern. C: The project will be carried out along the existing road, and as such, changes in land use associated with construction work are relatively minor, and land clearance for construction yards and workers' camps is temporary. No impact is expected as sufficient slope protection/ stabilization measures to protect land use.
3.3	Utilization of Local Resources	D	A-	D	P: No impact is expected. C: Mass-scale use of local resources such as sand and quarrying for the construction activities may obstruct there utilization by the local people for other purposes. O: No impact is expected as use of local resources is not expected during operation.
3.4	General, Regional /City Plans	D	D	D	P: No impact is expected. C: No impact is expected. O: Better infrastructure network may trigger influx of outsiders and economic development in the region.
3.5	Social Institutions and Local Decision-making Institutions	D	D	D	P/C/O: No impact is expected as there will be no change in social institutions and local decision-making institutions such as village councils and women groups
3.6	Social Infrastructure and Services	D	A-	B+	P: No impact is expected at this stage while community center and public hall may be used as a venue for consultation for EIA/RAP. C: Access to social infrastructure and services, such as water point in BP1, may be temporarily affected due to construction of construction yard and accommodation for workers as well as traffic jams due to the operation of construction vehicles. O: The project is expected to improve access to social infrastructure and services by providing better road network.
3.7	Local Economy and Livelihood	A-	A-	B+	P: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economic and livelihood.

					C: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economic and livelihood. On the other hand, construction work will have positive impact on local economy by creating employment and business opportunities in the project area.
					O: The project will have positive impact on local economy as improved road network ensures more stable supply of essential goods. In the long-term, this will lead to regional economic development with more job and business opportunities.
3.8	Unequal Distribution of Benefit and Damage	A-	A-	D	P: Land acquisition and involuntary resettlement will lead to unequal distribution of benefits and damage between groups who are directly affected by the project and who are not.
					C: While resettling households bear much of the damage, others may even enjoy benefits from new business opportunities created by construction work, resulting in unequal distribution of benefit and damage.
					O: No impact is expected.
3.9	Local Conflicts of Interest	D	D	D	P/C/O: No impact is expected.
3.10	Water Usage, Water Rights and Communal Rights	D	D	D	P/C/O: No impact is expected as rain water is used for both household and agricultural use.
3.11	Cultural and Historical Heritage	C-	D	D	P/C/O: No impact is expected as the project will not affect cultural and historical heritages
3.12	Religious Facilities	A-	A-	D	P: Local graveyard is located near the proposed bypass alignment (BP1), and a memorial stones located at the existing road (BP2) may be affected. Small religious facilities in built-up areas may also be affected.
					C: Roadside religious facilities may be affected by noise and vibration during construction and operation due to construction work and greater traffic volume.
					O: No impact is expected as sufficient noise control measures will be implemented.
3.13	Sensitive Facilities (ex. hospital, school, precision machine factory)	B-	B-	D	P: Pre-school near the starting point of BP1 may be affected.
					C: Noise and vibration during construction work may affect school and hospitals but the impacts are expected to be minor.
					O: Greater traffic volume is expected to increase noise and vibration level, but adequate mitigation measures will be implemented.
3.14	Poor People	A-	A-	D	P: Given the limited coping capacity of the poor, it is necessary to assess their vulnerability and develop appropriate mitigation measures to be included in rehabilitation plan.
					C: The poor may bear disproportionally higher burden due to their limited coping capacity, although they can be benefited from employment opportunities during construction work.
					P: No impact is expected. In the long-term, economic development in the region is likely to benefit the poor.
3.15	Ethnic Minorities/ Indigenous People	A-	A-	D	P/C/O: The project area is inhabited by several Mizo tribes and they co-exit peacefully without conflicts. All subtribes speak Mizo and therefore communication barrier does not exit either. Preparation of RAP and rehabilitation plan will take into account Mizo culture and customs.
3.16	Gender	D	C-	B+	P: No impact is expected.

					C: Equal opportunity should be sought for employment during construction work. Prevailing social and cultural norms must be carefully studied to avoid gender-related conflict.
					O: Better road condition is expected to reduce the burden of girls and women who carry water and fuel wood and improve their safety.
3.17	Children's Rights	C	C	C	P: No impact is expected.
					C/O : Child labor is unlawful according to article 24 of Indian Constitution. Only adult is eligible for potential employment opportunity created by the project.
3.18	Public Health (sanitation and infectious diseases)	D	B-	B-	P: No impact is expected.
					C: Influx of construction workers is likely to increase the health risk, particularly that of STD and HIV/AIDS. The risk of malaria should be properly managed in construction work in areas where malaria is prevalent.
					O: An increase in traffic volume and road users may have negative impact on public health.
3.19	Occupational Health and Safety (OHS)	D	B-	B-	P: No impact is expected.
					C: Occupational health and safety of construction work should be properly managed through adequate Environment Management Plan.
					O: Maintenance and repair work should take into account the occupational health and safety of the workers.
Others					
4.1	Accidents	D	B-	B+/B-	P: No impact is expected as the project at this stage does not alter existing condition.
					C: Increase of risks of accidents associated with construction activities is expected due to the operation of heavy equipment and vehicles.
					O: Risks of accidents is expected to increase due to greater traffic volume and speed. On the other hand, installment of accident-prevention measures (such as mirrors at curves) will reduce the risk of accidents.
4.2	GHG emissions	D	B-	B+/B-	P: No impact is expected.
					C: CO_2 emissions will increase due to the clearance of forest for bypass construction. The use of construction machines and operation of vehicles will result in an increase in GHG emissions, though the impact is small and short-term.
					O: Loss of forest cover will result in an increase in GHG emissions. The GHG emission will also increase due to an increase in traffic volume. The project is expected to improve the resilience of road against climate change by factoring long-term climate change (changes/increase in precipitation etc.) into the road design.

Note A-: Significant negative impact A+: Significant positive impact
B-: Some negative impact B+: Some positive impact
C: Impacts are not clear, need more investigation
D: No impact or impacts are negligible, no further study required

P: Pre-project Stage; C: Construction Stage: O: Operation Stage
Source: JICA Study Team

8.6 Assessment of Impacts and Mitigation Measures

The proposed project will have both positive and negative impacts on the surrounding environment during different stages of the project planning and implementation. For the assessment of impacts, the

baseline information has been supplemented by the field visits and the primary surveys of the various environmental components carried out during the study.

8.6.1 Natural Environment

(1) Climate

Pre-Construction and Construction Phase

No change in the macroclimate i.e. precipitation, temperature and wind is envisaged. However, there will be localized, temporary impact due to vegetation removal and the creation of paved surface for road. There may be an increase in daytime temperature around alignment due to loss of vegetation. The impact will be more prominent at locations where the cutting of trees is in clusters.

Operation Phase

During operation phase, increased traffic plying will lead to increase in temperature levels locally along the carriageway though it will be insignificant and temporary.

(2) Topography and geology

Pre-Construction and Construction Phase

The change in topography (that of existing) is envisaged to in section where new bypasses are constructed in hilly and mountaneous slopes. The change in topography will also happen due to operation of borrow areas. The construction of material handling yards and labor camps will also alter the existing topography temporarily.

Operation Phase

During the operation phase, there will be probable induced developments in the form of commercial establishments along the new bypasses. During monsoon, the change in topography will also be visible due to landslide and damage to side slope and breast wall. The benefits in the form of land leveling and tree plantations in the vicinity of the project road shall enhance the local aesthetics.

Mitigation Measures

During construction phase, the existing vegetation including shrubs and grasses along the alignment (except within the strip directly under embankment or cutting) will be properly maintained. The borrow areas shall be operated and closed as per the specifications for road and bridge construction standard. The borrow areas shall be filled with the rejected waste/material, spoil and then finally a layer of topsoil shall be spread over it before carrying out plantation and turfing.

During operation phase, maintenance of embankment will be carried out to avoid soil erosion. The slope protection/ retaining wall if damaged due to land slide will be repaired promptly. The slope protection will also be established/strengthened regularly through plantation of shrubs and vegetation.

(3) Soil Erosion

Pre-Construction and Construction Phase

Site preparation will involve demolition of building, clearing of brushwood, tree removal and temporary re-routing of utilities. This brings risks of erosion to the exposed ground and topsoil. The soil erosion in construction stage may take place at the slope of the embankments, construction sites of cross drainage structures, at borrow areas and at construction sites which will be cleared.

Operation Phase

The soil erosion in operation stage may take place during operation at side slopes of road and near the interchanges. The risk is higher during monsoon.

Mitigation Measures

To control roadside soil erosion, turfing with grasses and shrubs will be carried out in accordance with the recommended practice in IRC guidelines. At the locations of steep slopes near crossings of highway with major rivers suitable protection measures such as stone pitching will be adopted. The

surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill material operations shall be limited to the extent practicable. The contractor will provide immediate permanent erosion control measures to prevent soil erosion that will adversely affect construction operations, damage adjacent properties or cause contamination of nearby streams or other watercourses, village ponds or water bodies etc. The green belt will be developed simultaneously along with construction activities to control the erosion process. In addition, gabion and apron concrete will be installed at the outlet of culverts to avoid soil erosion due to water runoff.

During the operation phase, the slope protection measures like sodding, turfing shall be done and monitored regularly. The green belt will be monitored and replantation for the loss of plants species will be done immediately. The side ditch on road is designed as concrete lined ditch for all section of cut side to prevent damage from water runoff.

(4) Hydrology

Pre-Construction and Construction Phase

Potential impact on hydrology will be minor, as the project does not involve diversion or re-routing of existing water resources. However, the existing drainage will be slightly obstructed during the construction period, but for a limited period. Hence, change in natural drainage pattern is very insignificant from the present state of the project.

Operation Phase

The projects may marginally lead to increased run-off during operational stages due to increase in impervious surface and sediment will be accumulation in nearby water bodies.

Mitigation Measures

The new drainage system is designed by based on hydrological calculation result. Based on obtained location of water crossing and water discharge, dimension and locations for drainage system are determined. For cross drainage structure, appropriate culvert type is selected by taking account of economy, construction workability, and maintenance ability. Comparison of different culvert types is shown below. In principle, pipe culvert is used where the water discharge is comparably small. BOX culvert is proposed where the water discharge is comparable large. The size is determined to satisfy the water discharge obtained by hydrological calculation.

(5) Groundwater

No tunnel is proposed in this project and as such, the project will not affect groundwater level or quality in the area. If contractor propose to use water from under surface water source, however, permission from the Water Resource Department and Local Administration is mandatory. The contractor is expected to properly manage effluents and waste water during the construction stage to avoid potential influence to the groundwater.

(6) Ecosystem, Flora, Fauna and Biodiversity

Being part of India-Burma biodiversity hotspot, Mizoram is known for its rich biodiversity. Meanwhile, no pristine ecosystem remains in the areas along NH54, the main road network of the State, due to human activities. As such, there are significant differences in the level of biodiversity and richness of flora/faunal community between in the area the proximity of NH54 and in Natural Park and Protected Areas of the State. Even in sections where the bypasses pass through hilly and mountaneous slopes, the areas are not pristine forest but mostly jhum field, fallow or plantation. Natural vegetation grow in fallow area but they are to be burned in the next cycle of jhum farming.

Flora and fauna assessment were carried out for all the four areas where the bypasses are proposed for two seasons. Floral/Vegetation assessment carried out through quadrate methods: for trees 10mx10m, for shrubs 5mx5m and for Herbs 1m x1m square shaped quadrates were used. Quadrates were laid randomly in the corridors upside and downside of the road. All species in the quadrates were recorded & ecological parameters such as density and frequency were calculated. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. There is no

unique faunal community within the project area. No endangered or threatened fauna species were reported in the area.

The main impact on flora involves the removal of trees and grubbing of vegetative cover for construction and a clear zone within the Right of Way (ROW) and for spoil bank.

Mitigation Measures

In the process of finalizing ROW, efforts to minimize the scale of forest clearing and impacts associated with construction activity shall be made. The contractor shall review/renew relevant permit as necessary and fully cooperate with inspection by relevant authority.

