**Government of India**
**Ministry of Road Transport and Highways**

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

# FINAL REPORT

**(Volume 2: Preliminary Design of NH54 Bypass)**

June 2018


**Japan International Cooperation Agency (JICA)**

Study Team constituted by

NIPPON KOEI CO., LTD.

NIPPON KOEI INDIA PVT. LTD.


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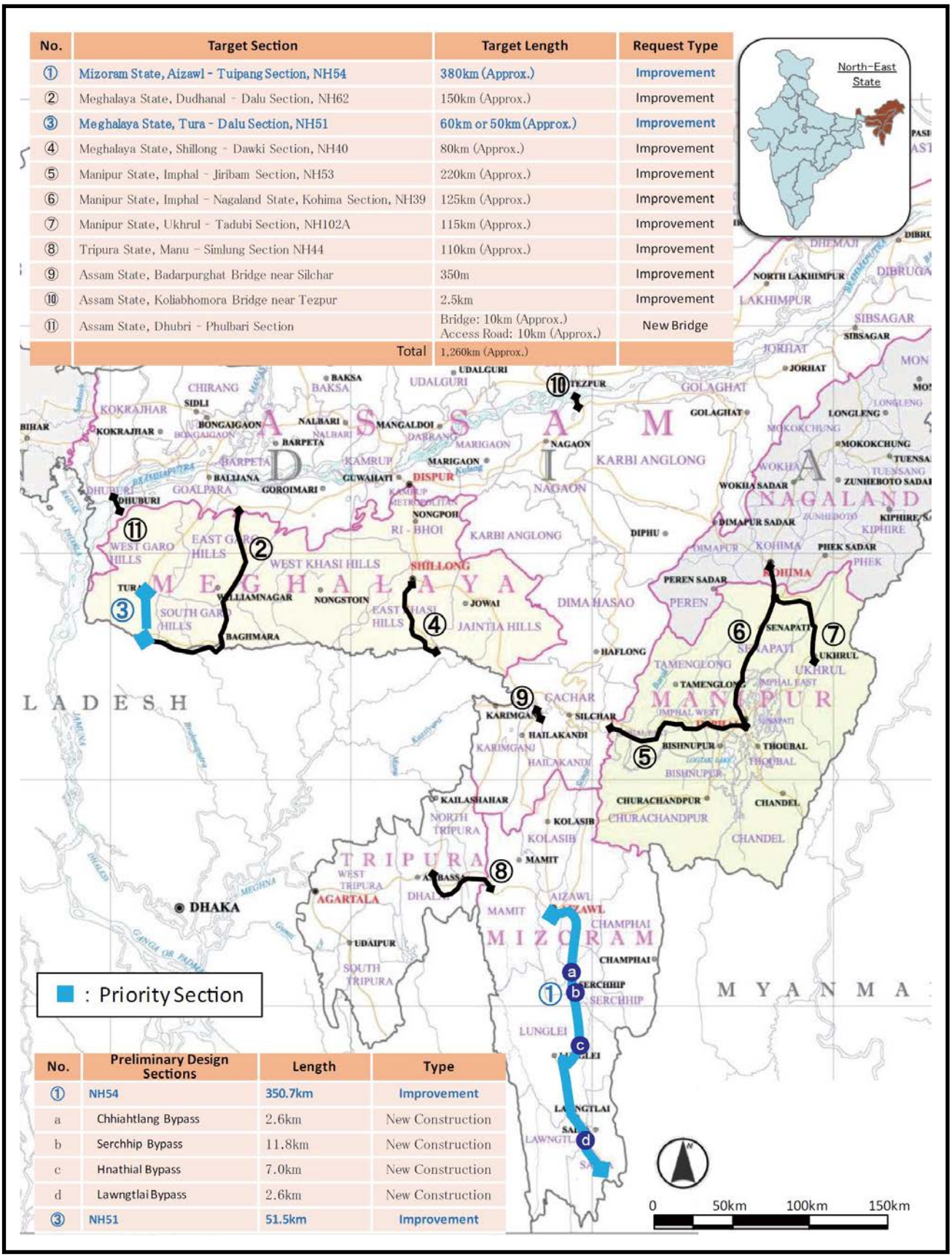


| No. | Target Section | Target Length | Request Type |
|---|---|---|---|
| ① | Mizoram State, Aizawl - Tuipang Section, NH54 | 380km (Approx.) | Improvement |
| ② | Meghalaya State, Dudhanal - Dalu Section, NH62 | 150km (Approx.) | Improvement |
| ③ | Meghalaya State, Tura - Dalu Section, NH51 | 60km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

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

Source: JICA Study Team

LOCATION MAP

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

## FINAL REPORT
## (Volume 2: Preliminary Design of NH54 Bypasses)

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## Abbreviations

| | |
|---|---|
| AADT | - Annual Average 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 | - Build Operate Transfer |
| CAGR | - 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 |
| DOEFCC | - Department of Environment, Forests and Climate Change |
| DPR | - Detailed Project Report |
| EIA | - Environmental Impact Assessment |
| EIRR | - Economic Internal Rate of Return |
| EMP | - Environmental Management Plan |
| EPC | - Engineering, Procurement, and Construction |
| FIDIC | - 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 |
| IUCN | - 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 |
| MOEFCC | - Ministry of Environment, Forest and Climate Change |
| 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 | - Non-governmental Organization |
| NH | - National Highway |
| NHDP | - National Highway Development Plan |
| NHIDCL | - National Highways and Infrastructure Development Corporation |
| NOx | - Oxides of Nitrogen |
| NP | - National Park |
| NPV | - Net Present Value |
| NRRP | - National Rehabilitation & Resettlement Policy |
| NSDP | - Net State Domestic Product |
| OFC | - Optical Fiber Cable |
| O&M | - Operation and Maintenance |
| PAP | - Project Affected Person |
| PC | - Prestressed Concrete |
| PCI | - Per Capita Income |
| PCU | - Passenger Car Unit |
| PHF | - Peak Hour Factor |
| PIU | - Project Implementation Unit |
| PM | - Penetration Macadam |
| PPP | - Public-Private Partnership |
| PQ | - Pre-qualification |
| PWD | - Public Works Department |
| RAP | - Resettlement Action Program |
| RCC | - Reinforced Cement Concrete |
| RO | - Regional Office |
| 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 Factor |
| 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 | - World Wildlife Fund |
| 3D | - Three Dimension |

## 1. Introduction

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

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

Based on such background, GOI requested the Government of Japan (hereinafter referred to as "GOJ") to provide loan assistance in carrying out the improvement of existing roads in eight sections, repair of two existing bridges, and construction of one new bridge within the six states of the North-East States in India. The JICA Study Team examined the applicability of the 11 projects for Yen Loan scheme and prioritized the 11 projects. NH54 and NH51 are selected as first priority sections and the preliminary design for NH54 and NH51 is carried out. As for the preliminary design of NH54, widening sections and bypass sections are included and the preliminary design of the bypass sections on NH54 is carried out in this study due to inadequate bypass study in the Detailed Project Reports (DPRs).

The major objective of this study is to examine the procurement and construction method, implementation schedule, social and environmental conditions, project cost, and feasibility of four bypass routes plan on NH54.

Target sections of this study are four bypasses on NH54 as shown in Table 1-1.

**Table 1-1 Additional Scope of Four Bypasses**

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

Source: JICA Study Team

## 2. Traffic Survey, Analysis and Forecast

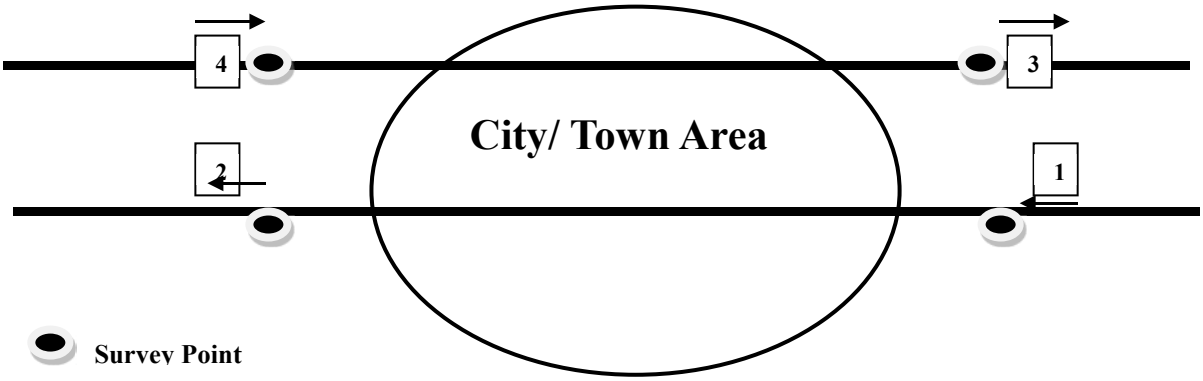
For estimating the bypass traffic for each of the four identified cities/ towns on NH54, the following two surveys were conducted at strategically selected locations (at two locations, one for the vehicles entering the town and another for vehicles leaving the town) on both sides of the road for each selected city/ town (Please refer to Figure 2-1)

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

The objective of both abovementioned surveys is to estimate the number of vehicles that would divert to the proposed bypasses. It may be mentioned that generally CVCS is done to determine the traffic volume at a location, but can be structured by organizing two nearby and consecutive CVCSs for the same time period in a day to obtain "through traffic" that can possibly get diverted to bypasses. 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 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 an equal time period. However, in CVCS, all the vehicles were covered, and for NPS, it was on sample basis.




Source: JICA Study Team

**Figure 2-1 Typical Survey Point Locations for Classified Traffic Count Survey and Number Plate Survey**

The total traffic, obtained by combining the existing traffic, Kaladan traffic, and the induced traffic, was thus projected by using the future growth rates for the horizon years – 2020, 2025, 2030, 2035, and 2040 (Table 2-1).

**Table 2-1 Traffic Projections (Daily Traffic)**

| Year | Cars/ Jeep/ Taxi | Bus | 3- Wheeler | 2- Wheeler | LCV | 2 Axle | Total | PCU |
|---|---|---|---|---|---|---|---|---|
| **Chhiahtlang Bypass ( Bypass 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 Bypass (Bypass 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 |
| **Hnahthial Bypass (Bypass 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 |
| **Lawngtlai Bypass (Bypass 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

The vehicle-wise diversion, in percentage terms, for the four bypasses was estimated through analysis of the CVCS and NPS data. It was found that the percentage diversion estimated by using the CVCS data was more consistent than by using the NPS data. Therefore, to obtain the diverted traffic (traffic that is expected to use the bypasses), the percentage diversion values (vehicle-wise) based on the CVCS data, presented in Table 2-2, were applied to the total traffic projections given in the previous table. The bypass traffic projections are set out in Table 2-3.

**Table 2-2 Percentage Traffic Diversion to Bypass**

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

Source: Traffic Survey by the JICA Study Team

**Table 2-3 Daily Traffic - Diverted to Bypasses**

| By-pass | Cars / Jeep/ Taxi | Bus | Three-Wheeler | Two-Wheeler | LCV | Truck | Total | PCU |
|---|---|---|---|---|---|---|---|---|
| **Chhiahtlang Bypass (Bypass 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 Bypass (Bypass 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 |
| **Hnahthial Bypass (Bypass 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 |
| **Lawngtlai Bypass (Bypass 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

## 3. Economic Analysis

The economic analysis to obtain the economic indicators for each bypass was performed and the results are set out in Table 3-1.

**Table 3-1 Results of Economic Analysis of Bypasses**

| NH54 Section + Bypass Name | EIRR (%) |
|---|---|
| NH54 Main Road Section + Chhiahtlang Bypass No. 1 | 13.21% |
| NH54 Main Road Section + Serchhip Bypass No. 2 | 12.07% |
| NH54 Main Road Section + Hnahthial Bypass No. 3 | 12.77% |
| NH54 Main Road Section + Lawngtlai Bypass No. 4 | 13.17% |
| NH54 Main Road Section + All Bypasses | 10.96% |

Source: JICA Study Team

For major urban centers along NH54, the potential negative impact associated with land acquisition and involuntary resettlement will be very high if the existing road is expanded. To minimize such impacts while maintaining and improving the function of NH54 as a main driver of the state's economy, construction of bypasses appears to be the optimal solution. Flat terrain does not exist in the proposed area for bypass construction. Bypasses will have to be constructed on hilly terrain and therefore, construction cost will be twice or three times more than that of bypasses on flat land. The EIRR for the bypass is relatively low because of this fact, but considering environmental and social dimensions, bypasses can still be the optimum long-term option for Mizoram. See Chapter 8 for more detailed analysis of environmental and social issues.

## 4. Alternative Route Study

The scope of bypasses in the Detailed Project Report (DPR) was not clearly mentioned. The alignments of the four bypasses in the DPR were given tentatively without much description of profile and detailed cross sections, especially for Chhiahtlang and Serchhip bypasses. Therefore, the JICA Study Team conducted Alternative Route Study for these four bypasses before conducting the 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 JICA Study Team members, optimum route for each bypass is established.

The scope of the 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.

### (1) Results of Alternative Analysis

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

1) The base case or Alternative-0 is also studied with the condition that the existing NH54 for the studied stretches is widened to 12 m 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 No. 4 (Lawngtlai Bypass Link), the base case or Alternative-0 is considered with the total length from where the Kaladan Multimodal Road starts before Lawngtlai Town to the end of Bypass No. 4. Therefore, in Alternative-1 and Alternative-2, the total construction cost is inclusive of 4.4 km of construction cost for the initial section of Kaladan Multimodal Road with assumed average cost of INR 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 4-1.

**Table 4-1 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 | Hnahthial Bypass | Geometry | 3 | 1 | 2 | -- | -- |
| | | Spoil volume | 1 | 3 | 1 | -- | -- |
| | | House compensation | 3 | 2 | 1 | -- | -- |
| | | 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

- Based on the results of the alternative analysis, the conclusions are made as shown in Table 4-2.
- Detailed topographic survey will be conducted for the optimum routes for each bypass in the preliminary design.

**Table 4-2 Conclusions from Alternative Analysis**

| No. | Bypass Name | Route | Length (km) | Conclusion |
|---|---|---|---|---|
| 1 | Chhiahtlang Bypass | Alternate-0 | 2.200 | Although 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 four alternatives. |
| | | Alternate-1 | 12.422 | |
| | | Alternate-2 | 11.629 | |
| | | Alternate-3 | 11.708 | |
| | | Alternate-4 | 12.164 | |
| 3 | Hnahthial 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

## 5. Preliminary Design of NH54 (Bypass)

### (1) Natural Condition Surveys

1) Meteorological and Hydrological Surveys

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

2) Topographic Survey

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 degrees E).

After the alternative analysis, detailed topographic survey was conducted for the optimum routes of all four bypasses. The topographic survey plan is given in Table 5-1.

**Table 5-1 Topographic Survey Plan**

| No. | Name | Length | GPS Control Survey | 3D Point Survey |
|---|---|---|---|---|
| 1 | Chhiahtlang Bypass | Approx. 3 km | 2 pairs | Bypass length x 90 m corridor |
| 2 | Serchhip Bypass | Approx. 12.4 km | 3 pairs | |
| 3 | Hnahthial Bypass | Approx. 6.8 km | 3 pairs | |
| 4 | Lawngtlai Bypass | Approx. 2.0 km | 2 pairs | |

Source: JICA Study Team

3) Geological Survey

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

(a) Geological Investigation for Bridge Planning

Geological investigation for bridge planning was conducted at four locations which include candidate location during the bypass route comparison stage. Survey quantity for each location is summarized as shown in Table 5-2.

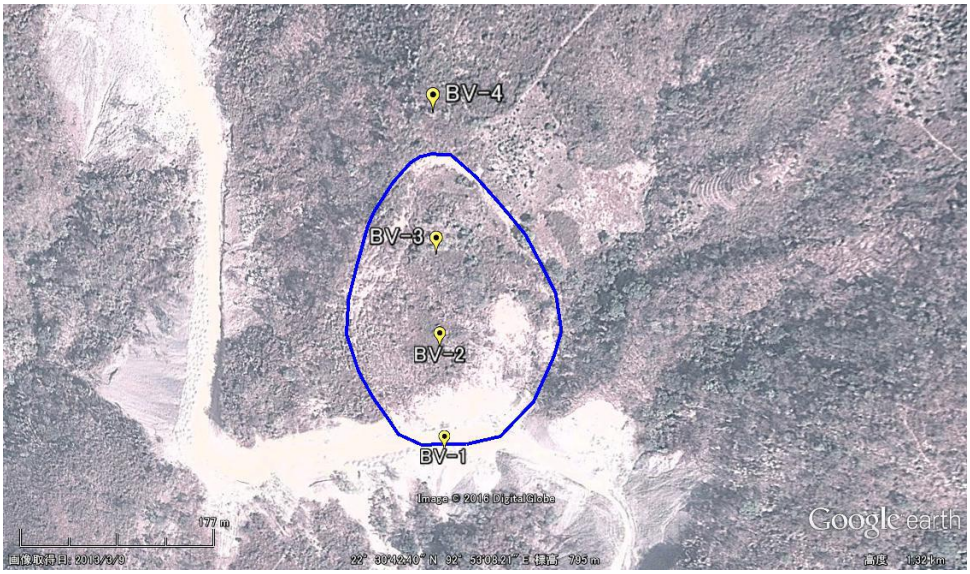
**Table 5-2 Survey Quantity for Each Location**

| Location | Boring No. | Drilling Length | SPT | Remarks |
|---|---|---|---|---|
| Bypass No. 1 | BV-01, BV-02 | 20 m each | Conducted | |
| Bypass No. 2 (A) | BV-01, BV-02 | 20 m each | Conducted | Bridge's planned location |
| Bypass No. 2 (B) | BV-03, BV-04, BV-05 | 20 m each | Conducted | Bridge's planned location |
| Bypass No. 3 | BV-01, BV-02 | 20 m each | Conducted | |

Source: JICA Study Team

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

The location and quantities of boring survey are shown in Figure 5-1and Table 5-3, respectively.




Source: JICA Study Team

**Figure 5-1 Location of Boring Survey**

**Table 5-3 Quantity of Boring Survey**

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

Source: JICA Study Team

### (2) Preliminary Design

1) Road Geometric Design

(a) Design Policy and Design Criteria

The following design policies are established:

- There were differences in the design concept in each bypass in DPR such as different road width, application of minimum design speed, minimum radius of horizontal curves, and application of transition curves. Therefore, uniformity in the design criteria is required for all bypasses as well as the improvement of NH54.
- Design of alignment shall be based on a policy of balancing between the application of minimum design standard and the terrain condition, so that balanced cut and fill will result as much as possible reducing the disposal volume.
- Alignment shall be designed based on the concept of minimizing the relocation of houses.
- As per the instruction of NHIDCL and IRC:37-1980, transition curves shall be designed for all horizontal curves. Exceptions maybe considered for the length of transition curves at difficult locations.

The established geometric design criteria is given in Table 5-4.

**Table 5-4 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 |
| | | 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- | Varies |
| 5 | Sight Dist | Stopping Sight Distance, SSD (m) | 30 (45) | () 40 km/h |
| | | Intermediate Sight Distance, ISD (m) | 60 (90) | () 40 km/h |
| | | Overtaking Sight Distance, OSD (m) | (165) | () 40 km/h |
| 6 | Horizontal Alignment | Horizontal Curve | | |
| | | Absolute Minimum Radius of Horizontal | 30 | |
| | | Ruling Minimum Radius of Horizontal Curve | 50 | |
| | | Widening of Carriageway on Horizontal Curves | | |
| | | Widening for Absolute Minimum Radius (21 | 1.5 | |
| | | Widening for Ruling Minimum Radius (41 m- | 1.2 | |
| | | Superelevation (Se) | | |
| | | Maximum Se for Absolute Minimum Radius | 7.0 | |
| | | Superelevation Runoff Rate | 1/60 | |
| | | Transition Curve | | |
| | | Minimum Length for Absolute Minimum | 30 | |
| | | Minimum Length for Ruling Minimum Radius | 20 | |
| 7 | Vertical Alignment | Vertical Gradient | | |
| | | Ruling Gradient (%) | 6.0 | |
| | | Critical Length of Continuous Ruling | 2000 | 120 m rise in 2 km for |
| | | Limiting Gradient (%) | 7.0 | |
| | | Exceptional Gradient (%) | 8.0 | |
| | | Critical Length for Exceptional Gradient | 100 | |
| | | Minimum Gradient for Drainage (%) | 0.5 | Cut sections with lined |
| | | Vertical Curve | | |
| | | Minimum Length of Vertical Curve (m) | 15 | |
| | | Minimum Radius of Summit (Crest) Curve | | |
| | | 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

(b) Horizontal Alignment Design

Total length of each bypass is given in Table 5-5.

**Table 5-5 Total Length of Each Bypass**

| SN | Bypass | Length (m) | Remarks |
|---|---|---|---|
| 1 | Bypass No. 1 | 2,572.851 | Start and end locations are similar to DPR |
| 2 | Bypass No. 2 | 11,805.031 | Start and end locations are similar to DPR |
| 3 | Bypass No. 3 | 7,025.157 | Start and end locations are similar to DPR |
| 4 | Bypass No. 4 | 2,635.921 | Start location is about 450 m before in the DPR, but end location is similar to DPR |

Source: JICA Study Team

The details of the applied horizontal curvature in each bypass are given in Table 5-6. The minimum radius applied satisfies the minimum design speed of 30 km/h.

**Table 5-6 Application Rates of Minimum Radius in Each Section of NH54**

| Bypass | | R<30 | R=30 | 30<R≤50 | R>50 | Remarks |
|---|---|---|---|---|---|---|
| Bypass No. 1 | No | 0 | 12 | 6 | 7 | |
| | (%) | 0% | 48% | 24% | 28% | |
| Bypass No. 2 | No | 0 | 45 | 53 | 44 | |
| | (%) | 0.0% | 31.7% | 37.3% | 31.0% | |
| Bypass No. 3 | No | 0 | 27 | 33 | 11 | |
| | (%) | 0.0% | 38.0% | 46.5% | 15.5% | |
| Bypass No. 4 | 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 5-7, with the percentage of spoil volume in relation to the excavation volume.

**Table 5-7 Excavation and Spoil Volume for the Bypasses**

| SN | Bypass | Excavation Volume ($m^3$) | Spoil Volume ($m^3$) |
|---|---|---|---|
| 1 | Bypass No. 1 | 120,193 | 89,987 (74.9%) |
| 2 | Bypass No. 2 | 711,152 | 555,682 (78.1%) |
| 3 | Bypass No. 3 | 360,654 | 289,997 (80.4%) |
| 4 | Bypass No. 4 | 241,385 | 179,248 (74.2%) |

Source: JICA Study Team

(c) Vertical Alignment Design

- The minimum gradient is designed as 0.5% at cut sections for drainage.
- The ruling gradient is designed as 6% as per the design standard given in Section 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 5-8 in percentage of the total length of each section.

**Table 5-8 Summary of Designed Vertical Profiles**

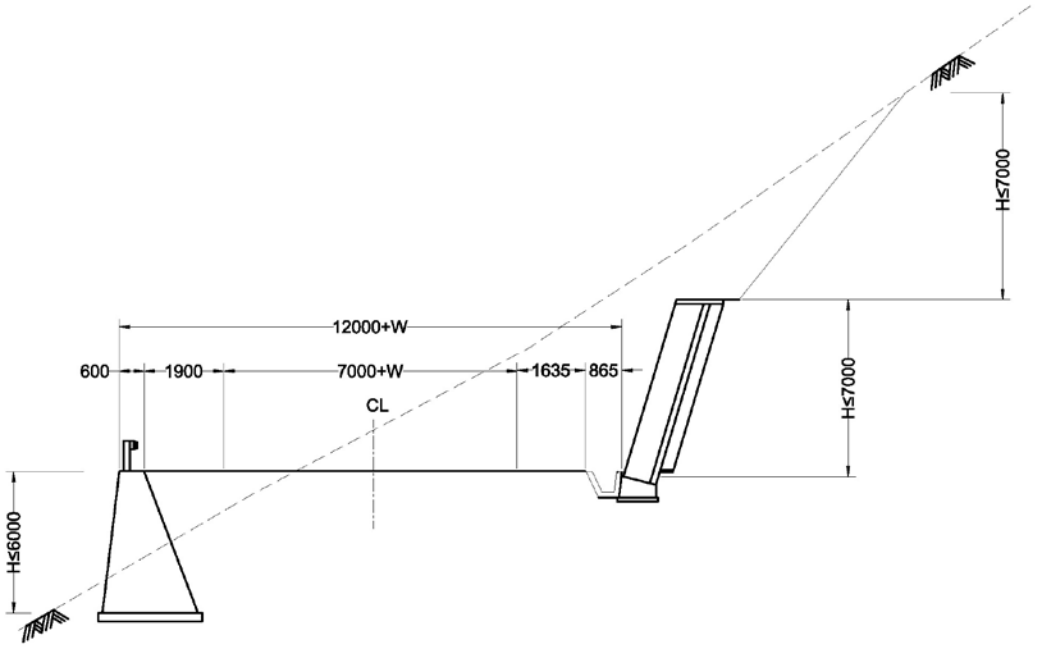
| SN | Bypass | Vertical Grade Range | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.5% | 0.5%-1% | 1%-2% | 2%-3% | 3%-4% | 4%-5% | 5%-6% | 6%-7% | 7%-8% |
| 1 | Bypass No. 1 | 13.1% | 4.9% | 0.0% | 31.3% | 0.0% | 12.1% | 38.6% | 0.0% | 0.0% |
| 2 | Bypass No. 2 | 0.0% | 4.3% | 21.0% | 12.3% | 19.4% | 11.1% | 17.4% | 14.5% | 0.0% |
| 3 | Bypass No. 3 | 8.9% | 7.6% | 15.0% | 27.9% | 16.8% | 5.1% | 11.0% | 7.7% | 0.0% |
| 4 | Bypass No. 4 | 2.7% | 31.2% | 0.0% | 0.0% | 41.9% | 9.8% | 9.6% | 4.7% | 0.0% |

Source: JICA Study Team

- Vertical grades higher than the ruling gradient of 6% but less than or equal to the limiting gradient of 7% were applied at total percentage lengths of 0%, 14.5%, 7.7%, and 4.7% for Bypass No. 1, Bypass No. 2, Bypass No. 3, and Bypass No. 4, respectively.

(d) Typical Cross Section

The typical cross section is given in Figure 5-2 for balanced cut and fill design.




Source: JICA Study Team

**Figure 5-2 Typical Cross Section for Balanced Cut/Fill Design**

The minimum paved shoulder width is 1.5 m. However, the small width between the end of the paved shoulder and the side drain shall also be paved 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 the paved shoulder and the parapet of the retaining wall shall also be paved for the same reason.

(e) Final Alignment in Bypass No. 4

As discussed in Section 4.5 (Alternative Route Study), Bypass No. 4 (Lawngtlai Bypass) starts from the Kaladan Multimodal 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 Multimodal 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 Bypass No. 4 was also surveyed. The designed alignment and profile data of MM Road were 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 Bypass No. 4 as well as the MM Road were also obtained and transferred to the same coordinate system.

Based on these data, it was observed that cutting of more than 70 m height will be required at the take off point of Bypass No. 4 for a length of about 200 m. In order to minimize the cutting, two alternatives were further studied. The first alternative considered the raising of profile of the MM Road for a length of about 500 m at the take off point of Bypass No. 4 and the second alternative considered the shifting of the MM Road alignment for a length of about 200 m to the valley side at the take off point, which is also required for junction development between Bypass No. 4 and MM Road.

The issue was discussed with the Chief Engineer of PWD Mizoram in the 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 the shifting of the MM Road alignment for a length of about 200 m 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.

2) Bridges and Structures Design

The NH54 bypass route is planned to pass 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 the planned road level and the ground level is high, or catchment area of rainwater is large. Hence, bridge is planned at two locations of Serchhip Bypass.

<u>Serchhip Bypass at Km 4+530</u>

- It is located at about 4.5 km from the beginning point of Serchhip Bypass.
- The route crosses the valley as curve section of horizontal alignment.
- Minor bridge 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 appear above the ground in the riverbed.
- Vegetation and shrubs are flourishing around the site.

<u>Serchhip Bypass at Km 10+800</u>

- It is located at about 10.8 km from the beginning point, and 0.8 km from the end point of Serchhip Bypass.
- The route crosses the valley as straight section of horizontal alignment.
- Major bridge 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 appear above the ground in the riverbed.

・Vegetation, shrubs, and trees are flourishing around the site.

Source: JICA Study Team

**Figure 5-3 (Left) Site View at Km 4+530 in Serchhip Bypass / (Right) Site View at Km 10+800 in Serchhip Bypass**

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

Steel arch type is frequently applied in valley terrain in mountainous area. It does not require pier construction at deep valley point through an arch rib built on rigid ground at both slopes. Manufacture of steel arch member in factory enables comparably short construction period. The valley terrain and shape of arch rib are well harmonized and make good landscape.

As an alternative PC bridge, T-type rigid frame bridge, which is frequently used for similar scales, was compared. The upper deck type steel arch bridge (RC slab + Steel arch + RC slab) was superior based on the total evaluation; therefore proposed.

3) Earthwork/ Slope Protection/ Landslide Prevention Design

(a) Proposed Design Policy and Design Criteria

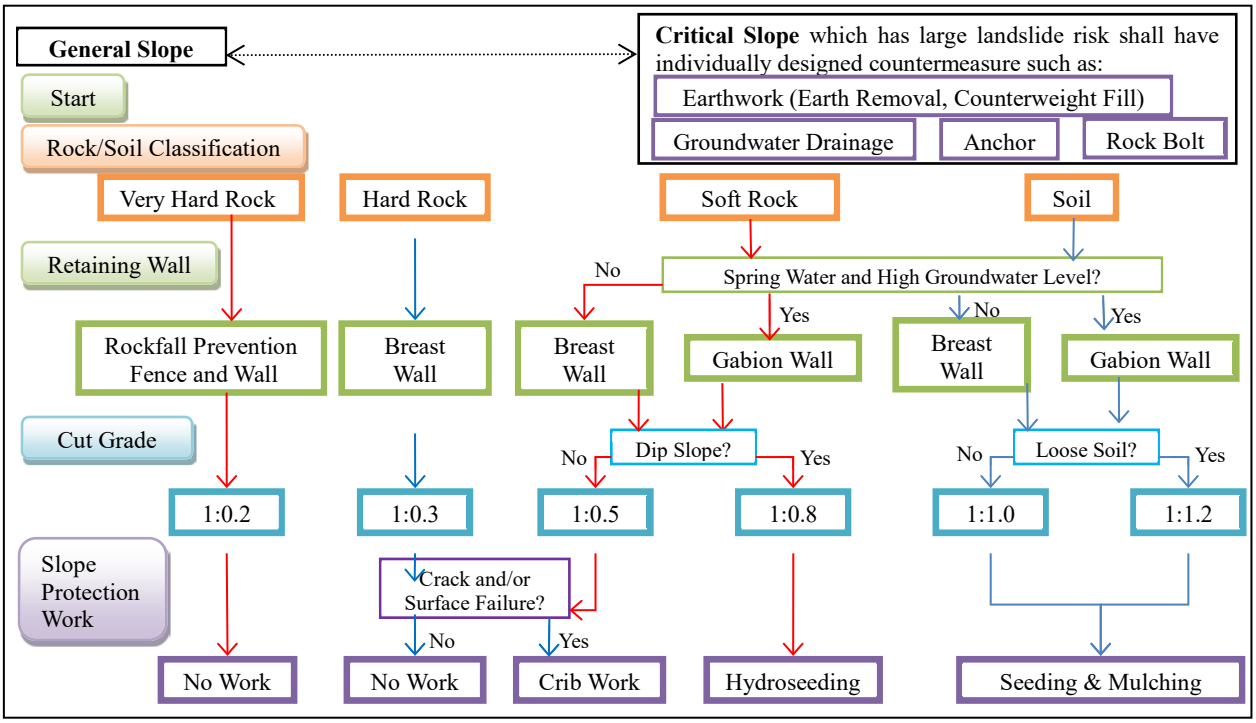
Against the general slopes, slope protection work, retaining wall, and grade of cut/embankment slope shall be planned according to the natural condition including geology, geotechnics, and topography of each slope based on the following design criteria:

- 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 adopt slope protection works.
- Height of one step of cut slope shall be a maximum of 7 m. When the height of slope exceeds 7 m, a berm with 1.5 m width shall be set between each slope.
- Total height of cut slope shall be a maximum of 20 m basically considering economy, workability, and safety.
- In case of a large slope, to prevent large cutting, slope gradient shall be steeper than that of the stable slope using slope protection works.
- Breast wall shall be built on the toe of the cut slope to prevent small collapse and to maintain the side ditch.

- Slope protection works shall be selected among the general construction methods in India and Japan.
- Landslide area shall be avoided basically by the road alignment as much as possible.
- If road alignment passes through landslide area, landslide countermeasures such as groundwater drainage works, counterweight fill work, earth removal works, and anchor work shall be examined for slope stabilization.

Figure 5-4 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 its countermeasures, e.g., earthworks including landslide removal and counterweight fill, groundwater drainage, anchor work, and rock bolt work, shall be designed

The JICA Study Team reviewed the existing manuals in India published by IRC (i.e., SP:48-1998, Hill Road Manual and Special Report, State of the Art: Landslide Correction Techniques, 1995) and started the design of slope protection works. The JICA Study Team improved the criteria of earthworks 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, the JICA Study Team designed them utilizing the Japanese technical guideline for road works published by the Japan Road Association.



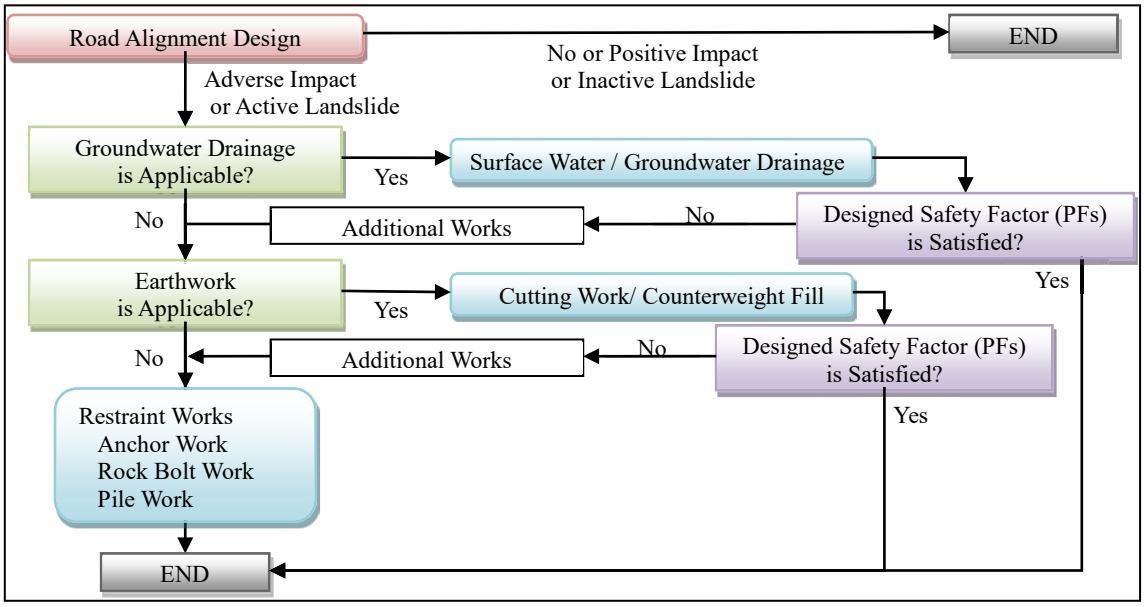

Source: JICA Study Team

**Figure 5-4 Flowchart of Selection of Slope Protection Work for Cut Slope**

(b) Landslide Prevention Design

Basically, design of road alignment has to be planned so as not to promote landslide movement. But if the road alignment unavoidably goes through the landslide, landslide prevention measures have to be planned and designed for the landslide. Figure 5-5 shows the flowchart of selection of landslide prevention measures. In terms of the landslide which

is active or can be destabilized by cutting or banking, landslide countermeasure is required. The landslide prevention measures are mainly divided into three types, namely: groundwater drainage work, earthwork such as earth removal and counterweight fill, and restraint work including anchor, rock bolt, and pile work. In general, groundwater drainage work is the cheapest followed by earthwork. But they are often constrained by topographical, geotechnical, and groundwater condition. On the other hand, restraint work which prevents the landslide movement by force is generally expensive, but the technique can be adopted as permanent countermeasure. Therefore, restraint works shall be introduced by combination of groundwater drainage works and earthworks considering the cost reduction of the countermeasures.




Source: JICA Study Team

**Figure 5-5 Flowchart of Landslide Prevention Measure**

4) Pavement Design

(a) Design Standards and Guidelines

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

(b) Pavement Design

Pavement design for NH54 is decided by NHIDCL in the meeting held on 14 August 2015 at NHIDCL as shown in Table 5-9 and pavement design for NH54 bypass applies the same pavement composition with NH54.

**Table 5-9 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 Subbase) | 300 |
| Total | 690 |

Source: JICA Study Team

5) Drainage Design

Pipe culverts are proposed where the water discharge is comparably small. Box culvert is proposed where the water discharge is comparably large. The size is determined to satisfy the water discharge obtained by hydrological calculation. The quantity of each culvert is summarized in Table 5-10.

**Table 5-10 Quantity of Each Culvert**

| | Bypass No. 1 | Bypass No. 2 | Bypass No. 3 | Bypass No. 4 |
|---|---|---|---|---|
| Pipe culvert, 1.2 m | 19 | 78 | 40 | 13 |
| (TYPE-A) | 8 | 31 | 16 | 5 |
| (TYPE-B) | 11 | 47 | 24 | 8 |
| Box culvert, 2x2 m | 1 | 8 | 12 | 6 |
| Box culvert, 3x3 m | 0 | 2 | 5 | 0 |
| Box culvert, 4x4 m | 0 | 3 | 0 | 0 |
| Total | 20 | 91 | 57 | 19 |

Source: JICA Study Team

6) Traffic Safety Facilities Plan

Traffic safety facilities are to be provided on roads or roadside to secure safety of all road users as well as nearby residents. In this study, considering road function of rural roads and usage situation of the target roads, facilities listed in Table 5-11 are discussed for application to the project.

**Table 5-11 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

7) Road Appurtenances Plan

Road appurtenances are miscellaneous facilities for road administrators to maintain their roads efficiently. In this study, facilities listed in Table 5-12 are suggested for NH54 bypass.

**Table 5-12 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

8) Preliminary Study of Spoil Bank

(a) General

Concerning the result of preliminary design for NH54 bypass, the necessary volume of spoil bank has been calculated as shown in Table 5-13.

**Table 5-13 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

(b) Condition of Spoil Bank Selection

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

- To find out suitable place along NH54 bypass with the following condition:
  - Ground shape with concavity topography
  - Ground gradient of less than 22 degrees which is assumed as the 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 at less than 30 m height

(c) Result of Examination for Spoil Bank Location

In accordance with the above assumed conditions, 3 locations along Chhiahtlang Bypass, 13 locations along Serchhip Bypass, 5 locations along Hnahthial Bypass and 5 locations along Lawngtlai Bypass was selected as possible locations were spoil bank.