During the construction stage, signboards will be used to make sure that workers will be aware of the vulnerable and other important species. Relevant information (e.g. encounter with vulnerable species during engineering work) shall be shared with State Environment and Forest Department with which the project authority will discuss potential measures to promote conservation and monitoring of ecosystem shall be carried out.

The tree cleard due to construction work will be replaced and compensated according to the Compensatory Afforestation Policy under the Forest Conservation Act, 1980. Apart from trees earmarked for feeling, no additional tree clearing within the ROW will be allowed. All construction workers should adhere to this rule. It is recommended that the two or more trees will be planted for a loss of one tree. The site of compensatory afforestation will be specified by the Forest Department during the process of obtaining forest clearance. As per its guidance, the project proponent will plant saplings (types and number to be specified) at designated location (either degraded forest or vacant/abandoned jhum area).

(7) Protected Areas/Forest

Pre-Construction and Construction Phase

The project road does not traverse or border with national park, wildlife sanctuary or reserved forest. As discussed above, however, three wildlife sanctuaries are located near the area (but more than 10km away). The conditions of these WLS should be monitored periodically so that potential indirect impacts to these sites can be identified and mitigation measures can be developed.

Operation Phase

Increases in traffic volume are likely to have negative impact on forest ecosystem.

Mitigation Measures

At the planning stage, efforts to avoid or minimize the number of trees to be cut have been done as part of the design for widening of the road. For greening the slope as part of slope protection, use species that indigenous breed in the project area to minimize impacts on existing ecosystem.

During the operation stage, monitoring shall be carried out to check the impact of increased emissions on forest/plantation and measures (e.g. additional plantation) shall be undertaken to mitigate negative impacts as necessary. All data related to increased traffic volume and emissions shall be shared with relevant state authorities. In addition, improved road network may trigger poaching. At the moment, educational activities and removal of traps by rangers are undertaken to reduce poaching. While NHIDCL is not responsible for the control of poaching, a proposal shall be made to relevant authority regarding the potential increase in poaching and the necessity of adequate management system, such as restriction of precious wildlife trade.

Deforestation is one of the main causes of climate change. The project clears forest in hilly and mountaneous slopes to construct new bypasses, which results in GHG emissions. The loss of forest also means the loss of long-term carbon sequestrating capacity. Given that more than 20% of the entire Mizoram state is jhum field, which is regularly burned yearly with considerable GHG emissions, the impact of the project in terms of GHG emission volume will be minor. Yet, as per the requirement of Forest Act, the project will undertake reforestation to compensate the loss of forest. Indeed, it is planned that more trees will be planted than cut due to the project, and therefore, the project will result

in net increase in carbon sequestration capacity in the State in the long-term. The detailed terms and conditions of reforestation will be finalized in consultation with the Environment and Forest Department of the State.

8.6.2 Living Environment

(1) Air Quality

Being on hill, towns and villages along NH54 generally have good ambient air quality. The project road alignment also has no polluting industry along it. There is congestion due to traffic in major the built up area. This leads to vehicular exhaust emissions and deterioration for which the proposed bypasses will have positive impact.

Pre-Construction and Construction Phase

The short-term and localized degradation of air quality will occur from dust generation due to procurement and transport of raw materials from quarries and borrow pits, site clearance, use of heavy vehicles, machinery/ equipment, stone crushing handling and storage of aggregates and generation of fine particulate matter (smoke) in asphalt processing. Dust would be generated from haulage of materials and detouring of traffic on non-permanent, temporary pavement etc.

Hot mix plants contribute substantially to the deterioration of air quality due to emissions of oxides of Sulphur, Hydrocarbons and particulate matter. During the construction period, temporary impacts include generation of Odor from construction activities as well as from construction camps. During construction of road, the movement of different types of construction machinery and vehicle will be increased. This in other way increases the fuel consumption.

From the results of the ambient air quality monitoring conducted along the road, it is noticed that the monitoring parameters are within the standards as prescribed by the Central Pollution Control Board. The concentration of the air pollutants will further increase during construction period but for limited period only. The impacts on air quality during construction will be mostly localized and concentrated within the ROW. The impacts due to dust generation may felt downwind of the site rather than the site itself due to local wind pattern.

Operation Phase

The project road is mostly passing through the rural areas with alluvial soil. Dust generation due to movement of vehicles is envisaged along the project road, but not in significant amount. Due to increase in speed and volumes of vehicular traffic on the project corridor, marginal increase in the air pollutant levels is expected but not significant. Widening of road will attract larger community to use this corridor which in-turn increase the fuel consumption and has direct impact on national economy and local ecosystem.

Mitigation Measures

The hot mix plants, crushers and the batching plants will be sited at least 500 m in the downwind direction from the nearest settlement. All precautions to reduce the level of dust emissions from the hot mix plants, crushers and batching plants will be taken up. The hot mix plant will be fitted with dust extraction system. Asphalt and concrete plants will be operated in conformity with government pollution control legislation, and located away from the settlements as far as possible. All vehicles, equipment and machinery used for construction will be regularly maintained to ensure that the pollution emission levels conform to the SPCB norms. Regular monitoring of particulate Matter at crusher sites, during the construction, will be conducted. Regular water sprinkling will be done on the cement and earth mixing sites, asphalt mixing site and temporary service and access roads. After compacting the earthwork, water will be sprayed to prevent dust emission. The vehicles delivering construction material will be covered to avoid spilling. Planting of trees/vegetation on the periphery of the construction site will be taken up.

During the operation stage of the project, vehicular emissions of critical pollutants (RSPM, CO, HC, SO_2, and NO_x) will be monitored and roadside tree plantation will be maintained. Over the long-term, projected increase in traffic volume, particularly ones of heavy trucks, may pose health threat in roadside community. The peak hourly estimated traffic volumes for the years 2020 and 2035 have

been considered to project future air quality scenarios to provide an indication of long-term variations in air quality. The future level of air pollution, modeled based on the projected increase in traffic volume indicates that the level of pollution (CO and NOx levels) will remain below the standard during the projected period (2035). Nevertheless, mitigation measures such as introducing speed limit and other measures to control congestion in built-up area may be necessary in the longer term. Also, local communities should be well informed of the risk of air pollution. Awareness raising campaign may include distribution of facemask to mitigate risk of air pollution and other information kit.

(2) Water Quality

Pre-Construction and Construction Phase

The bypasses may marginally lead to increased run-off during construction stages, which will increase sediment accumulation in nearby water bodies. Though most of the natural watercourses are perennial in nature, the impacts due to the increased run-off would be negligible due to the project road. During construction, the disposal of solid and liquid waste from labor camps, fuel and lubricant spills or leaks from construction vehicles, pollution from fuel storage and distribution sites and that from hot-mix plants is likely to affect water quality unless adequate mitigation measures are designed. The existing drainage will be slightly obstructed during the construction period, but for a limited period. Hence, change in natural drainage pattern is very insignificant from the present state of the project.

Use of water for construction activities such as compaction, suppression, concrete work may pose pressure on local water supplies; the demand would be met from surface water bodies like ponds, canal and rivers. Municipal water supply will be used only for drinking purposes (for construction camps), if available and if permitted by the local municipal authority. No local/municipal water supply would be used for construction purpose.

Operation Stage Impacts

In the operation stage, pollutants from vehicles, and accidental fuel spills may make their way into the receiving environment. The major pollutants of concern are suspended solids, oil and grease, lead etc. All the rivers present at this road section are non-perennial surface water bodies. No adverse direct impact on the water quality (both underground and surface water bodies) is expected during the operation period. The change in natural drainage pattern is very insignificant from the present state of the project.

Mitigation Measures

To avoid contamination of the various water bodies and drainage channels, construction work close to water bodies will be avoided during monsoon period. All necessary precautions will be taken to construct temporary or permanent devices to prevent water pollution due to increased siltation and turbidity. All wastes arising from the project will be disposed off, as per the State Pollution Control Board norms, so as not to block the flow of water in the channels. The wastes will be collected, stored and taken to approve disposal sites.

To avoid contamination of the water body and drainage channels from fuel and lubricants, the vehicles and equipment will be properly maintained and re-fuelled only at designated places. The slopes of embankment leading to water bodies will be modified and re-canalized so that contaminants do not enter the water body. Oil and grease traps will be provided at fuelling locations, to prevent contamination of water.

(3) Soil Contamination

Pre-Construction and Construction Phase

The contamination of soil during construction stage is primarily due to construction and allied activities. The soil contamination may take place due to solid waste from the labor camps set- up during construction stage. This impact is significant at locations of construction camps; stockyards, hot mix plants, etc. The sites where construction vehicles are parked and serviced are likely to be contaminated because of leakage or spillage of fuel and lubricants. The contamination of soils can also occur at the site of hot-mix plants from leakage or spillage of asphalt or bitumen. At the site of

batching plants, because of spillage of cement, leakage of curing agents the soil contamination can occur. The contamination of soil may take place due to dumping of solid waste in unscientific manner, leaching of fuel/oil & grease from workshops, petrol stations and DG sets.

Operation Stage Impacts

During the operation stage, soil pollution due to accidental vehicle spills or leaks is a low probability but potentially disastrous to the receiving environment, should they occur. These impacts can belong term and irreversible depending upon the extent of spill.

Mitigation Measures

At construction yards, the vehicles/equipment will be maintained and re-fuelled in such a fashion that oil/diesel spillage does not occur and contaminate the surrounding soil. It will be ensured that the fuel storage and re-fuelling sites are kept away from drainage channels and important water bodies. At the washdown and re-fuelling areas, "Oil Water Separators" shall be provided. All spills and discarded petroleum products shall be disposed off in accordance to the Hazardous Waste Management and Handling Rules. Fuel storage and re-fuelling areas will be located at least 500 m from all water bodies near the road alignment. The fuel storage and re-fuelling areas shall not be located on agricultural lands or productive lands to avoid topsoil contamination. The earthwork will be carried out strictly in accordance with the design so that no excess earth is borrowed. The construction waste generated will be reused in the construction of highway.

In the operation stage, the petrol pumps & vehicle washing area located along the ROW will be monitored regularly for any spillages and corrective remedial measures like spread of sand, provision of oil & greases separators for passing wash water of petrol pumps & vehicle washing area before diverting it to water bodies shall be done regularly. The solid waste generated from the way side amenities will include Municipal Waste both organic and inorganic, hazardous waste (like used batteries), will be treated in accordance with Municipal Solid Waste (Management & Handling) Rule and Hazardous Waste (Management, Handling & Transboundary Movement) Rules.

(4) Noise and Vibration

Pre-Construction and Construction Phase

During the construction, the major sources of noise and vibration are movement of vehicles transporting the construction material to the construction yard and the noise and vibration generating activities at the yard itself. Mixing, casting and material movement are primary noise generating activities in the yard and will be uniformly distributed over the entire construction period. Construction activities are expected to produce noise levels in the range of 80 - 95 dB (A). The major work will be carried out during the daytime. The noise levels in the project area during the construction stage will be intermittent and temporary in nature. Typical noise levels associated with the various construction activities and construction equipment are presented below.

Regarding this project, most areas where the bypasses go through are forests and far from the human settlements excluding the start/end points. Then, it is necessary to consider the impact from above activities specifically for the start/end points of each bypass.

Table 8.6-1 Typical Noise Levels of Construction Equipment

Construction Equipment	Noise Level dB(A)
Bulldozer	80
Front end loader	72-84
Jack hammer	81-98
Crane with ball	75-87
Crane	75-77
Bulldozer	80
Backhoe	72-93
Front end loader	72-84
Cement & Dump trucks	83-94
Jack hammer	81-98
Scraper	80-93

Construction Equipment	Noise Level dB(A)
Welding generator	71-82
Grader	80-93
Roller	73-75
Concrete mixer	74-88
Concrete pump	81-84
Concrete vibrator	76
Paver	86-88
Truck	83-94
Tamper	74-77
Air compressor	74-87
Pneumatic tools	81-98

Source: U.S. Environmental Protection Agency, noise from Construction Equipment and Operations. Building Equipment and Home Appliance. NJID. 300.1. December 31, 1971

At the moment, noise level is mostly within the desired level. The noise and vibration level will be increased during construction period, which have significant impact for a limited period on the surrounding environment. The noise levels in the working environment are compared with the standards prescribed by Occupational Safety and Health Administration (OSHA-USA) which in-turn are being enforced by Government of India through Model rules framed under the Factories Act. The acceptable limits for each shift being of 8 hour duration, the equivalent noise level exposure during the shift is 90 dB(A). Hence noise generated due to various activities in the construction camps may affect workers, if equivalent 8 hour exposure is more than the safety limit. ACGIH (American Conference of Government Industrial Hygienists) proposed an 8 hour Leq limit of 85 dB(A).

Operation Stage Impacts

During the operation stage of the project, reduction of vehicular engine noise (as a result of reduced congestion from earlier, smoother flow of traffic due to 2 separate lanes), vehicular body noise (as a result of reduced development roughness) and reduction of blowing of horns will bring the noise levels down, but as volume of traffic, mainly heavy duty traffic will be increase in future due to rapid development and industrialization along the road corridor this may increase noise and vibration slightly.

Mitigation Measures

The high noise and vibration levels may cause discomfort to local residents and workers specifically near start/end points of each bypass. Following mitigation measures shall be adopted to keep the noise and vibration levels under control.

- The plants and equipment used for construction will strictly conform to Central Pollution Control Board (CPCB) noise standards. Vehicles, equipment and construction machinery shall be monitored regularly with particular attention to silencers and mufflers to maintain noise levels to minimum;
- Workers in the vicinity of high noise levels must wear ear plugs, helmets and should be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 90dB (A);
- In construction sites within 150 m of human settlements, noisy construction will be stopped between 10 PM and 6 AM except in case of laying of cement concrete pavement for which lower working temperature is a requirement;
- Hot mix plant, batching or aggregate plants shall not be located within 500 m of sensitive land use as schools;
- Phase demolition, earthmoving and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately
- Careful planning of machinery operation and scheduling of operations can reduce the noise levels. Use of equipment, emitting noise not greater than 90 dB(A) for the eight-hour

operations shift and locating of construction yards at a distance of at least 500 m from any residential areas can be adhered to;

- Use of air horns should be minimized on the highway during nighttime. During daytime use of horns should be restricted at few sensitive locations. This can be achieved through the use of sign boards along the roadside;

Since there is no target level set in India, the tentative target vibration levels from traffic are set in accordance with the Japanese target level as shown in Table below.

Table 8.6-2 Tentative Target Vibration Level from Traffic

Construction Equipment	Daytime (L_{10})	Nighttime (L_{10})
Target Level (dB)*	65	60

* Applied "Residential Area"

Source: The Vibration Regulation Law (Japan) (Law No. 64 of 1976, Latest Amendment by Law No.75 of 1995)

(5) Wastes/Hazardous Materials

Types of construction waste to be generated include asphalt chunks, chunks of concrete, surplus soil, construction scrap materials and organic waste generated by construction workers. The amount and percentage composition of construction waste will depend on the final design and the schedule of the construction, and thus generic mitigation measures proposed in EMP should be updated once the final ROW drawing is completed. All other construction wastes are also planned to comply with relevant Center or State laws pertaining to waste management.

Based on the preliminary design for NH54 Bypass, the necessary volume of spoil bank has been calculated as below.

Table 8.6-3 Required Volume for Spoil Bank

Bypass Name	Item	Volume of Generated Soil	Coefficient of Compaction	Volume of Compacted Soil	Required Volume of Spoil Bank
		Cu.m		Cu.m	Cu.m
Chhiahtlang Bypass	Cut Soil	127,499	0.9	114,749	77,238
	Fill Soil			37,511	
Serchhip Bypass	Cut Soil	743,768	0.9	669,391	481,306
	Fill Soil			188,085	
Hnahthial Bypass	Cut Soil	379,505	0.9	341,555	252,047
	Fill Soil			89,508	
Lawngtlai Bypass	Cut Soil	247,013	0.9	222,312	154,547
	Fill Soil			67,765	

Source: JICA Study Team

Followings are assumed conditions for suitable locations for that.

- ❖ To find out suitable place along NH-54 Bypass with following condition;
  - Ground shape with concavity topography
  - Less ground gradient than 22 degree 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 in less than 30m height

The proposed location of the spoil bank is presented in section 5.2.9. Local communities are also encouraged to use residual soil for community development, for example for ground leveling and creating of playground. The proper measure will be applied to each spoil bank to prevent soil erosion (and damage to jhum field), which was one of the key concerns raised during consultation meetings..

8.6.3 Socio-Economic Environment

(1) Involuntary Resettlement

As per the preliminary ROW design, the project will affect 257 houholds (1,485 persons). Out of those, 20 households (133 persons), which include 4 house cum shops, will be resettled. Two rounds of consultation showed their strong support to the project. Also, it was confirmed that they prefer cash compensation over land-for-land compensation. The proposed compensation package is presented in Entitlement Matrix in section 8.11.

(2) Land Use

The construction of bypass and spoil bank will cause changes in land use pattern, affecting existing agricultural and plantation activities. For sections where the proposed alignment passes through forest, jhum area and plantation, engineering work should be scheduled in a way that minimize disruption of access by local people. At the same time, proper management of effluent and soil erosion shall be carried out to avoid negative impact on such resources.

(3) Utilization of Local Resources and Local Economy and Livelihood

Significant volume of local resources such as sand may be used for construction work. This could cloud out the use of such resources for other purposes in the short-term. In the long-term, the better road network may attract new business, possibly from outside the state with detrimental impact on local business/traders. While the project overall will have significant positive impacts on the local and regional economy, the better transport network may put some groups at risk at least in the short and medium-term. These potential high-risk groups should be identified in the preparation of R&R plan to ensure that they will not be in a disadvantaged position due to the project.

(4) General, Regional /City Plans

The project will create new opportunities for village and district-level development planning. In particular, the construction of spoil bank will create large area of flat land where such surface is a scarce commodity. The development of spoil bank, therefore, should be coordinated with the village/district's development plan so that the land will benefit the community. Similarly, development of resettlement site should be well coordinated with village development plan to ensure proper supply of basic utilities and integration of new sites with the existing village area.

(5) Social Institutions and Local Decision-making Institutions

Different tribes of Mizo people co-exist across the project area without tribe-rooted conflicts. Being a tribal state, district and village council and traditional community leaders have significant influence on decision-making process in the area. As such, their support and cooperation is critical in smooth implementation of the project, particularly activities related to resettlement. The implementation of EMP as well as RAP/R&R should be built on existing social institutions and will be best guided by local people, rather than outside experts.

(6) Social Infrastructure and Services

Where the prosed bypasses will be constructed by widening the existing community road, construction activity is likely to cause temporary disturbance to their access to social infrastructure and service and therefore, schedule and timing of the engineering activity should be developed in consultation with the local community. When road blockage is necessary, e.g. for blasting, the local community should be informed in advance so that they can make alternate plan accordingly.

There is a small pre-school near the starting point of BP1, but it can be shifted since there is an open space behind it. Also, one water point and two public toilets exist near the ending point of BP1, and one water pump, one public toilet, and one memorial stone near the ending point of BP2 will be affected. They will be relocated prior to the commencement of construction work to minimize disturbance to the local community.

(7) Unequal Distribution of Benefit and Damage

Roadside or near-road location offers critical advantages for local business (tea stalls, restaurant, petty shops). Resettlement to inner part o the village may significantly undermine the viability of these businesses, and therefore, business owners to be affected may be worse off compared with farmers to be relocated. Sound arbitration and conflict resolution mechanism by local leaders should be in place for smooth implementation of RAP and R&R activity.

(8) Religious and Sensitive Facilities

A local cemetery is located near the proposed alignment of bypass one. While the alignment is design so as not to affect the cemetery itself, extra efforts should be paid to minimize negative impact during the construction, including noise and vibration and disruption of access by local people. More stringent standard for noise and vibration and air quality should be adopted where sensitive facilities such as school and hospitals are located.

One pre-school is located near the starting point of BP1. While there is enough empty space to set back the pre-school, construction work in this section should avoid the school terms/hours as much as possible. One memorial stone (commemorating the inauguration of the road) will be affected near the end point of bypass two. While the stone itself does not have significant religious or cultural importance, it should be relocated to an appropriate location.

(9) Poor People

The baseline survey has identified gap between official poverty level and poverty level as reported by the people. R&R activity should take into account the limited coping capacity of the local community and develop measures that leads to sustainable income generation of the affected people, rather than one-off payment of compensation and assistance.

(10) Ethnic Minorities/ Indigenous People

In the state of Mizoram, the tribal (Scheduled Tribe: ST) population constitutes about 95% of the total population. Overwhelming majority of the affected people also belong to ST, and hence they are not minority. While tribal groups in project area holds traditional culture, including shifting cultivation in forest called jhum, they freely interact and share their sources of water, folklore, food, infrastructure and other belongings with the non-ST and other tribal population within and outside community. ST population in project area is not isolated from outside.

(11) Gender

In general, tribal and non-tribal women in North East States enjoy a relatively higher position in the society than what their non-tribal counterparts do, which is reflected in their high literacy rate. Mizo women are largely involved in household work, collection of forest produce, firewood collection, cultivation and other agricultural activities and thus they will be affected in a way that is different from their male counterpart. In order to ensure that affected women will not be disadvantaged, a dedicated chapter on gender issue is included in women in which options to facilitate women's participation in project implementation and various opportunities to be created by the project is discussed. In particular, women shall have preferential access to specific types of project-related job opportunities, including light-duty work and part-time jobs that do not interfere with women's responsibility at home. In addition, efforts should be made ensure participation of women in consultation meetings to be carried out during the implementation of RAP.

(12) Public Health and Occupational Health and Safety (OHS)

The health and safety measures at design, construction and operation phase are given below.

Table 8.6-4 Health and Safety Measures

Construction Stage	
Health hazard to workers due to bad water and sanitation	• At every workplace, good and sufficient potable water (as per IS) supply shall be ensured to avoid water-borne diseases and to secure the health of workers. • Adequate drainage, sanitation and waste disposal shall be provided at workplaces. • Preventive Medical care shall be provided to workers.
Health/ social hazard, sexual harassment to female workers	Segregation of male and female areas in labor camp shall be executed.
Hygiene at Construction Camps	• The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the resident engineer. • There shall be provided within the precincts of every workplace, latrines and urinals in an accessible place, and the accommodation, separately for each for these, as per standards set by the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act. Except in workplaces provided with water-flushed latrines connected with a well designed septic tank, all latrines shall be provided with low cost 'Twin Pit Latrine' system. The pit can be closed after the construction is over. There shall be adequate supply of water, close to latrines and urinals. • All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed off in a lined landfill sites. Construction camps are to be sited away from vulnerable people and adequate health care is to be provided for the work force. • On completion of the works, the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the whole of the site left clean and tidy, at the Contractor's expense, to the entire satisfaction of the Engineer.
Abandoned Quarry will accumulate water and act as a breeding ground for disease vectors.	• Reclamation measure shall be adopted with garland of trees around the periphery. The quarry dust and waste shall be used for refilling. The remaining portion should be covered with trees. If the quarry site is porous, it shall be used by groundwater recharging.
Risk from Operations	• The Contractor is required to comply with all the precautions as required for the safety of the workmen as far as those are applicable to this project. The contractor shall supply all necessary safety appliances such as safety goggles, helmets, masks, etc., to the workers and staff. The contractor has to comply with all regulation regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.
Risk from Explosives	• Except as may be provided in the contract or ordered or authorized by the Engineer, the Contractor shall not use explosives. • The Contractor shall at all times take every possible precaution and shall comply with appropriate laws and regulations relating to the importation, handling, transportation, storage and use of explosives and shall, at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the Engineer. • The Contractor shall at all times make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whatsoever concerned or

	affected or likely to be concerned or affected by blasting operations.
Malaria risk	• The Contractor shall, at his own expense, conform to all anti-malarial instructions given to him by the Engineer, including filling up any borrow pits which may have been dug by him
Operation Phase	
Safety Measures	• Traffic Management plan shall be developed especially along congested locations. • Traffic control measures including speed limits will be enforced strictly. • Further growth of encroachment and squatting within row shall be discoursed.