## 6. Preliminary Project Cost Estimate

Unit costs set out based on the SOR 2015 were applied. Price escalation from 2015 up to the time of bidding was estimated to be 5% and was added to the construction cost.

## 7. Implementation Plan

The implementation schedule of NH54 bypass construction is examined as the North–East States Road Network Improvement Project Phase-II. This schedule is formulated with the following assumptions:

[Loan Agreement]

- Phase-II Loan will be agreed between GoI and JICA till March 2017.

[Civil Works Contractors]

- In accordance with the implementation schedule of the Phase-I Project, the civil works of NH54 improvement will be commenced from July 2017 with four years construction period.

- Contractors of civil works will be procured in the NH54 bypass construction of the Phase-II Project.
- The construction of civil works may be commenced from the beginning of 2019 in parallel with the Phase-I construction works on NH54.

[Consultant Procurement]

- In case GOI will pledge Phase-II Project financed by JICA in the OECD Notification until the end of 2016, NHIDCL may commence procurement of the consultant from January 2017.
- The consulting service may be commenced from October 2017, and tender assistance such as technical evaluation of bids may be possible to be included in the scope of the consulting services.

[Land Acquisition]

- The state governments will be responsible for land acquisition implementation. NHIDCL is recommended to procure NGO to assist RAP implementation by the state government until June 2016 in order to catch up with the target project implementation schedule in compliance with JICA Environment Guideline.

## 8. Environmental and Social Considerations

### (1) Introduction

The proposed bypasses do not require environmental clearance from the Ministry of Environmental and Forest (today known as Ministry of Environmental, Forest and Climate Change: MOEFCC) as per the MOEFCC Environmental Impact Assessement (EIA) Notification dated September 14, 2006 (as amended in August 2013). However, underJICA's Environmental and Social Guidelines, an EIA study is necessary as the project has been classified as Catergory A. The project also results in involuntary resettlement of 20 households (133 persons). EIA and RAP study based on the preliminary design of the bypasses of NH54 was carried out in the environmental and social considerations study for the Project. It should be noted that in the state of Mizoram, the tribal (Scheduled Tribe: ST) population constitutes about 95% of the total population and the overwhelming majority of the affected people. While they are considered indigenous to India, they are not considered a minority in the state of Mizoram. While they hold traditional culture, including shifting cultivation in forest called jhum, they freely interact with the non-ST and other tribal population within and outside community and not considered isolated. Therefore OP4.10 has been incorporated into the RAP study. The EIA and RAP reports were disclosed to the residents in local languages (NH54=Mizo, NH51=GAR) to gain better comprehension.

While the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation, and Resettlement Act of 2013 has been in effect in India since January 2014, Mizoram state has developed their own rules, the Mizoram (Land Acquisition. Rehabilitation and Resettlement) Act of 2016, regarding land acquisition. The Mizoram Act of 2016 generally follows the LARR 2013 but there are differences in terms of the additional benefits to rural areas and solatium to be added to the compensation. The Act requires a Social Impact Assessment to ascertain social impacts associated with land acquisition and involuntary resettelement followed by an issuance of a preliminary notification for land acquisition. Subsequently, a survey and census of the affected families is undertaken and a rehabilitation and resettelement scheme is prepared. The RAP prepared with the support from the Project shall serve as the foundation for procedures for land acquisition in Mizoram state. The Mizoram state goverement has approved the RAP prepared with support from the study team October 31, 2016.

**(2) EIA Study**

The 2nd step of analysis of alternatives is for the four bypasses that have been identified in the feasibility study for widening and improvement of NH54 (refer to Vol.1). As discussed in Section 4.1, a total of ten 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 alternative has 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.

The project road does not traverse or border with national parks, wildlife sanctuaries or reserved forests. However, three wildlife sanctuaries are located near the area (but more than 10 km away). While no direct impact is expected from the bypass construction, increase in traffic volume during the operation stage is likely to have a negative impact on the forest ecosystem. The conditions of these WLS will be monitored periodically so that potential indirect impacts to these sites can be identified and mitigation measures can be developed. The Project shall also undertake reforestation as per the requirement of the forest act for the loss of forest due to construction works. Through discussion with the Environment and Forest Department of the state, it is planned that more trees will be planted than cut due to the project, and therefore, the project will result in a net increase in carbon sequestration capacity in the state in the long-term.

In terms of religious and sensitive facilites, a local cemetery is located near the proposed alignment of BP1. While the alignment is designed so as not to affect the cemetery itself, extra efforts shall be paid to minimize negative impacts during the construction, including noise and vibration and the disruption of access of the local people. Additionally, three other sensitive facilites are located along the route; a pre-school, an elementary school about 50m south and a church about 170m. For the pre-school while there is enough empty space to set it back, construction work in this section should avoid the school terms/hours as much as possible.

In preparation of the EIA, public consultation meetings were held twice. The first consultation meetings were held in each village where the bypass was located, a total of 4 times. It was later found that some villages while administratively stated as one consisted of multiple Village Councils. The seoncd consultation meetings were held not in each village but per each Village Council, a total of 9 times. Participation of women were encouraged, through the help of women empowering NGO (MHIP), by holding meetings early in the morning or in the afternoon when even women who were busy with housework or fieldwork could participate. Participants raised concerns such as the disposal method of waste, the dangers of landslide and the separation of farm due to the bypass. These concerns were incorporated in the preparation of mitigation measures and environmental management and monitoring plans.

**(3) RAP Study**

Land acquisition for this project will result in involuntary resettlement. As discussed earlier, the bypasses are designed to minimize resettlement, but a total of 46 ha of land will have to be acquired for the four bypasses and in a limited stretch where the bypass uses an existing community road, resettlement is unavoidable. This bypass will result in involuntary resettlement of 20 households. The total number of project affected households is estimated to be 257 (1458 persons). but this figure is provisional due to the lack of updated and accurate cadastre map in the forest and jhum fields in the hilly area where other bypasses are located. The number has been estimated based on the confirmation meeting with the Village Council and villagers who claim that their farmland or plantation are likely to be affected

The cut-off date, as per World Bank OP4.12, was provisionally declared as February 16 which was the start date of the census survey and was disclosed to Village Councils. The

information about the cut-off date was also distributed during the census survey and other interviews. In the meantime, the Mizoram Land Acquisition Act which was enforced after the study began stipulates that the census survey will be carried out once the Social Impact Assessment is carried out by the state government and premilinary notification on land acquisition was issued. The act does not include a specific reference to cut-off date, but it specifies the start date of the census to be undertaken by the state government and may also be used as the official cut-off date.

Baseline survey found that Period Patta and Village Pass are more common types of land ownership/use pattern in Mizoram than the Land Settlement Certificate. They are allocated specific plots in the village by the state government or the Village Council, and this is customally understood as "private land ownership". The preference of cash compensation raised during the consultation meetings regardless of land use is a sign that allocated plots for farming has been understood as "private land".

Survey on household incomes found that out of the 223 households that responded 83 were Below Proverty Line (73 households considering themselves as Below Poverty Line). The rehabilitation plan for this project as mentioned above will be developed and implemented by the state government with the details of the plan keeping with the guidelines and principles of JICA and World Bank policies and tailored with inputs from stakeholders. The three options considered are the support for expanding plantation, shared-market place, and Backyard Poultry.

Public consultation meetings for RAP were held likewise to the EIA public consultation meetings. While in general residents supported the construction of the bypass, early confirmation of the route (as it might of affect plans for construction, or extension, of houses or work sheds) and, based on previous experience, an affirmation of compensation before relocation was requested. Some raised comments on the approach of brokers that expressed to negotiate the land transaction, and confirmed that extensive care must be taken to prevent residents to get caught in unnecessary trouble.

## 9. Conclusions and Recommendations

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

1) The study team examined the viability of the NH54 bypass project by reviewing the contents of the 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 meets the SARDP-NE target of development of the region through improvement of connectivity as part of the NH54 mainline project. The possibility of access from the NH54 project to Kaladan Multimodal Transit Transport Project was confirmed. In this regard, the 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 the traffic study, project costs and economic analyses of the Project, the EIRR of the Project of the NH54 main road section plus the four bypasses are estimated at 10.96%.

### (2) Confirmation of Appropriateness of the Project Components

1) After the study team reviewed the preliminary design in the DPR, it was confirmed that design concept for alignment design does not consider well environmental impact and natural disaster prevention. The study team introduced the design concept for the environment and disaster prevention such as earth balanced alignment design and advanced slope protection design, which was introduced in developed countries. The

team also introduced the spoil bank to provide flat land for the promotion of effective use and disposal of soil.

2) Since the preliminary design in the DPR has not carried out topographic survey and geotechnical survey, accuracy of the basis for the alternative route study is low. Therefore, the study team carried out topographic surveys and geotechnical surveys for the alternative route study and preliminary design to ensure accuracy of the design.

3) The study team prepared the preliminary project cost in reference to the SOR in 2015 and cost of advanced slope protection works which is introduced to the design.

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

5) The study team conducted surveys on the NHIDCL's institutional structure, annual budget, and maintenance of the existing roads under their administration. As a result of the surveys, it was confirmed tha the NHIDCL has just started their organizational function and maintenance systems by the NHIDCL is still under consideration. Therefore, the study team proposed an institutional structure for maintenance of the project road in consideration of the importance of maintenance aiming for disaster prevention.

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

**(3) Recommendations**

Since implementation schedule of the NH54 mainline and the NH54 bypasses will be overlapped, efficient procurement of contractor and consultant for the NH54 bypass project is proposed with reference to the geographical condition.

# CHAPTER 1 INTRODUCTION

## 1.1 Background of the Study

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

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

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

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

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

## 1.2 Objective of the Study

The major objective of this study is:

- To examine the 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 Table 1.3-1.

**Table 1.3-1 Additional Scope of Four Bypasses**

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

Source: JICA Study Team

# CHAPTER 2 TRAFFIC SURVEY, ANALYSIS AND FORECAST

## 2.1 General

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

The number and type of vehicles expected to use the proposed bypasses have been estimated through traffic surveys conducted in 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 of 2020, 2025, 2030, 2035, and 2040.

The proposed bypass sections included in the present study are set out in Figure 2.1-1. There are four bypasses in total, adding up to about 24.2 km. The longest bypass (about 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<br>23°22'53.20"N | 92°50'30.11"E<br>92°50'22.22"E | 3.0 km |
| 2. Serchhip Bypass | 23°20'50.76"N<br>23°17'24.04"N | 92°50'57.17"E<br>92°51'41.78"E | 12.4 km |
| 3. Hnahthial Bypass | 22°59'06.90"N<br>22°56'00.06"N | 92°55'29.90"E<br>92°55'29.28"E | 6.8 km |
| 4. Lawngtlai Bypass | 22°31'04.79"N<br>22°30'29.10"N | 92°53'14.90"E<br>92°53'23.29"E | 2.0 km |
| | | **Total** | **24.2 km** |

Source: JICA Study Team

**Figure 2.1-1 Study Road (Bypass) Sections**

## 2.2 Traffic Survey Methodology

For estimating the bypass traffic for each of the four identified cities/ towns on NH54, the following two surveys were conducted at strategically selected locations (at two locations, one for the vehicles entering the town and another for vehicles leaving the town) on both sides of the road for each selected city/ town (Please refer to Figure 2.2-1):

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

The objective of both abovementioned surveys is to estimate the number of vehicles that would divert to the proposed bypasses. It may be mentioned that generally CVCS is done to determine the traffic volume at a location, but can be structured by organizing two nearby and consecutive CVCSs for the same time period in a day to obtain "through traffic" that can possibly get diverted to bypasses. 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 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 an 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 to Figure 2.2-1). Likewise, same arrangement was done to capture vehicle movement in the other (opposite) direction. The "through traffic" for each direction was determined through the following method:

(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-minute traffic count in each direction of traffic flow (vehicles entering and leaving the city in each direction), the following steps were carried out:

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

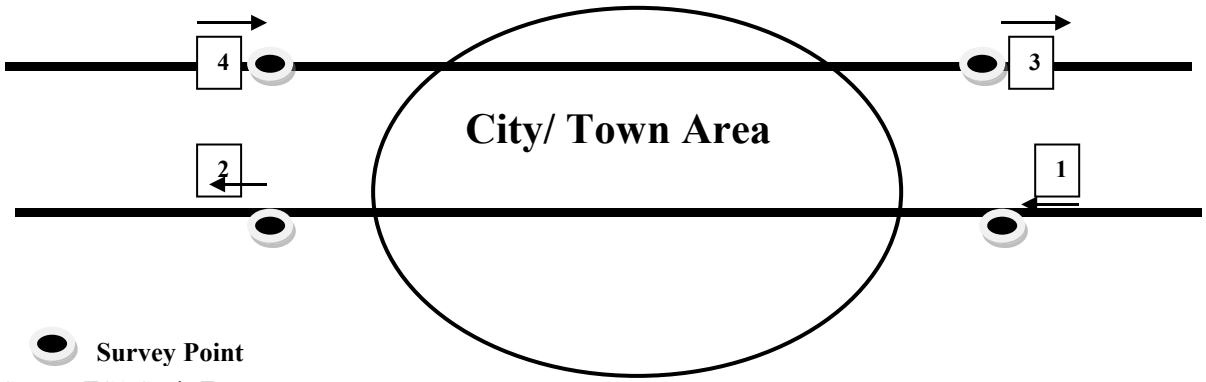
### 2.2.2 Number Plate Survey

Along with the CVCS, one-day NPS was conducted by noting down vehicle registration number for each category of vehicles at every 15-minute frequency. The NPS is an alternate for O-D survey, wherein if the vehicle registration number recorded at the two survey points located on the same side of the road (e.g., survey locations 1 and 2 in Figure 2.2-1) matches, then it means that the vehicle has crossed the city, i.e., it is a "through vehicle" and therefore, can be considered as bypass traffic.

By doing NPS and CVCS simultaneously at the same location, 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 the exit locations are matched to obtain the common registration number. Thus, it becomes

probable 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 and this may result in a wrong entry.




Source: JICA Study Team

**Figure 2.2-1 Typical Survey Point 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 the bypass, the CVCS and NPS were carried out simultaneously at two locations (one at the entry and another at the exit point close to the city/ town) of each of the four cities/ towns proposed for the construction of bypass. The following Table 2.3-1 shows the survey dates and chainage of each of the four bypass cities/ towns.

**Table 2.3-1 Traffic Survey Dates**

| Bypass Name | Bypass Start and End Chainage | Traffic Survey Date |
|---|---|---|
| Chhiahtlang Bypass (Bypass No. 1) | Km 96.945 to Km 98.185 | 15.02.2016 |
| Serchhip Bypass (Bypass No. 2) | Km 104.430 to Km 114.170 | 25.02.2016 |
| Hnahthial Bypass (Bypass No. 3) | Km 169.550 to Km 178.550 | 22.02.2016 |
| Lawngtlai Bypass (Bypass 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 bypass. 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 the north and south directions.

**Table 2.3-2 Daily Traffic at Bypass Locations**

| Bypass Name | Cars/ Jeep/ Taxi | Mini Bus | Bus | Three-Wheeler | Two-Wheeler | LCV | Trucks | PCU |
|---|---|---|---|---|---|---|---|---|
| **Chhiahtlang Bypass (Bypass 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 Bypass (Bypass No. 2)** | | | | | | | | |
| North Direction | 128 | 1 | 1 | 44 | 123 | 42 | 22 | 367 |
| South Direction | 154 | 3 | 2 | 34 | 83 | 21 | 12 | 308 |
| **Total** | **282** | **4** | **3** | **78** | **206** | **63** | **34** | **675** |

| Bypass Name | Cars/ Jeep/ Taxi | Mini Bus | Bus | Three-Wheeler | Two-Wheeler | LCV | Trucks | PCU |
|---|---|---|---|---|---|---|---|---|
| **Hnahthial Bypass (Bypass 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** |
| **Lawngtlai Bypass (Bypass 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 in February 2016 by the 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 JICA Study Team 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)<br>• EI = Economic Indicator (GDP/NSDP/Population/PCI)<br>• A0 = Regression Constant<br>• A1 = Regression Coefficient (Elasticity Index) |
| **Step2** | | |
| Passenger Vehicles | Grp = [(1+Rp) (1+ Rpci x Em) – 1] | • Grp = Growth Rate Passenger Vehicle<br>• Rp = Population Growth<br>• Rpci = Per capita Income Growth<br>• Em= Elasticity |
| Goods Vehicles | Grg = Em * R(nsdp) | • Grg = Growth Rate Goods Vehicle<br>• Em = Elasticity Value<br>• R(nsdp) = NSDP Growth Rate |

Source: Derived from IRC: 108-1996

### 2.4.1 Registered Vehicles

In the 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**

| Year | Two- Wheeler | Auto 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 |
| 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

The net state domestic product (NSDP) at constant prices has been used as the independent variable for estimating the elasticity of the goods vehicles such as trucks, LCVs, etc. The per capita income (PCI) data was used as the independent variable for estimating elasticity for passenger vehicles such as cars, buses, two-wheeler, etc. The data series of NSDP and PCI at constant prices are presented in Table 2.4-3.

**Table 2.4-3 NSDP and PCI (at Constant Prices)**

| Year | NSDP (Million 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 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 |
| Auto 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 ($y = 0.929x - 2.774$, $R^2 = 0.772$) | 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 bypass locations was estimated through the traffic survey. In addition to this, traffic is expected due to the commencement of the Kaladan Project (explained below) and due to the induced effect (combined impact of overall improvement of NH54, construction of bypasses and Kaladan Project).

Traffic projections have been made using the methodology elaborated in the 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-Wheeler | 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 the Kaladan Project, it is expected that a part of the traffic entering the North-East Region (NER) from Kokrajhar (West Bengal side) will 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 NH54 (Lawngtlai) (in India) | Road | 100 km |
| Lawngtlai to Aizawl | Road | 334 km |
| **Kolkata – Aizawl** | **Multimodal** | **1260 km** |

Source: Ministry of Development of North Eastern Region

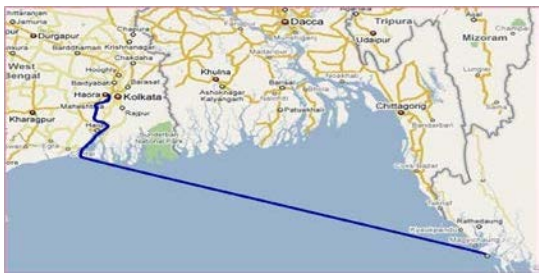



**Figure 2.5-1 Kaladan Multimodal Transit Transport Project**

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

**Table 2.5-2 Traffic on Account of Kaladan Project**

| Vehicle Type | Traffic in 2020 |
|---|---|
| Two-Wheeler | 196 |
| Auto Rickshaw | 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 2020) has been considered due to the expected combined impact of the improvement of NH54, construction of bypasses, and opening of the Kaladan Project.

The total traffic, obtained by combining the existing traffic, Kaladan traffic, and the induced traffic, was thus projected by using the future growth rates for the horizon years – 2020, 2025, 2030, 2035, and 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 Bypass ( Bypass 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 Bypass (Bypass 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 |
| **Hnahthial Bypass (Bypass 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 |
| **Lawngtlai Bypass (Bypass 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 Bypass Traffic

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

**Table 2.6-1 Percentage Traffic Diversion to Bypass**

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

Source: Traffic Survey by the JICA Study Team

**Table 2.6-2 Daily Traffic - Diverted to Bypasses**

| By-pass | Cars / Jeep/ Taxi | Bus | Three- Wheeler | Two- Wheeler | LCV | Truck | Total | PCU |
|---|---|---|---|---|---|---|---|---|
| **Chhiahtlang Bypass (Bypass 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 Bypass (Bypass 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 |
| **Hnahthial Bypass (Bypass 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 |
| **Lawngtlai Bypass (Bypass 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 the 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 (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 cost items (under 'with' and 'without' project cases) estimated at base year prices are adjusted for transfer of payments such as taxes, duties, and subsidies on materials and equipment. A 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 Bypasses and Corresponding Road Sections

Table 3.2-1 presents the length of the four bypasses 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 bypass). The lengths of the bypasses and the road section lengths are inputs for economic analysis.

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

| Bypass Name | Bypass Start and End Chainage | Bypass Length after Design | Equivalent Length of Corresponding NH54 Road Section |
|---|---|---|---|
| Chhiahtlang Bypass (Bypass No. 1) | Km 96.945 to Km 98.185 | 2.57 km | 1.24 km |
| Serchhip Bypass (Bypass No. 2) | Km 104.430 to Km 114.170 | 11.80 km | 9.74 km |
| Hnahthial Bypass (Bypass No. 3) | Km 169.550 to Km 178.550 | 7.02 km | 9.00 km |
| Lawngtlai Bypass (Bypass No. 4) | Km 472.000 to Km 478.850 | 2.63 km | 6.85 km |

Source: JICA Study Team

The features of the road sections corresponding to the four bypasses are set out in Table 3.2-2.

**Table 3.2-2 Features of Road Sections Corresponding to the Four Bypasses**

| Bypass Reference | Applicable Existing Road Section of NH54 | Lane Configuration | Shoulder Width (Mt) | Terrain | Wt. Avg. IRI |
|---|---|---|---|---|---|
| No.1 | Km 55- Km 125 | 3.75 (SL) | 0.5 (UP) | Steep | 5.00 |
| No.2 | Km 55- Km 125 | 3.75 (SL) | 0.5 (UP) | Steep | 5.00 |
| No.3 | Km 125 - Km 250 | 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 related to vehicle cost, cost of tire, fuel prices, maintenance labor cost, 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 (INR '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 (INR '000) | 3.26 | 0.77 | 1.01 | 9.19 | 9.19 | 9.19 | 9.19 | 5.88 | 9.19 |
| Fuel (INR per L) | 38.63 | 38.63 | 38.63 | 39.75 | 39.75 | 39.75 | 39.75 | 39.75 | 39.75 |
| Maint. Labor (INR per hr) | 105 | 63 | 105 | 189 | 157.5 | 189 | 210 | 157.5 | 210 |
| Crew Wages (INR per hr) | 16.8 | 0 | 14.7 | 67.2 | 40.95 | 37.8 | 43.05 | 28.35 | 0 |
| Annual Overhead (INR '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* (INR 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 |
| Average Life (year) | 8 | 8 | 8 | 8 | 8 | 10 | 10 | 8 | 8 |

Source: Market Survey and Previous Studies in India

## 3.4 Project Cost

The cost estimates for the four bypasses were prepared by the JICA Study Team. It may be noted that the proposed construction works are only applicable for the construction of new bypasses ('with' the project cases), and are not applicable for the base case alternative ('without' the project case).

The first year of the construction period is considered as 2019, with the construction period lasting for 2.5 years (i.e., up to 2021). The opening year of traffic operations is expected to be 2021. The construction is expected to be completed in a phased manner 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 the 'base case' alternative is based on the existing practices being followed by the road agency. For the project alternatives, the maintenance cost has been defined by the JICA Study Team.

## 3.6 Economic Evaluation

The economic analysis based on the method elaborated above allowed the JICA Study Team to obtain the economic indicators for each bypass. The economic indicators such as economic internal rate of return (EIRR) are 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 Bypasses**

| NH54 Section + Bypass Name | EIRR (%) |
|---|---|
| NH54 Main Road Section + Chhiahtlang Bypass No. 1 | 13.21% |
| NH54 Main Road Section + Serchhip Bypass No. 2 | 12.07% |
| NH54 Main Road Section + Hnahthial Bypass No. 3 | 12.77% |
| NH54 Main Road Section + Lawngtlai Bypass No. 4 | 13.17% |
| NH54 Main Road Section + All Bypasses | 10.96% |

Source: JICA Study Team

For major urban centers along NH54, the potential negative impact associated with land acquisition and involuntary resettlement will be very high if the existing road is expanded. To minimize such impacts while maintaining and improving the function of NH54 as a main driver of the state's economy, construction of bypasses appears to be the optimal solution. Flat terrain does not exist in the proposed area for bypass construction. Bypasses will have to be constructed on hilly terrain and therefore, construction cost will be twice or three times more than that of bypasses on flat land. The EIRR for the bypass is relatively low because of this fact, but considering environmental and social dimensions, bypasses can still be the optimum long-term option for Mizoram. See Chapter 8 for more detailed analysis of environmental and social issues.

# CHAPTER 4 ALTERNATIVE ROUTE STUDY

## 4.1 Objectives of Alternative Route Study

The scope of bypasses in the Detailed Project Report (DPR) was not clearly mentioned. The alignments of the four bypasses in the DPR were given tentatively without much description of profile and detailed cross sections, especially for Chhiahtlang and Serchhip bypasses. Therefore, the JICA Study Team conducted Alternative Route Study for these four bypasses before conducting the 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 JICA Study Team members, optimum route for each bypass is established.

## 4.2 Scope of Alternative Route Study

The scope of the 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 96.945 km, End near 99.185 km | Approx. 3 km |
| 2 | Serchhip Bypass | Start near 104.430 km, End near 114.170 km | Approx. 12.4 km |
| 3 | Hnahthial Bypass | Start near 169.550 km, End near 178.550 km | Approx. 6.8 km |
| 4 | Lawngtlai Bypass | Start near 472.000 km, End near 478.850 km | Approx. 2.0 km |
| Total | | | Approx. 24.2 km |

Source: JICA Study Team

Preliminary review of four bypasses by the JICA Study Team was conducted initially by desk.

### 4.3.2 Chhiahtlang Bypass

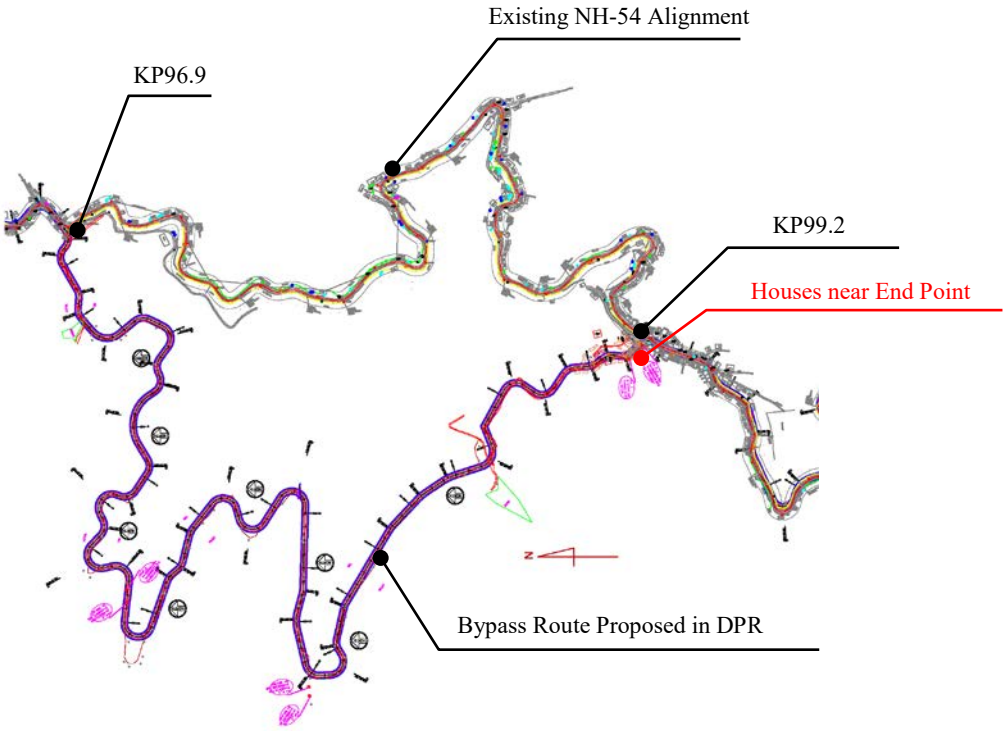
The layout of Chhiahtlang Bypass proposed in the DPR is given in Figure 4.3-1.

It is confirmed that there exists a national park in the eastern part of Chhiahtlang. Therefore, the JICA Study Team recommends to follow the bypass route proposed in the DPR which passes through the western side of the existing NH54. The bypass route starts near the existing KP96.9 and ends near KP99.2 with an approximate length of about 3 km. Based on the initial desk study, the JICA Study Team 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

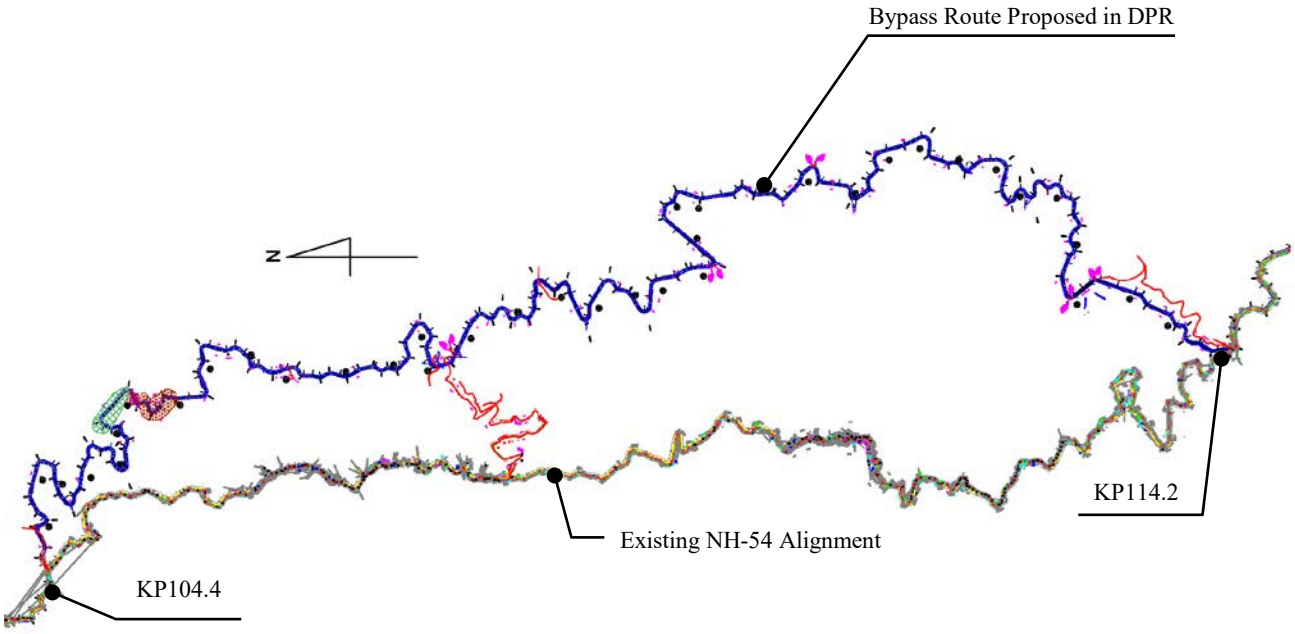
The layout of Serchhip Bypass proposed in the DPR is given in Figure 4.3-2.

The bypass in the DPR is proposed from the eastern side since much longer length would be required if the western side is selected for bypass construction for Serchhip. Therefore, the JICA Study Team considers that the eastern route proposed by the DPR is appropriate. However, some residences were observed based on the available map in the area near the end point, 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

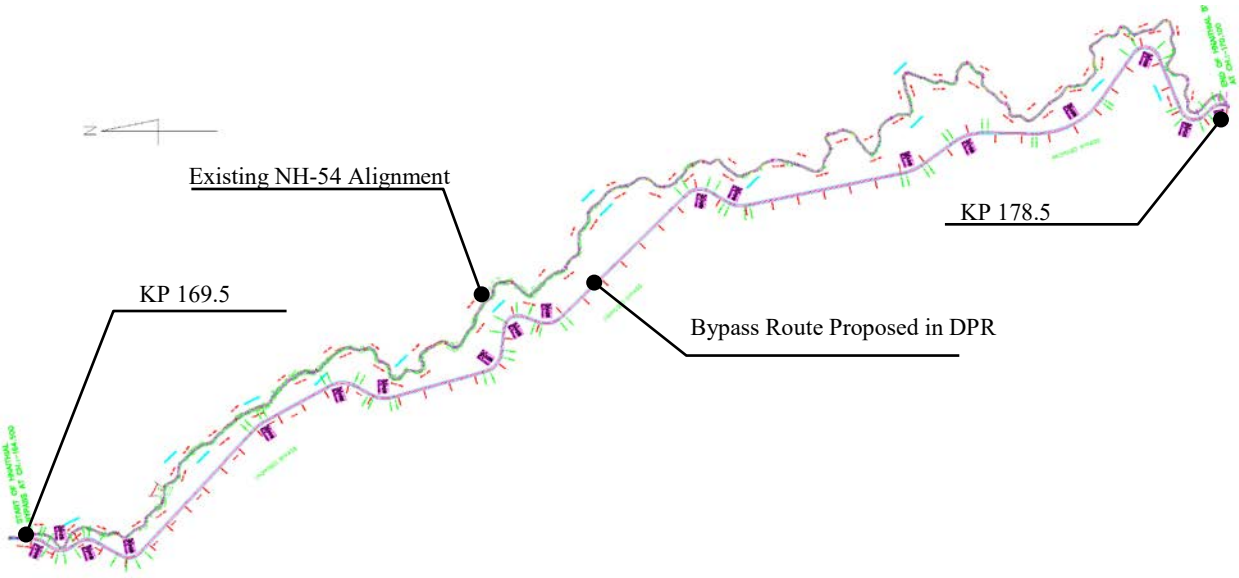
**Figure 4.3-2 Serchhip Bypass Route Proposed in DPR**

### 4.3.4 Hnahthial Bypass

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

The bypass in the 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 the bypass which makes it difficult to connect

back to NH54. Therefore, the eastern side proposed in the DPR seems appropriate. The bypass starts at the existing KP169.5 and ends at KP178.5.



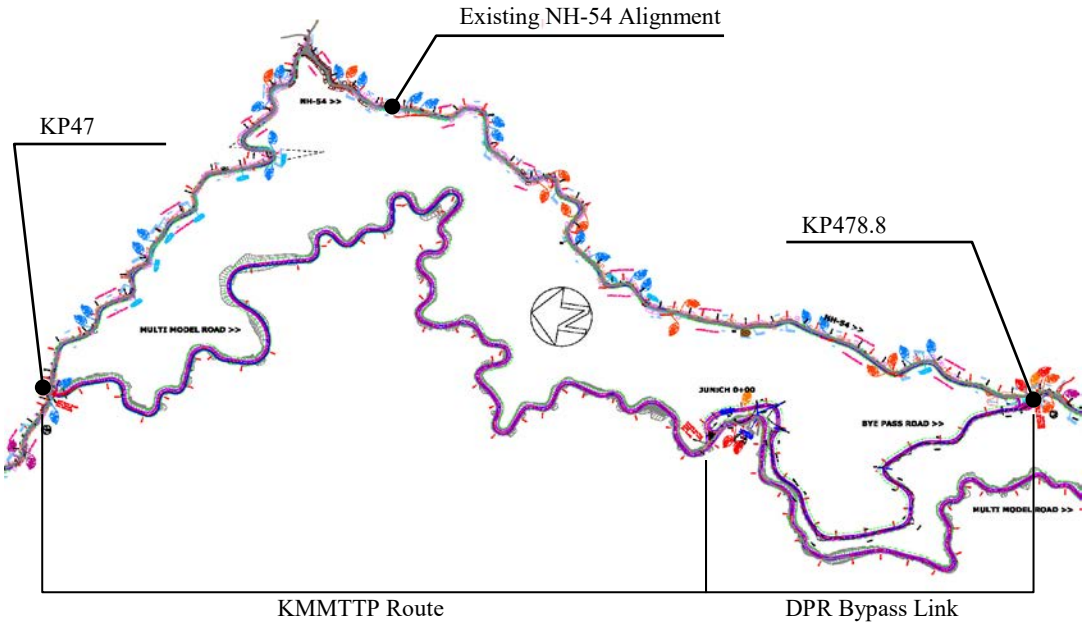

Source: JICA Study Team

**Figure 4.3-3 Hnahthial Bypass Route Proposed in DPR**

### 4.3.5 Lawngtlai Bypass Link

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

In the Lawngtlai area, there is another road construction project which is the Kaladan Multimodal Transit Transport Project (KMMTTP) which is under construction and which will avoid the route of the urbanized area of Lawngtlai. Therefore, the beginning section of the bypass for Lawngtlai actually belongs to the KMMTTP. However, the road under this project does not connect back to 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 nine members of the 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 investigated 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 the 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 passes through difficult terrain condition. |
| 3 | Hnahthial 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 No. 1 (Chhiahtlang Bypass)

The details are given in the figure of Appendix 1-1. Basically, the alignment is the 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:

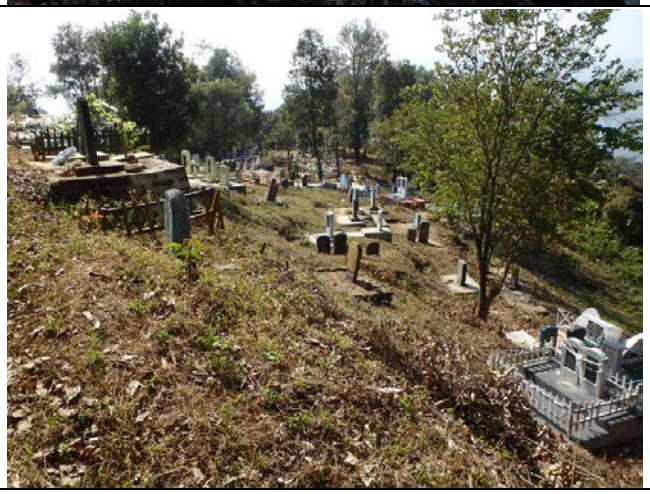
1. Large cemetery area near Km0+200
   The DPR alignment passes along the existing road near the cemetery area at Km0+200. In order to pass the bypass route below the cemetery area, alternative to start the bypass alignment about 200 m ahead was also checked. But the topographic condition was found to 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 sides of existing road at end section
   The bypass alignment ends by 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 the site such that the end of the bypass is extended for about 400 m further south. But there exists large slope failure area and many houses are also located below the existing NH54, which will require relocation. Therefore, the alternative to extend the end point of the bypass was abandoned.

**Table 4.4-2 Control Points in Bypass No. 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 sides of existing road at end section |  |

Source: JICA Study Team

### 4.4.4 Alternatives and Control Points in Bypass No. 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, namely: Alternative-1, 2, and 3, pass the river at almost the 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 the 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 much 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 with all other alternatives.

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

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

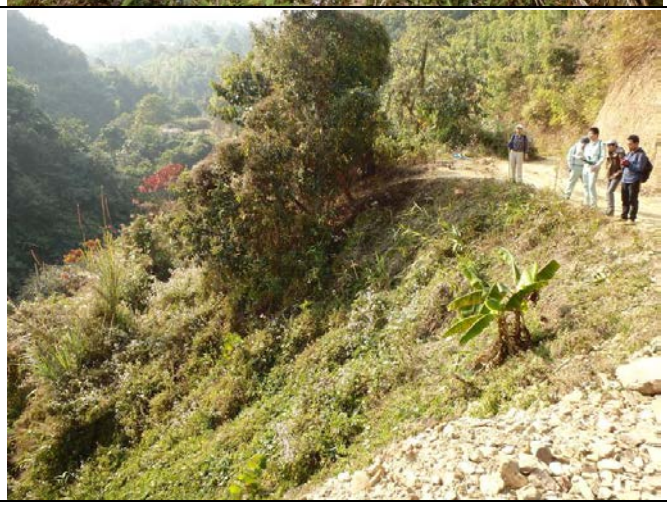
**Table 4.4-3 Major Control Points in Alternatives of Bypass No. 2**

| 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 | |

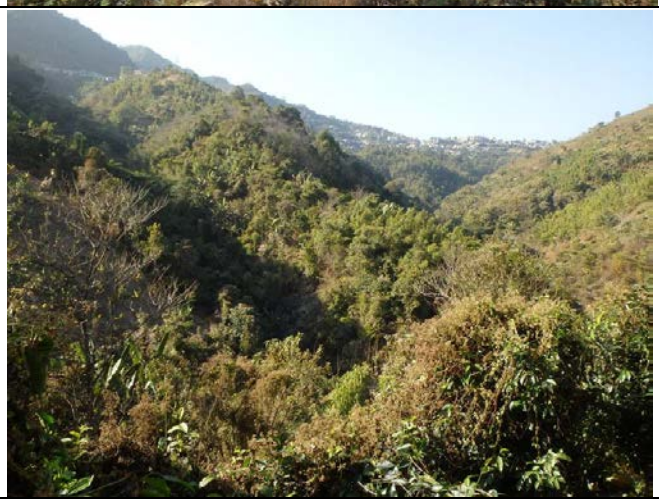
| S.N. | Control Points | Description | Remarks |
|---|---|---|---|
| 8 | CP8 | Steep slope in DPR | Steep slope in DPR is avoided by passing through CP9 |
| 9 | CP9 | Gentle slope in Alternative-2, 3, 4 | |
| 10 | CP10 | Bridge location in Alternative-1, 2, 3 | Straight, but longer bridge |
| 11 | CP11 | 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 No. 2**

| Control Point | Site Photo |
|---|---|
| CP1 |  |
| CP2 |  |

| Control Point | Site Photo |
|---|---|
| CP3/CP4 |  |
| CP5 |  |
| CP6 |  |

| Control Point | Site Photo |
|---|---|
| CP7 |  |
| CP8/CP9 |  |
| CP10 |  |

| Control Point | Site Photo |
|---|---|
| CP11 |  |
| CP12 |  |

Source: JICA Study Team

### 4.4.5 Alternatives and Control Points in Bypass No. 3 (Hnahthial 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 the upper side of the hill, closer to the existing NH54. Therefore, this alternative requires relocation of a large number of houses and a football ground as shown in the figure of Appendix 1-3. Therefore, another alternative was studied, which passes relatively along the 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 quantity of earthwork 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 No. 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 No. 3**

| Control Point | Site Photo |
|---|---|
| CP1 |  |
| CP2 |  |

| Control Point | Site Photo |
|---|---|
| CP3 |  |
| CP4 |  |
| CP5 |  |

| Control Point | Site Photo |
|---|---|
| CP6 |  |
| CP7 |  |

Source: JICA Study Team

### 4.4.6 Alternatives and Control Points in Bypass No. 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 Multimodal 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 Multimodal Road to the existing NH54 after the Lawngtlai 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 the landslide area around Km1+100. Therefore, another alternative was studied so that it would pass through above 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 at about 250 m prior to the starting point of Alternative-1, making it longer in length.

**Table 4.4-7 Control Points in Bypass No. 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 or Alternative-0 is also studied with the condition that the existing NH54 for the studied stretches is widened to 12 m 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 No. 4 (Lawngtlai Bypass Link), the base case or Alternative-0 is considered with the total length from where the Kaladan Multimodal Road starts before Lawngtlai Town to the end of Bypass No. 4. Therefore, in Alternative-1 and Alternative-2, the total construction cost is inclusive of 4.4 km of construction cost for the initial section of Kaladan Multimodal Road with assumed average cost of INR 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 | Hnahthial Bypass | Geometry | 3 | 1 | 2 | -- | -- |
| | | Spoil volume | 1 | 3 | 1 | -- | -- |
| | | House compensation | 3 | 2 | 1 | -- | -- |
| | | Construction cost | 1 | 3 | 2 | -- | -- |
| | | **OVERALL RANKING** | **3** | **2** | **1** | **--** | **--** |

| Bypass No. | Bypass Name | Items for Analysis | Ranking for Each Alternative | | | | |
|---|---|---|---|---|---|---|---|
| | | | Alternate-0 | Alternate-1 | Alternate-2 | Alternate-3 | Alternate-4 |
| 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** | **--** | **--** |

Note: 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 in the preliminary design.

**Table 4.6-1 Conclusions from Alternative Analysis**

| No. | Bypass Name | Route | Length (km) | Conclusion |
|---|---|---|---|---|
| 1 | Chhiahtlang Bypass | Alternate-0 | 2.200 | Although 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 four alternatives. |
| | | Alternate-1 | 12.422 | |
| | | Alternate-2 | 11.629 | |
| | | Alternate-3 | 11.708 | |
| | | Alternate-4 | 12.164 | |
| 3 | Hnahthial 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

b) Return Period

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

-For side drain of national highway : 25 years (at valley points)

-For cross drainage of national highway : 25 years (up to 2 m span)/ 50 years (2 to 6 m span)

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

The project highway is located at a high hill, and floodwater may cause high risk of fatal accident. Also, with the increase of rainfall intensity in recent years, the application of 50 years for all drainage is not an overestimation.

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

c) Rainfall Intensity

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

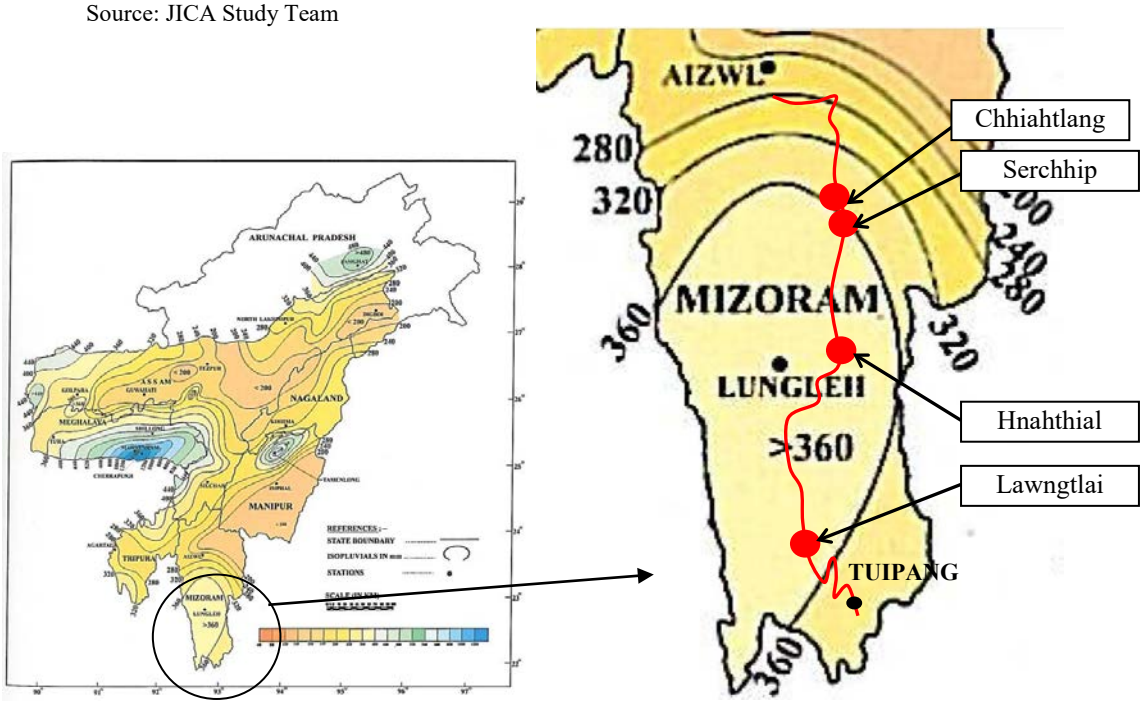
Location of NH54 and the bypass planned site is identified on the isopluvial map. The isopluvial map with the project location is shown in Figure 5.1-1. It is sectioned by range of rainfall intensity whose value is read from the higher edge of the counter value.

Rainfall intensity for each section in the NH54 bypass is shown in Table 5.1-1 .

**Table 5.1-1 Rainfall Intensity for Each Section in NH54 Bypass**

| Bypass No. | City | 50 years- 24 hours Rainfall Intensity |
|---|---|---|
| Bypass No. 1 | Chhiahtlang | 360 mm/hr |
| Bypass No. 2 | Serchhip | 360 mm/hr |
| Bypass No. 3 | Hnahthial | 400 mm/hr |
| Bypass No. 4 | Lawngtlai | 400 mm/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 NH54 Bypass Project Location (For 50 years)**

d) Runoff Coefficient

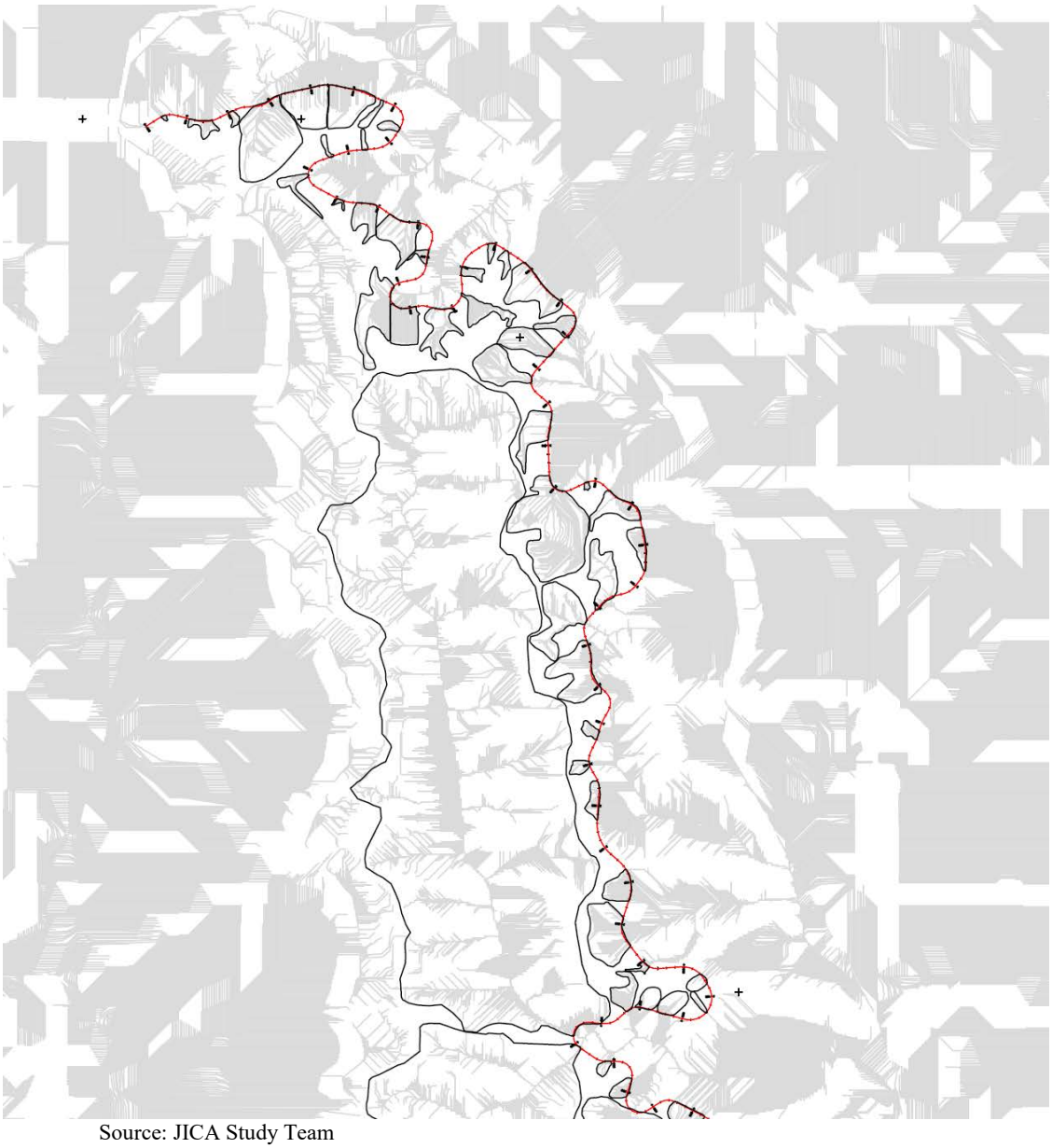
The guideline on runoff coefficient is described in IRC:SP:13.
The topographical condition at the project area on the NH54 bypass is wholly rocky mountainous to steep terrain. Hence, runoff coefficient C: 0.8 is applied (Rock, steep but wooded).

e) Catchment Parameters

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

- Satellite data: CatoSat I
- Software: ArcGIS 10.1 and Erdas

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



Source: JICA Study Team

**Figure 5.1-2 Example of Catchment Area Map Obtained by Computation for NH54 Bypass**

(5) Discharge Result

Through the hydrological study, discharge results for water crossing point with catchment area are obtained.

The discharge summary for large discharge (Q>4 $m^3/s$) is shown in Table 5.1-2 .

All discharge results including for small catchment area are shown in the "cross drainage list" prepared in the Appendix-4.

It is noted that cross drainage is planned not only on locations where crossing water appears in the hydrological computation but also on locations that need to satisfy the capacity of side ditches which drain out water falling down onto road surface and surroundings. It is explained in the chapter on 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 ($m^3/s$) |
|---|---|---|---|---|---|
| Bypass No. 1 | 1+280 | 41,975 | 312 | 88 | 4.71 |
| Bypass No. 2 | 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 |
| Bypass No. 3 | 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 |
| Bypass No. 4 | 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 degrees E).

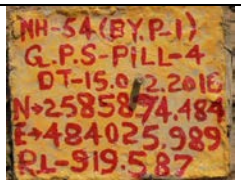
After the alternative analysis, detailed topographic survey was conducted for the optimum routes of all four bypasses. The topographic survey plan is given in Table 5.1-3.

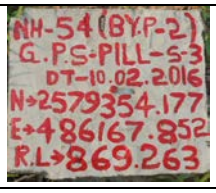
**Table 5.1-3 Topographic Survey Plan**

| No. | Name | Length | GPS Control Survey | 3D Point Survey |
|---|---|---|---|---|
| 1 | Chhiahtlang Bypass | Approx. 3 km | 2 pairs | Bypass length x 90 m corridor |
| 2 | Serchhip Bypass | Approx. 12.4 km | 3 pairs | |
| 3 | Hnahthial Bypass | Approx. 6.8 km | 3 pairs | |
| 4 | Lawngtlai Bypass | Approx. 2.0 km | 2 pairs | |

Source: JICA Study Team

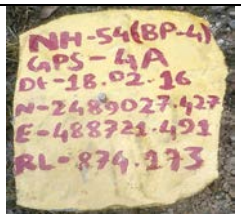
The GPS pillar for each bypass is given below.

| GPS Pillar for Chhiahtlang Bypass (Bypass No. 1) | |
|---|---|
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2586780.297<br>Easting: 484282.645<br>Elevation: 901.238 | UTM North-Zone_46: 90E<br>Northing: 2586781.389<br>Easting: 484265.06<br>Elevation: 903.143 |
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2585897.915<br>Easting: 484021.147<br>Elevation: 928.596 | UTM North-Zone_46: 90E<br>Northing: 2585874.484<br>Easting: 484025.989<br>Elevation: 919.587 |

| GPS Pillar for Serchhip Bypass (Bypass No. 2) | |
|---|---|
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2582007.356<br>Easting: 484686.211<br>Elevation: 876.290 | UTM North-Zone_46: 90E<br>Northing: 2582000.032<br>Easting: 484646.616<br>Elevation: 869.256 |
|  |  |

| **GPS Pillar for Serchhip Bypass (Bypass No. 2)** | |
|---|---|
| UTM North-Zone_46: 90E<br>Northing: 2579354.177<br>Easting: 486167.852<br>Elevation: 869.263 | UTM North-Zone_46: 90E<br>Northing: 2579322.216<br>Easting: 486130.370<br>Elevation: 876.226 |
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2575742.556<br>Easting: 485828.055<br>Elevation: 861.718 | UTM North-Zone_46: 90E<br>Northing: 2575677.915<br>Easting: 485827.262<br>Elevation: 865.605 |

| **GPS Pillar for Hnahthial Bypass (Bypass No. 3)** | |
|---|---|
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2541613.323<br>Easting: 492107.985<br>Elevation: 660.514 | UTM North-Zone_46: 90E<br>Northing: 2541575.894<br>Easting: 492102.769<br>Elevation: 661.444 |
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2539074.875<br>Easting: 492460.521<br>Elevation: 607.635 | UTM North-Zone_46: 90E<br>Northing: 2539039.231<br>Easting: 492483.807<br>Elevation: 608.153 |
|  |  |
| PILL=G5<br>UTM North-Zone_46: 90E<br>Northing: 2536661.635<br>Easting: 492387.822<br>Elevation: 544.457 | PILL=G6<br>UTM North-Zone_46: 90E<br>Northing: 2536638.741<br>Easting: 492386.391<br>Elevation: 543.530 |

| GPS Pillar for Lawngtlai Bypass (Bypass No. 4) | |
|---|---|
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2490510.310<br>Easting: 488427.631<br>Elevation: 757.394 | UTM North-Zone_46: 90E<br>Northing: 2490600.458<br>Easting: 488465.034<br>Elevation: 761.599 |
|  |  |
| UTM North-Zone_46: 90E<br>Northing: 2489065.966<br>Easting: 488689.256<br>Elevation: 869.590 | UTM North-Zone_46: 90E<br>Northing: 2489027.427<br>Easting: 488721.491<br>Elevation: 874.173 |

### 5.1.3 Geological Survey

#### (1) General

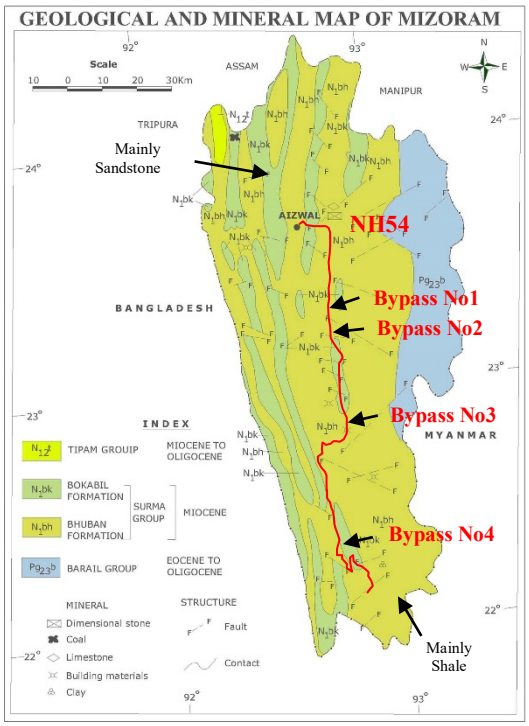
In order to clarify the geology and geological condition of NH54 bypasses and utilize the result for the road design, the JICA Study Team conducted geological survey including data collection, site reconnaissance, slope inventory survey, and boring survey.

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

(i) Geological and Topographical Setting

Northeast India is located on the northeast edge of the Himalayan Orogenic Belt, which resulted from the Indo-Eurasian continental plate collision that took place during Cenozoic 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 Plateau in the west, and the expansive Brahmaputra forming the Assam Plains in between.

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




Source: Geological Survey of India

**Figure 5.1-3 Geological Map of Mizoram State**

Figure 5.1-3 shows the geological map of Mizoram State. According to this map, the geology along NH54 consists of Bokabil formation and Bhuban formation of Surma groups. This lithology is as shown in Table 5.1-4.

The geology of the state is represented by repetitive succession of Neogene sedimentary rocks of Surma groups that mostly include sandstone, siltstone, and shale. In the formations, there are many folds caused by the plate collision. Mizoram Fold Belt is composed of tight linear folds with their axes mostly trending north to south and longitudinally plunging anticlines and synclines. The density of folds increases from west to east where the Indian Plate has been subducting below the Burmese Plate. The sedimentary rocks such as shale distributed in Mizoram State are very vulnerable to weathering, which often 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**

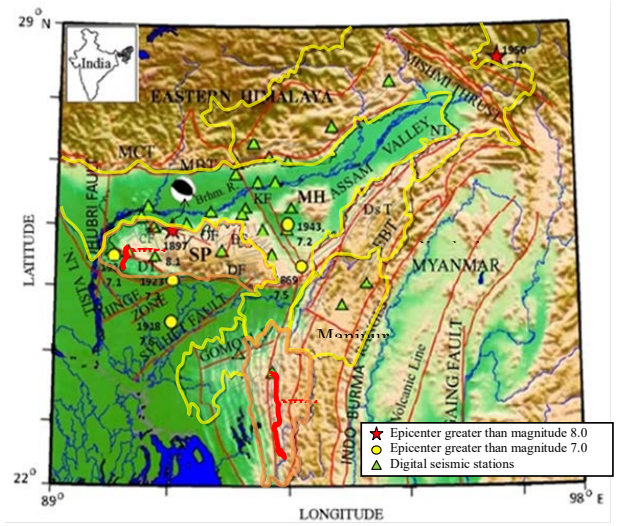
| Formation | Lithology |
|---|---|
| Bokabil | Mainly argillaceous rocks represented by shale/ siltstone and thinly bedded sandstone alternations with subordinate buff colored, fine to medium grained soft, friable sandstone |
| Upper Bhuban | Mainly arenaceous rocks which include mainly thickly bedded, 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 include 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, Miscellaneous Publication No. 30 Part IV, Vol 1(Part-2)

(ii) Seismologic Situation

The northeast states are located between the northern collision and eastern seduction margins of the Indian Plate. Two big earthquakes with a magnitude greater than 8.0 on the Richter Scale occurred north of Meghalaya and northeast of Arunachal Pradesh in 1897 and 1950, respectively, as shown in Figure 5.1-4. Also, an earthquake with a magnitude 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 Mizoram State (Table 5.1-5). In the past, the biggest historic earthquake had a magnitude of 6.1, which occurred in Chittagong near the border with Bangladesh, and other earthquakes had low magnitudes 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 the Indian earthquake intensity scale.




Source: Geological Survey of India

**Figure 5.1-4 Epicenter Distribution Map**

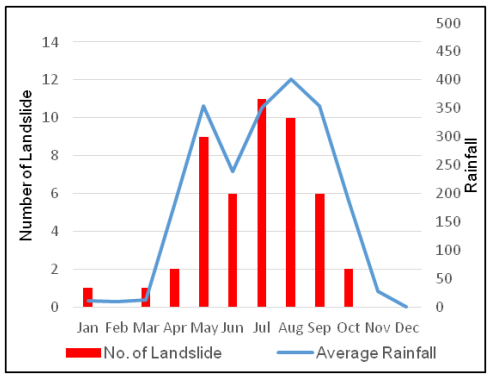
**Table 5.1-5 Historical Earthquake in Mizoram**

| 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

The JICA Study Team collected information on past landslide disaster in and around Mizoram State because the area is an extremely high rainfall region and mountainous area. Figure 5.1-5 shows the number of landslides reported in newspapers and academic paper from 1992 to 2015 and plotted by month. In September 2014, a large landslide occurred near the 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 during the 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 at 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 |
|---|---|---|---|---|
| Bypass No. 1 | BV-01, BV-02 | 20 m each | Conducted | |
| Bypass No. 2 (A) | BV-01, BV-02 | 20 m each | Conducted | Bridge's planned location |
| Bypass No. 2 (B) | BV-03, BV-04, BV-05 | 20 m each | Conducted | Bridge's planned location |
| Bypass No. 3 | BV-01, BV-02 | 20 m each | Conducted | |

Source: JICA Study Team

The Standard Penetration Test (SPT) result for two locations, which are finally taken as the planned bridge locations, is summarized in Table 5.1-7.

**Table 5.1-7 SPT Result for Planned Location of Bridge**

| Location | Boring No. | Depth (m) | N-value |
|---|---|---|---|
| Bypass No. 2 (A) | BV-01 | 0.0 - | Not penetrated |
| | BV-02 | 0.0 - | Not penetrated |
| Bypass No. 2 (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 the bridge foundation at the two locations is estimated as follows:

i) Bypass No. 2 (A)

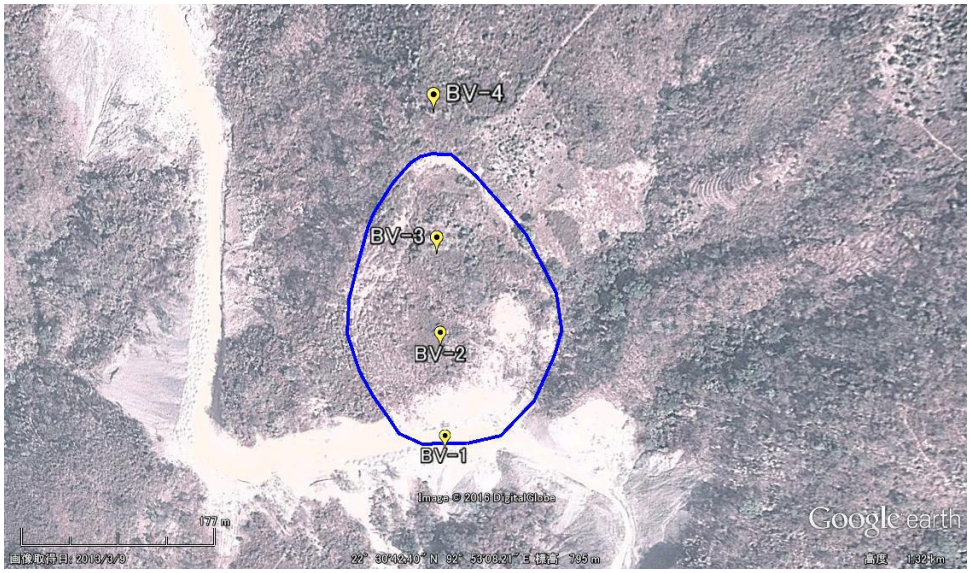
Surface soil is accumulated with 1.5 m thickness below the ground surface. Under the depth, weakly weathered rock is present with 7-8 m thickness. Because the layer cannot be penetrated by SPT, it is assumed to be hard enough for bearing layer. Therefore, bearing layer for the foundation is estimated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

ii) Bypass No. 2 (B)

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

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

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 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: 20 m) |
| BV-3 | m | 20 | |
| BV-4 | m | 30 | |

Source: JICA Study Team

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

Source: JICA Study Team

**Figure 5.1-7 Drilling Core**

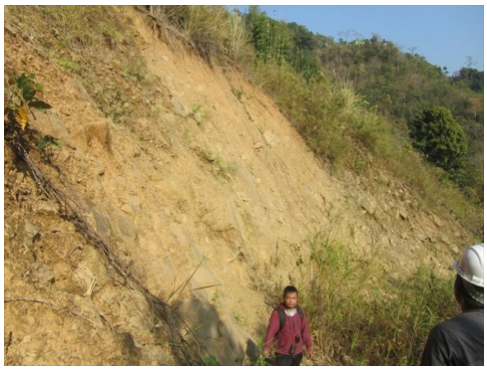
Location of the head and lower end of landslide is judged as follows:

i) Location of the Head of Landslide

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

ii) Location of the Lower End of Landslide

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

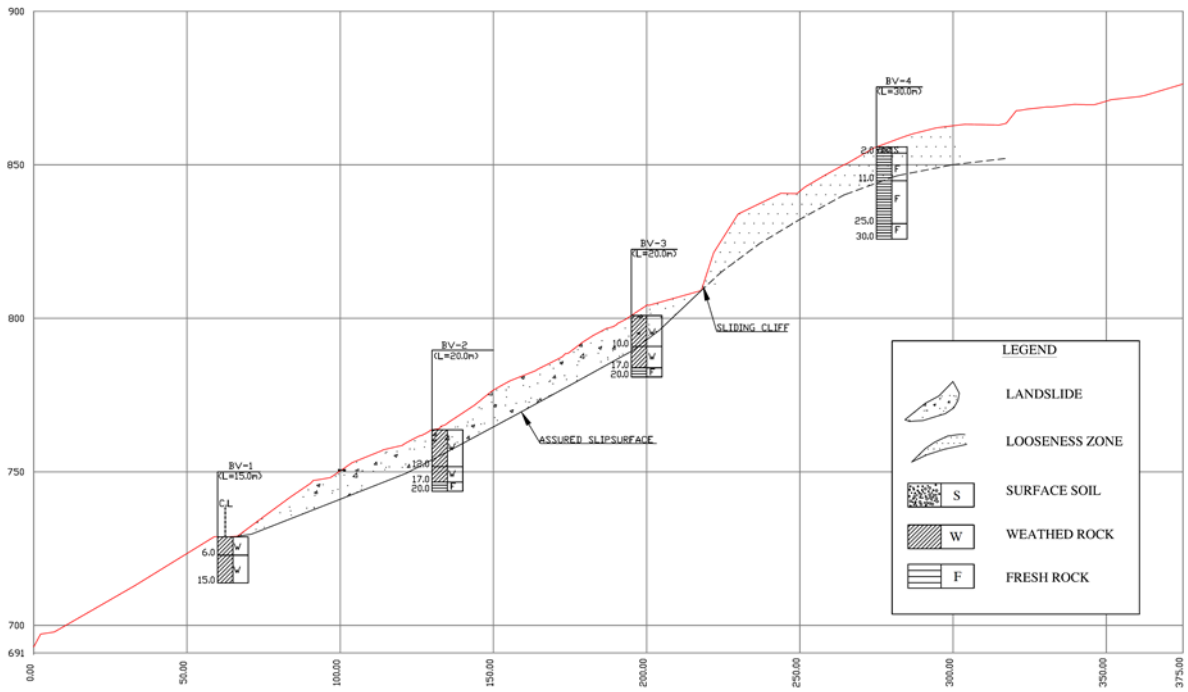


Sliding Cliff

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

The JICA Study Team conducted a road inventory survey along the 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

The JICA Study Team conducted the road inventory survey along the following national highway in Mizoram State:

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

b) Measurement Items

1) Road Cross Section Element

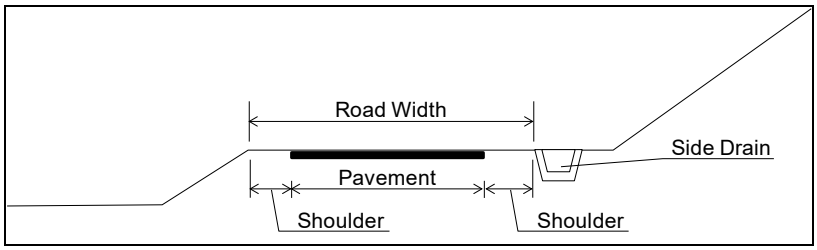
The following items were measured by measuring tape and visual observation at every 100 m section or any location where the target objects were found:

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

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

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

The road width was obtained at each 100 m interval along the 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 location where the target objects of cross drain and waterway were found:

- 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 location where the target objects of retaining wall and guardrail were found:

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

4) Social Infrastructure and Religious Object

The following items were recorded based on the existing local information collected in advance and visual observation at any location where the target objects of social infrastructure and religious object were found. The distance from 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 location where the target objects of overhead utility lines were found. 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 with local resident, and visual confirmation at sites along the target routes during the 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 location where the objects were found.

**(3) Summary of Results**

a) Road Cross Section Element

1) Road Width (Pavement and Shoulder)

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

- Chhiahtlang Bypass (Bypass No. 1)

Existing road sections have around 4 m to 5.5 m width with pavement, which is mostly in poor condition, from the beginning and end short sections of the bypass. Shoulder of 2 m in total is existing only at the beginning side of the bypass.

- Serchhip Bypass (Bypass No. 2)

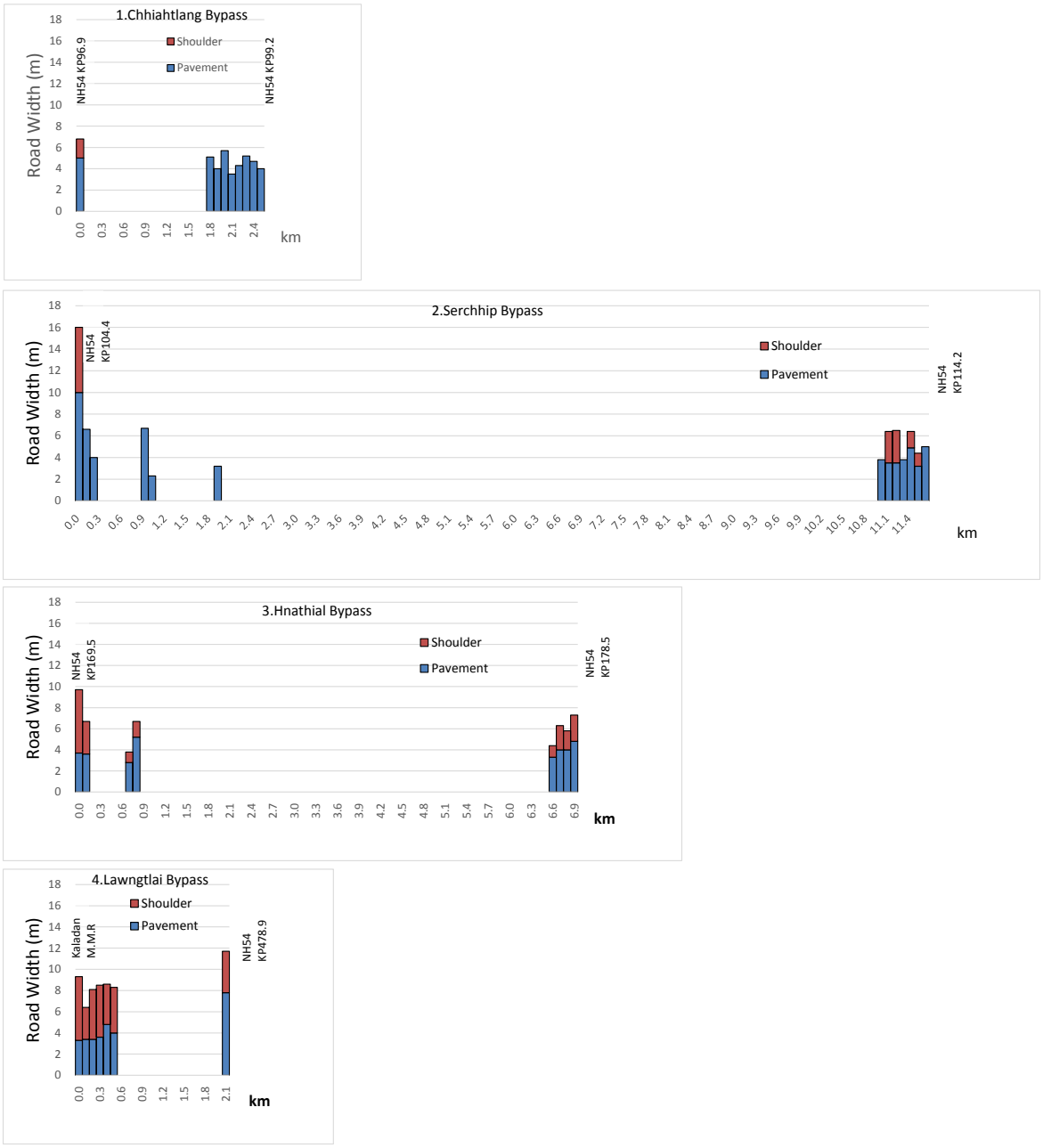
Existing road sections have around 4 m to 6 m width with pavement, which is in poor condition, from the beginning and end short sections of the bypass. Shoulder of 2.5 m in total is partially existing at the end side of the bypass. A section with a width of about 16 m in total is observed at the beginning side of the bypass and this is the wide intersection point with the NH54 mainline.

- Hnahthial Bypass (Bypass No. 3)

Existing road sections have around 4 m to 5 m width with pavement, which is mostly in poor condition, from the beginning and end short sections of the bypass. Around 1.0 m to 2.5 m shoulder in total is partially existing.

- Lawngtlai Bypass (Bypass No. 4)

Existing road sections have around 4 m width with pavement, which is in poor condition, from the beginning short section of the bypass. Shoulder of 4 m in total is given. Section with a width of about 12 m in total is observed at the end side of the bypass and this is the wide intersection point with the NH54 mainline.




Source: JICA Study Team

**Figure 5.1-11 Road Width (Pavement and Shoulder)**

2) Others

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

- Topography

The section where one side is hill and the other side is valley is found in almost the whole section of the existing road sections in the four bypasses.

- Land Use

Rural land use is dominant in almost all sections. However, there are built-up areas near the beginning and end short sections which are near to the NH54 mainline.

- Pavement Condition

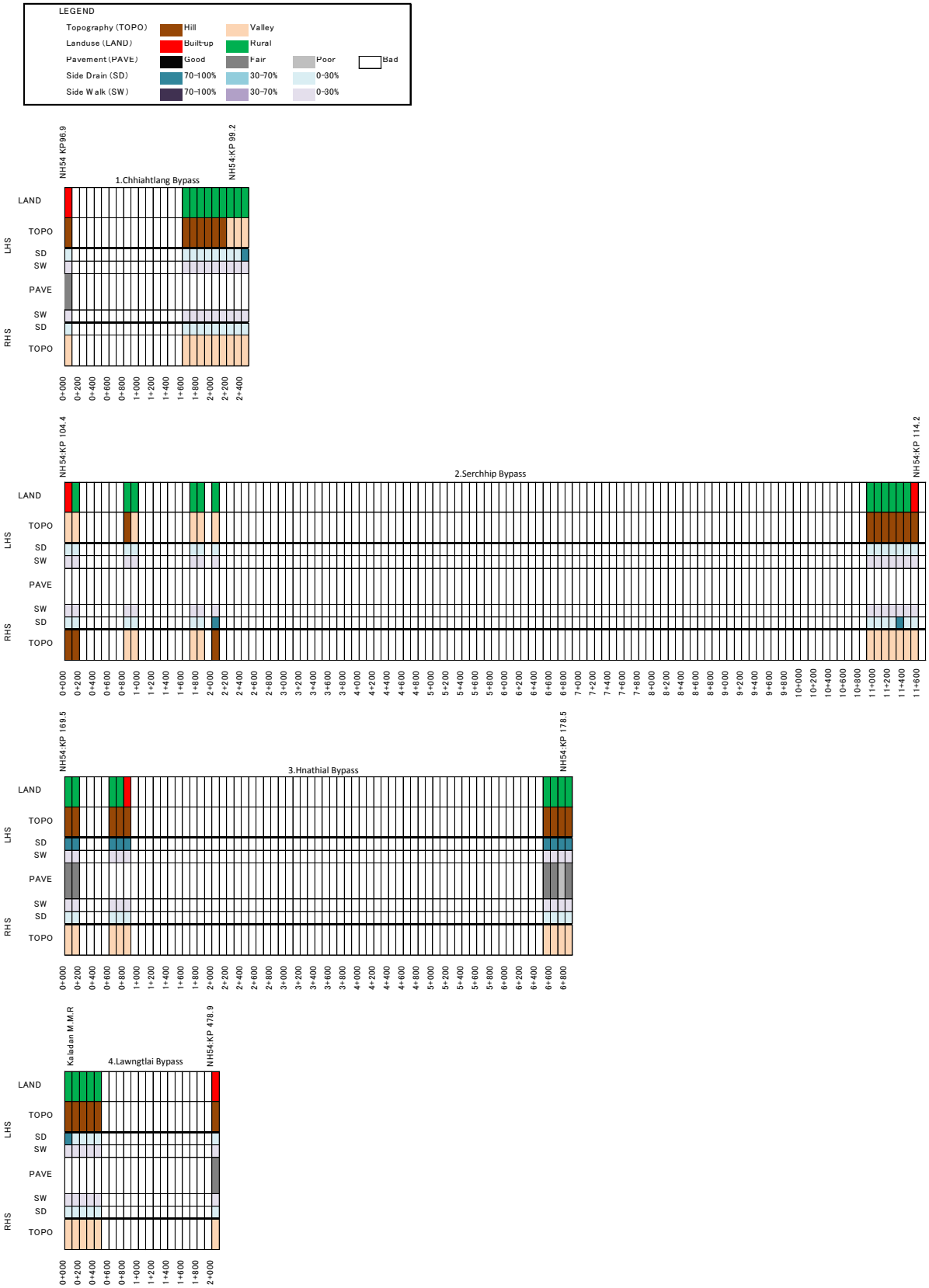
Bad pavement condition is mostly observed in Bypass No. 1, 2, and 4. However, pavement condition near the intersection with NH54 in Bypass No. 3 is mostly fair.