Source: JICA Study Team

8.6.4 Other Issues

(1) Accidents

Construction Phase Impacts

During the construction stage, dismantling of structure, cutting of trees, haulage material obstructing vision, spillage of lubricants on road making it slippery is generally the cause of road accidents. Similarly, in operation stage, increase in traffic and increase in speed would tend to increase in accidents. It is likely that there will be some concern of safety for highway users during construction period, as haulage of material and other equipment would restrict movement of vehicles. Highway patrolling system with ambulance facility and crane will render assistance to users in distress and disabled vehicles which in-turn will improve the safety level.

Operation Phase Impacts

In operation stage, increase in traffic and increase in speed would tend to increase in accidents. In-spite of these, the social benefits from the project are quite significant.

Mitigation Measures

The proposed traffic safety measures are presented in section 5.2.7.

(2) GHG emissions

There is a possibility of increased GHG emission due to the operation of heavy vehicles as well as traffic jams incidental to the construction works, this impact will be temporary. On the other hand, it is expected that the GHG emission will be increase due to increase traffic volume. The increase will be mitigated by keeping good road conditions which will reduce consumption of extra fuel and congestion, thereby mitigating GHG emissions over time.

Deforestation is one of the main causes of climate change. The project clears forest in hilly and mountaneous slopes to construct new bypasses, which results in GHG emissions. The loss of forest also means the loss of long-term carbon sequestrating capacity. Given that more than 20% of the entire Mizoram state is jhum field, which is regularly burned yearly with considerable GHG emissions, the impact of the project in terms of GHG emission volume will be minor. Yet, as per the requirement of Forest Act, the project will undertake reforestation to compensate the loss of forest. Indeed, it is planned that more trees will be planted than cut due to the project, and therefore, the project will result in net increase in carbon sequestration capacity in the State in the long-term. The detailed terms and conditions of reforestation will be finalized in consultation with the Environment and Forest Department of the State.

8.7 Environmental Management Plan

Descriptions of environment management measures during different stages of the project are provided below.

Table 8.7-1 Environmental Management Plan for Pre-Construction Stage

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
P1	Relocation of Project Affected Persons (PAP)	• All requirements of the RAP as applicable shall be completed before start of construction works. The activities broadly include acquisition of land and structures, relocation of utilities, payment of compensation and provision assistance	All areas (involuntary resettlement takes place in Bypass 1 and 2)	Before construction begins	Government of Mizoram, District Revenue authorities, Village Councils, NGO	PIU, SC
P2	Removal of vegetation	• Minimize the scale of vegetation clearing / damage to jhum field by factoring vegetation/forest cover in the final design of the bypass route alignment process • Removal of trees to be carried out after forest clearance is obtained • Reforestation/replantation of trees at a term as instructed by the Forest Department • Activity shall be supervised to avoid poaching of animals	All areas	Before construction begins (Reforestation /plantation may extend to during/after construction)	PIU, Contractor, Forest Dept.	PIU, SC, Forest Dept.
P3	Setting up construction camps	• Construction camps shall be located reasonably away from the nearest built-up area to avoid nuisance • Sewage system for a construction workers' camp shall be designed, built and operated to prevent pollution to ground or adjacent water body. Garbage bins shall be provided in the camps and regularly emptied and the garbage disposed of in a hygienic manner, to the satisfaction of the relevant norms and the Engineer. • In relation to underground water resources, the contractor shall take all necessary precaution to prevent interference with such water resources. • All relevant provisions of the Factories Act, 1948 and the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996 shall be adhered to.	All construction campsite identified by the contractor and approved by SC	During Establishment, Operation and Dismantling of Such Camps	Contractor	PIU, SC
P4	Setting up hot mix plants	• Hot mix plants and batching plants shall be located sufficiently away from habitation and agricultural operations. • Where possible such plants will be located at least 1,000 m away from the nearest habitation.	All hot-mix and batching plants	During Erection, Testing, Operation and Dismantling of Such Plants	Contractor	PIU, SC

P5	Finalizing sites for surplus soil dumping	• Location of dumping sites shall be finalized in consultation with relevant village authorities. The site and its design shall meet following conditions: i) dumping does not impact natural drainage courses; ii) no endangered/rare flora is impacted by such dumping	All areas identified as potential dumping sites	During mobilization	Contractor	PIU, SC
P6	Identification of hazard-prone locations	• The contractor shall identify locations sensitive to landslides (in addition to the ones that area already identified) and shall duly report these to the Supervision Consultant (SC) and to PIU.	All areas	During mobilization	Contractor	PIU, SC

Source: JICA Study Team

Table 8.7-2 Environmental Management Plan for Construction Stage

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
Soil						
C1	Soil Erosion in Borrow Pits	• The depth of borrow pits shall be restricted so that sides of the excavation shall have a slope not steeper than 1:4 from the edge of the final section of the bank, if applicable	On approved locations of borrow pits.	Construction Stage	Contractor and Supervision Consultant	PIU
C2	Loss of top soil in Borrow pits	• Agricultural fields or productive land shall be avoided for borrowing earth. If unavoidable, topsoil shall be preserved and used for tree plantation	On approved locations of borrow pits.	Construction Stage	Contractor and Supervision Consultant	PIU
C3	Compaction of Soil	• Construction equipment and vehicles shall be restricted to move only within designated area to avoid compaction of productive soil	All areas	Construction Stage	Contractor and Supervision Consultant	PIU
C4	Soil erosion in embankments	• Pitching shall be done for slope stabilization as per the IRC guidelines, if applicable	At the places of embankments	Construction Stage	Contractor and Supervision Consultant	PIU
C5	Contamination of soil from fuel and lubricants	• Construction vehicles and equipment shall be operated and maintained in such a manner so that soil contamination due to its spillage shall be minimum • Fuel storage shall only be done on vacant area and will be kept away from drainage channels and natural water bodies	Near Labor camp and sites of installation of construction machineries.	Construction Stage	Contractor and Supervision Consultant	PIU

C6	Contamination of land from construction waste and quarry materials	• Debris generated due to the dismantling of the existing pavement structure and the cutting of the hillside for the widening (where section of existing community road is used for new bypass) shall be suitably reused in the construction, such as for fill materials for embankments • Debris and other material obtained from existing embankment shall be dumped in approved landfill site identified by concerned agency. All spoils shall be disposed of and the site shall be fully cleaned before hand over • Construction waste including non-bituminous and bituminous waste shall be dumped in approved landfill site identified by State Pollution Control Board (SPCB) or competent authority. All spoils shall be disposed of and the site shall be fully cleaned before hand over	Solid waste dump site identified and approved by SPCB or competent authority Throughout the area	Construction Stage	Contractor and Supervision Consultant	PIU
C7	Loss of top soil in land acquisition	• Topsoil shall be stripped, stored and shall be laid on ground for landscaping purpose as far as possible	Throughout the area	Construction Stage	Contractor and Supervision Consultant	PIU
Water						
C8	Contamination of water by fuel/ oil spillage of vehicle	• Construction vehicles/ equipment shall be operated and maintained in such a manner to avoid contamination of water bodies due to oil spillage • Fuel storage shall only be done on vacant area and will be kept away from drainage channels and natural water bodies	Near labor camp and sites of installation of Construction machineries.	Construction Stage	Contractor and Supervision Consultant	PIU
C9	Contamination of stagnant water body by fecal matters from labor camp	• Labor camp shall not be allowed near any of the water bodies • The proper sanitation facilities shall be provided	Preapproved locations away from the water bodies	Construction Stage	Contractor and Supervision Consultant	PIU
C10	Deposition of dust in open wells near construction site	• The mouth/opening of the well shall be covered with suitable material when construction activity is taking place so as to prevent dust entering in the well	All the wells along the bypass route	Construction Stage	Contractor and Supervision Consultant	PIU
C11	Using drinking water for construction purpose	• The contractor shall make arrangements for water required for construction in such a way that water availability and supply to nearby community is unaffected • Wastage of water shall be kept minimum during construction	At respective planned construction sites	Construction Stage	Contractor and Supervision Consultant	PIU
C12	Hand pump close to road may get affected by construction work	• All the hand pumps shall be relocated to suitable alternate place	At the respective locations	Construction Stage	Contractor and Supervision Consultant	PIU
C13	Wells or water storage system may get affected by construction work	• Alternate arrangements will be made for all the affected wells and water storage system	At the respective locations	Construction Stage	Contractor and Supervision Consultant	PIU
C14	Altering flow of natural drains	• Drain shall be channelized with slope protection – gabion Structure.	At the respective locations	Construction Stage	Contractor and Supervision Consultant	PIU

C15	Sanitation of waste disposal in construction camps	• The construction of camps will be located with sufficient buffer from habitation. • At construction sites and labor camps sufficient numbers of latrines shall be provided • The sewage generated from the camps will be properly disposed of so that it does not pollute water bodies	Wherever labor camp is located	Construction Stage	Contractor and Supervision Consultant	PIU
Air Pollution						
C16	Emission from construction vehicles and machinery.	• All vehicles, equipment and machinery shall be selected to meet recognized international and national standards for emissions and shall be maintained and operated in a manner that ensures relevant air, noise and discharge rules. • Only unleaded petrol and low sulfur diesel or sulfur free diesel shall be used as fuel for vehicles, equipment and machinery.	Wherever the hot mix plant and batching plant is set up.	Construction Stage	Contractor and Supervision Consultant	PIU
C17	Air pollution from various plants affecting settlements	• The asphalt plants, crushers and batching plants shall not be sited at least 500 m in leeward direction from nearest human settlement	Locations near Settlement	Construction Stage	Contractor and Supervision Consultant	PIU
C18	Air pollution may exceed the limits prescribed by Central Pollution Control Board.	• Regular monitoring or air quality parameters during the construction period as envisaged in the Environmental Monitoring Plan.	Locations given in Environmental Monitoring Plan.	Construction Stage	Contractor and Supervision Consultant	PIU
C19	Vehicles will generate dust and suspended particles.	• The dust generated by vehicles on site shall be arrested using a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surface but without any flooding.	Wherever the plants are setup and sensitive locations as suggested in monitoring plan.	Construction Stage	Contractor and Supervision Consultant	PIU
Noise						
C20	Noise levels from vehicles. Asphalt plants and equipment	• The plants and equipment used for construction shall conform to CPCB norms. • Vehicles and equipment used shall be fitted with silencer. • Any vehicle and machinery shall be kept in good working order and engines turned off when not in use. • All equipment and plants shall strictly be placed away from educational institutes and hospitals. • Regular monitoring of noise parameters (Leq) during the construction period as envisaged in the Environmental Monitoring Plan.	Wherever the plants are setup.	Construction Stage	Contractor and Supervision Consultant	PIU
C21	Noise from blasting operations	• Blasting as per Indian Explosives act will be carried out. • People living near such blasting operation sites shall be informed before the operational hours. • Workers at blasting sites shall be provided with earplugs.	At the sites where the blasting is required and in quarry sites	Construction Stage	Contractor and Supervision Consultant	PIU
Flora and Fauna						

C22	Tree cutting for widening	• Three trees shall replace each tree cut for the purpose (as suggested by Environment and Forest Dept. Mizoram). • The Engineer shall approve such felling only when the NHIDCL receives a "clearance" for such felling from the MOEF, as applicable. • Trees felled shall be replaced as per the compensatory afforestation criteria in accordance with the Forests (Conservation) Act, 1980.	Throughout the project area	Construction Stage	Contractor and Supervision Consultant Forest Dept.	PIU
C23	Damage or Loss of Important Flora	• During construction, at any point of time, if a rare/ threatened/endangered flora species is found, it shall be conserved in a suitable manner in consultation with authorities. The Engineer shall approve detailed conservation processes, plans and designs as well as associated modification in the project design.	Throughout the project area.	Construction Stage	Contractor and Supervision Consultant	PIU
Health and Hygiene						
C24	Health hazard to workers due to bad water and sanitation	• At every workplace, good and sufficient potable water (as per IS 10500) supply shall be ensured to avoid water-borne diseases and to secure the health of workers. • Adequate drainage, sanitation and waste disposal shall be provided at workplaces. • Preventive Medical care shall be provided to workers.	Wherever labor camp is setup	Construction Stage	Contractor and Supervision Consultant	PIU
C25	Health hazard to workers by various construction activity	• Personal protective equipment shall be provided to worker as per the Factories Act.	Throughout the project area	Construction Stage	Contractor and Supervision Consultant	PIU
C26	Health/ social hazard, sexual harassment to female workers	• Segregation of male and female areas in labor camp shall be executed.	Wherever labor camp is setup	Construction Stage	Contractor and Supervision Consultant	PIU

C27	Hygiene at Construction Camps	• The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labor to standards and scales approved by the resident engineer. • These shall be provided within the precincts of every workplace, latrines and urinals in an accessible place, and the accommodation, separately for each for these, as per standards set by the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996. There shall be adequate supply of water, close to latrines and urinals. • All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed off in a lined landfill sites. Construction camps are to be sited away from vulnerable people and adequate health care is to be provided for the work force.	Wherever labor camp is setup	Construction Stage	Contractor and Supervision Consultant	PIU
C28	Demolishment of Construction Camps	• On completion of the works, the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the whole of the site left clean and tidy, at the Contractor's expense, to the entire satisfaction of the Engineer.				
C29	Abandoned Quarry will accumulate water and act as a breading ground for disease vectors.	• Reclamation measure shall be adopted with garland of trees around the periphery. The quarry dust and waste shall be used for refilling. The remaining portion should be covered with trees.	All quarry locations.	Construction Stage	Contractor and Supervision Consultant	PIU
Safety						
C30	Safety of vehicles plying on road while the construction activity is going on.	• Prior arrangement/traffic diversion for safe passage of vehicles shall be made with proper direction and signage at the construction site. • Detailed Traffic Control Plans shall be prepared and submitted to the Site Engineer/ Project Director for approval 5 days prior to commencement of works, particularly in section where the bypass intersects with existing road. The traffic control plans shall contain details of temporary diversions, details of arrangements for construction under traffic and details of traffic arrangement after cessation of work each day.	Throughout the project area	Construction stage	Contractor and Supervision Consultant	PIU

C31	Risk from Operations	• The Contractor is required to comply with all the precautions as required for the safety of the workmen as far as those are applicable to this contract. • The contractor shall supply all necessary safety appliances such as safety goggles, helmets, masks, etc., to the workers and staff. The contractor has to comply with all regulation regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.	All construction sites	Construction stage	Contractor and Supervision Consultant	PIU
C32	Risk from Electrical Equipment	• Adequate precautions will be taken to prevent danger from electrical equipment. No material or any of the sites will be so stacked or placed as to cause danger or inconvenience to any person or the public. • All necessary fencing and lights will be provided to protect the public. All machines to be used in the construction will conform to the relevant Indian Standards (IS) codes, will be free from patent defect, will be kept in good working order, will be regularly inspected and properly maintained as per IS provisions and to the satisfaction of the Engineer.	All construction Site	Construction stage	Contractor and Supervision Consultant	PIU
C33	Risk at Hazardous Activity	• All workers employed on mixing asphaltic material, cement, lime mortars, concrete etc., will be provided with protective footwear and protective goggles. Workers, who are engaged in welding works, would be provided with welder's protective eye-shields. Stone-breakers will be provided with protective goggles and clothing and will be seated at sufficiently safe intervals. • The use of any herbicide or other toxic chemical shall be strictly in accordance with the manufacturer's instructions. The Engineer shall be given at least 6 working day's notice of the proposed use of any herbicide or toxic chemical. A register of all herbicides and other toxic chemicals delivered to the site shall be kept and maintained up to date by the Contractor. The register shall include the trade name, physical properties and characteristics, chemical ingredients, health and safety hazard information, safe handling and storage procedures, and emergency and first aid procedures for the product. This should comply with Hazardous Material Act.	All construction sites	Construction stage	Contractor and Supervision Consultant	PIU
C34	Risk of Lead Pollution	• Nobody below the age of 18 years and no woman shall be employed on the work of painting with products containing lead in any form. No paint containing lead or lead products will be used except in the form of paste or readymade paint. • Facemasks will be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint dry rubbed and scrapped	All construction sites	Construction stage	Contractor and Supervision Consultant	PIU

C35	Risk caused by Force' Majure	• All reasonable precaution will be taken to prevent danger of the workers and the public from fire, flood, drowning, etc. All necessary steps will be taken for prompt first aid treatment of all injuries likely to be sustained during the course of work.	All construction Site	Construction stage	Contractor and Supervision Consultant	PIU
C36	Risk from Explosives	• Except as may be provided in the contract or ordered or authorized by the Engineer, the Contractor shall not use explosives. Where the use of explosives is so provided or ordered or authorized, the Contractor shall comply with the requirements of the following Sub-Clauses of this Clause besides the law of the land as applicable. • The Contractor shall at all times take every possible precaution and shall comply with appropriate laws and regulations relating to the importation, handling, transportation, storage and use of explosives and shall, at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the Engineer. • The Contractor shall at all times make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whatsoever concerned or affected or likely to be concerned or affected by blasting operations.	Place of use of Explosives	Construction stage	Contractor and Supervision Consultant	PIU
C37	Malarial risk	• The Contractor shall, at his own expense, conform to all anti-malarial instructions given to him by the Engineer, including filling up any borrow pits which may have been dug by him	All construction sites, particularly BP3 and BP4 in southern part of the State	Construction stage	Contractor and Supervision Consultant	PIU
C38	First Aid	• At every workplace, a readily available first aid unit including an adequate supply of sterilized dressing material and appliances will be provided.	At the construction site /labor camp	Construction stage	Contractor	PIU
Disruption to Users						
C39	Loss of Access	• At all times, the Contractor shall provide safe and convenient passage for vehicles, pedestrians and livestock to and from side roads and property accesses connecting the project road. Work that affects the use of side roads and existing accesses shall not be undertaken without providing adequate provisions to the prior satisfaction of the Engineer. • The works shall not interfere unnecessarily or improperly with the convenience of public or the access to, use and occupation of public or private roads, railways and any other access footpaths to or of properties whether public or private.	Near built-up areas	During Construction.	Contractor	Engineer

C40	Traffic Jams and Congestion	• Detailed Traffic Control Plans shall be prepared and submitted to the Site Engineer/ Project Director for approval 5 days prior to commencement of works on areas where bypass intersects with existing road. The traffic control plans shall contain details of temporary diversions, details of arrangements for construction under traffic and details of traffic arrangement after cessation of work each day. • Special consideration shall be given in the preparation of the traffic control plan to the safety of pedestrians and workers at night. • The Contractor shall ensure that the running surface is always properly maintained, particularly during the monsoon so that no disruption to the traffic flow occurs. As far as possible idling of engines shall be avoided to curb pollution.	Near built-up areas	During Construction.	Contractor	Engineer
C41	Traffic Control and Safety	• The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required by the Engineer for the information and protection of traffic approaching or passing through the section of the highway under improvement. • All signs, barricades, pavement markings shall be as per the MORTH specification. Before taking up construction on any section of the highway, a traffic control plan shall be devised to the satisfaction of the Engineer as per EMP. Excavated pits shall be filled to avoid falling of animals/ human beings.	Near built-up areas	During Construction.	Contractor	Engineer
Environment Enhancement						
C42	Hand pumps enhancement/relocation for ground water recharging	• Hand pumps within Right of Way shall be enhanced/relocated in consultation with the community	At the respective locations along the corridor.	Construction Stage	Contractor and Supervision Consultant	PIU
C43	Roadside landscape development	• Avenue plantation of foliage trees mixed with flowering trees, shrubs and aromatic plants shall be considered whereever land is available between ditches and Right of Way.	Throughout the corridor	Construction Stage	Contractor and Supervision Consultant	PIU
C44	Abandoned Quarry will accumulate water and act as a breeding ground for disease vectors.	• The abandoned quarry locations shall be planted suitably as the plan	Wherever quarries are located and abandoned	Construction Stage	Contractor and Supervision Consultant	PIU

C45	Erosion of embankments, shoulders, side slopes, and pavement leading to deterioration and affecting stability and integrity of road	• Earth works specifications will include provision for stable slope construction, compacting and laying out turf including watering until ground cover is fully established • Proper construction of Breast wall and retaining wall at the locations identified by the design team to avoid soil erosion • The measures proposed for slope stabilization are: Discharge zones of drainage structures (culverts and minor bridges) provided with riprap • Construction in erosion and flood prone areas will not be in monsoon /season. • Side slopes will be kept flatter wherever possible, and in case of steeper slopes it will be supported by the retaining wall.	At the respective locations throughout the project area.	Construction Stage	Contractor and Supervision Consultant	PIU

Source: JICA Study Team

Table 8.7-3 Environmental Management Plan for Operation Stage

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
O1	Water quality degradation due to road-run-off	• Silt fencing, oil & grease traps, etc. shall be provided at sensitive water bodies to ensure that the water quality is not impaired due to contaminants from road run-off • Monitoring shall be carried out as specified in the monitoring plan	As specified in the monitoring plan	As per monitoring plan	PIU, SPCB	PIU
O2	Soil and water contamination from accidental spills	• Contingency plans to be in place for cleaning up of spills of oil, fuel and toxic chemicals • Monitoring shall be carried out as specified in the Monitoring Plan	All area and as specified in the monitoring plan	Plan to be developed at state/district level by early operation stage	PIU, SPCB, Local Government Bodies	PIU
O3	Air quality degradation due to increases in traffic volume	• Monitoring shall be carried out as specified in the Monitoring plan • Share air quality data with SPBC and relevant agencies and discuss options for mitigate air quality degradation associated with greater traffic volume	As specified in the monitoring plan	As per monitoring plan	PIU, SPCB	PIU
Q4	Increases in noise and vibration due to greater traffic volume	• Monitoring shall be carried out as specified in the Monitoring plan • Install noise barrier (wall etc.) in sensitive areas, if necessary	As specified in the monitoring plan	As per monitoring plan	PIU, SPCB	PIU

O5	Traffic safety	• Traffic control measures including speed limits to be enforced strictly. • Local government bodies and development authorities will be encouraged to control building development along the highway.	All area	Throughout operation stage	PIU, Local Government Bodies	PIU
O6	Accidents involving hazardous materials	• Compliance with the Hazardous Wastes (Management and Handling) Rules, 1989 including: ✓ For delivery of hazardous substances, permit license, driving license and guidance license will be required. ✓ These vehicles will only be harbored at designated parking lots. ✓ In case of spill of hazardous materials, the relevant departments will be notified at once to deal with it with the spill contingency plan.	All area	Manual/guideline to be prepared during early operation stage	PIU	PIU
O7	Plantation, flora and fauna	• Trees planted for reforestation shall be maintained for a period of three years. Maintenance works include, watering of the saplings, replacement of the bamboo fence (if applicable) every year for three years and other necessary measures for survival of the sapling. • Monitoring of flora and fauna along the highway shall be carried out to assess conditions of ecosystem against the baseline. Condition of nearby protected area shall be collected from Environment Department for checking any indirect impacts due to greater traffic volume.	All area and as per the monitoring plan	Immediately from the planting of sapling, and as per monitoring plan	PIU, NGO	PIU

Source: JICA Study Team

8.8 Environment Monitoring Plan

To ensure effective implementation of the EMP, it is essential that an effective monitoring plan be designed and carried out. The environmental monitoring plan provides such information on which management decision may be taken during construction and operational phases. It provides basis for evaluating the efficiency of mitigation and enhancement measures and suggest further actions that need to be taken to achieve the desired effect. The monitoring plan for the various performance indicators of the project in the construction and operation stages is summarized below.