- Side Drain

Installation of side drain on the 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 in the other existing road sections.

- Sidewalk

Sidewalk is not observed in the 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

The following Table 5.1-9 shows the result of cross drain inventory data. The average no. of cross drain is 0.5 no. per km due to the short section length of existing road for all bypasses.

**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 the whole section along the existing road on NH54 bypass, masonry type is 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 with short length of 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 in 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 closely passing utilities' line was counted as shown in Table 5.1-14 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.

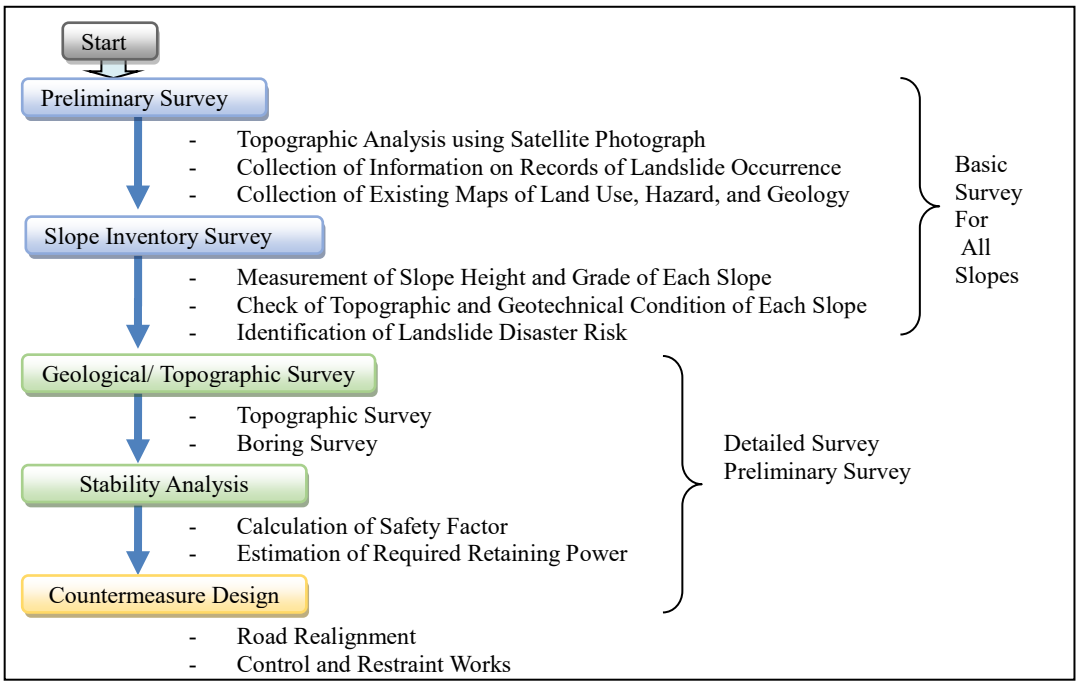
**Table 5.1-14 Result of Public Utilities**

| Route | Section | Section Length (km) | No. of Neighboring Public Utilities (Location of Crossing / Close Passage) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Electric Line | | Telecommuni-cation 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 vegetation, no outcrop can be found. Figure 5.1-13 shows the flowchart of slope study.



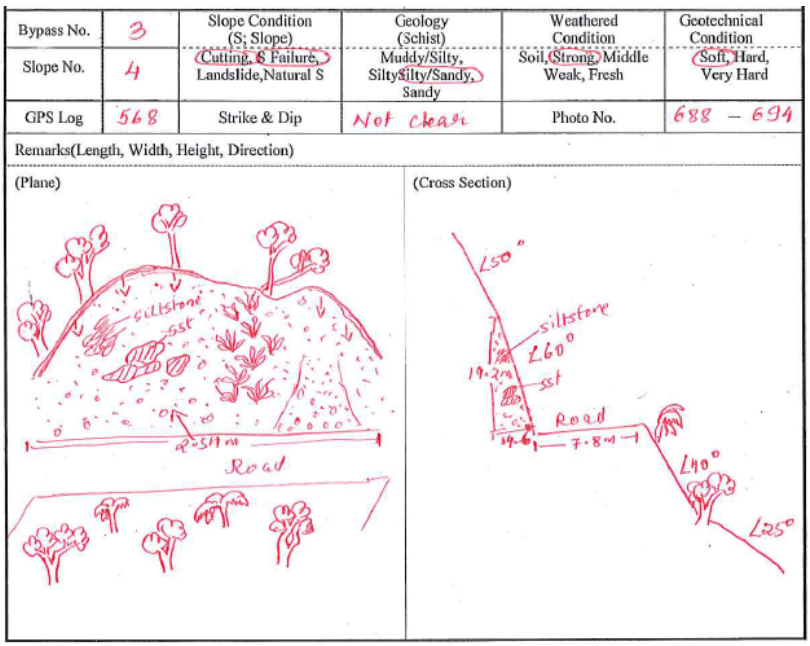

Source: JICA Study Team

**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. The results are presented in the list. The details of the results are attached in the Appendix-3.



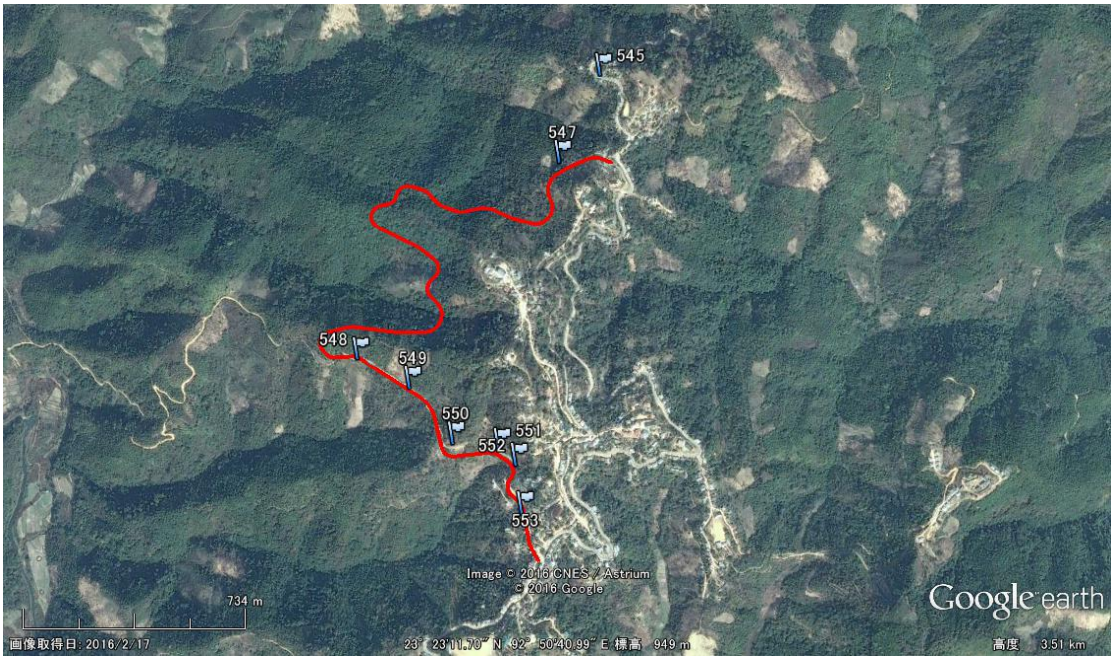

Source: JICA Study Team

**Figure 5.1-14 Example of Inventory Sheet**

(ii) Bypass No. 1

Figure 5.1-15 shows the planned bypass route and inventory survey sites. Table 5.1-15 shows the survey results.

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 due to weathering. As a whole, self-standing of the cutting slope is good. Therefore, 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 No. 8 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 No. 1)**

| 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 |

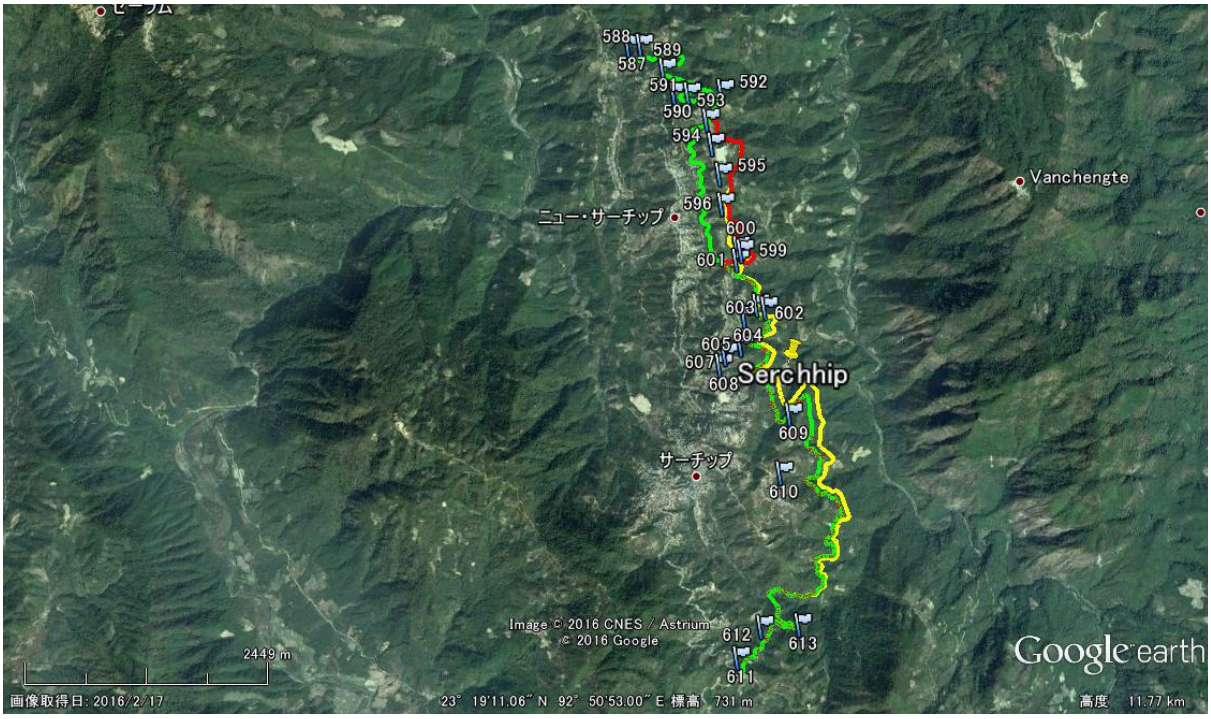
Source: JICA Study Team

(iii) Bypass No. 2

Figure 5.1-16 shows the planned bypass routes and inventory survey sites. Table 5.1-16 shows the survey results.

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, 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 due to 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 No. 6 to No. 10. 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 No. 7 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 No. 2)**

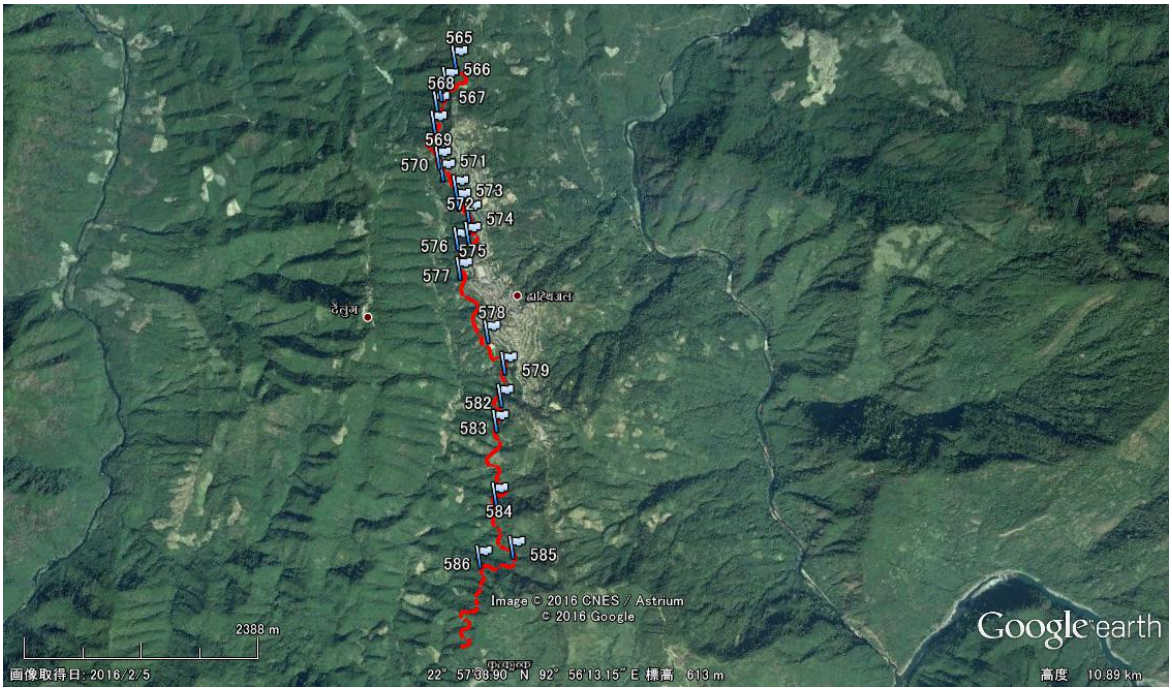
| Slope No. | Location GPS Log | Geology | Weathered Condition | Geotechnical Condition | Strike | | | Dip | | Disaster Risk (due to slope cutting) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 587 | Muddy/Silty | Middle(Cracky) | Soft | N | 50° | E | 10° | S | Slope Failure |
| 2 | 588 | Muddy/Silty | 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 No. 3

Figure 5.1-17 shows the planned bypass route and inventory survey sites. Table 5.1-17 shows the survey results.

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, 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 due to weathering. As a whole, self-standing of the cutting slope is good. But as seen in No. 4, No. 5, No. 8, No. 9, No. 13, No. 16, and No. 20, 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 No. 3)**

| 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

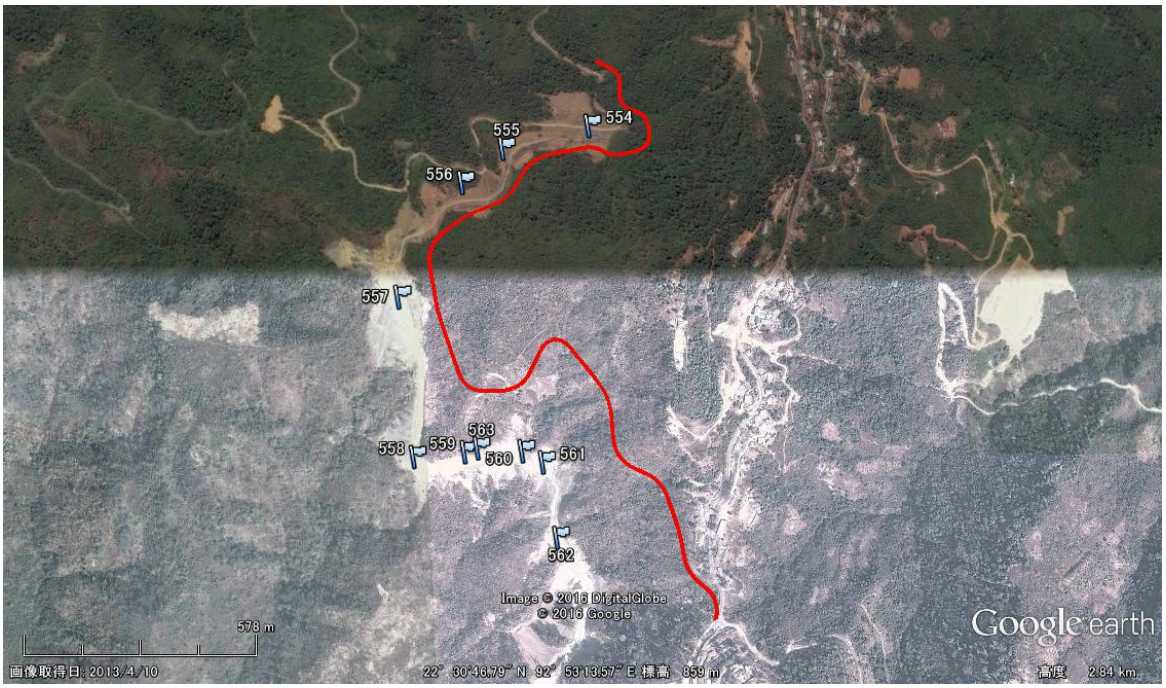
(v) Bypass No. 4

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

- Weathering condition of bedrock which got a lot of stress is remarkable compared with the other bypass areas. Therefore, this area has characteristics wherein slope failure and landslide are easy to occur.
- The active landslide which was due to cutting was observed along the road (No. 7). 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 (No. 10).

Actually, sediment deposition which has a variation history is distributed on the slope along Bypass No. 4. This condition is obviously different from the other three areas (No. 1 - No. 3).

Probably, the landslide of No. 7 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 No. 4)**

| 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 fold structure formed by 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. As a result, the present stable topography is thought to have been formed through topographic dissection (Figure 5.1-19).

The uplift of Mizoram area is thought to be little compared with that of Himalayan area in northern India. This is presumed to be one of the factors for the formation of stable topography in this area.

Source: JICA Study Team

**Figure 5.1-19 Stable Topographical Condition (Hnahthial)**

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

Weathered rock condition can be defined here as follows:

- Fresh rock: Original rock shows grayish color.
- Weak weathered rock: Rock shows grayish color, but the surface of the layer is brownish

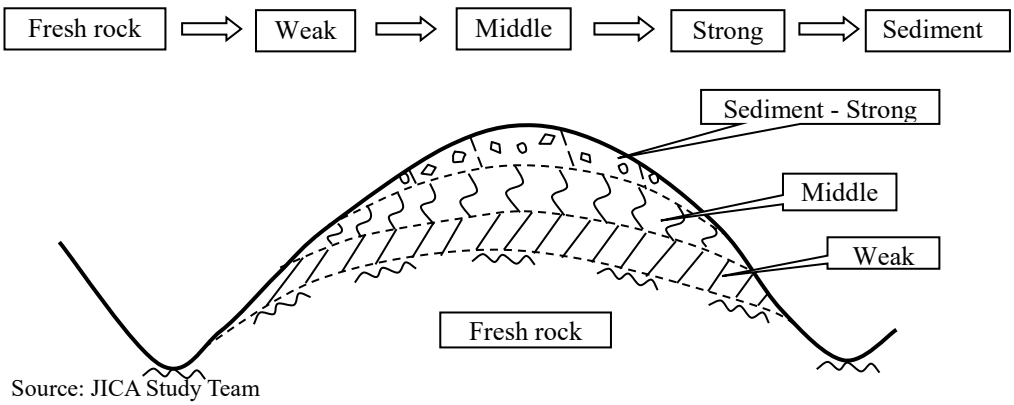
- Middle weathered rock: Rock shows grayish - brownish color, and there are lots of joints
- Strong weathered rock: Rock shows brownish color; rock condition is very soft and a part of the rock changes to sediment

Figure 5.1-20 shows example of weathered rocks.


Source: JICA Study Team

**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 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**

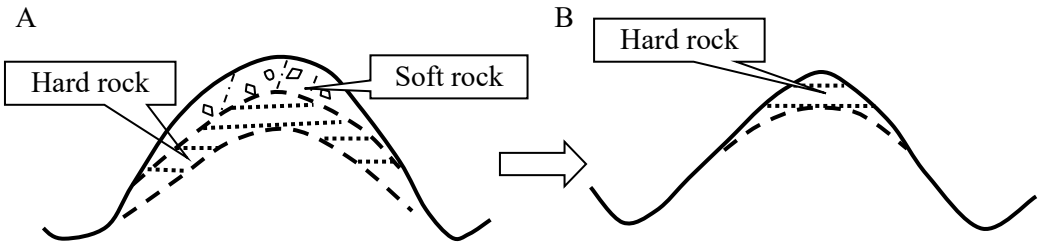
But there are cases that hard rock like sandstone is distributed on or below the ridge as shown in Figure 5.1-23. This condition is thought to be formed because the soft rock on the hard rock was eroded for a long time as shown in Figure 5.1-24.

Sandstone on the ridge

Sandstone near the ridge

Source: JICA Study Team

**Figure 5.1-23 Hard Sandstone Distributed on or below the Ridge**



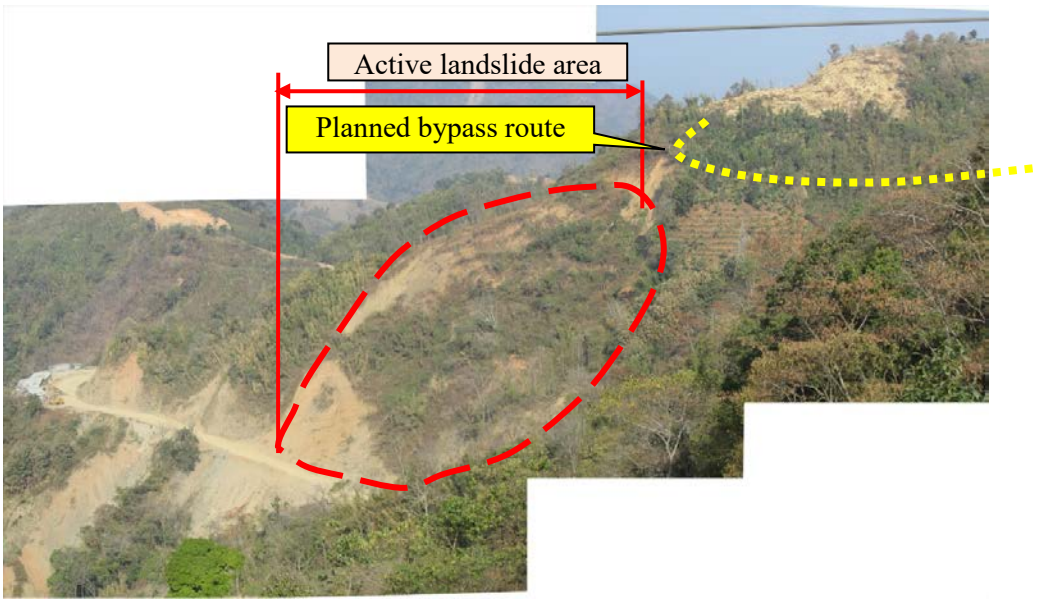

Source: JICA Study Team

**Figure 5.1-24 Distribution of Hard Rock and Formation of Ridge**

### (3) Occurrence of Landslide by Cutting

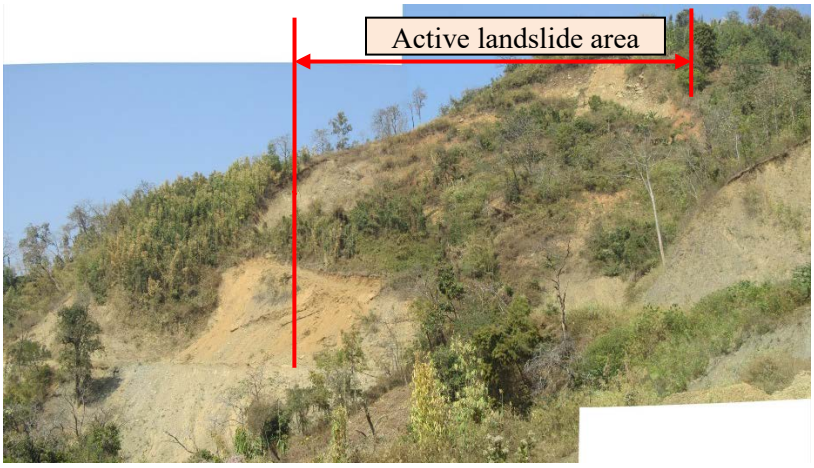
Large slope failures and landslides are seen along the current road near the planned Bypass No. 4. Especially, the bypass route is planned on the head of the landslide which is very active as shown in Figure 5.1-25.

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. The 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.

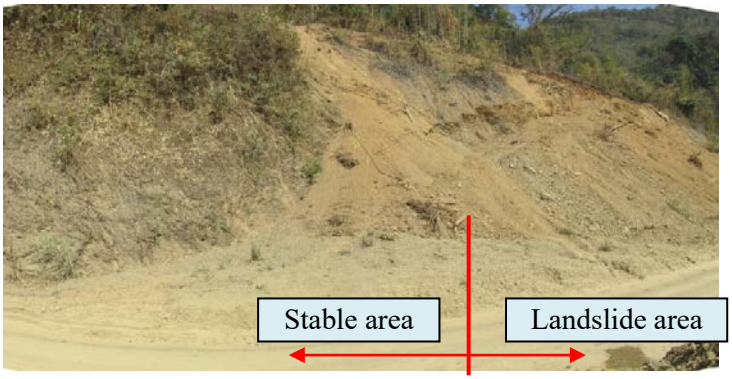



Source: JICA Study Team

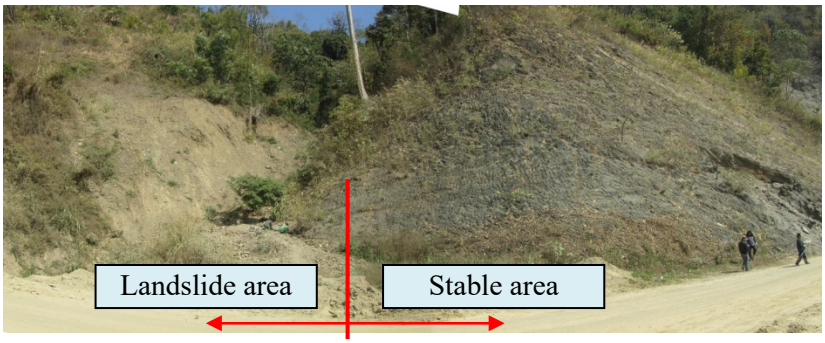
**Figure 5.1-25 Landslide Formed by Cutting and Planned Route**




A: Full View of Landslide



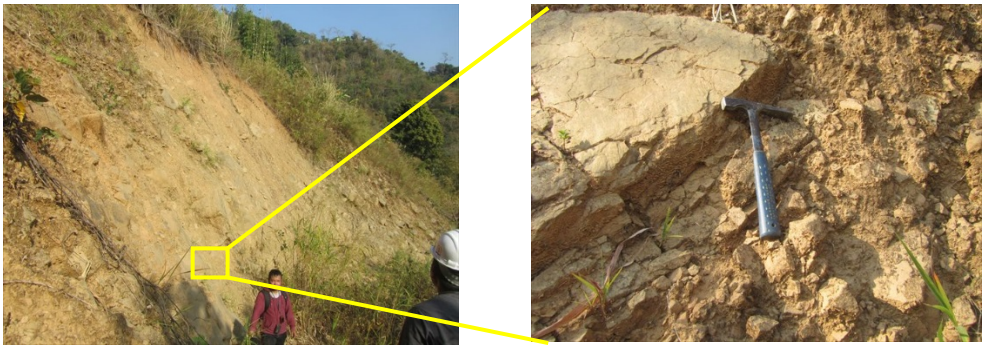

West Side of Landslide




B: East Side of Landslide

C: Scarp of West Side

D: Sliding Cliff



E: Sliding Cliff F: Near View (Disturbed Materials)

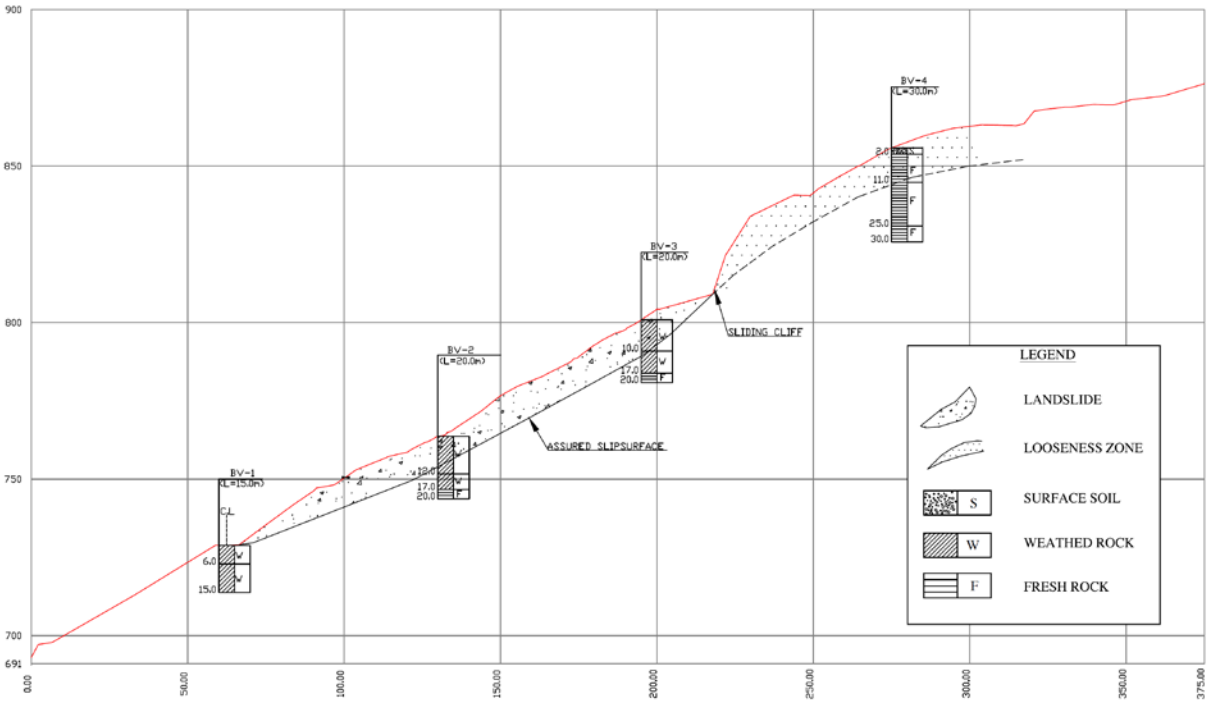
Source: JICA Study Team

**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**

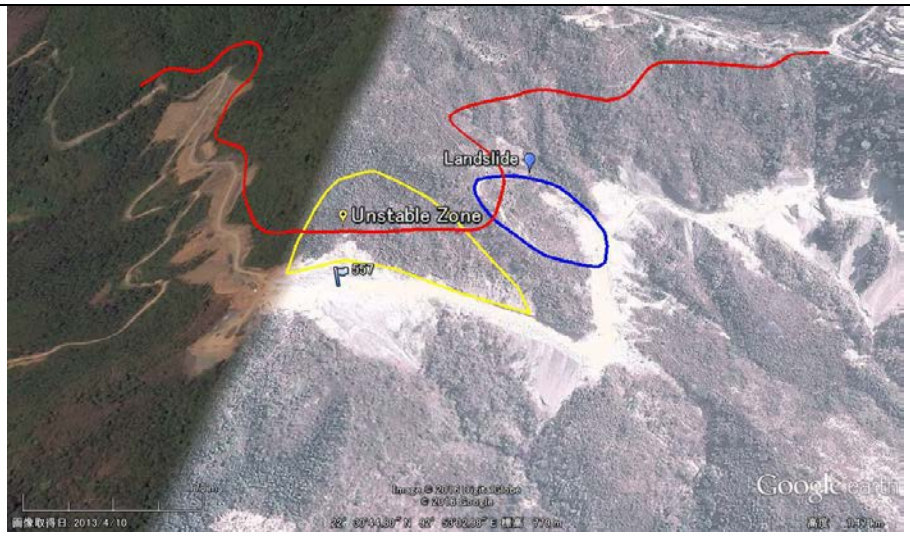
### (4) Another Unstable Slope along Bypass No. 4

There is another unstable zone along Bypass No. 4 besides the landslide. The slope is distributed around the survey point No. 4 (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. Probably, 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.

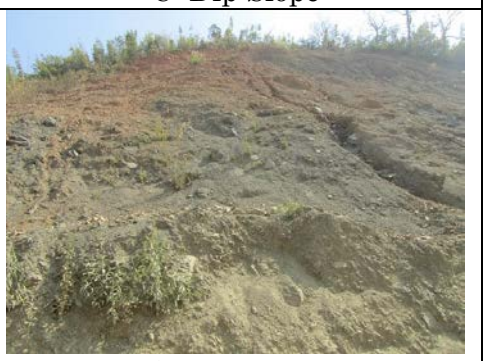



A: Side Oblique Satellite Photo (Red line is the original alignment plan.)

B: Full View of Crashing Zone

C: Dip Slope

D: Condition from the Front



E: Remarkable Surface Failure

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 the Indian Roads Congress (IRC) standards, codes, guidelines and special publications will be referred. The 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 these standards, the relevant standards of AASHTO (A Policy on Geometric Design of Highways and Streets, 2011) or JRSO (Japan Road Structure Ordinance, 2004) will be referred if necessary.

(2) Design Policy and Design Criteria

The following design policies are established:

- There were differences in the design concept in each bypass in DPR such as different road width, application of minimum design speed, minimum radius of horizontal curves, and application of transition curves. Therefore, uniformity in the design criteria is required for all bypasses as well as the improvement of NH54.
- Design of alignment shall be based on a policy of balancing between the application of minimum design standard and the terrain condition, so that balanced cut and fill will result as much as possible reducing the disposal volume.
- Alignment shall be designed based on the concept of minimizing the relocation of houses.
- As per the instruction of NHIDCL and IRC:37-1980, transition curves shall be designed for all horizontal curves. Exceptions maybe considered for 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 Highway | |
| 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) | () 40 km/h |
| | | Intermediate Sight Distance, ISD (m) | 60 (90) | () 40 km/h |
| | | Overtaking Sight Distance, OSD (m) | (165) | () 40 km/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 (21 m-40 m) | 1.5 | |
| | | Widening for Ruling Minimum Radius (41 m-60 m) | 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 | 120 m rise in 2 km 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 | Bypass No. 1 | 2,572.851 | Start and end locations are similar to DPR |
| 2 | Bypass No. 2 | 11,805.031 | Start and end locations are similar to DPR |
| 3 | Bypass No. 3 | 7,025.157 | Start and end locations are similar to DPR |
| 4 | Bypass No. 4 | 2,635.921 | Start location is about 450 m before in the DPR, but end location is similar to DPR |

Source: JICA Study Team

The details of the applied horizontal curvature in each bypass are given in Table 5.2-3. The minimum radius applied satisfies the minimum design speed of 30 km/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 |
|---|---|---|---|---|---|---|
| Bypass No. 1 | No | 0 | 12 | 6 | 7 | |
| | (%) | 0% | 48% | 24% | 28% | |
| Bypass No. 2 | No | 0 | 45 | 53 | 44 | |
| | (%) | 0.0% | 31.7% | 37.3% | 31.0% | |
| Bypass No. 3 | No | 0 | 27 | 33 | 11 | |
| | (%) | 0.0% | 38.0% | 46.5% | 15.5% | |
| Bypass No. 4 | 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 | Bypass No. 1 | 120,193 | 89,987 (74.9%) |
| 2 | Bypass No. 2 | 711,152 | 555,682 (78.1%) |
| 3 | Bypass No. 3 | 360,654 | 289,997 (80.4%) |
| 4 | Bypass No. 4 | 241,385 | 179,248 (74.2%) |

Source: JICA Study Team

(4) Vertical Alignment Design

- The minimum gradient is designed as 0.5% at cut sections for drainage.
- The ruling gradient is designed as 6% as per the design standard given in Section 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**

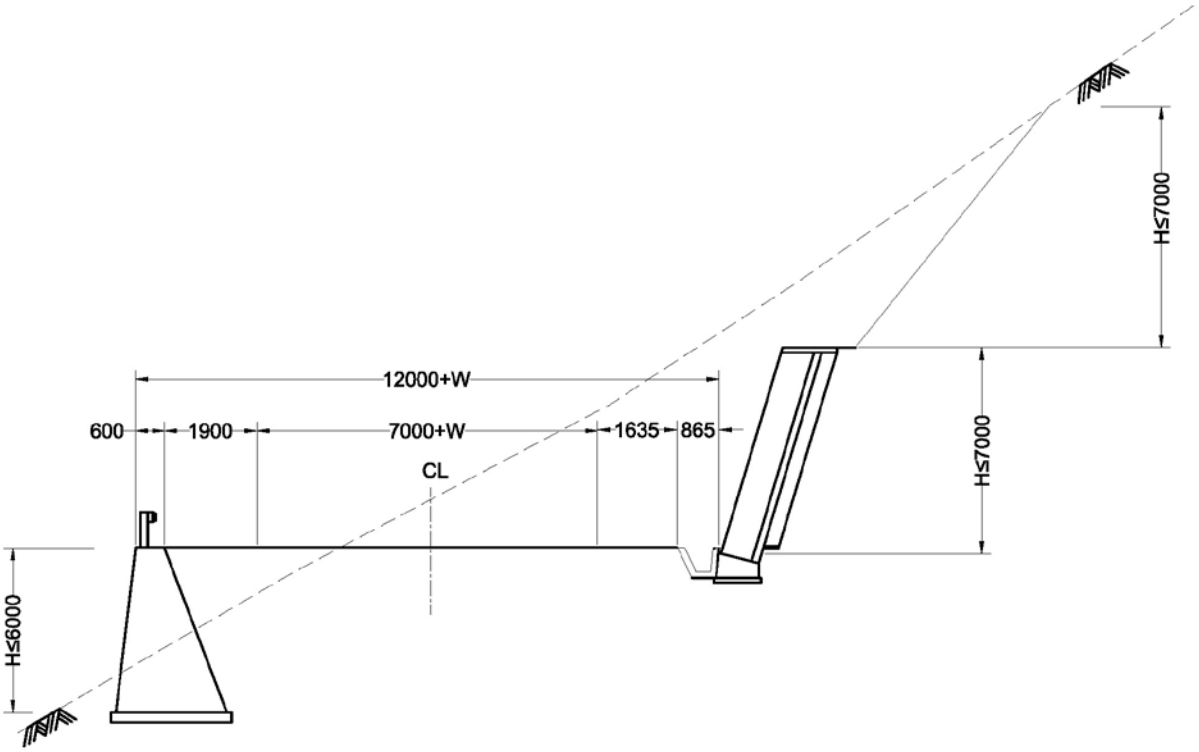
| SN | Bypass | Vertical Grade Range | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.5% | 0.5%-1% | 1%-2% | 2%-3% | 3%-4% | 4%-5% | 5%-6% | 6%-7% | 7%-8% |
| 1 | Bypass No. 1 | 13.1% | 4.9% | 0.0% | 31.3% | 0.0% | 12.1% | 38.6% | 0.0% | 0.0% |
| 2 | Bypass No. 2 | 0.0% | 4.3% | 21.0% | 12.3% | 19.4% | 11.1% | 17.4% | 14.5% | 0.0% |
| 3 | Bypass No. 3 | 8.9% | 7.6% | 15.0% | 27.9% | 16.8% | 5.1% | 11.0% | 7.7% | 0.0% |
| 4 | Bypass No. 4 | 2.7% | 31.2% | 0.0% | 0.0% | 41.9% | 9.8% | 9.6% | 4.7% | 0.0% |

Source: JICA Study Team

- Vertical grades higher than the ruling gradient of 6% but less than or equal to the limiting gradient of 7% were applied at total percentage lengths of 0%, 14.5%, 7.7%, and 4.7% for Bypass No. 1, Bypass No. 2, Bypass No. 3, and Bypass No. 4, respectively.