Table 8.8-1 Environmental Monitoring Plan

Sl. No	Item	Project Stage	Parameters	Guidance	Standards	Location	Frequency	Duration	Responsibility	
									Implementation	Supervision
M1	Air	Construction	SPM, RSMP, SO_2, NOx, CO, HC	• Dust sampler to be located 50m from the plan in the downwind direction. • Use method specified by CPCB for analysis	Air (P&CP) Rules, CPCB, 1994	Hot mix plant/ batching plant	Twice a year for three years	Continuous 24 hours	Contractor through approved monitoring agency	PIU
M2		Construction	SPM, RSPM	• Dust sampler to be located 50m from the earthworks site downwind direction. Follow CPCD method for analysis	Air (P&CP) Rules, CPCB, 1994	Stretch of road where construction is underway	Twice a year for three years	Continuous 24 hours	Contractor through approved monitoring agency	PIU
M3		Operation	SPM, RSMP, SO_2, NOx, CO, HC	• Use method specified by CPCB for analysis	Air (P&CP) Rules, CPCB, 1994	Sampling location specified in EIA report	Twice a year for one year	Continuous 24 hours	PIU	PIU
M4	Water	Construction	pH, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb	• Sample collected from source and analyze as per Standard Methods for Examination of Water and Wastewater	Water quality standards by CPCB	Sampling locations specified in EIA report	Twice a year for three years		Contractor through approved monitoring agency	PIU
M5		Operation	pH, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb	• Grab sample collected • from source and analyze as per Standard Methods for Examination of Water • and Wastewater	Water quality standards by CPCB	Sampling locations specified in EIA report	Twice a year for one year		PIU	PIU
M6		Operation	Cleaning of drains and water bodies	• Choked drains, water bodies undergoing siltation and subject to debris disposal should be monitored under cleaning operations	To the satisfaction of the engineer (PWD)	All area	Post-monsoon		PIU	PIU

M7	Noise and vibration	Construction	Noise levels on dB (A) scale	• Free field at 1m from the equipment whose noise levels are being determined	Noise standards by CPCB	At equipment yard	Once every 3 Month (max) for three years, as required by the engineer	Reading to be taken at 15 seconds interval for 15 minutes every hour and then averaged	Contractor through approved monitoring agency	PIU
M8		Operation	Noise levels on dB (A) scale	• Equivalent Noise levels using an integrated noise level meter kept at a distance of 15 m from edge of Pavement	Noise standards by CPCB	At maximum 15 sites inc. those listed in EIA report for noise monitoring locations	Twice a year for 1 years	Readings to be taken at 15 seconds interval for 15 minutes every hour and then averaged.	PIU	PIU
M9	Soil erosion	Construction	Turbidity in Storm water; Silt load in ponds, water courses	• Visual observations during site visits	As specified by the engineer / Water quality standards	At locations of stream crossings and at locations of retaining wall and breast wall	Pre-monsoon and post-monsoon for three years		Contractor	PIU
M10		Operation	Turbidity in Storm water; Silt load in ponds, water courses	• Visual observations during site visits	As specified by the engineer / Water quality standards	As directed by the engineer	Pre-monsoon and post-monsoon for one year		PIU	PIU
M11	Construction camp	Construction	Monitoring of: 1.Storage Area; 2. Drainage Arrangement 3. Sanitation in Camps	• Visual Observations and as directed by the engineer	To the satisfaction of the engineer and Water quality standards	At storage area and construction workers' camp	Quarterly during construction stage		PIU	PIU

M12	Afforestation	Construction and operation	Plant survival	• The success of tree planting. Monitor the rate of survival after six months, one year and 18 months in relation to total numbers of trees planted		All area	Minimum three years after planting		NGO, PIU	PIU
M13	Flora and Fauna	Construction and Operation	Condition of ecosystem	• Comparison to pre-project flora and fauna • Regular checking of baseline condition of protected areas near bypasses	As specified in TOR	As specified in TOR	Twice a year for three years		PIU	PIU

Source: JICA Study Team

8.9 Land Acquisition and Involuntary Resettlement

8.9.1 Necessity and Scale of Land Acquisition and Resettlement

Land acquisition for this project will result in involuntary resettlement. As discussed earlier, the bypasses are designed to minimize resettlement, but in a limited stretch where the bypass uses existing community road, resettlement is unavoidable. In particular, BP1 will result in involuntary resettlement of 19 households (131 persons) and one household (two persons) will be resettled near the end point of BP2. The total number of project affected households (target of land acquisition) is estimated to be 257, but this figure is provisional due to the lack of updated and accurate cadastre map in forest and jhum field in the hilly area. The number has been esmated based on the confirmation meeting with Village Council and villagers who claims that their farmland or plantation are likely to be affected. The number of affected households and persons for each bypass are presented below.

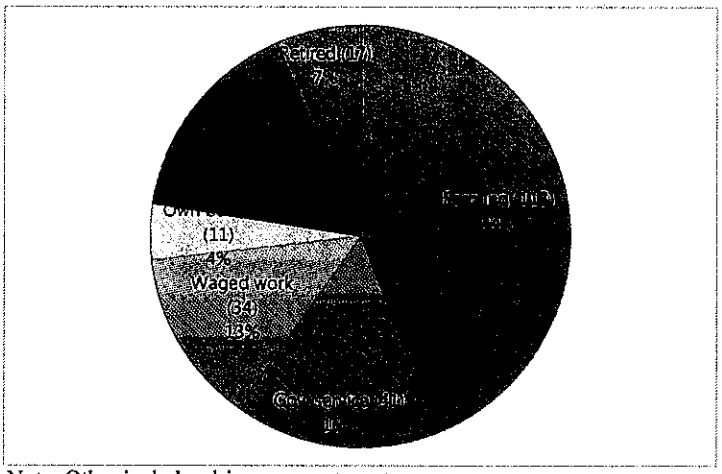
Table 8.9-1 Number of PAH and PAP per Bypass

Bypass	No. of PAH	No. of PAP
BP1: Chhiahtlang	49	303
BP2: Serchhip	120	700
BP3: Hnathial	77	410
BP4: Lawngtlai	11	72
Total	257	1485

8.9.2 Profile of Project Affected Households/Persons

Overwhelming majority of PAHs are Mizo. Out of 257 PAHs, there are only four non-Mizo PAHs. They are Asamese in BP2 area and they are not going to be relocated. While there are different sub-tribes among Mizo, all of them, including four Asamese PAHs, speak Mizo. About 20% of PAHs are also fluent in English while most others can understand basic conversation. All 257 PAHs follow Christianity with presbyterian being the most popular church.

Primary source of income of household heads is shown below. Farming is the most commong primary income source followed by government sector.



Note: Other includes driver, carpenters etc.

Figure 8.9-1 Primary Income Source of PAH

Annual income of PAHs is shown below. It is important to note that the cash income may not reflect the real well-being of PAHs engaged in subsistence agriculture. The minimum and maximum income as reported by PAHs is Rs.4,000 and Rs.1,250,000 respectively.

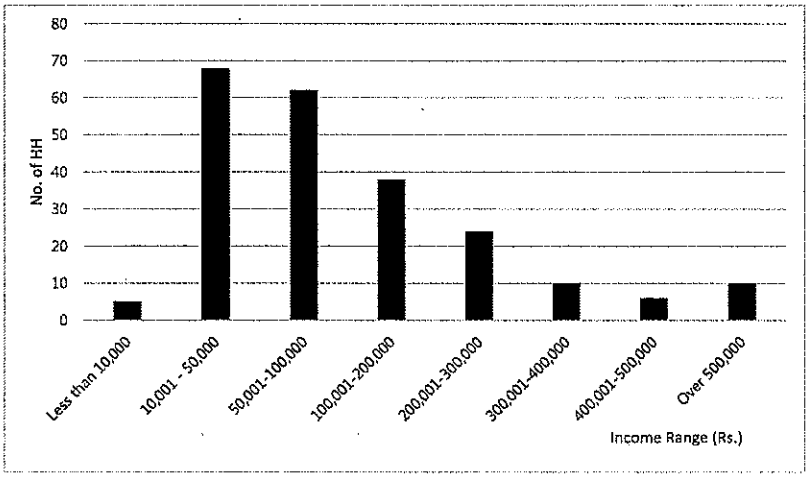


Figure 8.9-2 Annual Income of PAH

According to Reserve Bank of India, the share of the poor in Mizoram is 23% in rural area and 7.9% in urban area in 2012[3]. However, the survey found that about 30% or 78 PAHs consider themselves as BPL household, which may reflect their real coping capacity against negative impacts. The type and number of vulnerable PAH is shown below.

Table 8.9-2 Summary of Vulnerable PAH

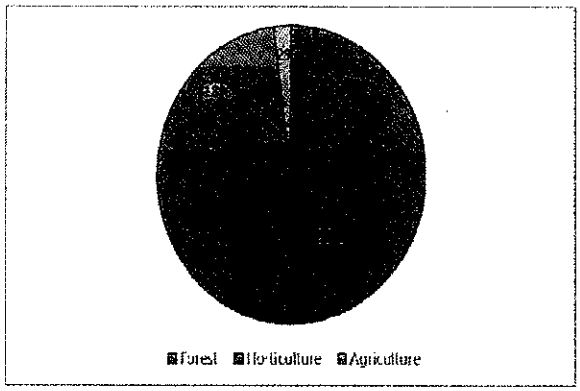
Bypass	HH with disabled member	HH with orphan	Eldery with no immediate support member	HH with Widow	Women headed HH	Below Poverty Line[1]	Total[2]
BP1	8	4	2	7	5	17	22
BP2	10	8	0	16	14	38	60
BP3	3	3	0	8	5	22	30
BP4	0	0	0	2	1	1	2
Total	**21**	**15**	**2**	**33**	**25**	**78**	**114**

Note: 1. Self-reported figures without cross-checking with actual income data etc.
2. The total number of vulnerable households does not match to the sum of each category because several PAHs fall under more than one category.

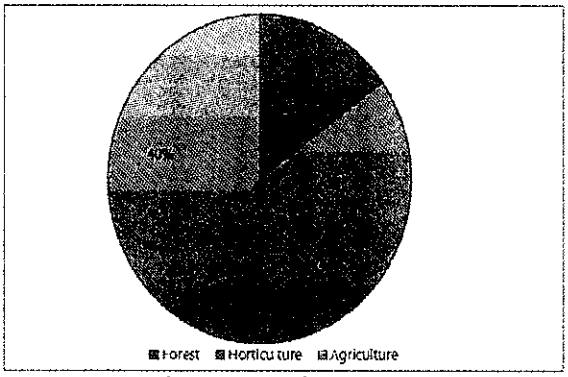
8.9.3 Land Use Pattern

Based on the interviews, field surveys and satellite imagery, land use patterns of proposed bypass ROW area has been estimated. While some variations exist among four bypasses, the areas are predominantly forest and jhum areas.

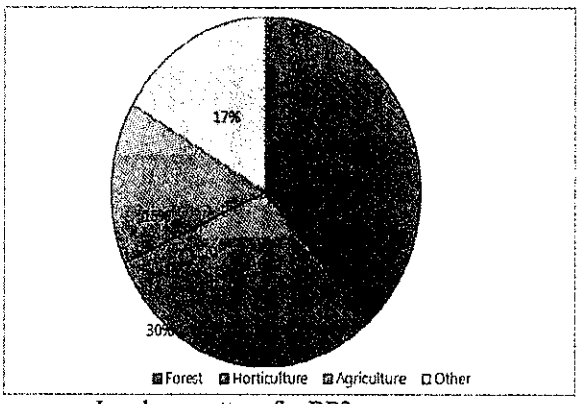
3 Number and Percentage of Population Below Poverty Line, Reserve Bank of India, Sep 16, 2013 (accessed August 11, 2015), https://www.rbi.org.in/scripts/PublicationsView.aspx?id=15283



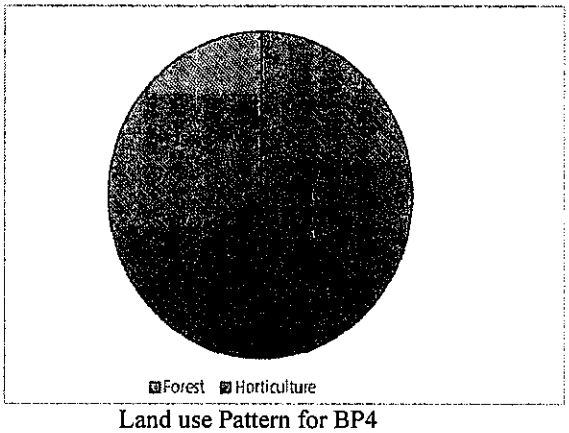
Land use pattern for BP1



Land use Pattern for BP2



Land use pattern for BP3



Land use Pattern for BP4

Figure 8.9-3 Land Use Pattern in Each Bypass

8.10 Entitlement Matrix

The Entitlement Matrix has been developed in accordance with JICA Guideline and analysis of project impacts. The Entitlement Matrix recognizes and lists various types of losses associated with the project and provides the basic tools and guidelines for preparation of compensation and resettlement packages.

Table 8.10-1 Entitlement Matrix

Type of Loss	Occupant of Property	Unit of Entitlement	Entitlement	Details of Entitlement
Agricultural land	Titleholder	Household	Compensation at Replacement value and Assistance	a) Cash compensation for the land at replacement cost, which will be determined by District Collector. b) If the compensation amount is less than the replacement cost mentioned above, the difference amount will be paid as Assistance. c) If the residual land is unviable for agriculture, PAPs hall have the following three options: • Compensation for affected land and continue on the remaining unaffected plot of land; or • If eligible person surrenders the residual plot, then compensation and assistance given for the entire plot of land; or • Replacement land, if so wished by eligible persons, subject to availability of land that is at least equally productive d) Resettlement allowance of Rs. 50,000/- will be provided to those who do not get land for land, irrespective of the size of land. e) Subsistence Grant equivalent to Rs. 3000 (MAW: Minimum Agricultural Wage) per month for 6 months. f) In case of severance of cultivable land, an additional grant of 10% shall be paid over and above the amount paid for land acquisition. g) Four (4) months' notice to harvest standing crops shall be given. However, if notice cannot be given then compensation for these crops shall be paid at market value
	Periodic Patta Holder/ Temporary Village Pass Holder		Assistance	a) Replacement value of land as determined by District Collector shall be given to land owners/holders. b) Resettlement allowance of Rs. 50,000/- will be provided to those who do not get land for land, irrespective of the size of land. c) Subsistence grant equivalent to Rs. 3,000.00 per month (MAW) for 6 months. d) Four (4) months' notice to harvest standing crops shall be given. However, if notice cannot be given then compensation for these crops shall be paid at market value.

Non- agricultural vacant land (Homestead, Commercial and others)	Titleholder	Household	Compensation for structure at Replacement Cost plus assistances	a) Replacement cost for structure at latest Basic Schedule of Rates (BSR) without depreciation. b) Two (2) months' notice for removal of structure c) In case of partially affected structures and the remaining structure continues to be viable, in such case an additional assistance equivalent 25% of replacement cost will be paid towards repair/restoration of Structure d) Right to salvage materials from the demolished structure e) For the displaced eligible persons whose remaining structure is unviable, the following shall be payable ● Subsistence grant of Rs. 3,000/- per month for a period of twelve (12) months from the date of displacement ● One time resettlement allowance of Rs.50,000/- ● Transportation cost of Rs. 50,000.00 for shifting family, building materials, domesticated animals etc. ● Lumpsum Assistance amount of Rs. 7,500/- for re-establishing other basic facilities such as electricity connection, water supply pipeline ● All fees, taxes and other registration charges incurred for the replacement structure
	Periodic Patta Holder/ Temporary Village Pass Holder			For land ● Subsistence grant equivalent to Rs. 3,000.00 per month of MAW for 6 months. ● Four (4) months' notice to harvest standing crops/trees shall be given. However, if notice cannot be given then compensation for these crops shall be paid at market value For structure ● Replacement cost for structure at latest Basic Schedule of Rates (BSR) without depreciation with a minimum of Rs. 1,50,000.00 ● Two (2) months' notice for removal of structure ● Right to salvage materials ● Lump sum Transportation cost of Rs.50,000
Loss of Plants/Trees	Owner/Occupant	Household	Compensation	Revenue Department or Special Committee to determine the current cost. For perennial fruit bearing trees such as Pineapples, Jackfruits, etc.), average productivity of such trees will be taken as 20 years.

Loss of Cattle shed, poultry shed or any other shed for domestic animals	Owner/Occupant	Household	Compensation	Rs. 600 per m^2 for Thatched roof and Rs. 1000 per m^2 for GCI sheet roof (to be paid as per revised/latest available updated basic schedule of rates for buildings). In case of non-revision, 10% premium per year will be added to the latest rate available.
Loss of residence/ commercial unit	Tenant	Household	Assistance	a) The amount of deposit or advance paid by the tenant to the landlord or the remaining amount at the time of expropriation (this will be deducted from the payment to the landlord) b) Subsistence grant of Rs. 3,000/- per month for a period of twelve (12) months from the date of displacement c) Lump sum shifting allowance of Rs. 15000/-
Loss of kiosk	Owner/occupant	Household	Assistance	a) Lump sum shifting allowance of Rs. 7500/- b) Right to salvage materials from the existing structure
Loss of employment	Wage earner	Household	Assistance	a) Economic Rehabilitation Grant equivalent to twenty-five (25) days of Minimum Agricultural Wages (MAW) per month for a period of three months. b) Priority work opportunities in the project construction work □ c) Rs. 20,000/- towards vocational/skill improvement as per choice. □
Loss of Livelihood (losing commercial unit, losing agricultural land and with balance land below MEH)	Titleholder/ Periodic Patta holder/ Village Pass holder	Household	Assistance	a) Priority work opportunities in the project construction works. □ b) Rs. 20,000/- towards vocational/skill improvement as per choice. The amount will cover daily stipend equivalent to MAW for the duration of training and shall also cover costs towards boarding, lodging, transportation, etc.
Additional support to vulnerable groups	Titleholder/ Periodic Patta holder/ Village Pass holder	Household	Assistance	One time additional financial assistance of Rs. 25,000/- as Economic Rehabilitation Grant towards income generation
Loss of Jhum /Fallow land)	Village	Village	Compensation at 'replacement value'	Replacement value for the common property transferred/acquired shall be paid to Village Council and the amount will be utilized through participatory planning by the villagers within 6 months from date of release of payment. PIU shall monitor its utilization

Loss of Common Property Resources	Village	Village	Enhancement of community resources	Replacement /Restoration or augmentation of existing infrastructure and provision of additional infrastructure facilities based on identified need
Loss of Access	Village	Village	Alternate access	Provision of access path(s), steps, footpaths at identified locations in consultations with community
Temporary and unforeseen impacts.	Affected entity	Household	Mitigation measures in line with principles of resettlement policy framework	Unforeseen and temporary impacts during construction will be documented and dealt with on case by case basis through the GRM in accordance with the principles laid down in the resettlement policy framework

Source: JICA Study Team

8.11 Institutional Arrangement for RAP Implementation

As per Indian regulatory framework, activities related to resettlement and rehabilitation will be carried out by the State Government. Given the autonomous characteristics of Mizoram and its District, however, it is proposed that the district as well as village council and traditional village leaders also play a major role in implementing RAP. NHIDCL established an office in Aizawl, which is expected to serve as a project office (Project Implementation Unit: PIU). A dedicated NHIDCL staff (or expert hired by NHIDCL) will work closely with State and district/village officials to ensure that implementation of RAP is in line with JICA Guidelines for Environmental and Social Considerations. The institutional arrangement for RAP implementation is shown below.

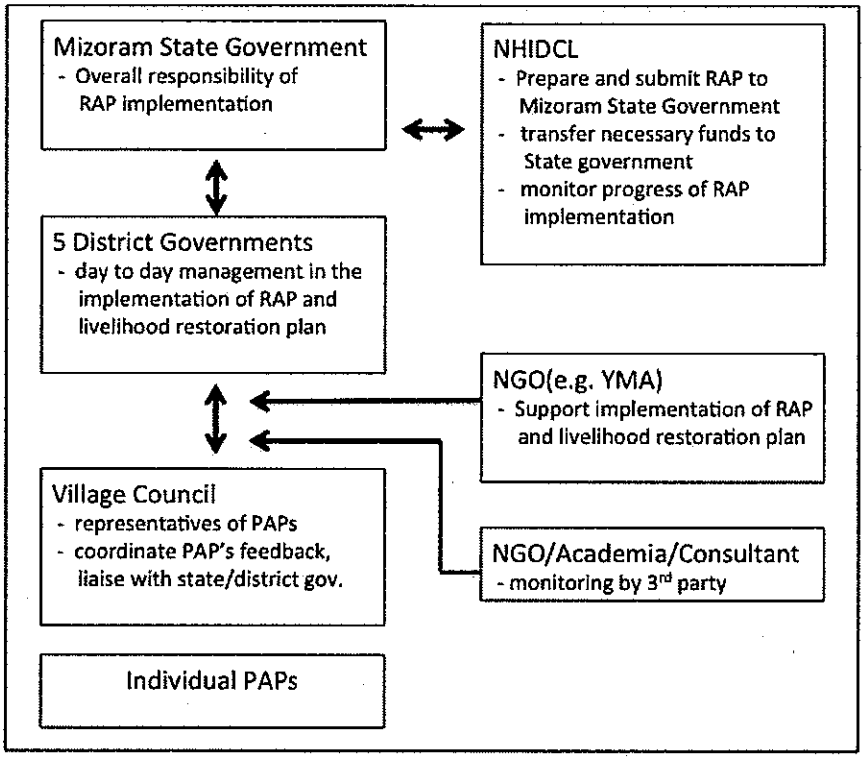


Figure 8.11-1 Institutional Arrangement for RAP Implementation

8.12 Grievance Redress Mechanism

The two-tier Grievance Redress Mechanism will be established for this project. The main objective is to provide a step-by-step process of registering and addressing the grievances with respect to land acquisition. It is expected that this mechanism will ensure redress of disputes through participative process.

The first tier of GRM takes place at village level and involves physical verification and certification upon receipt of any grievance such as inaccurate measurement of impacted asset, loss of access, damage to structures and/or crops during construction. The verification and certification will be carried out by the RAP implementation agency and/or members of Village Council in presence of PAPs who file the grievance, and appropriate documentation shall be done. Response would be provided to the concerned PAP within 7-10 days of receipt of grievance. Financial implications of any changes would be presented to the Grievance Redress Committee (GRC) for consideration and approval.

The second tier of resolution will be undertaken by GRC. A GRC will be formed by the Project Authority within one month from the date of mobilization of RAP implementation agency at site. The

GRC will comprise Project Director, NHIDCL; Deputy Commissioner of three districts in which proposed bypasses are located; representatives of the concerned Village Council or his/her authorized representative, PAPs and RAP implementation agency. Grievances of PAPs in writing will be brought to GRC for redress by the RAP implementation agency. The RAP implementation agency will provide necessary assistance to PAPs in presenting his/her case before the GRC. The GRC will respond to the grievance within 7 days. The GRC will hold monthly meeting but may meet more frequently, depending upon the number and type of grievance. The decision of the GRC will not be binding to PAPs. In other words, decision of the GRC does not bar PAPs taking recourse to court of law. The flow of grievance redress mechanism is shown below.