(5) 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 1.5 m. However, the small width between the end of the 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 the paved shoulder and the parapet of the retaining wall shall also be paved for the same reason.

(6) Final Alignment in Bypass No. 4

As discussed in Section 4.5 (Alternative Route Study), Bypass No. 4 (Lawngtlai Bypass) starts from the Kaladan Multimodal 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 Multimodal 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 Bypass No. 4 was also surveyed. The designed alignment and profile data of MM Road were 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 Bypass No. 4 as well as the MM Road were also obtained and transferred to the same coordinate system.

Based on these data, it was observed that cutting of more than 70 m height will be required at the take off point of Bypass No. 4 for a length of about 200 m. In order to minimize the cutting, two alternatives were further studied. The first alternative considered the raising of profile of the MM Road for a length of about 500 m at the take off point of Bypass No. 4 and the second alternative considered the shifting of the MM Road alignment for a length of about 200 m to the valley side at the take off point, which is also required for junction development between Bypass No. 4 and MM Road.

The issue was discussed with the Chief Engineer of PWD Mizoram in the 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 the shifting of the MM Road alignment for a length of about 200 m 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

The NH54 bypass route is planned to pass 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 the planned road level and the ground level is high, or catchment area of rainwater is large.

Hence, bridge is planned at two locations of Serchhip Bypass.

Serchhip Bypass at Km 4+530

- It is located at about 4.5 km from the beginning point of Serchhip Bypass.
- The route crosses the valley as curve section of horizontal alignment.
- Minor bridge 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 appear above the ground in the riverbed.
- Vegetation and shrubs are flourishing around the site.

Serchhip Bypass at Km 10+800

- It is located at about 10.8 km from the beginning point, and 0.8 km from the end point of Serchhip Bypass.

・The route crosses the valley as straight section of horizontal alignment.
・Major bridge 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 appear above the ground in the riverbed.
・Vegetation, shrubs, and trees are flourishing around the site.


Source: JICA Study Team

**Figure 5.2-2(Left) Site View at Km 4+530 in Serchhip Bypass / (Right) Site View at Km 10+800 in Serchhip Bypass**

(2) Design Standard

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

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

**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 into account the regional and project characteristics. Major load conditions are as follows:

- Live load: IRC Class 70R Loading (in accordance with IRC:6 Clause 201)
- Live load combination: One lane of Class 70R OR Two lanes of Class A (in accordance with IRC:6 Clause 204.3)
- Impact load: (in accordance with IRC:6 Clause 208)
- Temperature load: +5 to +40 degree (in accordance with IRC:6 Clause 215)
- Seismic load: Zone-V, Important Factor: 1.5 (in accordance with IRC:6 Clause 219)

Other load conditions shall also be determined in accordance with IRC standards.

(3) Planning for Major Bridge

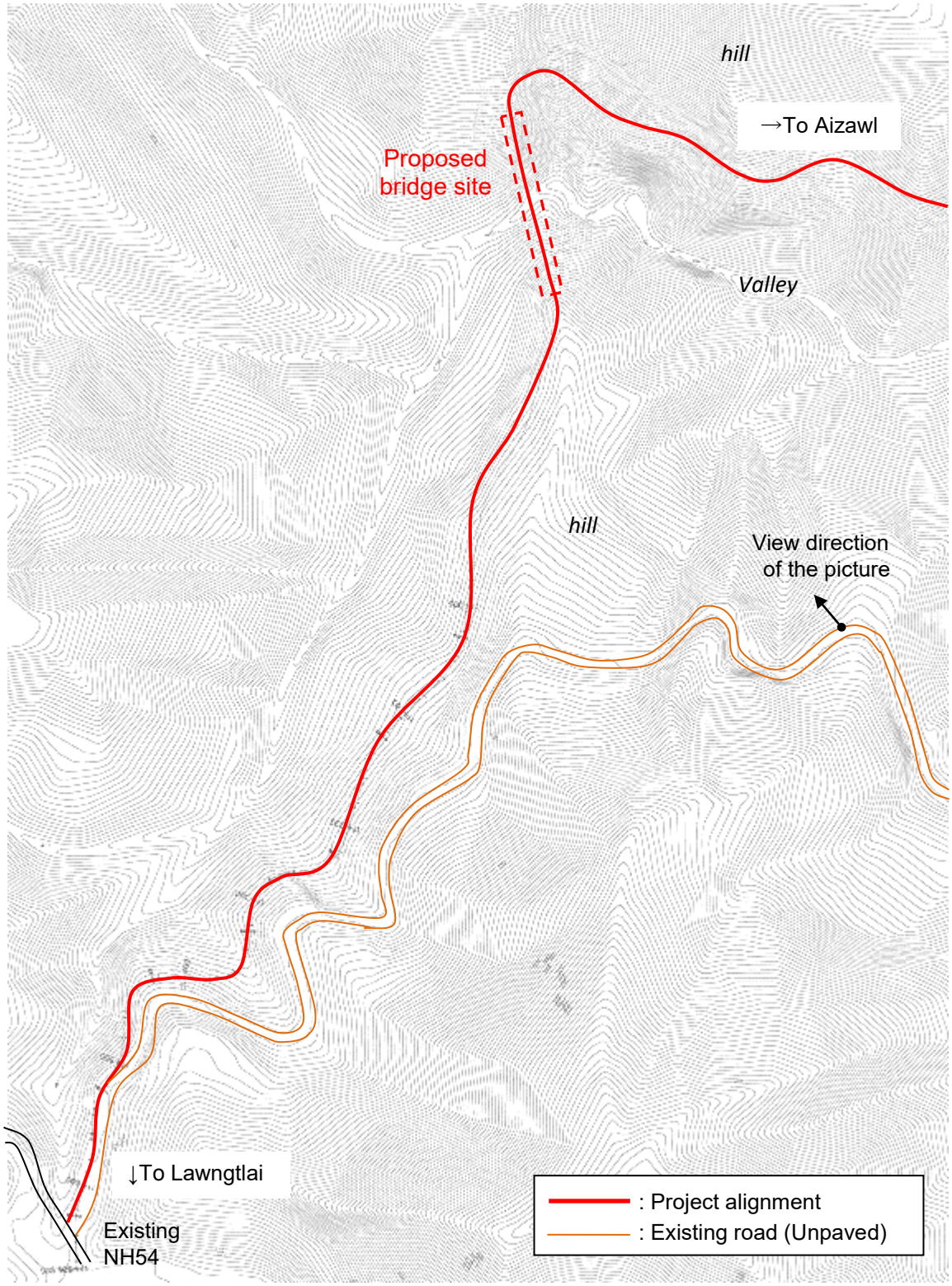
A major bridge is planned for crossing over the valley at 10.8 km from the beginning point of Serchhip Bypass. For the selection of bridge type, appropriate bridge type should be selected considering the condition of 140 m length and valley terrain at the site.

Steel arch type is frequently applied in valley terrain in mountainous area. It does not require pier construction at deep valley point through an arch rib built on rigid ground at both slopes. Manufacture of steel arch member in factory enables comparably short construction period. The valley terrain and shape of arch rib are well harmonized and make good landscape.

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

Source: JICA Study Team

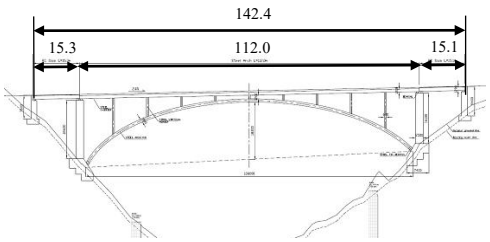
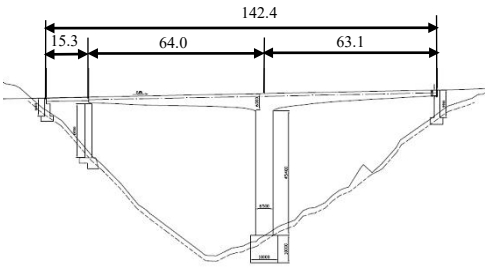
**Figure 5.2-3 Location of Planned Major Bridge (Km 10+800, View from E.P. Side)**




Source: JICA Study Team

**Figure 5.2-4 Location Map of Major Bridge (Km 10+800) on Serchhip Bypass**

**Table 5.2-7 Comparison of Structural Type of Major Bridge**

| | Upper Deck Type Steel Arch Bridge<br>(RC slab + Steel arch + RC slab) | T-type Rigid Frame PC Box Bridge<br>(RC slab + T-type 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 is supported on rigid ground.<br>It can be built by cable erection method with cable crane facilities and temporary steel tower. | PC cantilever type is applied in conditions where bent support is unsuitable due to high location.<br>The girder is built by cantilever method with mobile work machine from pier head construction. |
| Construction Cost Ratio | 1.00<br>- It is supposed that an overseas contractor such as from Japan is procured. A part of equipment and staff may need to be imported. | 0.85<br>- It is a familiar method in India. All of the materials, equipment, staff will be procured from domestic. |
| Construction Period | 1.5 years<br>- The sub-structural work can proceed during the manufacturing of the member of steel arch in factory. Hence. construction period can be comparably short.<br>-Because site work is less, the construction period is more reliable. | 2 years<br>- The cantilever work is mobilized after the pier head is completed. Hence, the construction period takes comparably long.<br>- The concrete work is more influenced by weather condition. It has a risk of huge delay. |
| Landscape | Good<br>- The arch bridge is generally considered to be good landscape. The valley terrain and shape of arch rib are well harmonized. | Poor<br>- Due to large dimension of main pier and box girder, the bridge looks so artificial and heavy. |
| Construction Condition | Good<br>- It can be built by cable erection method from existing road side.<br>- Steel member is manufactured in factory so that it has good quality control. | Poor<br>- Materials and equipment need to be transported to the pier construction point at slope bottom with construction road.<br>- Large concrete works at site in long period need more notification to control quality. |
| Environmental Aspect | Good<br>- Effect on natural environment can be minimized because site works are comparably short. | poor<br>- Construction of road to access the pier bottom at the slope bottom is needed.<br>- Due to largeness of structure, traffic of concrete mixer truck will be frequent. |
| Evaluation | ○ | - |

Source: JICA Study Team

Geographical and Geological Condition

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

Outline of Bridge Plan

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

For Design Stage

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

For Construction Stage

- Steel arch member will be manufactured in the 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.

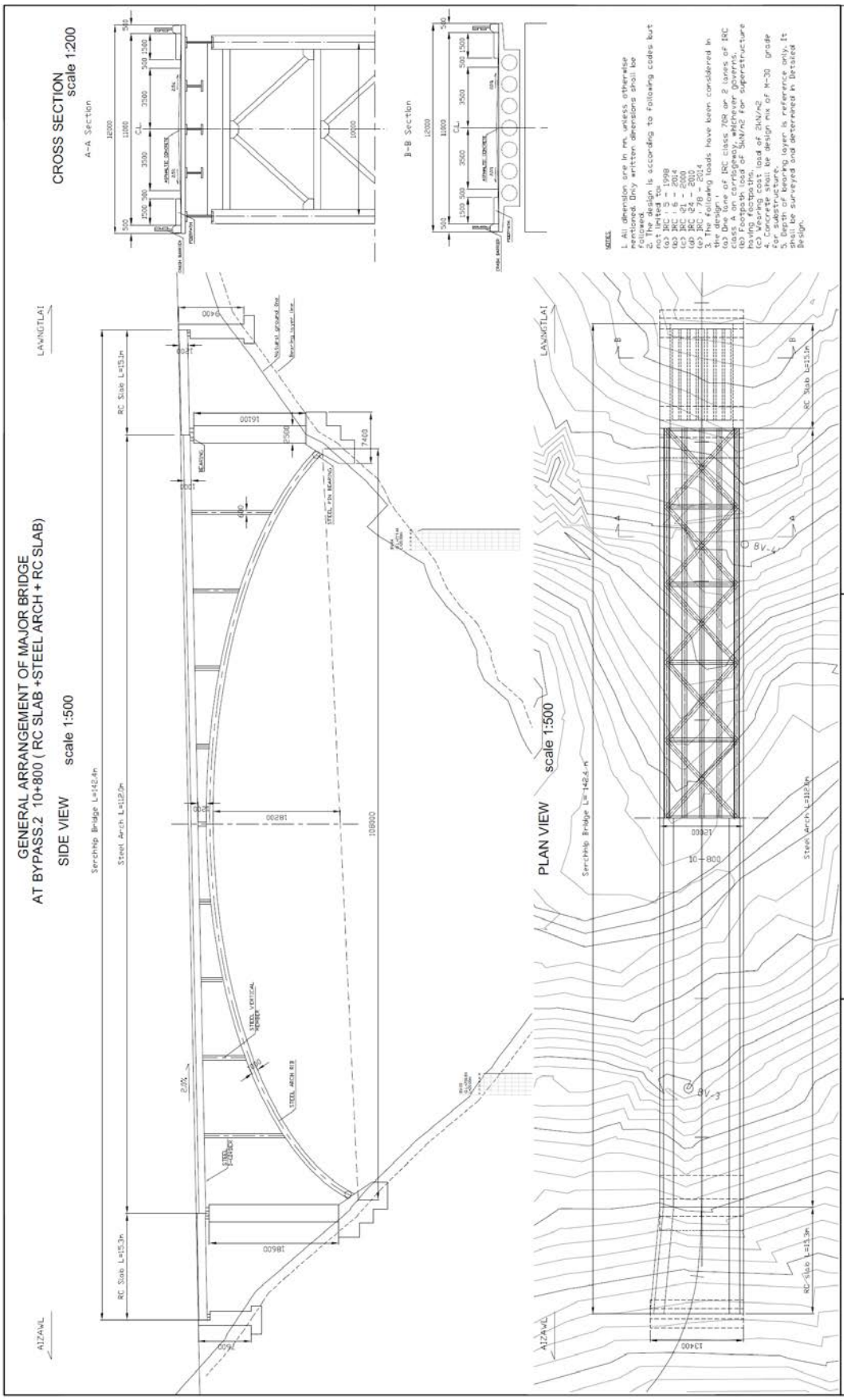



**Figure 5.2-5 General View of the Major Bridge**

Source: JICA Study Team

(4) Planning for Minor Bridge

Minor bridge is proposed for Serchhip Bypass as shown in Table 5.2-8 below.

**Table 5.2-8 Plan of Minor Bridge at Serchhip Bypass**

| Location | Bridge Type | Outline |
|---|---|---|
| Serchhip Bypass<br>Km 4+530 | RC slab bridge<br>(Hollow slab) | Bridge length: L=15 m<br>Total width: W=12 m<br>Foundation: Spread foundation |

Source: JICA Study Team

- Total width of the bridge is 12 m in accordance with IRC standards. For provision of passenger walking space, footpath with 1.5 m width is provided at both sides.
- Boring survey was conducted at two points around the planned bridge location. SPT result is non-penetration at a depth of 1.5 m. Hence, each foundation under the arch rib, pier and abutment can be designed as spread foundation and shall reach to a depth of 1.5 m.
- 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 the increase of flowing water during the rainy season, construction work in the dry season is recommended.

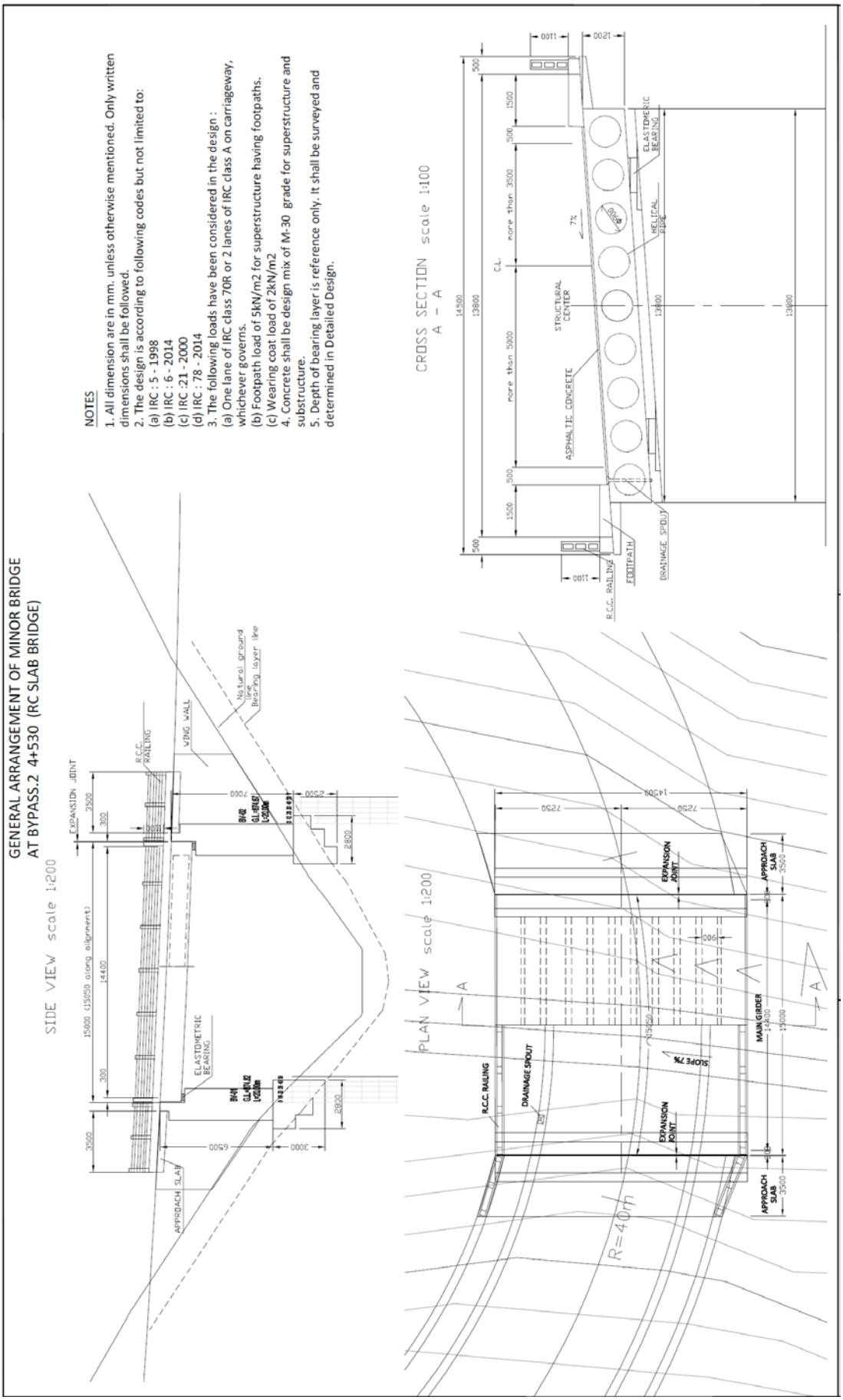


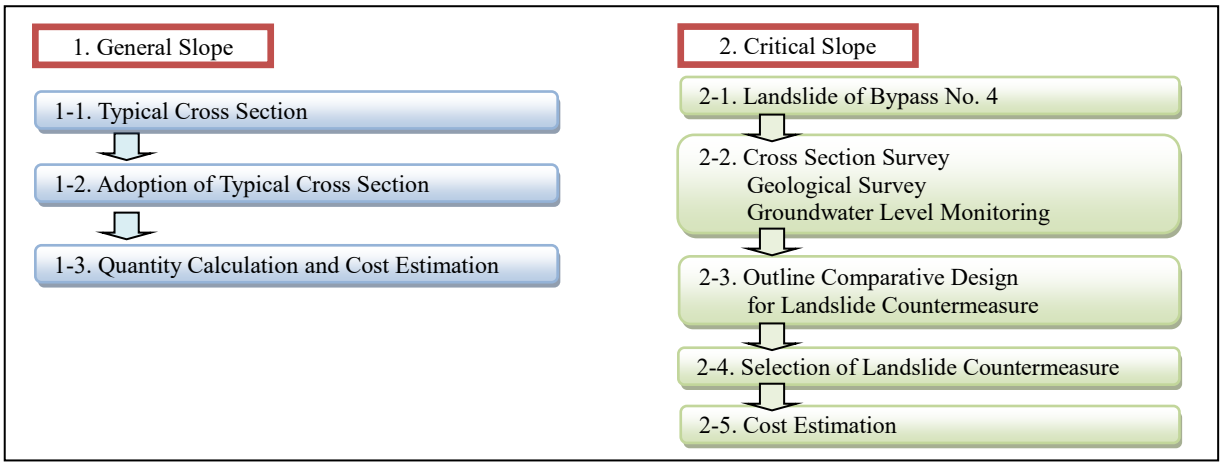

**Figure 5.2-6 General View of the Minor Bridge**

Source: JICA Study Team

### 5.2.4 Earthwork/ Slope Protection/ Landslide Prevention Design

#### (1) Methodology

Figure 5.2-7 shows the flow of the methodology of planning for earthwork, slope protection, and landslide prevention works. Based on the slope inventory survey as mentioned above, slopes along the road were evaluated in terms of their stability. Also, the landslide prevention works for Bypass No. 4 were studied based on the landslide survey.




Source: JICA Study Team

**Figure 5.2-7 Flowchart of Plan for Slope Protection Work**

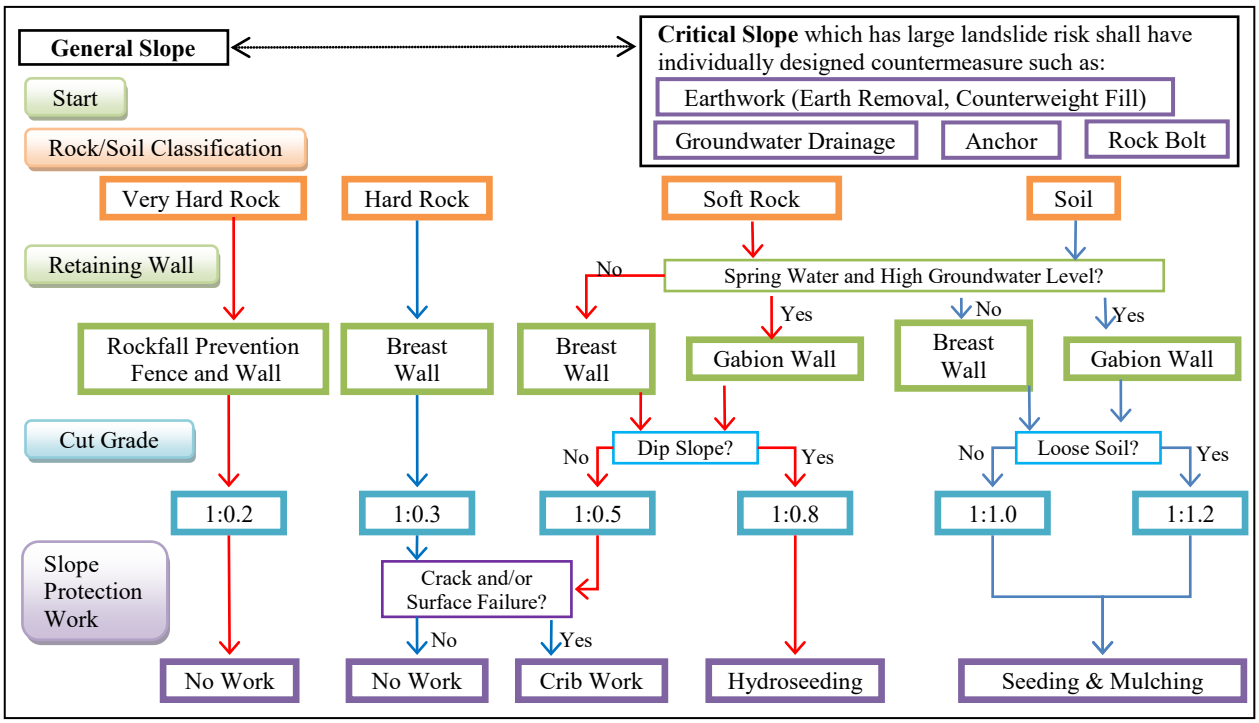
#### (2) Proposed Design Policy and Design Criteria

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:

- 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 adopt slope protection works.
- Height of one step of cut slope shall be a maximum of 7 m. When the height of slope exceeds 7 m, a berm with 1.5 m width shall be set between each slope.
- Total height of cut slope shall be a maximum of 20 m basically considering economy, workability, and safety.
- In case of a large slope, to prevent large cutting, slope gradient shall be steeper than that of the stable slope using slope protection works.
- Breast wall shall be built on the toe of the cut slope to prevent small collapse and to maintain the side ditch.
- Slope protection works shall be selected among the general construction methods in India and Japan.
- Landslide area shall be avoided basically by the road alignment as much as possible.
- If road alignment passes through landslide area, landslide countermeasures 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 its countermeasures, e.g., earthworks including landslide removal and counterweight fill, groundwater drainage, anchor work, and rock bolt work, shall be designed

The JICA Study Team reviewed the existing manuals in India published by IRC (i.e., SP:48-1998, Hill Road Manual and Special Report, State of the Art: Landslide Correction Techniques, 1995) and started the design of slope protection works. The JICA Study Team improved the criteria of earthworks 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, the JICA Study Team designed them utilizing the Japanese technical guideline for road works published by the 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 | |
|---|---|---|---|
| **Earthwork** | | | |
| Cut | IRC: 11.8<br>SR: 7.9.3.1 | A | Modified the design criteria of cut grade in IRC based on the current condition of the slope. Berm presented in SR is so wide (6-11 m) that the team propose 1.5 m width following Japanese guidelines. |
| Embankment | - | A | Not shown in the Hill Road Manual.<br>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 | Exact dimension is not shown in IRC. |
| Reinforced Earth Wall | IRC: 9.7 | B | Explanation of the design method including the design calculation is not sufficient. IRC introduces only band steel |

| Item | Clause | JICA Study Team Evaluation | |
|---|---|---|---|
| | | | strip type and does not mention about panel material of the front slope. |
| | SR 7.6. | B | SR shows the basic formulas of internal stability. It does not show the typical soil and tensile coefficient of embankment and reinforcement material for economical design. |
| **Slope Protection** | | | |
| Vegetation Work | IRC: 11.7.3<br>SR: 7.5.7. | B | Turfing and netting are introduced for prevention of erosion. Hydroseeding is not shown in IRC and SR. |
| Crib Work | - | C | Not shown in both IRC and SR. |
| Wire Rope Crib Work | - | C | Not shown in both IRC and SR. |
| Rockfall Prevention Wall and Fence | SR: 7.9.4. | C | SR presents the location to set the rockfall prevention fence. However, height and specification of the fence including allowable rockfall energy and calculation of the rockfall energy are not presented as well as implementation of rockfall simulation. |
| **Landslide Countermeasure** | | | |
| Groundwater Drainage | IRC: 11.6.2(c) | C | Specification in IRC is not effective for large landslide, and 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 other points to be considered such as stability and permeability of the embankment are not mentioned. |
| Earth Removal | - | C | Not shown in IRC. |
| | SR 7.4.1.6. | B | Similar to counterweight fill, SR suggests to reduce soil amount at the top of the landslide slope. But other 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.<br>SR: 7.9.3.5.<br>SR: 8.3.3. | C | SR introduces the anchor wall and practical example; however, it does not show the design method including calculation. |
| Rock Bolt Work | - | C | Not shown in IRC. |
| | SR: 7.9.3.5. | C | SR introduces the basic information on 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 detailed design
C: No description, necessary to be introduced

### (3) Design of Earthwork

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 the design criteria of cut grades for each rock and soil classification compared with those in IRC. Because there are many slope failures on the existing cut slope with 1:0.3 grade consisting of weathered and loosen rock, the soft rock shall be cut with gentler grade than IRC and 1:0.5 to 1:0.8 grades. Harder rock slope can be applied with steeper cut grade, i.e., very hard rock and hard slope shall be cut with 1:0.2 and 1:0.3 grades, respectively. On the other hand, loosen and weakened rock and soil slope shall be carefully cut with gentler cut grades of more than 1:0.8.

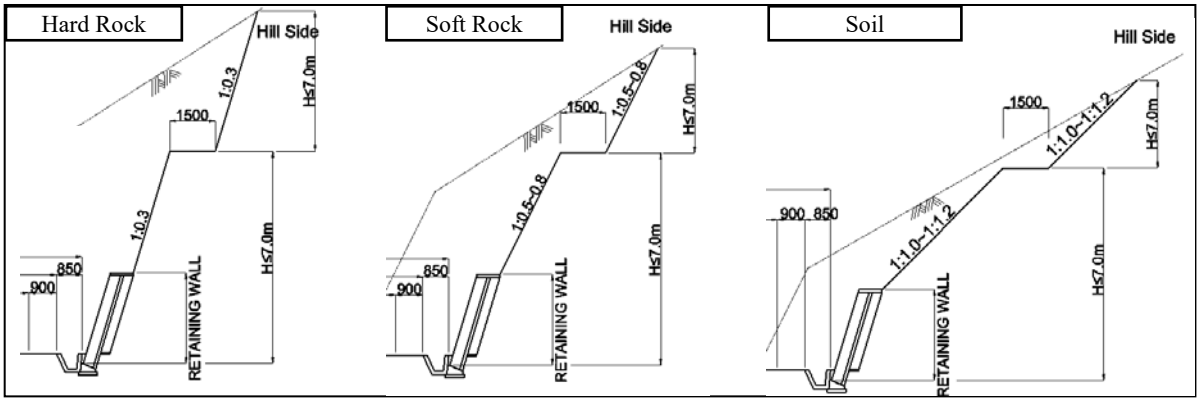
Against rock slope which is cracky and has a risk of rockfall or slope failure, crib work shall be applied for prevention of damage, which can deter surface failure and rockfall at around 10 $m^3$ (less than 3 m width and less than 1 m depth) on the cut slope. In case that larger landslide is a concern, 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 the cut slopes shall be covered by hydroseeding work or seeding and mulching, and shall be greened. The thickness of the sprayed hydroseeding shall be varied from 3 cm to 7 cm depending on the geotechnical condition. The cut slope of soft rock which is cut with 1:0.8 grade shall be applied with 5 cm thick hydroseeding. Seeding and mulching are applied for soil cut slope. As very hard or hard rock slope consists of intact bedrock and is cut with steep grade, 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 No. 1 | Bypass No. 2 | Bypass No. 3 | Bypass No. 4 |
|---|---|---|---|---|
| Common soil | 20 | 20 | 30 | 10 |
| Soft rock | 80 | 75 | 70 | 80 |
| Hard rock | - | 5 | - | 10 |

Source: JICA Study Team

2) Embankment on the Valley Side

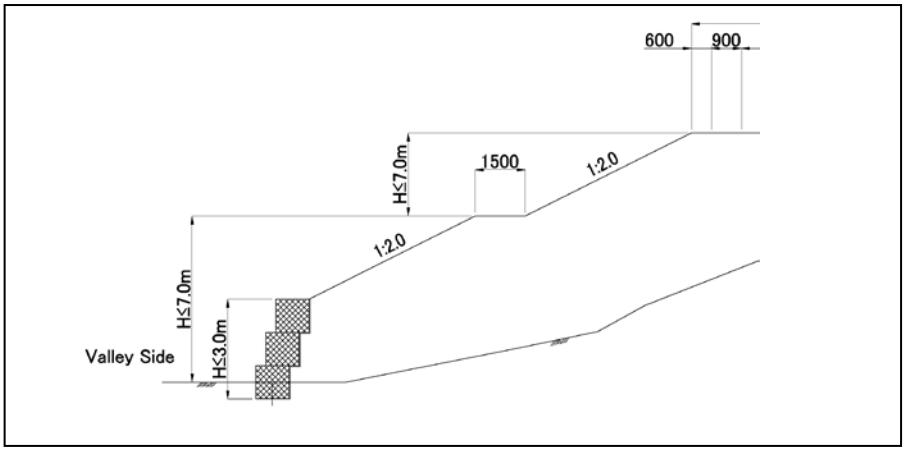
Slope grade of embankment slope is generally decided based on the embankment material and total slope height. Because generated soil by cutting is expected to be utilized as embankment material in this project, the embankment material shall be composed of gravelly soil derived from sandstone and shale. 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**

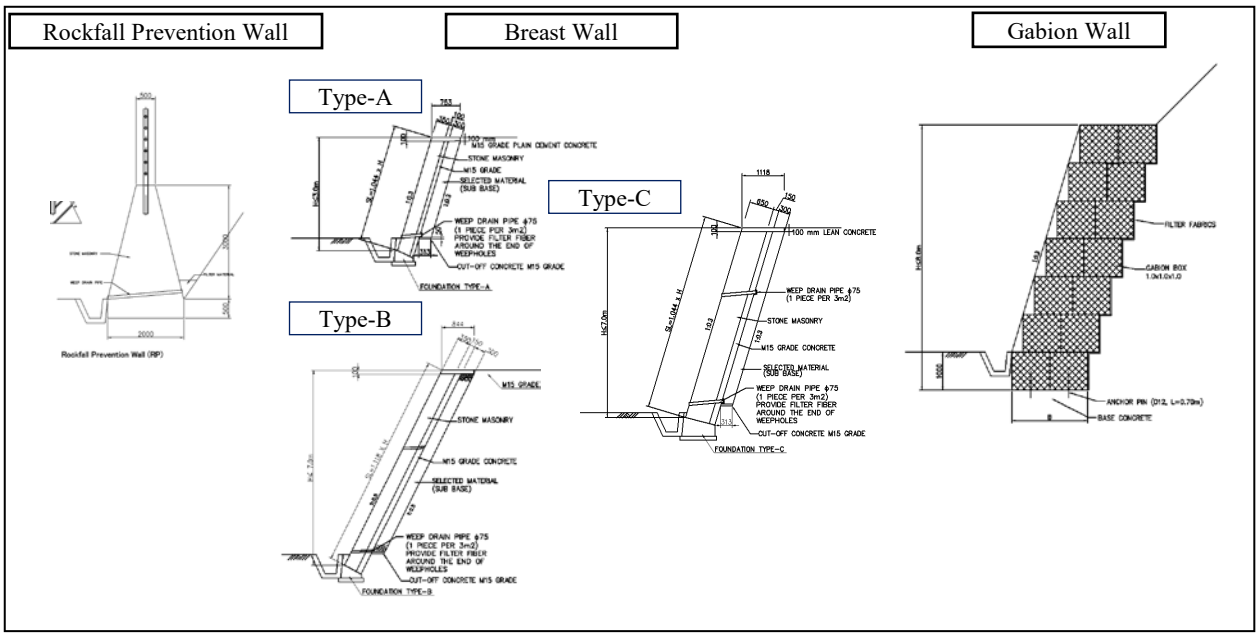
### 3) Retaining Wall

Retaining walls shall be built on the toe of almost all slopes on the hill side along the road in order to prevent small slope failure on the first step of cutting and to maintain the side ditch. Table 5.2-13 shows the 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 springwater is found and groundwater level is presumed to be high. In steep slope consisting of very hard rock strata, gravity-type retaining wall with a rock fall prevention fence should be built at the toe of the 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**

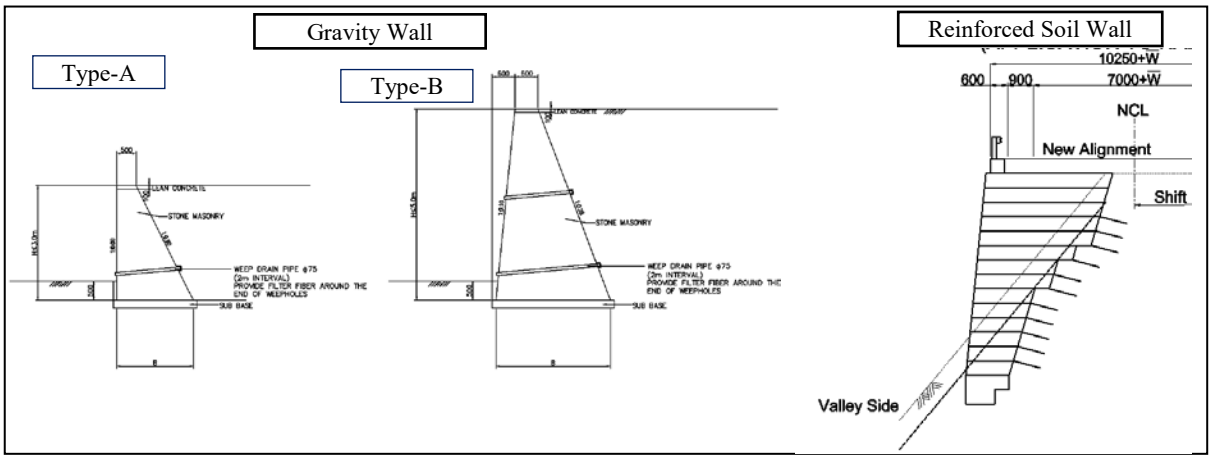
#### 4) Embankment Structure

Retaining walls are built in front of the road embankment with road widening on the valley side. Type of retaining wall should be selected depending on the slope topography on the valley side. For gentle and low valley slope which is gentler than 30 degrees, gravity wall is frequently used for soil retaining. Because the gravity walls which have vertical or very steep grade on the front slope need to be excavated largely behind the wall during construction, it is necessary to pay attention to ensure the present traffic during construction. Steep and high slope needs reinforced earth wall which can be built to more than 20 m high. Table 5.2-14 shows the design criteria of the 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 degrees |
| Reinforced Earth Wall | | 5 ~ 20 m | **1:0.1** | High and Steep Slope |

Source: JICA Study Team

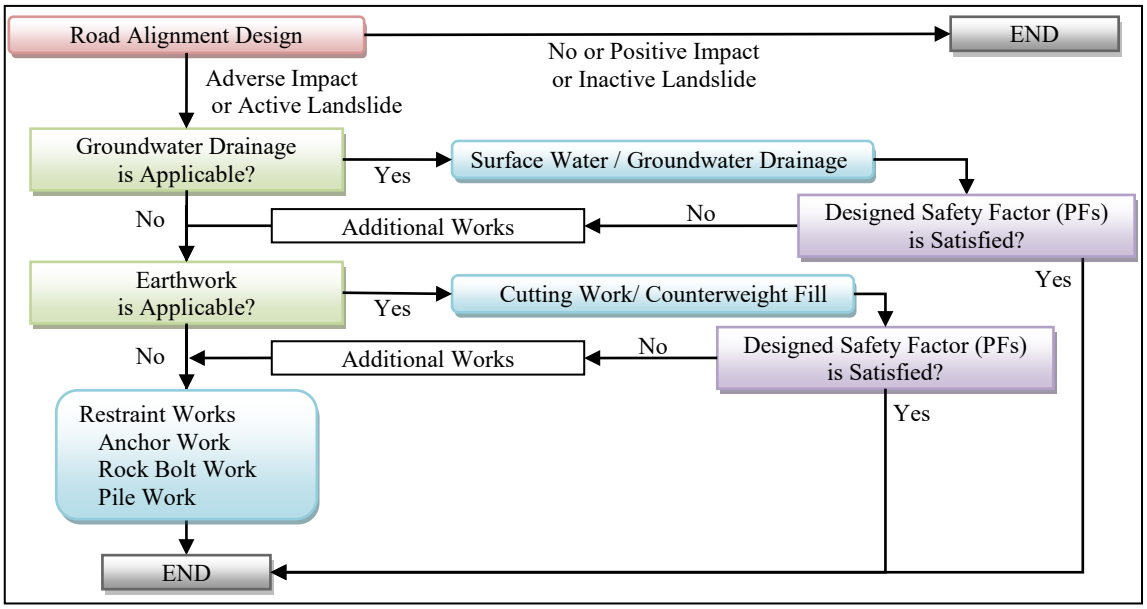



Source: JICA Study Team

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

### 5) Landslide Prevention Design

Basically, design of road alignment has to be planned so as not to promote landslide movement. But if the road alignment unavoidably goes through the landslide, landslide prevention measures have to be planned and designed for the landslide. Figure 5.2-13 shows the flowchart of selection of landslide prevention measures. In terms of the landslide which is active or can be destabilized by cutting or banking, landslide countermeasure is required. The landslide prevention measures are mainly divided into three types, namely: groundwater drainage work, earthwork such as earth removal and counterweight fill, and restraint work including anchor, rock bolt, and pile work. In general, groundwater drainage work is the cheapest followed by earthwork. But they are often constrained by topographical, geotechnical, and groundwater condition. On the other hand, restraint work which prevents the landslide movement by force is generally expensive, but the technique can be adopted as permanent countermeasure. Therefore, restraint works shall be introduced by combination of groundwater drainage works and earthworks 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 No. 4, road alignment was eventually reviewed because the landslide is assumed to be very active. The planned alignment 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. However, 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.