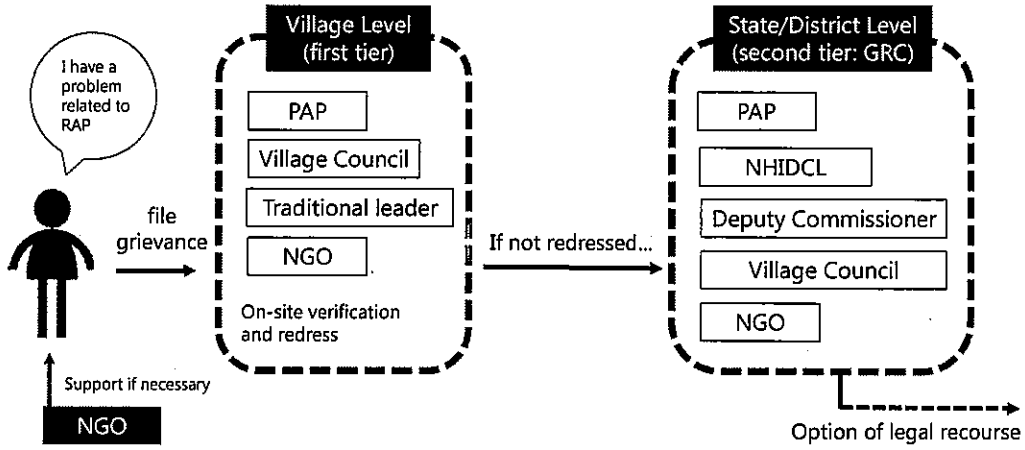


Figure 8.12-1 Grievance Redress Mechanism

8.13 Income Restoration Plan

The socioeconomic survey of the PAPs (see details in Chapter 4) indicates 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 rehabilitation plan will be developed and implemented by the state government in the course of this project and the details of the plan should be tailored with inputs from stakeholders in the later stage of the project. Keeping JICA and World Bank policies in perspective, their guidelines and principles are proposed for inclusion to the rehabilitation plan.

Support for Expanding Plantation

Horticulture and plantation are commong livelihood activity in bypass areas. Insufficient supply of saplings and/or lack of quality thereof is a barrier for initiative towards better methods of farming. Productivity and income generation potential of horticulture and plantations in project area can be enhanced through supply of quality saplings.

Shared Market Place

While the new bypass (and road widening and improvement of NH54) is expected to facilitate trade across borders, these roads also may have the potential to boost local level trade and improving linkages of the villages in the interiors with the local and regional markets. At the same time, relocation is likely to cause negative impact on households who have benefited from the near-road location suitable for business. It is recommended that project creates benefit sharing arrangements with communities along the project roads and build capacity for increasing the production and trade

potential, for example, through improvement and/or construction of common market place in a convenient location, for example where the bypass intersects with NH54 where community members can buy and sell agricultural goods and engage in small businesses.

Backyard Poultry

Many households rear chicken for their own consumption but rarely doing it commercially. Small marketing effort may work to the benefit of the producer.

8.14 Monitoring and Evaluation of RAP

Monitoring and evaluation are important activities of any infrastructure development project, and even more so for projects involving involuntary resettlement. It helps make suitable changes, if required during the course of RAP implementation and also to resolve problems faced by the PAPs. Monitoring is periodical checking of planned activities and provides midway inputs, facilitates changes, if necessary, and provides feedback to project authority for better management of the project activities. On the other hand, evaluation assesses the resettlement effectiveness, impact and sustainability. In other words, evaluation is an activity aimed at assessing whether the activities have actually achieved their intended goals and purposes. Thus monitoring and evaluation of RAP implementation are critical in order to measure the project performance and fulfillment of project objectives. Summary of specific tasks to be carried out in each type of monitoring activities is shown below.

Table 8.14-1 Summary of Monitoring Activity

Type	Frequency	Prepared by	For	Report Contents
Internal RAP Monitoring	Quarterly	PIU	NHIDCL/ State Government	10-15 page report (plus supporting documentation) summarizing progress against the RAP; outline of any issues and agreed related actions; summary schedule of grievance status; minutes of any stakeholder or affected people consultations or meetings
External Monitoring	Harf-yearly	Expert Panel	NHIDCL/ State Government	25-35 page report (plus supporting documentation) summarizing assessment of progress towards living standard restoration, livelihood restoration; compliance of JICA Guidelines; discussions of any RAP issues of concern; identification of any areas of non-compliance and agreed corrective actions; and summary or resettlement status.
Completion Audit	One-off	Expert Panel	NHIDCL/ State Government	RAP Completion Audit to verify NHIDCL has complied with undertakings defined by the RAP and that land acquisition and compensation has been completed in accordance with JICA Guidelines

Source: JICA Study Team

8.15 Public Consultation

Stakeholder consultation is an important method of involving various stakeholders particularly, local community with reference to the proposed development initiatives. Consultations provide a

platform to participants to express their views, concerns and apprehensions that might affect them positively or negatively. This process is of particular importance for this project given the high ST share among the affected population. The World Bank OP 4.10 on Indigenous Peoples emphasizes "a process of free, prior, and informed consultation with the affected Indigenous People's communities at each stage of the project, and particularly during project preparation, to fully identify their views and ascertain their broad community support for the project. Stakeholder Through participation and consultation stakeholders influence development initiatives, and decision-making process. The effectiveness of participation and consultation is directly related to the degree of involvement by the likely project affected persons and the local community and integration of outcome of consultations wherever feasible in the proposed development initiatives.

The purpose of consultations was to inform people about the project, take note of their issues, concerns and preferences, and allow them to make meaningful choices. It ensured participation of potential project affected persons (PAPs), local community and other stakeholders. People in general were informed in advance, and allowed to participate in free and fair manner. Consultations provided meaningful contributions with regard to reducing adverse impacts, address safety issues, etc. Concerns, views and suggestions expressed by the participants during these consultations were integrated into the design aspects wherever feasible. The following sections present the results of consultations.

8.15.1 Meeting Schedule and Profiles of Attendees

The schedule and attendance of 1st round of consultation meetings are shown below.

Table 8.15-1 Schedule and Attendance of 1st Round of Consultation

Bypass	Date	No. of Attendees		
		M	F	Total
BP1	26 February 2016	30	10	40
BP2	24 February 2016	14	1	15
BP3	23 February 2016	68	14	82
BP4	22 February 2016	39	6	45
	Total	151	31	182

The 2nd round of consultation meetings were organize meetings per Village Council in response to the request from the community so that participants can discuss issues thoroughly. Hence, a total of nice consultation meetings were held. In addition, additional briefing session targeting two Village Council in BP2 area was held in July 23rd and 25th for those who have missed the official consultation meetings. The two meetings were attended by 12 and 17 people respectively.

Table 8.15-2 Schedule and Attendance of 2nd Round of Consultation

Bypass	Date	Target VC	No. of Attendees		
			M	F	Total
BP1	12 July 2016	Chhiathlang VC,	45	16	61
BP2	11 July 2016	New Serchhip 'North' and 'South'	51	15	66
	11 July 2016	New Serchhip, 'P& E'	21	5	26
	12 July 2016	New Serchhip, ' Thianga' VC VII, VC II, 'Court '	13	13	26
		BP2 Total	85	33	118
BP3	8 July 2016	Peniel VC	42	7	49
	9 July 2016	Hnathiel N 1	28	7	35
	13 July 2016	Hnathiel N 2, 'Court'	13	3	16
		BP3 Total	83	17	100
BP4	6 July 2016	Lawngtlai VC, College Veng	8	2	10
	7 July 2016	Lawngtlai VC, Chanmary	13	2	15
		BP4 Total	21	4	25
Overall Total			**234**	**70**	**304**

Source: JICA Study Team

8.15.2 Key Concerns and Opinions Raised During the Meetings

During the consultation meetings, the preliminary alignment was presented with participants and it was explained that the proposed bypass is in response to the request from the community who would like to have a new bypass rather than widening of the existing road during consultation meetings held in 2015. Participants were also informed of the results of environmental impact assessment and proposed measures for mitigation and management plan for each stage of project implementation. Also, they were informed of the activities related to land acquisition and resettlement, including social impact assessment to be carried out by the Government of Mizoram and proposed Grievance Redress Mechanism. Measure concenrs and comments raised during the meetings and responses from NHIDCL and relevant government officers such as Revenue and Environment and Forest Department are summarized below. In the table, issues/comments specific to a particular bypass is marked in blacket.

At the end of the meeting, PAHs (for all four bypasses) expressed their support to the project and demanded that the project be implemented as soon as possible. Some reminded that fair and timely payment of compensation will be crucial for smooth and successful implementation of the project.

Table 8.15-3 Summary of Consultation Meeitngs

Bypass	Key Concerns/Comments	Responses
BP1: Chhiahtlang	*General issues*	
	• While appreciating the new bypass project, participants requested that the alignment be finalized as soon as possible because they may need to adjust their plan for renovating their current house or constructing a new agricultural hut.	• A satellite imagery with proposed alignment was presented at the meeting, and participants were assured that the final alignment will be shared with them as soon as they are ready. Also, social impact assessment will be carried out by the Government of Mizoram so that their views and concerns can be incorporated in the final design, if necessary.
	• Village Council members suggested that vegetation be cleared so that villagers can clearly see the proposed alignment in hilly area.	• Clearance of vegetation and forest will be done after forest clearance permit is obtained. Also, reforestation will be carried out to offset the loss of forest.
	Environment and Social Impacts	
	• PAHs raised concerns about the treatment of surplus soil. Based on their past experience, they do not trust what is written in paper (such as EMP) and want to have a mechanism that actually works.	• In addition to the provisions in EMP for properly managing surplus soil, monitoring will be undertaken both internally and externally so that any deviation or negligence of environmental safeguards will be identified and rectified. • Also, PAHs and village council members were encouraged to use surplus soil for local construction (for playground etc.) if appropriate.
	• Some raised concerns if construction of bypass will increase the risk of landslide. Also, they were worried about the potential impacts on their jhum land that will be bifurcated by bypass	• Slope protection measures will be installed to reduce the risk of land slide and other hazard. The risk will actually decrease compared with no-project scenario. • The bypass is designed in a way to minimize impacts to jhum land, for example by not disturbing natural waterways.
	• PAHs asked if local graveyard is affected by the project (BP1).	• It was confirmed that local graveyard will not be affected by the project.

	Land Acquisition and Resettlement • PAHs requested that compensation to be paid in cash and in advance the start of the project implementation. • PAHs shared their experience in Multi-Modal Project in which the amount of compensation was not fair and the payment was delayed or not paid in full (BP4)	• The compensation at replacement cost will be disbursed before the construction activity begins, as per the provisions in JICA Guidelines.
	• A PAP asked why the valley side of the community road is planned to be widened for the bypass (BP1).	• The alignment is proposed based on the technical feasibility, volume of spoil soil and the scale of involuntary resettlement.
	• Some participants said they were approached by a "broker" who pretend to serve as a negotiator between PAHs and NHIDCL	• PAHs were reminded not to negotiate with such middleman, as all project related activities will be done directly by NHIDCL and/or Government of Mizoram. If there is questions, PAHs were advised to contact with District Settlement officers.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Effects of the Project on Development and Road Network in North Eastern States

1) The study team examined the viability of the Project of NH54 bypasses by reviewing the contents of DPR study and preliminary design by the study team as well as by linking it to the present traffic conditions as of 2016. As a result, the study team confirmed that the NH54 bypass project properly met the SARDP-NE target of development of the region through improvement of connectivity as part of NH54 mainline project. 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 road networks in the region but also with other transport systems.
2) According to the results of traffic study, project costs and economic analyses of the Project, EIRR of the Project of NH54 main road section plus four bypasses are estimated at 10.96%.

9.2 Confirmation of Appropriateness of the Project Components

1) After the study team reviewed the preliminary design in DPR, it was confirmed that design concept for alignment design does not well considered environmental impact and natural disaster prevention. The study team introduced design concept for the environment and disaster prevention such as earth balanced alignment design and advanced slope protection design introduced in developed country, as well as spoil bank to provide flat land for promotion of effective use of disposal soil.
2) Since the preliminary design in DPR has not carried out topographic survey and geotechnical survey, accuracy of basis for alternative route study is low and the study team carried out topographic survey and geotechnical survey for the alternative route study and preliminary design to ensure accuracy of the design.
3) The study team prepared preliminary project cost in reference to SOR in 2015 and cost of advanced slope protection works which is introduced to the design.
4) The study team examined that the construction and implementation plans as shown in Figure 9.2-1.