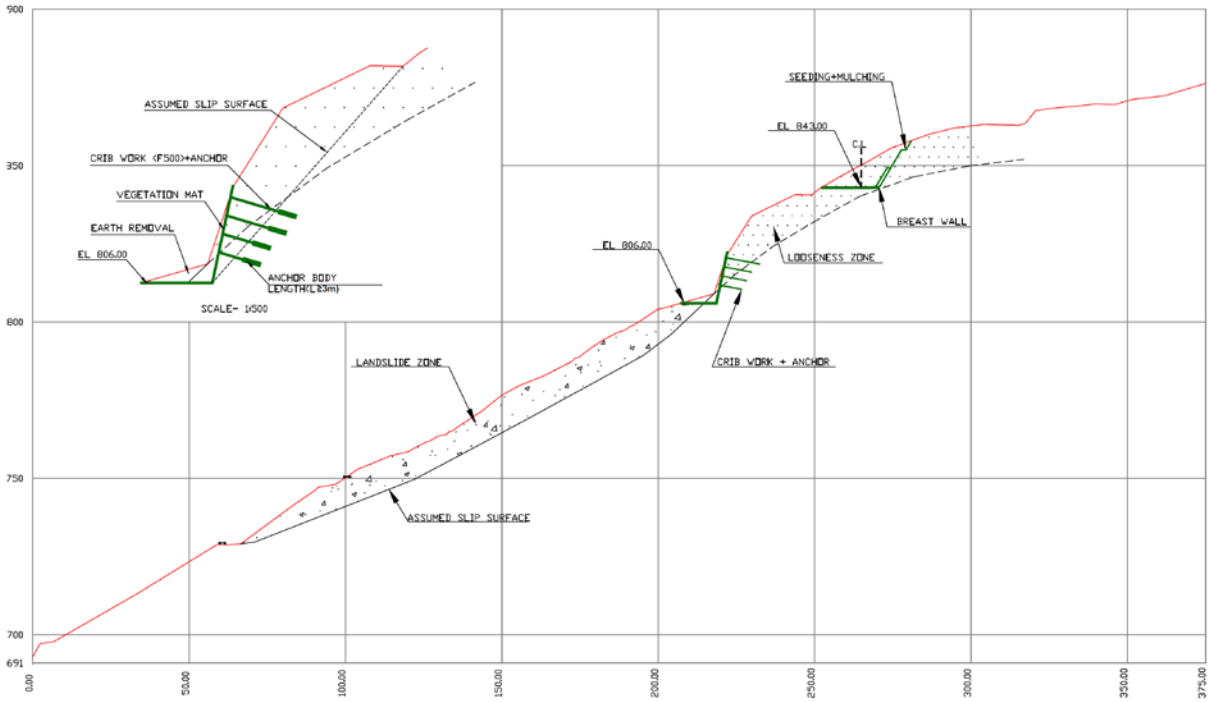



**Figure 5.2-14 Countermeasure for Looseness Zone**

### 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 applies the 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 Subbase) | 300 |
| Total | 690 |

Source: JICA Study Team

### 5.2.6 Drainage Design

(1) General

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

The new drainage system is designed based on the hydrological calculation result. Based on obtained location of water crossing and water discharge, dimension and locations of 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 standards in principle. For detailed design stage, it shall be designed based on the IRC standards.

Major codes regarding drainage design is referred to bridge design. The additional codes and typical drawings for drainage design are 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 culvert, and slab culvert.

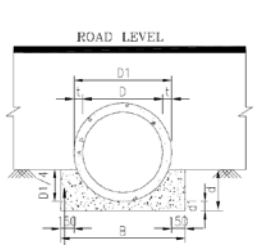
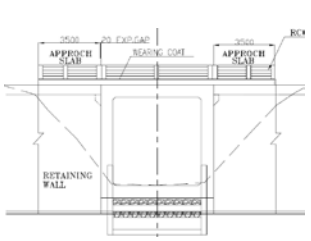
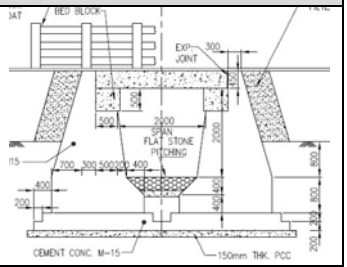
Pipe culvert is the most appropriate structure where the water discharge is comparably small. It has advantage of economy and provision of quality because of precast manufacturing for RC pipes.

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

For such reason, box culvert was applied to the World Bank road which is neighboring NH54 and constructed few years before.

Each type of culvert is compared in Table 5.2-17 below.

**Table 5.2-17 Comparison of Culvert Types**

| | Pipe Culvert | Box Culvert | Slab Culvert |
|---|---|---|---|
| Layout |  |  |  |
| Economy | ◎ | ○ | △ |
| Construction Ability | ◎ | ○ | △ |
| Durability | ○ | ○ | △ |
| Capacity | ○ | ◎ | ◎ |
| Comment | To be applied for small discharge point | To be applied for large discharge point | Not applied |

Source: JICA Study Team

Hence, pipe culvert is proposed where the water discharge is comparably small. Box culvert is proposed where the water discharge is comparably large. The size is determined to satisfy the water discharge obtained by hydrological calculation.

The contents of pipe culvert and box culvert are explained below.

- Culvert length from inlet to outlet is 12 m which is the same as the road width in the general section. However, it shall be widened to match the widening in the curved section.
- General arrangement of pipe culvert for straight section is planned as in Figure 5.2-16. Also, pipe culvert for curved section is planned as in Figure 5.2-17. However, it is noted that actual details such as culvert length and inlet and outlet structures shall be determined during implementation stage in order to satisfy the road width widening and topographical condition in each location.
- Box culvert is based on the IRC standard drawings. Approach slab is needed for the approach part. RC railing is needed at the kerb at both sides. The inner dimension of box culverts is arranged to be between 2 m x 2 m and 4 m x 4 m to satisfy the discharge in each location. However, the dimension shall also take account of topographical condition in each location during the detailed design.
- Pipe culvert is NP4 type based on IRC:13. It is based on the standards of IS458: Precast concrete pipes. The diameter of 1.2 m is planned to satisfy the capacity for discharge.
- At the inlet of the culvert, catch pit is provided. For the section of excavation at slope side, chute is provided.
- At the outlet of the culvert, gabion is required to protect against erosion due to flowing water at hill slope.
- The headwall is required to retain earth at the inlet and outlet. It should be considered with retaining wall at the back and front side.

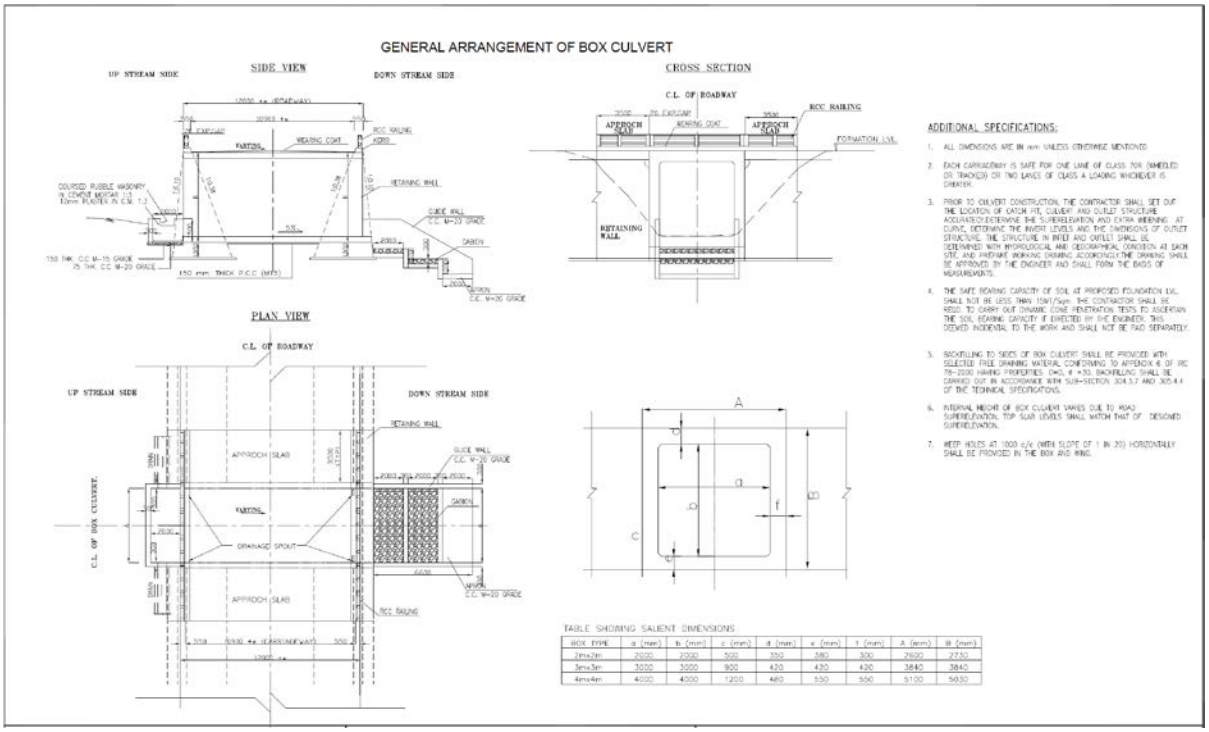
The capacity for each size of culvert to be applied in the NH54 bypass is summarized in Table 5.2-18.

**Table 5.2-18 Capacity for Each Size of Culvert**

| | Size | A ($m^2$) | n | i (%) | Capacity ($m^3$) | Applied Condition |
|---|---|---|---|---|---|---|
| Pipe culvert | φ1.2 m | 1.028 | 0.013 | 5.0 | 4.17 | Flowing full condition |
| Box culvert | 2 m x 2 m | 4.000 | 0.033 | 5.0 | 15.88 | Flowing full condition |
| | 3 m x 3 m | 9.000 | 0.033 | 5.0 | 36.19 | Flowing full condition |
| | 4 m x 4 m | 12.400 | 0.033 | 5.0 | 95.71 | Open section with vertical clearance of 0.9 m |

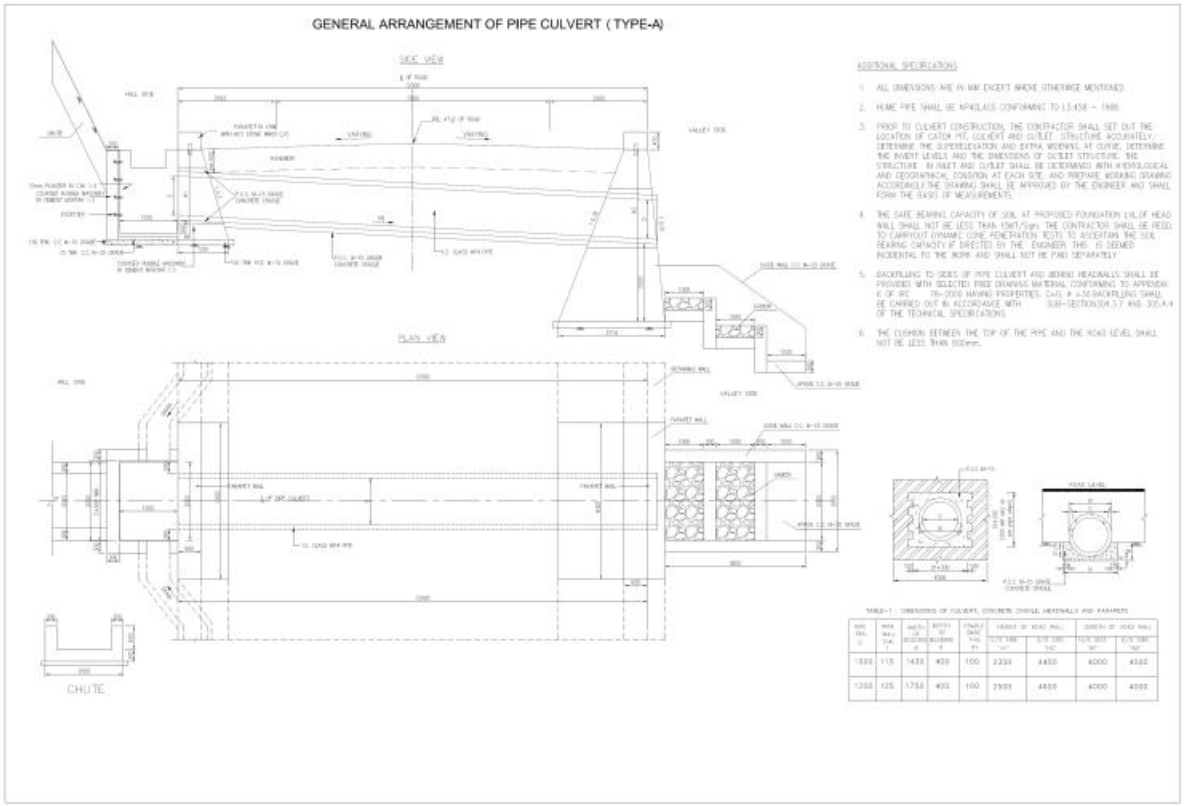
Source: JICA Study Team

The general arrangement plans for box culvert and pipe culvert are shown in Figures 5.2-15 to 5.2-17 below.



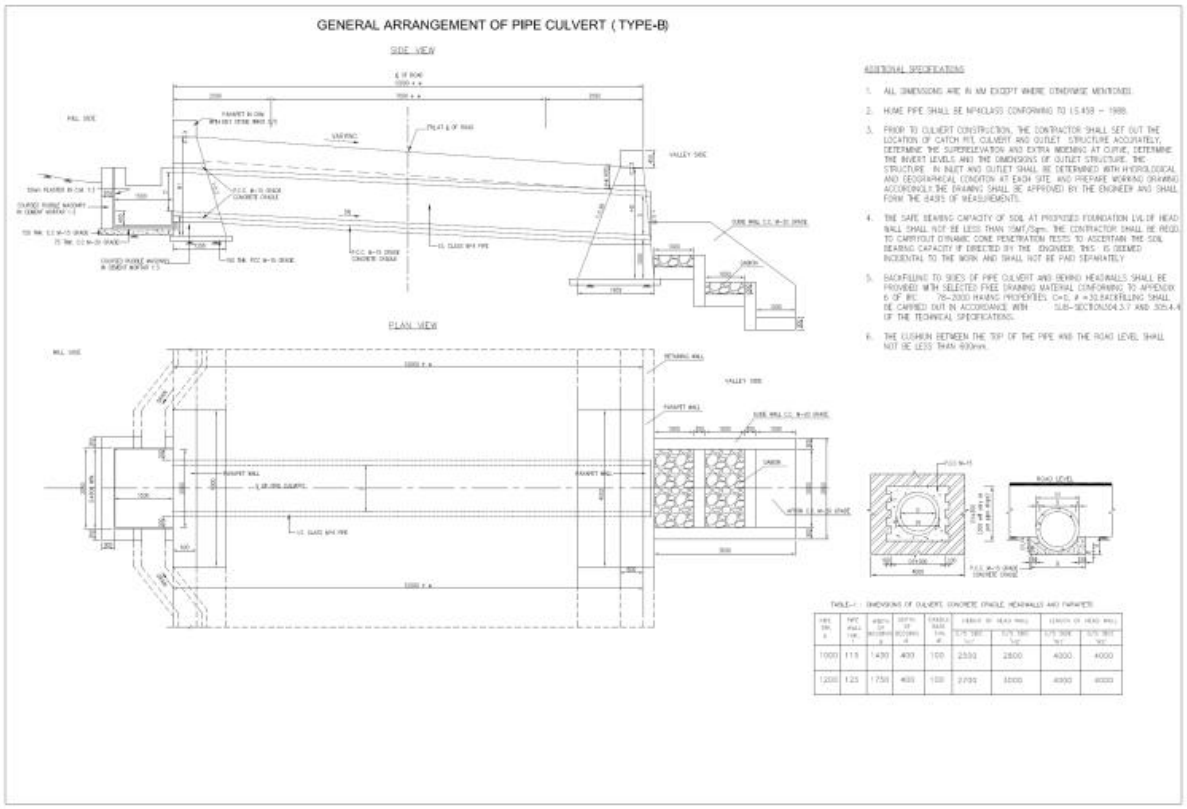

Source: JICA Study Team

**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)**



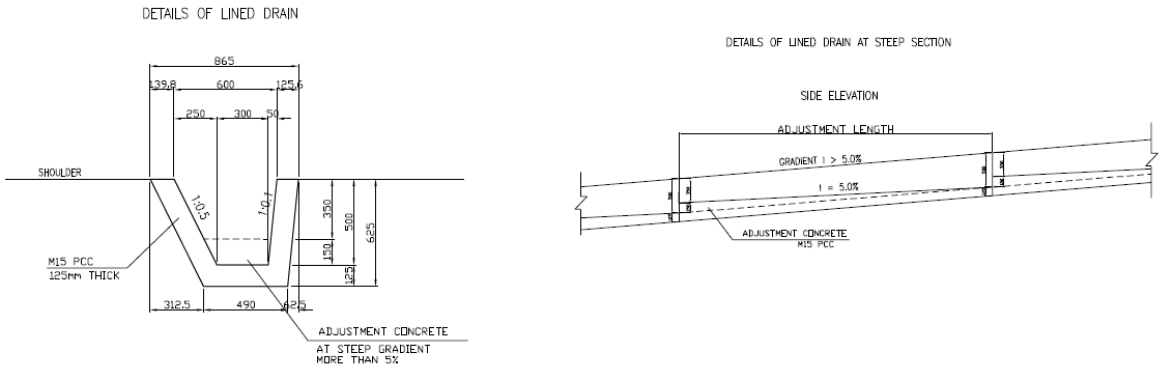

Source: JICA Study Team

**Figure 5.2-17 General Arrangement Plan for Pipe Culvert (Type-B)**

(b) Side Ditch Structure

The side ditch on the road is designed as concrete lined ditch for all sections of the cut side.

The general arrangement plan for side ditch is shown in Figure 5.2-18 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 the following policy:

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

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

The quantity of each culvert is summarized in Table 5.2-19.

The ratio between Type-A and Type-B pipe culvert quantity is estimated at 0.4:0.6 for convenience.

The cross drainage list for all NH54 bypasses is prepared in the Appendix-4.

**Table 5.2-19 Quantity of Each Culvert**

| | Bypass No. 1 | Bypass No. 2 | Bypass No. 3 | Bypass No. 4 |
|---|---|---|---|---|
| Pipe culvert, 1.2 m | 19 | 78 | 40 | 13 |
| (TYPE-A) | 8 | 31 | 16 | 5 |
| (TYPE-B) | 11 | 47 | 24 | 8 |
| Box culvert, 2x2 m | 1 | 8 | 12 | 6 |
| Box culvert, 3x3 m | 0 | 2 | 5 | 0 |
| Box culvert, 4x4 m | 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

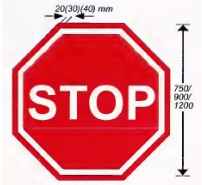
(2) Traffic Sign

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.

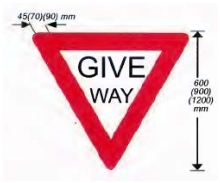
IRC: 67-2012 stipulates three types of traffic signs, namely: 1) Mandatory/Regulatory Signs, 2) Cautionary/Warning Signs, and 3) Informatory/Guide Signs.

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

Mandatory/Regulatory Signs




Stop




Give Way

No Overtaking

No Parking

Cautionary/Warning Signs

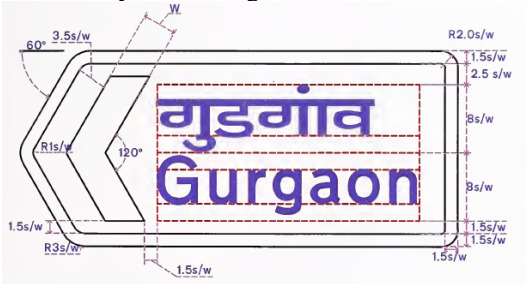
Hair-Pin Bend

Side Road

Narrow Road Ahead

Narrow Bridge Ahead

Informatory/Guide Sings




Flag Type Direction Sign

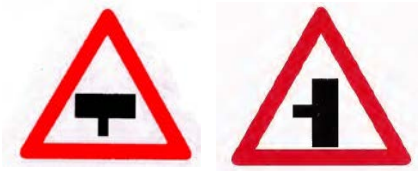
Toilet

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 shown in Table 5.2-21 in accordance with IRC: 67-2012.

**Table 5.2-21 Suggested Traffic Signs for NH54 Bypass**

| Item | Type of Traffic Signs | Location of Installation |
|---|---|---|
| 90 cm equilateral triangle |  | - Installation at front side of intersection and side road |
| 90 cm equilateral triangle |   | - Installation at front side of reverse bend and hand curve |
| 90 cm equilateral triangle |  | - Installation at front side of bridge |
| 60 cm circular |   | - Installation at start and end point of bypass<br>- Installation every 2 km |
| 80 cm x 60 cm rectangular |   | - Installation at front side of intersection |

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

In this study, as a result, the number of traffic signs is 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-reflectorized cautionary, mandatory and informatory sign as per IRC: 67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminum 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 |

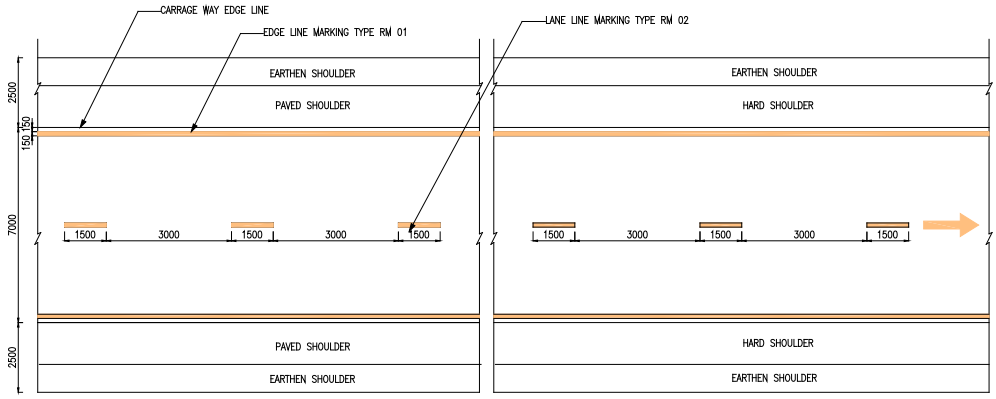
Source: JICA Study Team

(3) Road Marking

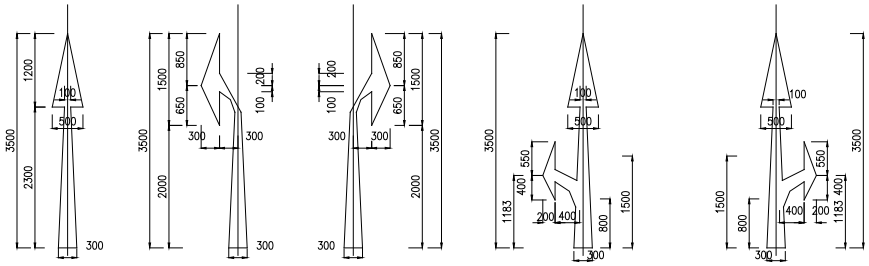
Road markings perform important functions of guiding and controlling traffic on roads. They serve as a psychological barrier and signify the delineation of traffic hazards for safe movement of traffic. Traffic markings also channelize, and ensure smooth and orderly flow of traffic. Therefore, suitable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

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

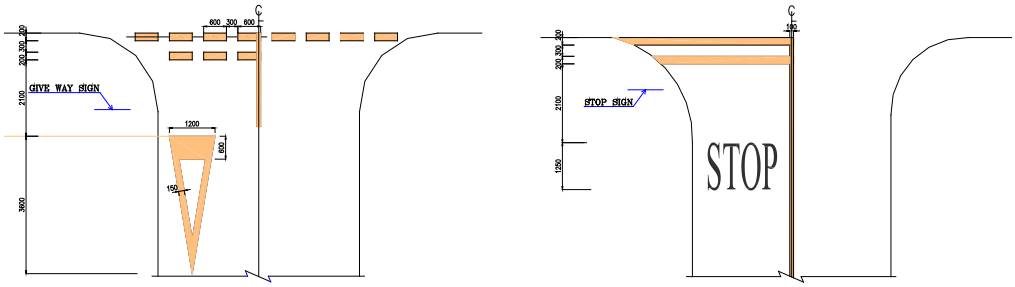
Typical Layout of Road Marking



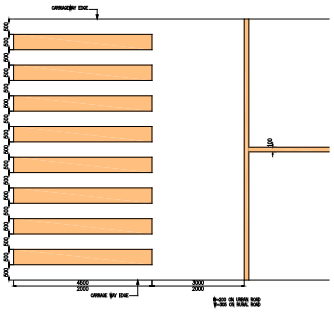
Route Directional Arrows



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 the DPR.

**Table 5.2-23 Road Markings Proposed in the 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 the 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 the JICA Study Team

In this study, the 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 the DPR.

**Table 5.2-24 Road Markings Estimated for NH54 Bypass**

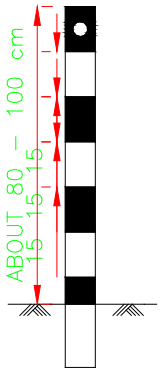
| SOR No. | Item | Unit | Chhiahtlang Bypass | Serchhip Bypass | Hnahthial Bypass | Lawngtlai Bypass |
|---|---|---|---|---|---|---|
| | | | L=2.573 km | L=11.805 km | L=7.025 km | L=2.636 km |
| 8.13 | Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorizing glass 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.




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

**Figure 5.2-21 Typical Road Delineator**

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.

**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**

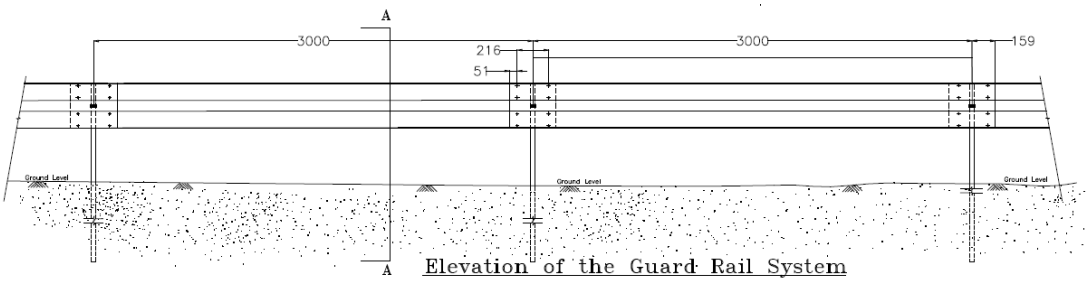
| SOR No. | Item | Unit | Chhiahtlang Bypass | Serchhip Bypass | Hnahthial Bypass | Lawngtlai Bypass |
|---|---|---|---|---|---|---|
| 8.15 | Road delineators (supplying and installation of delineators (roadway indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black 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

The 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 the 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 | meter | 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 the 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 be installed at the center and both sides of the road in the locations below. 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 Lens Reflector (Providing and fixing of road stud 100x100 mm, die cast in aluminum, resistant to corrosive effect of salt and grit, fitted with lens reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm up to 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 the 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=2.573 km | L=11.805 km | L=7.025 km | L=2.636 km |
| 8.14 | Kilometer Stone (Reinforced cement concrete M15grade kilometer stone of standard design as per IRC: 8-1980, fixed in position including painting and printing, etc.) | sqm | | | | |
| (i) | 5th Kilometer Stone (Precast) | each | 0 | 2 | 1 | 0 |
| (ii) | Ordinary Kilometer 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 right of way (ROW) and those shall be incorporated in the as-built drawings for future use. Design of boundary stones shall be made in accordance with IRC: 25-1967.

Table 5.2-31 summarizes the boundary stones of NH54 proposed in the DPR.

**Table 5.2-31 Boundary Stones Proposed in the DPR for NH54**

| Item | NH54-S1 | NH54-S2 | NH54-S3 |
|---|---|---|---|
| Boundary Stone | To be provided at ROW boundaries.<br>No detailed quantities are available in the report. | To be provided at ROW boundaries.<br>Detailed quantities are as follows:<br>Boundary Stone: 2,260 (20.02/km) | To be provided at ROW boundaries.<br>Detailed quantities are as follows:<br>Boundary Stone: 1,500 (12.23/km) |

Summarized by JICA Study Team

In this study, the 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 the DPR.

**Table 5.2-32 Boundary Stones Estimated for NH54 Bypass**

| SOR No. | Item | Unit | Chhiahtlang Bypass | Serchhip Bypass | Hnahthial Bypass | Lawngtlai Bypass |
|---|---|---|---|---|---|---|
| | | | L=2.573 km | L=11.805 km | L=7.025 km | L=2.636 km |
| 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 NH54 bypass, the necessary volume of spoil bank has been calculated as shown in 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

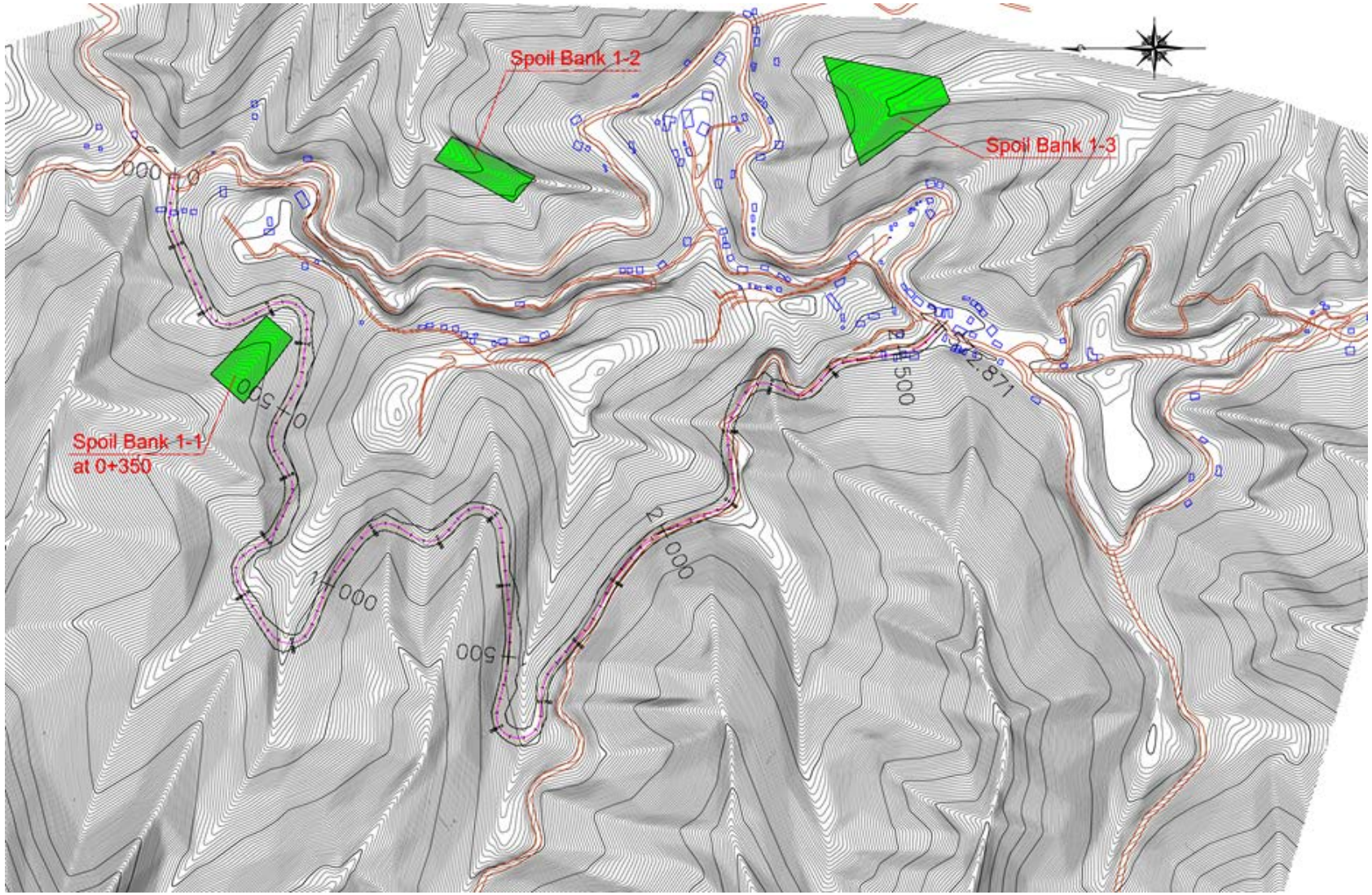
(2) Condition of Spoil Bank Selection

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

- ❖ To find out suitable place along NH54 bypass with the following condition:
  - Ground shape with concavity topography
  - Ground gradient of less than 22 degrees which is assumed as the 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 at less than 30 m height

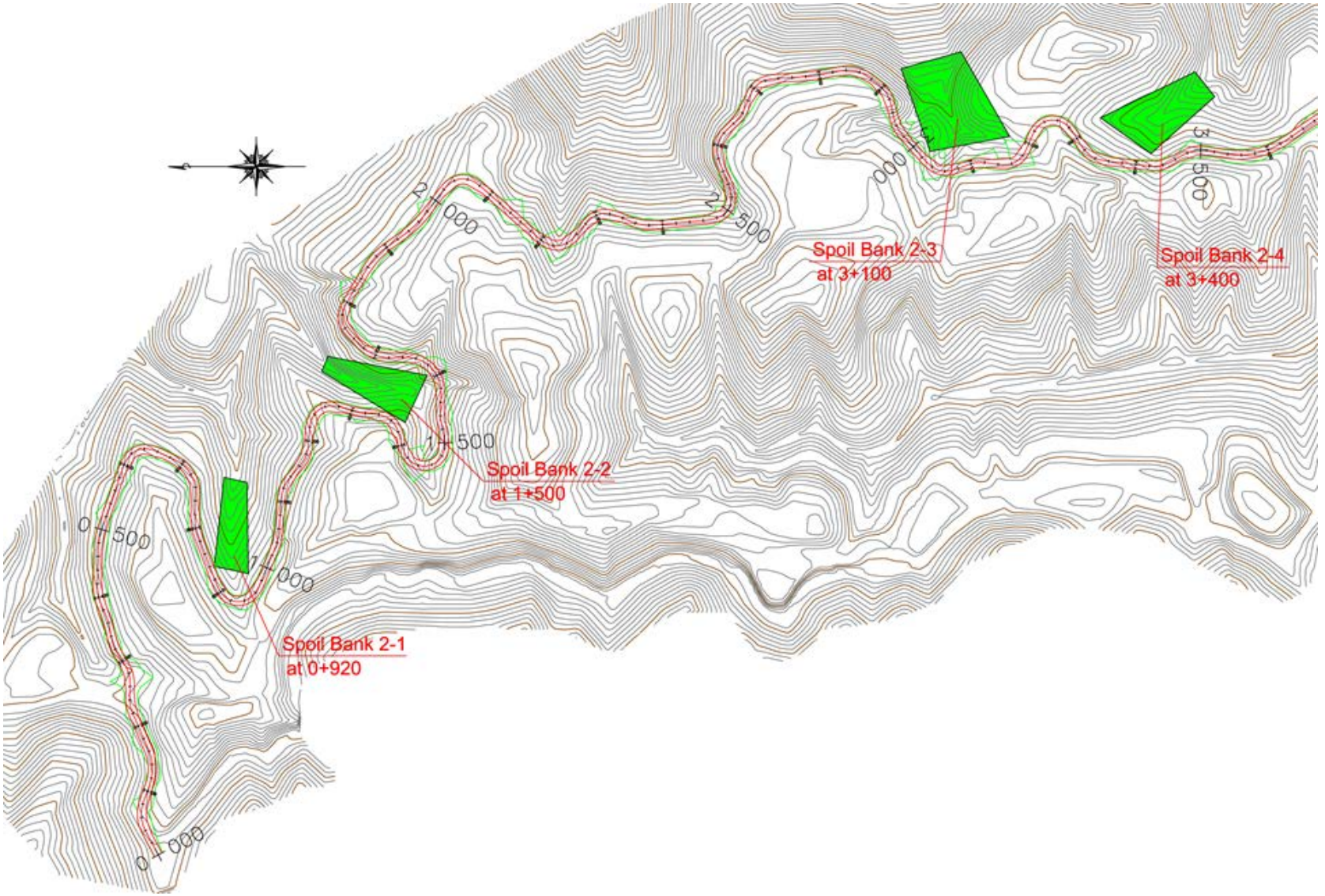
(3) Result of Examination for Spoil Bank Location

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



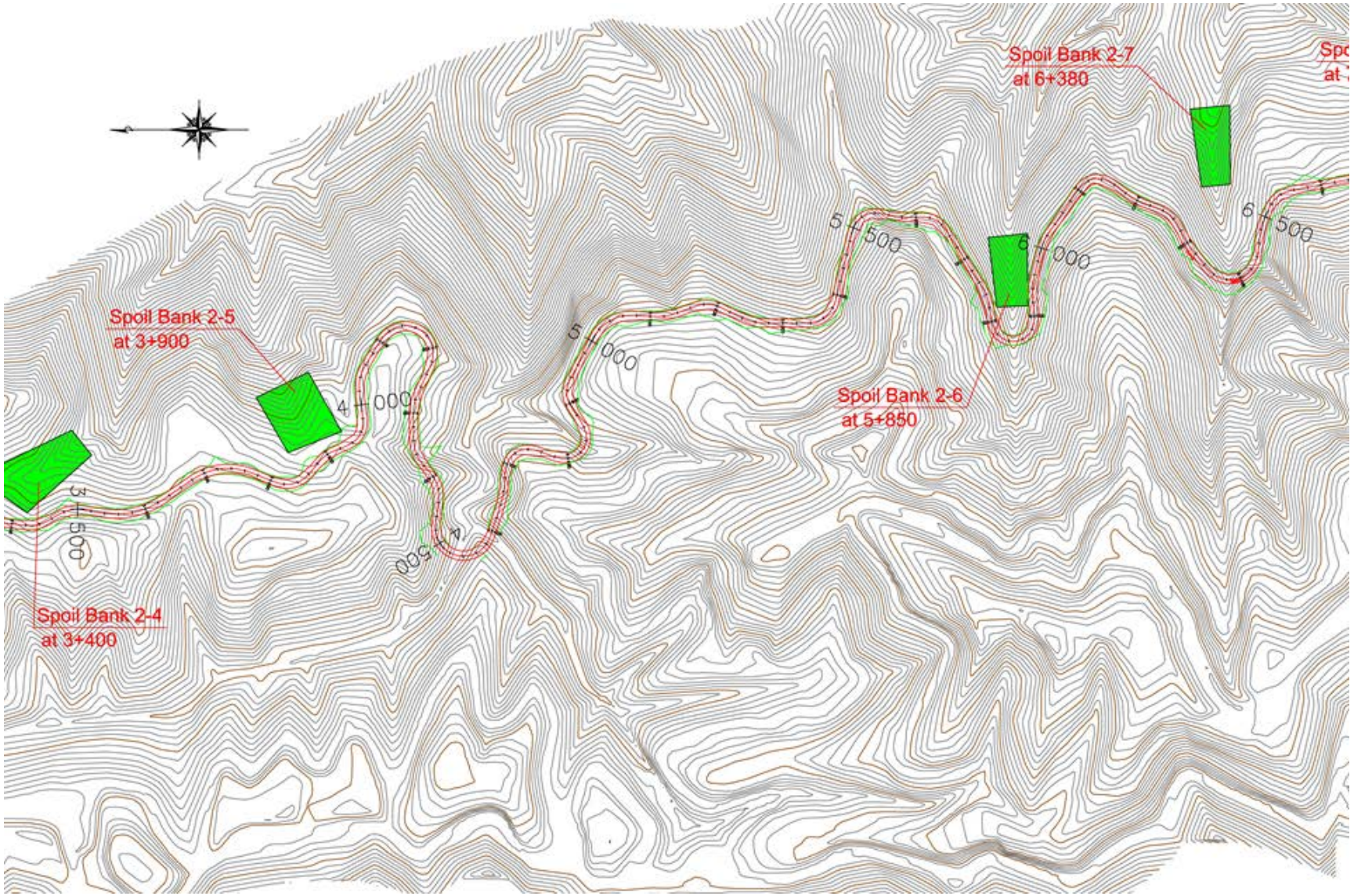

Source: JICA Study Team

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



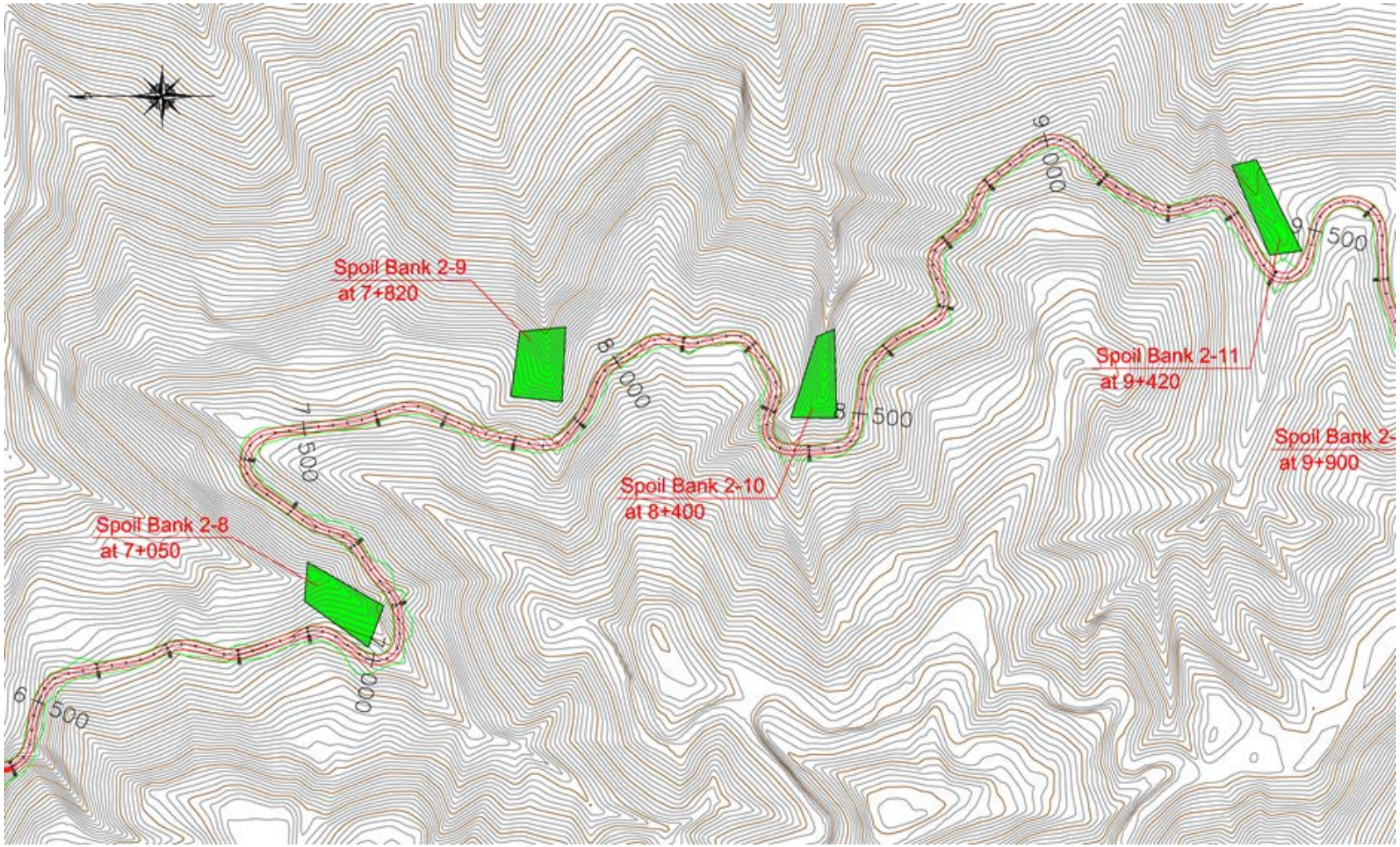

Source: JICA Study Team

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



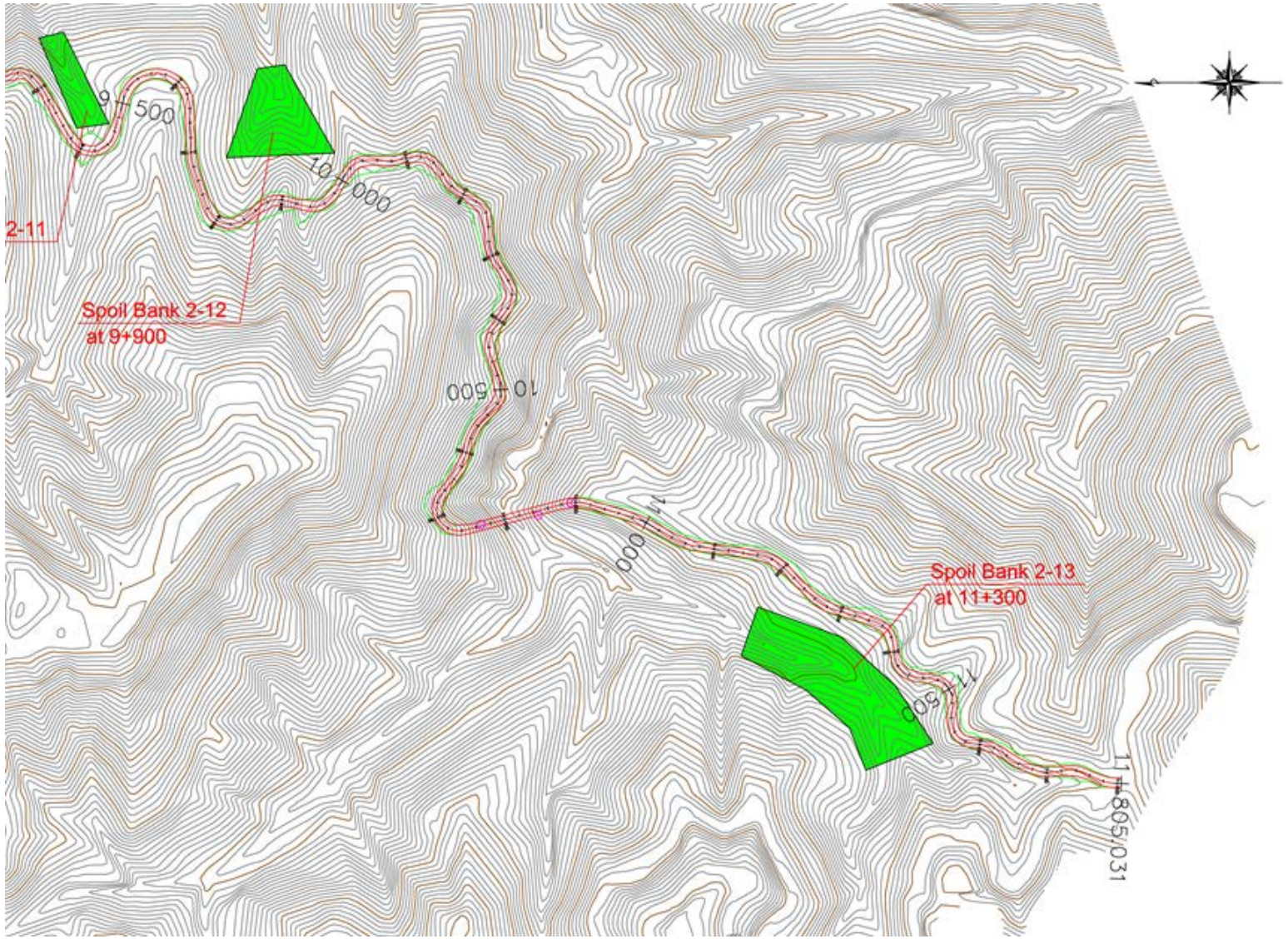

Source: JICA Study Team

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



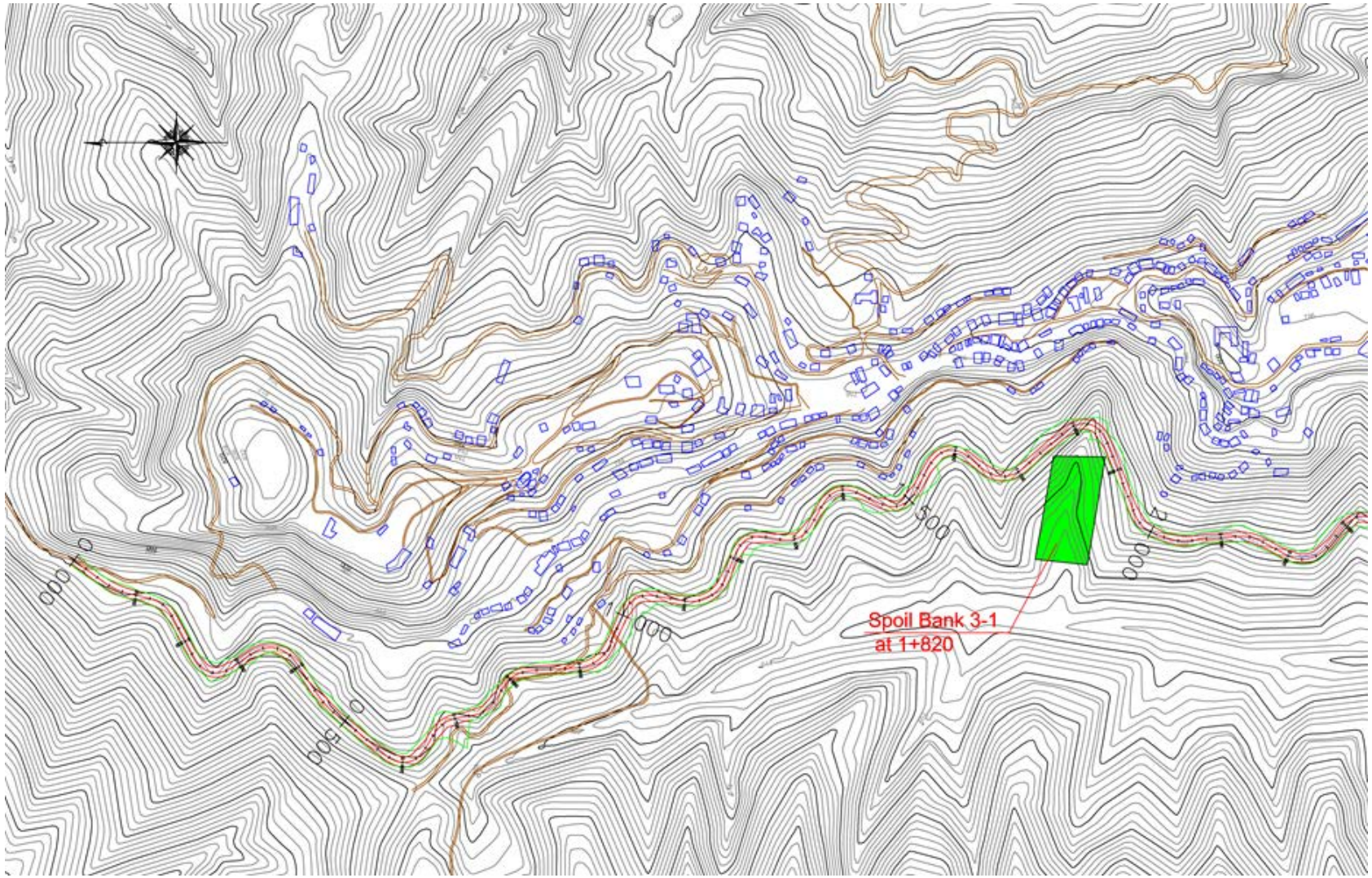

Source: JICA Study Team

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



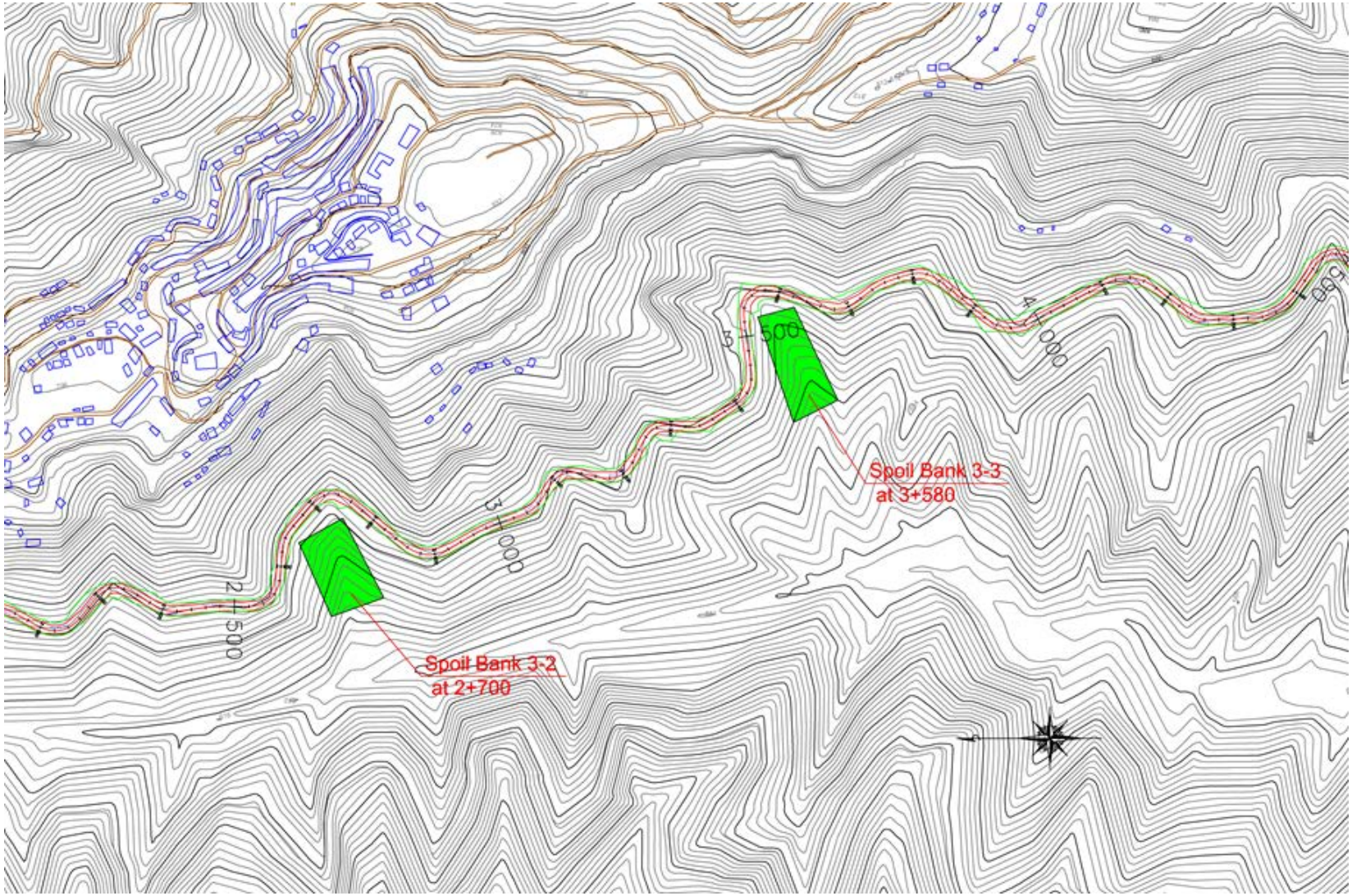

Source: JICA Study Team

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



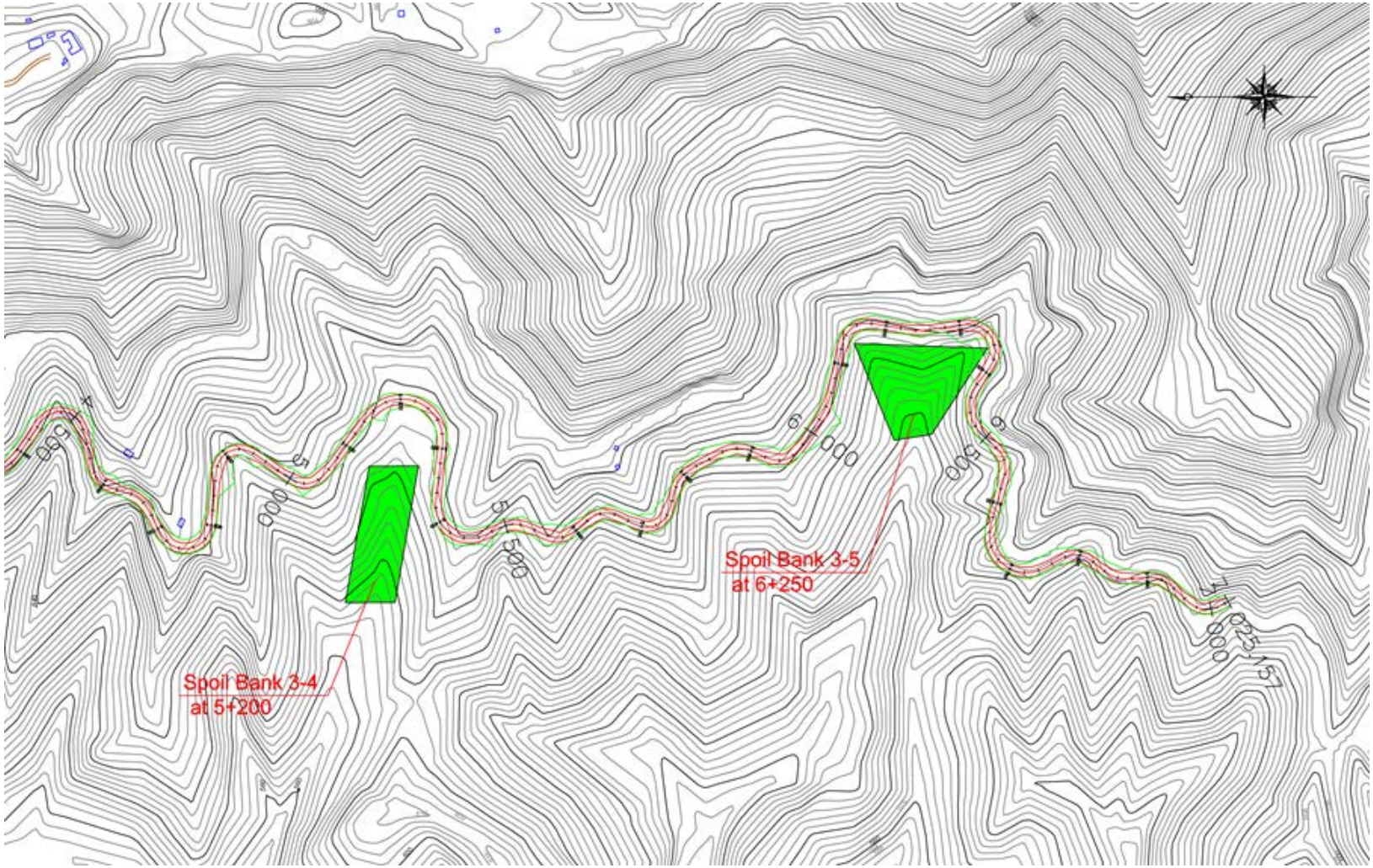

Source: JICA Study Team

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



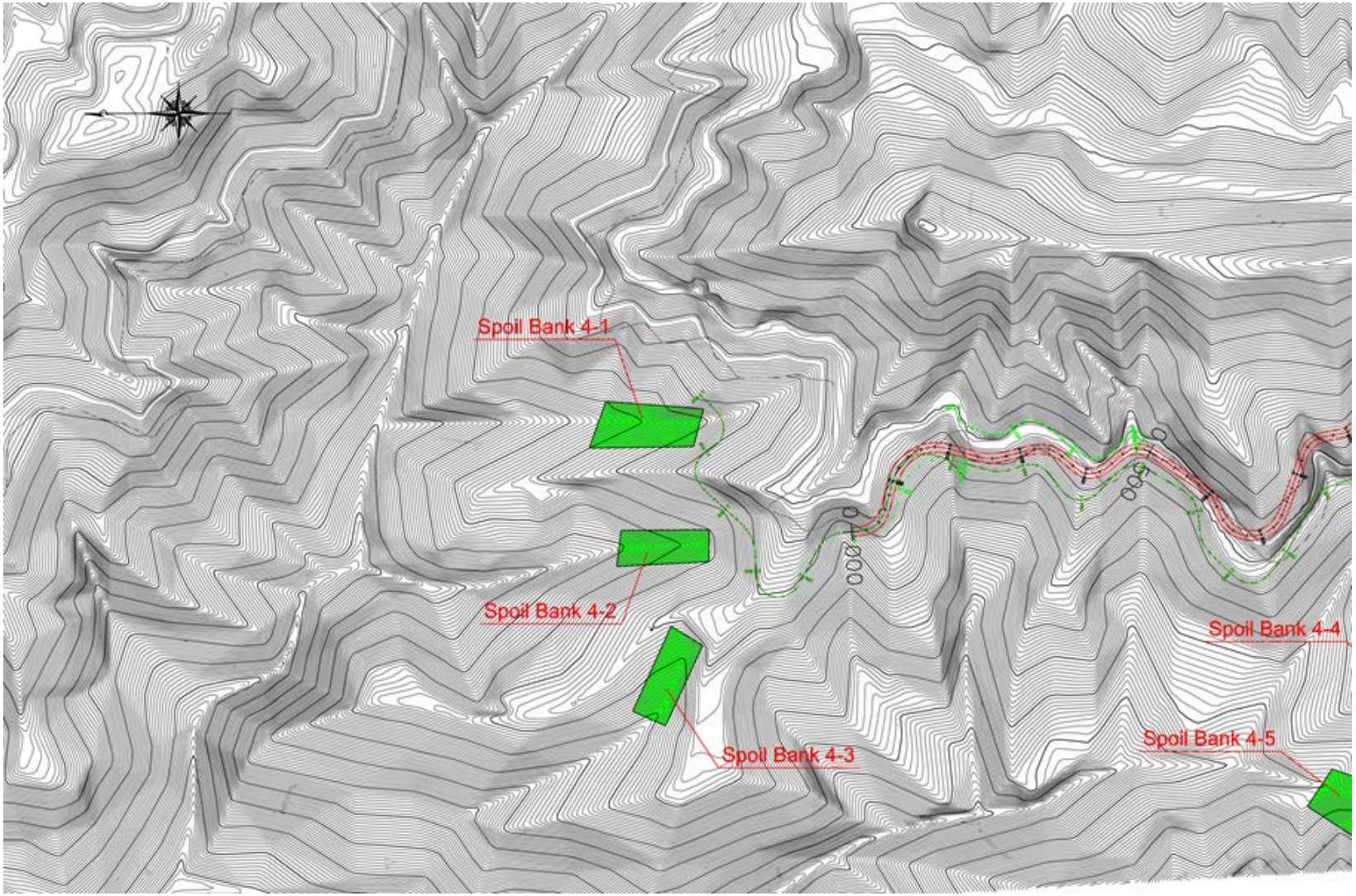

Source: JICA Study Team

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



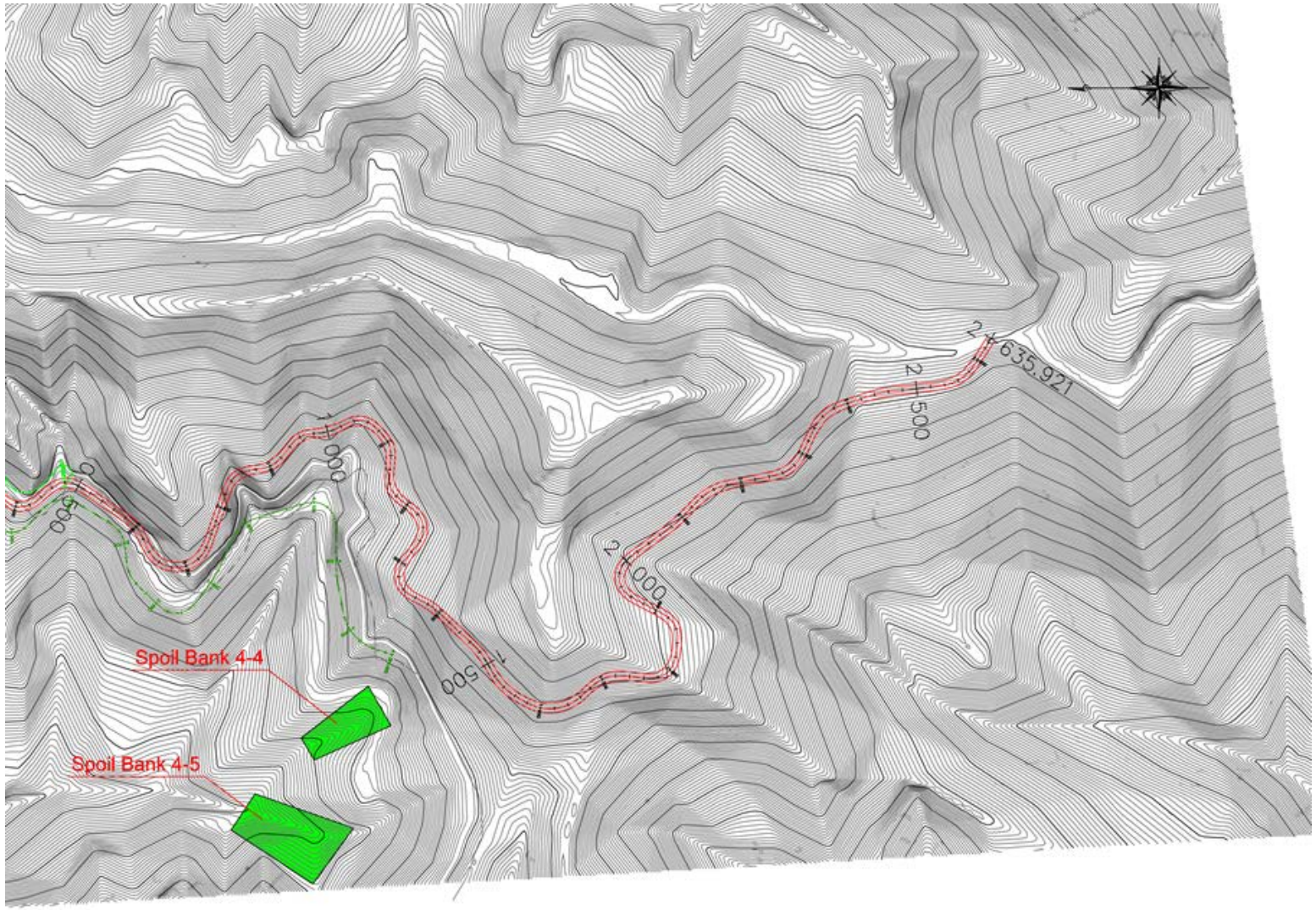

Source: JICA Study Team

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




Source: JICA Study Team

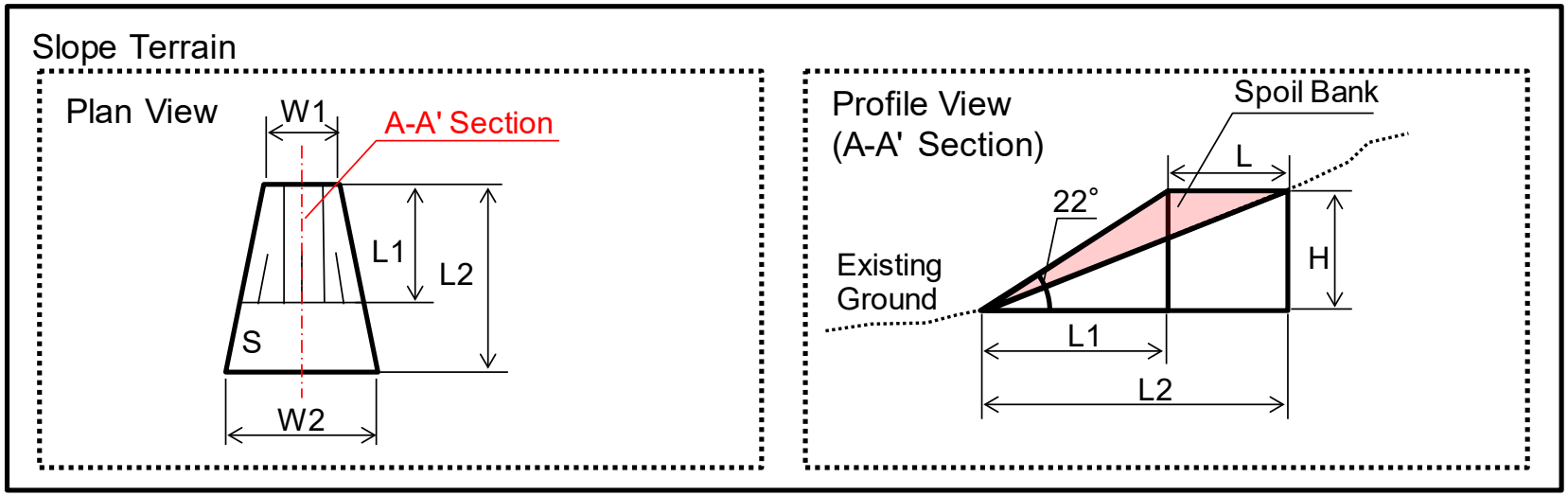
**Figure 5.2-31 Plan for Locations of Spoil Bank (Lawngtlai Bypass) - 1/2**




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

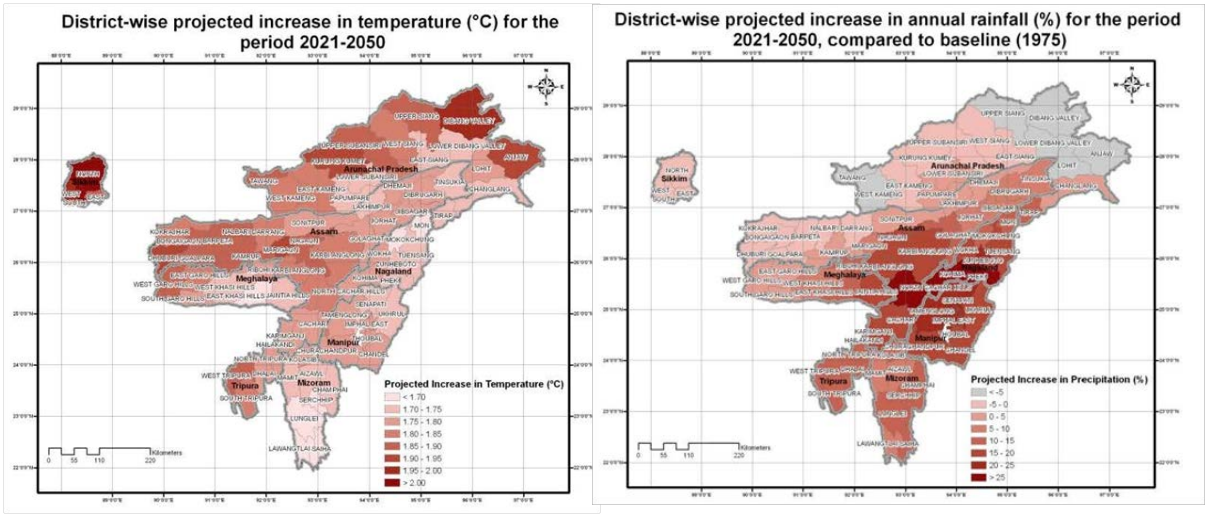
(1) Climate Change Situation in India

The 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 the rising of river level and variation of wind load with the increase of frequency and intensity of cyclone, it will be necessary to improve and reinforce the road facilities.

Multi-sector mitigation strategies for climate change are proposed in India's Intended Nationally Determined Contribution submitted to the United Nations Framework Convention on Climate Change. Safe, Smart and Sustainable Green Transportation Network is proposed as mitigation strategy in the transportation sector and green highways (plantation and maintenance) policy to develop 140,000 km long "tree-line" with plantation along both sides of national highways is proposed as the 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 climate change is examined together with the Ministry of Development of North-East Region. The project document under the program mentioned the prediction of impact of climate change in the North-East States as follows:

- 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 the 1901-2007 period, the annual mean precipitation has increased by 51 cm in 100 years.
- The projected increase in annual rainfall is high in the central and east part of the states (see Figure 5.2-33 right). Especially, rainfall increase during the rainy season (June-September) is expected to be significant in the eastern part including Mizoram State.
- Extreme rainfall events of 100-150 mm per day and greater than 150 mm are predicted to increase at around 20% and 38%, respectively.




Source: North East Climate Change Adaptation Programme

**Figure 5.2-33 Projected Increase in Temperature (°C) (left) and Annual Rainfall (%) (right) for the 2021-2050 Period**

(2) Vulnerability to Climate Change

The largest impact of climate change is the increase of rainfall intensity in NH54. As presented in Figure 5.2-33, the increase of annual rainfall is predicted at 5-15% in NH54 for the 2021 to 2050 period. Increase of intensity and frequency of rainfall and groundwater rise and erosion due to 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 Road by Climate Change**

| Factor | Vulnerability |
|---|---|
| **Rainfall**<br>Higher rainfall causing flash floods, higher groundwater and moisture content in soil | - Overflow and wash out by flood discharge<br>- Inundation on the road<br>- Decrease of drain capacity by increase of silt discharge<br>- Occurrence of landslide disaster<br>- Instability of road structure and road embankment failure |
| **Temperature**<br>Rising maximum temperature | - Damage on road pavement |
| **Wind (Cyclone)**<br>Higher wind speed and load | - Deterioration of bridge safety<br>- Fallen trees and facilities such as electrical pole around road |

Source: JICA Study Team

(3) Adaptation Measure

The design policy of each item mentioned in Clause 5.2 takes into consideration adaptation measures to 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 NH54 because of fallen debris from the slope that has caused heavy damage on the pavement. Therefore, retaining wall and slope protection work are planned all along the road in this study.

Table 5.2-37 shows the adaptation measures for climate change considered in this road design.

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

**Table 5.2-37 Adaptation Measures for Climate Change in NH54**

| Factor | Design Policy Considering Adaptation |
|---|---|
| Side Slope | - Retaining wall is built all along the road.<br>- Slope protection work is constructed on some weathered and loosen slopes.<br>- Cut slope is covered with vegetation works to prevent erosion and collapse.<br>- Design safety factor in landslide stability analysis is set in consideration of high groundwater level.<br>- Countermeasure including restraint works is planned for unstable landslide. |
| Embankment | - Drain filter is sandwiched in embankment. |
| Bridge and Drainage System | - Rainfall intensity is carefully determined based on the authorized data: Atlas of Statewise Generalised Isopluvial Maps of Eastern India published by the Indian Meteorological Department. The isopluvial value from higher edge of the counter range is applied.<br>- The capacity of all structures is determined to be sufficient for a discharge with 50 years return period. |
| Pavement | - Superelevation is installed properly.<br>- Pavement material is examined not to rise over 60 °C on the surface. |
| Road Sign | - Wind load and visibility are taken into consideration. |

Source: JICA Study Team

# CHAPTER 6 PRELIMINARY PROJECT COST ESTIMATE

## 6.1 Outline of the Project

(1) Objectives of the Project

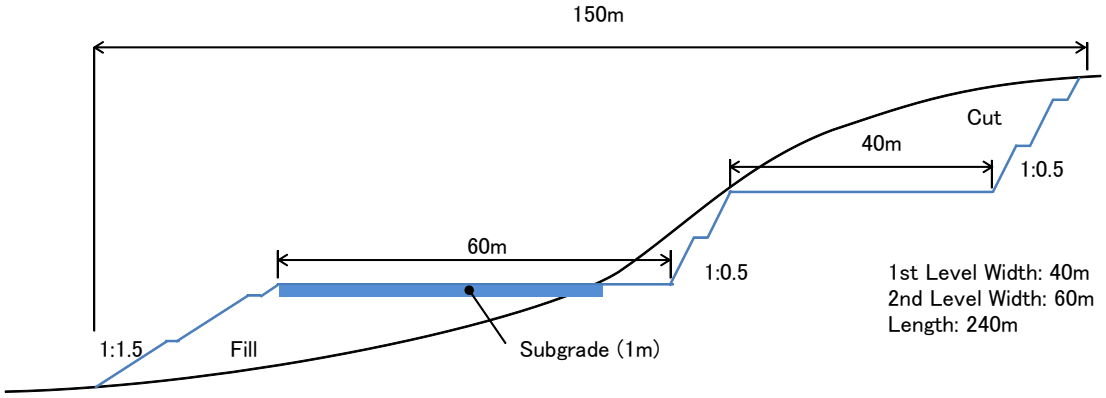
The objective of the project is to plan NH54 bypass considering the reduction of land acquisition cost and environmental impact depending on avoidance of settlement.

(2) Construction Package

The project is to be implemented under the package plan in consideration of NH54 mainline project, project scale of NH54 bypass, and etc..

## 6.2 Construction Plan

Mobilization of machine, material, workers, and preparation of main camp and plant yard are scheduled to be implemented within six months from the beginning of the construction period. Figure 6.2-1 shows the typical configuration of the camp site.




Source: JICA Study Team

**Figure 6.2-1 Typical Configuration of the Main Camp**

The construction yard (main camp) shall be developed along the project road. Required area for the yard is estimated to be 2.4 ha (1.4 ha for camp and 1 ha for plants and stockyard) based on past practices. Major buildings to be constructed in the yard are the consultant's and contractor's offices, staff quarters, staff lounge, canteen, laboratory, general warehouse, cement storage, workshop, medical room, and security guard's house. Since the project road is located in mountainous terrain and usable flat land is limited in the neighboring area, land development is required. Assuming the topography is as illustrated in Figure 6.2-1, the cut and fill volumes are estimated to be 120,000 $m^3$ and 110,000 $m^3$, respectively. Furthermore, subgrade (1 m layer below the construction level) preparation of 10,000 $m^3$ is required.

## 6.3 Applied Law, Regulation, and Guidelines

Preliminary project cost was estimated with reference to the following documents:

1) Specifications for Road and Bridge Works (Fifth Revision), Ministry of Road Transport & Highways

2) Schedule of Rates (SOR) 2015 for National Highways & State Road, Government of Mizoram

## 6.4 Preliminary Project Cost Estimate

(1) Conditions of Construction Cost Estimate

Unit costs set out based on the SOR 2015 were applied to most work items. Besides, unit costs derived from experience in foreign countries were employed for some specific items considering the possibility of participation of international contractors. These items are:

1) Crib Work (F300)
2) Crib Work (F500)
3) Anchor Work
4) Rock Bolt Work

Price escalation from 2015 up to the time of bidding was estimated to be 5% and was added to the construction cost.

(2) Procurement of Construction Materials

The JICA Study Team confirmed the procurement of construction materials with local T Company and C Company. It was confirmed that materials such as stone, sand, and aggregate can be procured from the quarry shown in Table 6.4-1.

**Table 6.4-1 Quarry Location for Stone, Sand, and Aggregate**

| Sr. No. | Bypass Name | Quarry Location | Location | Distance | Remarks |
|---|---|---|---|---|---|
| 1 | Chhiahtlang Bypass | Mat River | On Serchhip Thenzawl Road | 15+16 km Existing BT Road & 4 km Earthen Road | Plenty of materials used for Sand GSB & WMM. This quarry is presently used for an ADB project in Serchhip–Thenzawl–Buarpui |
| | | Baktawng | On NH54 | | Only for GSB & WMM, very limited |
| | | Phulmawi | On NH54 | | Only for GSB & WMM, very limited |
| | | Airport report | On MSRP-I Road | 8+15+16 km BT Road | Plenty of materials used for DBM & BC. This quarry is presently used for an ADB project in Serchhip–Thenzawl–Buarpui |
| 2 | Serchhip Bypass | Mat River | On Serchhip Thenzawl Road | 15 km Existing BT Road & 4 km Earthen Road | Plenty of materials used for Sand GSB & WMM. This quarry is presently used for an ADB project in Serchhip–Thenzawl–Buarpui |
| | | Airport report | On MSRP-I Road | 8+15 km BT Road | Plenty of materials used for DBM & BC. This quarry is presently used for an ADB project in Serchhip–Thenzawl–Buarpui |
| 3 | Hnahthial Bypass | Tuipui River | On Hnahthial-Tuipui | 12 km Gravel Road | Only for sand WMM & GSB, plenty materials |
| | | Tuichang River | On Keitum-Tuichang Road | | Only for sand WMM & GSB, plenty materials |
| | | Airport report | On MSRP-I Road | 8+15+58 km BT Road | Plenty of materials used for DBM & BC. This quarry is presently used for an ADB project in Serchhip–Thenzawl–Buarpui |
| 4 | Lawngtlai Bypass | Liapha (R. Kaladan) | At Liapha Village on MMTR | NH54 at Km 473+300 on Multi-modal Transit Route at 38 km then 5 km Earthen Road. | Plenty of materials. Sand, GSB, WMM, DBM, BC and stone aggregates. This quarry is presently used for the MMR Project. |

Source: JICA Study Team

Other construction materials (cement, bitumen, steel) are procured in Aizawl. Therefore, haulage costs of construction materials are considered in the cost estimate. The haulage distance on unsurfaced road is considered to be half the length of each bypass.

The haulage distance of construction materials is assumed as shown in Table 6.4-2.

**Table 6.4-2 Haulage Distance of Construction Materials**

| Bypass Name | Haulage Distance (km) | | | |
|---|---|---|---|---|
| | Cement, Bitumen and Steel | | Stone, Sand and Aggregate | |
| | Surfaced Road | Unsurfeced Road | Surfaced Road | Unsurfeced Road |
| Chhiahtlang | 100 | 0 | 40 | 2 |
| Serchhip | 110 | 0 | 25 | 6 |
| Hnahthial | 175 | 0 | 85 | 4 |
| Lawngtlai | 290 | 0 | 40 | 7 |

Source: JICA Study Team

(3) Abstract of Cost Estimate

The abstracts of the cost estimate for the NH54 bypass project are prepared.

# CHAPTER 7 IMPLEMENTATION PLAN

## 7.1 Implementation Schedule

### 7.1.1 Proposed Implementation Schedule

The implementation schedule of NH54 bypass construction is examined as the North–East States Road Network Improvement Project Phase-II. This schedule is formulated with the following assumptions:

[Loan Agreement]

- Phase-II Loan will be agreed between GoI and JICA till March 2017.

[Civil Works Contractors]

- In accordance with the implementation schedule of the Phase-I Project, the civil works of NH54 improvement will be commenced from July 2017 with four years construction period.
- Contractors of civil works will be procured in the NH54 bypass construction of the Phase-II Project.
- The construction of civil works may be commenced from the beginning of 2019 in parallel with the Phase-I construction works on NH54.

[Consultant Procurement]

- In case GOI will pledge Phase-II Project financed by JICA in the OECD Notification until the end of 2016, NHIDCL may commence procurement of the consultant from January 2017.
- The consulting service may be commenced from October 2017, and tender assistance such as technical evaluation of bids may be possible to be included in the scope of the consulting services.

[Land Acquisition]

- The state governments will be responsible for land acquisition implementation. NHIDCL is recommended to procure NGO to assist RAP implementation by the state government until June 2016 in order to catch up with the target project implementation schedule in compliance with JICA Environment Guideline.

### 7.1.2 Recommendation of Construction Period for Bypass Construction

Since the project route runs along sparsely populated regions in steep mountainous area, the hiring condition of construction labor from the village/ community along the project route will impact on the implementation schedule of the construction works.

Large volumes of gravity wall on filling slope and wet masonry retaining wall on cutting slope are adopted for the slope protection works on bypass construction as well as NH54 improvement construction. Because gravity wall and wet masonry retaining wall construction are labor intensive works, the Contractor will be required to hire a lot of labor from the village/ community along NH54 in order to minimize the construction cost.

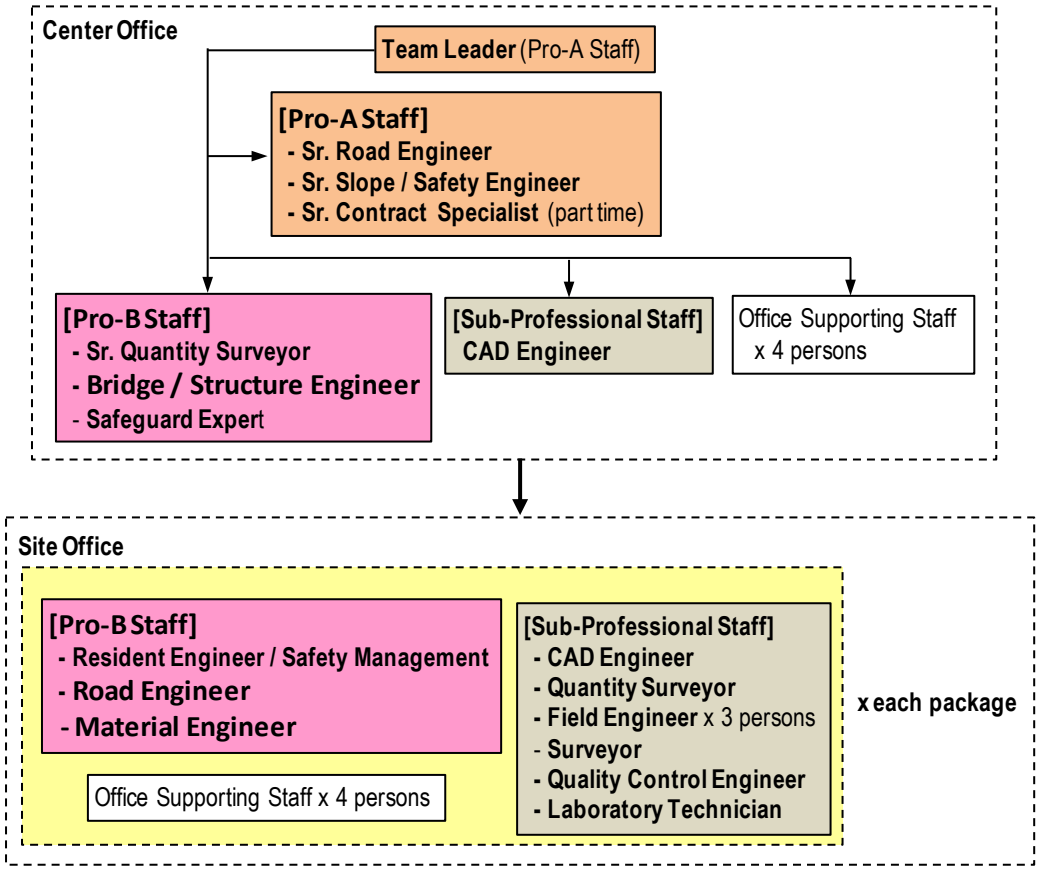
## 7.2 Project Implementation Framework

NHIDCL has been established on 1 January 2015 as a fully owned company of MoRTH. NHIDCL promotes, surveys, establishes, designs, builds, operates, maintains, and upgrades national highways and strategic roads including interconnecting roads in parts of the country which share international boundaries with neighboring countries. The regional connectivity so enhanced would promote cross border trade and commerce and help safeguard India's international borders. This would lead to the formation of a more integrated and economically consolidated South and Southeast Asia.

NHIDCL is appointed as the executing agency of the national road network improvement project in North-East States by MoRTH, accordingly, NHIDCL will execute the JICA ODA Phase-I Project as well as Phase-II Project.

## 7.3 Construction Supervision Service

In the work components of NH54, there are several advanced technologies which are not familiar in India and will have difficulties due to steep mountainous terrain. Therefore, the construction supervision (C/S) consultant of NH54 should be recommended to be procured by international competitive bidding (ICB) through expression of interest (EOI) process, and the proposed organization of C/S consultant for NH54 bypass construction is shown in Figure 7.3-1.




Source: JICA Study Team

**Figure 7.3-1 Proposed C/S Consultant Structure of NH54 Bypass**

## 7.4 Operation and Maintenance Plan

Based on the government policy of private sector participation, NHIDCL is scheduled to procure the operation and maintenance (O&M) contractor and the supervision consultant for the O&M contractor after the civil works contracts.

The following points are recommended to be considered in the O&M contract:

- Five years O&M contract should follow after finishing the defects liability period of the civil works contract.
- The inspection and requirement of road maintenance works should be performance-based, and the indicators shall be specified in the O&M contract.
- The obligation of the O&M contractor should include the following: i) safety, vehicle breakdown and accident, ii) emergency de-commissioning, iii) road property management, iv) engineering improvement, v) horticultural maintenance, and vi) vigilance on unauthorized encroachments.
- JICA is scheduled to conduct a technical project to focus on mountainous road development whose scope includes technical guideline and manual for O&M of mountainous road. The said technical documents that will be prepared by JICA should be recommended to be utilized in the implementation of the O&M contract.

## 7.5 Technical Assistance for Examination of Contract Mode

The EPC (design and build) contract system has basically been adopted in national highway project in India since the cabinet approval in 2012. However, some risks (tender period, risk share, payment condition, maintenance, authority of consultant, and design approval process) are found in the EPC contract since the projects under this study are in mountainous areas and the quality assurance of slope protection works is essential for disaster prevention. Therefore, contents of applicable contract are widely examined to be appropriate to the projects under this study.

First official meeting between the Government of India, represented by MORTH and NHIDCL, and JICA was held in February 2016 to explain JICA's proposed modifications to the Model EPC Agreement. JICA submitted 72 proposed modifications.

In May, NHIDCL expressed that 28 out of the 72 proposals cannot be accepted. JICA has again reviewed the reasoning for the rejection and it is preparing further notes to be presented to NHIDCL by the end of 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 the Ministry of Environment and Forest (today known as Ministry of Environment, Forest and Climate Change: MOEFCC) Environmental Impact Assessment (EIA) Notification dated September 14, 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 100 km involving additional right of way or land acquisition greater than 40 m on existing alignments and 60 m on re-alignments and bypasses*. The proposed bypasses do not trigger these requirements and therefore, the project does not require environmental clearance from the MOEFCC[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 (RAP) has been prepared.

### 8.1.2 Requirements of Clearance and Permits

As discussed earlier, an environmental clearance is not required for this project as the scale of road widening and land acquisition for this project is not significant enough to trigger the requirement. However, a forest clearance permit will have to be obtained prior to the commencement of the construction activity, as per the requirement of the Forest Act. According to the discussions held with the Department of Environment, Forests and Climate Change (DOEFCC), the application will be processed at various forest department offices at the division, state and central government level depending on the forest land requirements for non-forest purposes. Part 1 of the application format, the project proponent, has to be filled in by the National Highways and Infrastructure Development Corporation (NHIDCL), while Part 2 of the application will be cleared by the Forest Division. Part 3 will be cleared by the State Environment, Forest and Climate Change Department while Part 4 (with the Nodal Officer under Forest Conservation Act) and Part 5 (with the Secretary of Department of Environment, Forest and Climate Change) will be cleared before forwarding it to the MOEFCC in Delhi for appraising and issuance of 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 to 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 operation periods. The applicability of environmental and other relevant rules and acts is shown in Table 8.1-1.

[1] Responding to the inquiry from JICA Study Team, Mr. Manoj Kumar Singh, Joint Secretary of MOEFCC answered verbally that the clearance is not needed for this project. However, MOEFCC has not confirmed the same in official letter.

**Table 8.1-1 Requirements of Environment-Related Clearance**

| No. | Activity | Statute | Requirement | Competent Authority | Responsible Agency for Obtaining Clearance | Time Required |
|---|---|---|---|---|---|---|
| **Pre-Construction Stage (Responsibility: MORTH)** | | | | | | |
| **1** | Road-side tree cutting and clearing forest | Forest Conservation Act 1980 and MOEFCC Letter Dt.18.02.1998 | Permission for road-side tree cutting | State and Central Government | MORTH | 2-3 months |
| **2** | Filling of roadside water bodies (ponds and borrow pits) | State Fisheries Policy Draft Wetlands (Conservation and 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)** | | | | | | |
| **3** | 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 sections | Contractor | 4-6 months |
| **4** | 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 |
| **5** | 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 |
| **6** | 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 |
| **7** | Quarry operation | State Minor Mineral Concession Rules, Mines Act of 1952, Indian Explosive Act of 1984, Air Act of 1981 and Water Act of 1974 | Quarry lease deed and quarry license | State Department of Mines and Geology | Contractor | 4-6 months |
| **8** | 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 |
| **9** | 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. The following agencies would play important roles in this project.

#### (1) Ministry of Environment, Forest and Climate Change (MOEFCC)

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

#### (2) MOEFCC Regional Offices

The MOEFCC has set up several regional offices, with each region having an office. The office that covers the northeastern zone including Mizoram is located at Shillong, Meghalaya. This office is responsible for collecting and furnishing information relating to the 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)

The CPCB is a statutory authority attached to the MOEFCC located in New Delhi. The main responsibilities of the CPCB include 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 role while the project shall adhere to the norms and standards set up by the Mizoram State Pollution Control Board (M-SPCB).

#### (4) Departments of Environment, Forest and Climate Change (DOEFCC)

They perform functions similar to the MOEFCC 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 management of the forest designated areas within the state. The Forest Department creates forest working plans for the various forest divisions to manage and protect the forest resources. The 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 clearance 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 served as the base policy document on which the state government passes resolution on acquiring 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 grounds that being under the sixth schedule of the Constitution, the land within the state belongs to the 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 of 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 view of the requirements under the JICA Guidelines, the resettlement policy and entitlement proposed in a Resettlement Assistance Plan (RAP) report will be adopted in this project. Other applicable acts, notifications, and policies relevant in the context of the project are summarized in Table 8.2-1.

**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, the State of Meghalaya opposed the provisions on grounds that being under the Sixth Schedule of the Constitution, the land in the State belongs to the individuals and not the Government. |
| 2 | Mizoram (Land Acquisition, Rehabilitation and Resettlement) Act 2016 | The Act that will be followed for land acquisition in this project. The Act is mainly drawn from the national law, LARR 2013, but differ in several areas, including additional assistance for rural areas and the provision of solatium to be added to the compensation. See 3.1.2 for more details. |
| 3 | Mizoram (Land Revenue) Rules 2013 | The Rules articulate the type of land rights and land use rights in Mizoram and stipulate procedures regarding how such rights can be obtained, renewed, or revoked. See 3.1.3 for more details. |
| 4 | National Rehabilitation and Resettlement Policy, 2007 ((NRRP 2007) | Provides limited benefits to affected families (an ex-gratia payment of not less than Rs. 20,000 and in case a landholder will become landless or a small or marginal farmer in such cases other rehabilitation benefits as applicable. |
| 5 | 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. |

| No. | Acts, Notifications, Policies | Relevance and Applicability to the Project |
|---|---|---|
| 6 | The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 | Provides recognition of forest rights to Scheduled Tribes in occupation of the forest land prior to December 12, 2015 as well as 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. |
| 7 | The Right to Information Act, 2005 | Sets up the practical regime of right to information for citizens secure access to information under the control of public authorities. This act was done in order to promote transparency and accountability in the work of every public authority, the Constitution of a Central Information Commission and State Information Commissions and for matters connected therewith or incidental thereto. |
| 8 | World Bank OP 4.12 – Involuntary Resettlement | The project requires additional land area for widening and strengthening, junction improvements, realignments, and safety provisions. 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. |
| 9 | OP 4.10 – Indigenous Peoples | Over 90% of the population in the State belongs to the tribal community, and almost all affected households belong to the Scheduled Tribe. While a separate Indigenous Peoples Plan report is not prepared, the issues discussed in RAP takes into account this fact and addresses issues related to the indigenous people in the RAP.<br>The project shall ensure broad community support for the project based on free prior and informed consultation. |
| 10 | JICA Guidelines for Environmental and Social Considerations | See Box 3.1 below. |

Source: JICA Study Team

### 8.2.2 Mizoram (Land Acquisition, Rehabilitation and Resettlement) Act 2016

#### (1) The Flow of Land Acquisition Under the Mizoram Act 2016

The procedures for land acquisition and involuntary resettlement under the Mizoram Act 2016 can be broadly divided into two stages. In the first stage, the State Government carries out a Social Impact Assessment (SIA) to ascertain social impacts associated with land acquisition and involuntary resettlement. Based on the SIA, a Social Impact Management Plan will be prepared along with a Social Impact Assessment Report. A Public Hearing is also held during the process of preparing a SIA Report. In examining and appraising a SIA Report, the State Government confirms the following:

(a) There is a legitimate and bona fide public purpose for the proposed acquisition which necessitates the acquisition of the land identified;

(b) The potential benefits and the public purpose referred to in clause (a) shall outweigh the social costs and adverse social impact as determined by the Social Impact Assessment that has been carried out;

(c) Only the minimum area of land required for the project is proposed to be acquired;

(d) There is no unutilized land which has been previously acquired in the area;

(e) The land, if any, acquired earlier and remained unutilised, is used for such public purpose and make recommendations in respect thereof.

The approval of the SIA Report concludes the first stage and then the second stage for preparing and implementing the resettlement and rehabilitation schemes starts with the issuance of a preliminary notification for land acquisition. Upon the approval of the SIA Report, the State Government will publish a preliminary notification on land acquisition, and after issuance of a preliminary notification, land records of the targeted area shall be updated within two months. A written objection can be submitted within 60 days of the issuance of a preliminary notification with regards to the area and suitability of the land proposed to be acquired; (b) justification offered for public purpose; and the findings of the SIA report. Meanwhile, the SIA Report will be lapsed if a preliminary notification is not issued within 12 months from the date of appraisal of the SIA Report. Upon the publication of the preliminary notification, a survey and census of the affected families will be undertaken to collect information including:

(a) Particulars of lands and immovable properties being acquired of each affected family;

(b) Livelihood lost in respect of the land losers and landless whose livelihoods are primarily dependent on the lands being acquired;

(c) A list of public utilities and government buildings that are affected or likely to be affected, where resettlement of affected families is involved;

(d) Details of the amenities and infrastructural facilities that are affected or likely to be affected, where resettlement of affected families is involved; and

(e) Details of any common property resources being acquired.

Based on the survey and census results, a rehabilitation and resettlement scheme will be prepared. The draft rehabilitation and resettlement scheme shall be made known locally by wide publicity in the affected area and as is the case of the SIA report preparation, a public hearing will be conducted. On completion of the public hearing, the draft rehabilitation and resettlement scheme will be submitted to the collector along with a specific report on the claims and objections raised in the public hearing. The

state government will issue a declaration of land acquisition once the rehabilitation and resettlement scheme is approved. Following the declaration, the public notice for land acquisition will be published and the land will be acquired. The award (compensation) needs to be paid within 12 months from the date of publication of the declaration and if no award is made within that period, the entire proceedings for the acquisition of the land shall lapse.

**(2) Preparation and Implementation of Rehabilitation (Income Restoration) Plan**

The commissioner for rehabilitation and resettlement, appointed by the State Government, will be the one responsible for supervising the formulation of the rehabilitation and resettlement scheme as well as the proper implementation of such scheme. When the land proposed to be acquired is equal to or more than fifty acres (this project applies to this criteria), the government will form a rehabilitation and resettlement committee to monitor and review the progress of the implementation of the rehabilitation and resettlement scheme. The committee will also carry out post-implementation social audits in consultation with the public of the concerned villages. In addition to relevant government officers at state and district levels, the committee shall include a representative of women residing in the affected area and a representative of a voluntary organization working in the area, among others.

### 8.2.3 Mizoram (Land Revenue) Rules 2013

In Mizoram, the state government owns the land in the state and an individual can obtain land-use permits such as periodic patta through the state government or the Village Council. For agricultural land, the land use permits can take the form of periodic patta or land lease agreement specificing the duration and purpose of the land use. The maximum area of periodic patta allowed for one family is

80.268 $m^2$. The owners of period patta may apply for an Agricultural Land Settlement Certificate (A-LSC) after the review of land use and records of tax payment.

For residential area, the permits can generally be divided into Residential Land Settlement Certifiate (R-LSC) for urban areas and house pass for rural area. In areas where a land survey by the state government has not yet been carried out, the Village Council will issue the latter. The state government is working to integarate the two systems in an effort to consolidate mandates related to land use and ownership of the state, but at the moment, the two systems co-esist in some areas. In this study, owners of periodic patta, house pass and lease agreement are considered as landowners.

### 8.2.4 World Bank OP4.10

Majority of the population in Mizoram including the PAPs are scheduled tribes in India.The World Bank OP4.10 requires preparation of an Indigenous Peoples Plan. The OP4.10 defines the indigenous people as follows:

a) Self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;

b) Collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories

c) Customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture; and

d) An indigenous language, often different from the official language of the country or region.

The Project Affected Peoples (PAPs) partly meet the above definition in the sense that they share the same identity as the Mizo group and uses the same common language. However, given that the Mizos consist of the majority of the population in the state, their livelihood and culture are not considered as "separate from those of the dominant society and culture".

In India, Scheduled Tribes including Mizo are considered as indigenous people. Given that the majority of the affected people are Mizo, however, the project incorporates the requirements of World Bank OP4.10 in preparation of RAP. In particular, the principle of Free Prior and Informed Consent is adhered to during the preparation of the RAP to ensure meaningful participation of the PAPs, and the project has broad community support.

### 8.2.5 Key Gaps between LARR 2013 and the JICA Guidelines

Table 8.2-2 summarizes key deviations between the two sets of legal and policy frameworks i.e., the JICA policies and the existing Indian policies relevant to this project. The table also makes recommendations for measures to resolve 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 a social impact assessment to identify the scope of impact, which will provide the basis for the design of Rehabilitation Plan.<br><br>Also, the collector shall consider the impacts 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 of not less than 3 years preceding the date of declaration.<br><br>Both LARR and Mizoram Act are silent on the 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, and transitional support, to be provided only if residing/ drawing livelihood for a continuous 3-year period in the area, preceding the declaration of 'affected area'. | Recognize claims of non-title holders (as identified by a census survey and irrespective of their residing period status) and in respect of:<br>- Compensation for structures, trees<br>- Structure transfer assistance<br>- Structure reconstruction assistance<br>- Shifting assistance for residential house owner<br>- Tenant shifting allowance<br><br>Assistance to be provided at par with similar R&R support extended to titleholder families |

| 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. In addition, 100% of solatium is added to the final award. | Compensation made on the market rate as determined by the collector. The collector may add solatium to final compensation amount. | Yes, market rate as calculated by the government is usually far below the actual prevailing market rates. A solatium may serve as a gap-filling tool, but in the Mizo Act, the provision of a solatium is not mandatory. | Compensation should 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 the NRRP | -- | | - |
| 6 | For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. | Requirement for RAP is mentioned and subject to the 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 | - |

| 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 |
|---|---|---|---|---|---|
| 9 | Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans | Specified | Government carries out a social impact assessment and prepares an appropriate rehabilitation program in consultation with the community | No | - |
| 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, an R&R Committee will only be set up if the project area has more than 400 families (in plains) or 200 in tribal/hilly areas are to be displaced. | - Two-tier GRM to be set up.<br>- R&R implementing NGO/consultant will be stationed in each project affected district and facilitating and informing 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 want 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 | Specified R&R benefits to non-titleholders provisioned are subject to them residing/drawing livelihood for a period of not less than 3 years in the project affected area (from | -- | Yes, non-titleholders if residing or drawing livelihood for a period of 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 |
|---|---|---|---|---|---|
| | recognized under law), 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 recognizable legal right to the land they are occupying | the date of formal declaration) | | | |
| 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 of 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 the 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 Team

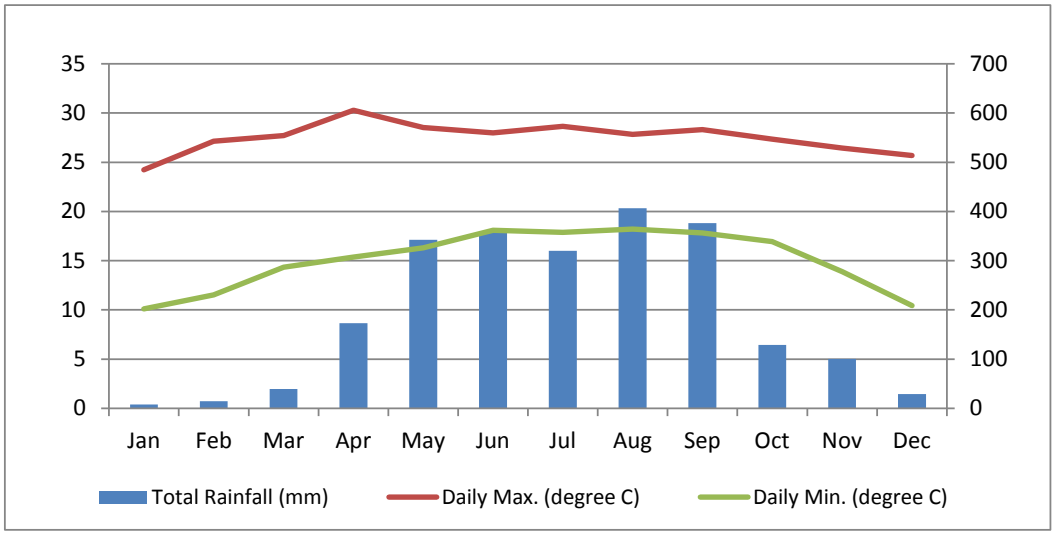
## 8.3 Environmental and Social Baseline

Existing environment and socio-economic conditions against which likely environmental and social impacts of the project have been analyzed. The baseline data presented in this section 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 the summer with temperatures ranging from 20 °C to 29 °C (68 °F to 84 °F)[2] and winter temperatures range from 7 °C to 22 °C. The region is influenced by a monsoon, raining heavily from May to September, while also having little rain in the dry season. The climate pattern is described to be moist tropical to moist sub-tropical, with an average state rainfall of 2,540 mm per annum. The data collected is visualized in Figure 8.3-1.




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 in Table 8.3-1. The Lawngtlai (BP4) area tends to have lower rainfall compared with other areas.

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

| Report Center | Annual Rainfall (mm) | | | | |
|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 |
| Serchhip (for BP1 and 2) | 1940.3 | 1784.8 | 1725.9 | 1811 | 2214.7 |
| Hnahthial (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

North-East India is located on the north-east edge of the Himalayan orogenic belt resulted from the Indo-Eurasian continental plate collision that took place during the Cenozoic era. 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 the lithology and existence of argillaceous groups of rocks, occurring relatively in lower altitudes as compared with 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 the opportunity of desiccation of the upper topsoil creating a weak bond through a 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 as well as the 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 causing the low water table in Mizoram. The soils of Mizoram are deficient in potassium, phosphorous, nitrogen and humus. In addition to this, the traditional jhum cultivation has adversely affected productivity. Although superficial greenery is observed, owing to the profuse rainfall, the tracts are 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 in Table 8.3-2.

**Table 8.3-2 Soil Structures in the 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 under forest cover (India State Forest Report FSI, 2013). Mizoram is a hilly region receiving heavy rainfall with soil characteristics conducive for luxuriant growth. Flora and fauna assessments were carried out for all the three districts that the targeted section of the NH54 bypasses through.

Floral and vegetation assessments carried out through quadrate methods; for trees 10 m x10 m, for shrubs 5 m x 5 m and for herbs 1 m x 1 m square shaped quadrats were used. Quadrats were laid randomly in the corridors uphill and dowhill of the road. All species in the quadrats were recorded and ecological parameters such as density and frequency were calculated. Faunal species were recorded using visual observation during site visits, while secondary data were also collected from the forest department and local information from peoples. The flora and fauna surveys were carried out twice, once during the dry season (from February to March 2016) and second during 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 of Environment and Forest is taking steps to regenerate the forest area either naturally and/or artificially through plantation. In most parts these plantations consist 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 is 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 the seasonal monsoon arrives. This is one of the main reasons that in abandoned jhum lands 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 Chhiahtlang (BP1).

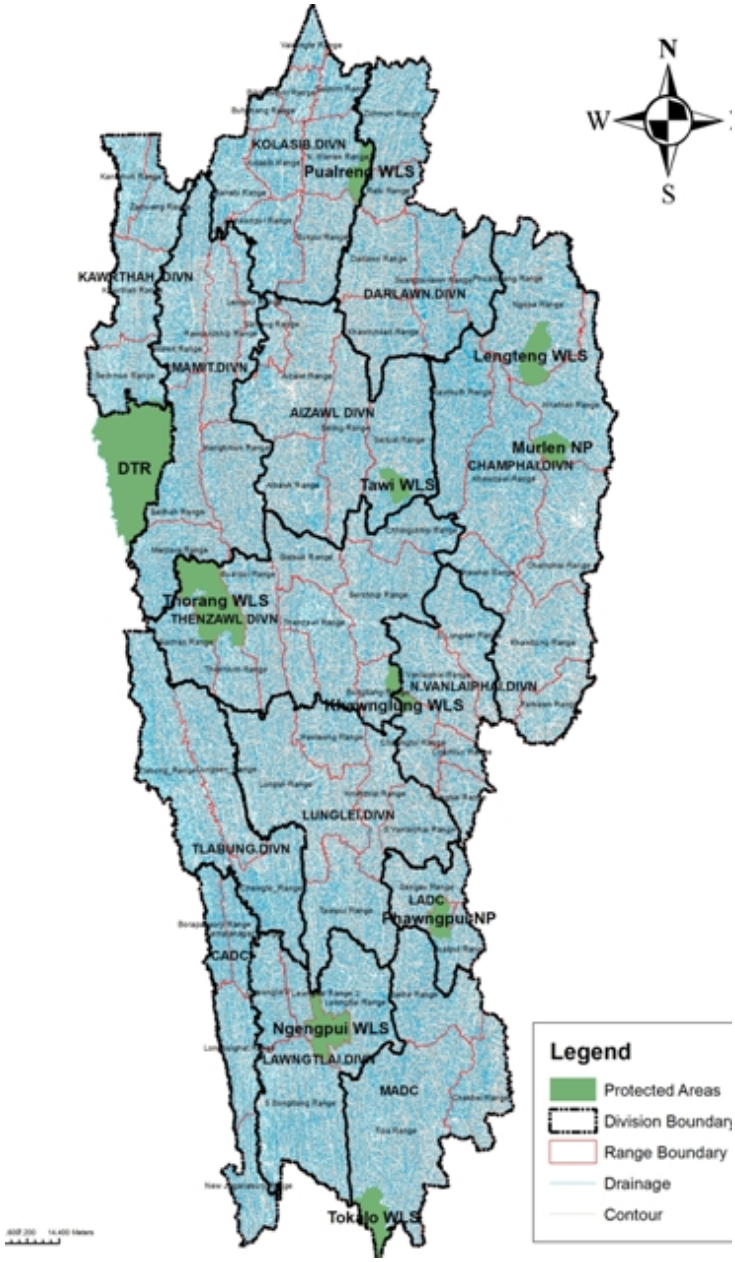
No endangered or vulnerable floral species have been spotted during the field surveys. The floral diversity recorded during the field study and secondary data collected from the Environment and Forest Department of Mizoram are listed in the Table 8.3-3. The common name, local name, red list category of International Union for Conservation of Nature (IUCN) and Indian Wild Life Protection Act category (wherever applicable) as well as the field observations are included in Appendix 6.

**2) Fauna**

Being part of the 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 the flora/faunal community between the area proximity of NH54 and in the 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. This was confirmed in the field study in both dry and monsoon seasons (see Appendix 7 for the list of species spotted in the field survey). Meanwhile, one “vulnerable” species as per the 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 ten protected areas (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, Forests and Climate Change, Government of Mizoram

**Figure 8.3-2 Protected Areas in Mizoram**

According to the discussion with the official in the State Environment and Forest Department, three wildlife sanctuaries, namely; Tawi, Khawnglung, and Ngengpui are located near the proposed bypasses as shown in Figure 8.3-2. The Tawi WLS is located about 12 km northwest of BP1 and 20 km north of BP2. The Khawnglung WLS is located about 13 km east of BP3 and the Ngengpui WLS is located about 11 km southwest 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 are tabulated in Table 8.3-3 to Table 8.3-5, 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, approximately 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 the 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*<br>- *Betula species*<br>- *Wild orchids*<br>- A few clumps of *Chimnobambusa collasa* etc. |
| | | Fauna | - Clouded Leopard (Threatened)<br>- Leopard Cat (Endangered)<br>- Hoolock Gibbon (Endangered)<br>- Serow (Threatened) etc. |

Note: *) Finally notified in 2001 vide Government of Mizoram letter No.B.12012/1/91-FST Dt. 16 Nov/2001
Source: "Review Management Plan of Tawi Wildlife Sanctuary Mizoram for the period (2006-2007 to 2015-2016)", Wildlife Wing Environment and 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, approximately 140 km south from Aizawl, and its covering area is approx. 35 km$^2$. The sanctuary is situated in Lunglei District, under the Development Block of Hnahthial and carved out from the 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<br>- Rhesus Macaque<br>- Assamese macaque<br>- Stump Tailed Macaque<br>- Phayre's Leaf Monkey<br>- Capped Langur<br>- Leopard<br>- Clouded leopard<br>- Himalayan black bear<br>- Malayan sun bear<br>- Sambar<br>- Barking deer<br>- 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, approximately 280 km south of Aizawl and 39 km west of Lawngtlai. This area is under the Lawngtlai District and under Lawngtlai Rural Development Block within the Lai Autonomous District Council. Its covering area is approximately 110 km$^2$, declared as a Wildlife Sanctuary in 1997 vide Govt. Notification No. B. 12012/4/01-FST dated July 22, 1997. The Ngengpui Wildlife Sanctuary is very rich in biodiversity. The forest type of this area is tropical wet evergreen forest and semi-evergreen forest. There are also a number of medical plants. Besides the fauna, elephants, gaurs and other mammals can be found. This area is one of the most important bird areas in India as this area contains bird species classified under 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 and Indo Bangladesh border. | |
| 2 | Area | 110 $km^2$ | |
| 3 | Principal Species | Flora | - *Raulfia serpentine*<br>- *Bergenia ciliate*<br>- *Ardisia macrocapa*<br>- *Cautraya gracillis*<br>- *Gardenis caronania*<br>- *Rajanda longifolia*<br>- *Zingiber purphotium*<br>- Orchids etc. |
| | | Fauna | - Elephant<br>- Gaur<br>- Serow<br>- Sambar<br>- Barking Deer<br>- Leopard<br>- Clouded Leopard (Threatened)<br>- Marble Cat<br>- Golden Cat<br>- Leopard Cat<br>- Hoolock Gibbon<br>- Phayre's Leaf Monkey<br>- Pig tailed macaques<br>- Stump Tailed Macaques<br>- Himalayan Black Bear<br>- Malayan Sun Bear<br>- Capped Langur<br>- 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 forests, jhum lands (shifting cultivation), and abandoned jhum areas. Given that the forest and forest produce play an important role in local livelihood, efforts are needed to minimize deforestation and disturbance that can be caused during the 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 a 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 in Table 8.3-6 and Table 8.3-7. The stone and sand production are mainly concentrated in Aizawl, and in Mamit, Kolasib and Lunglei districts. Mizoram has also 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 offer 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 |
|---|---|---|---|---|---|
| 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

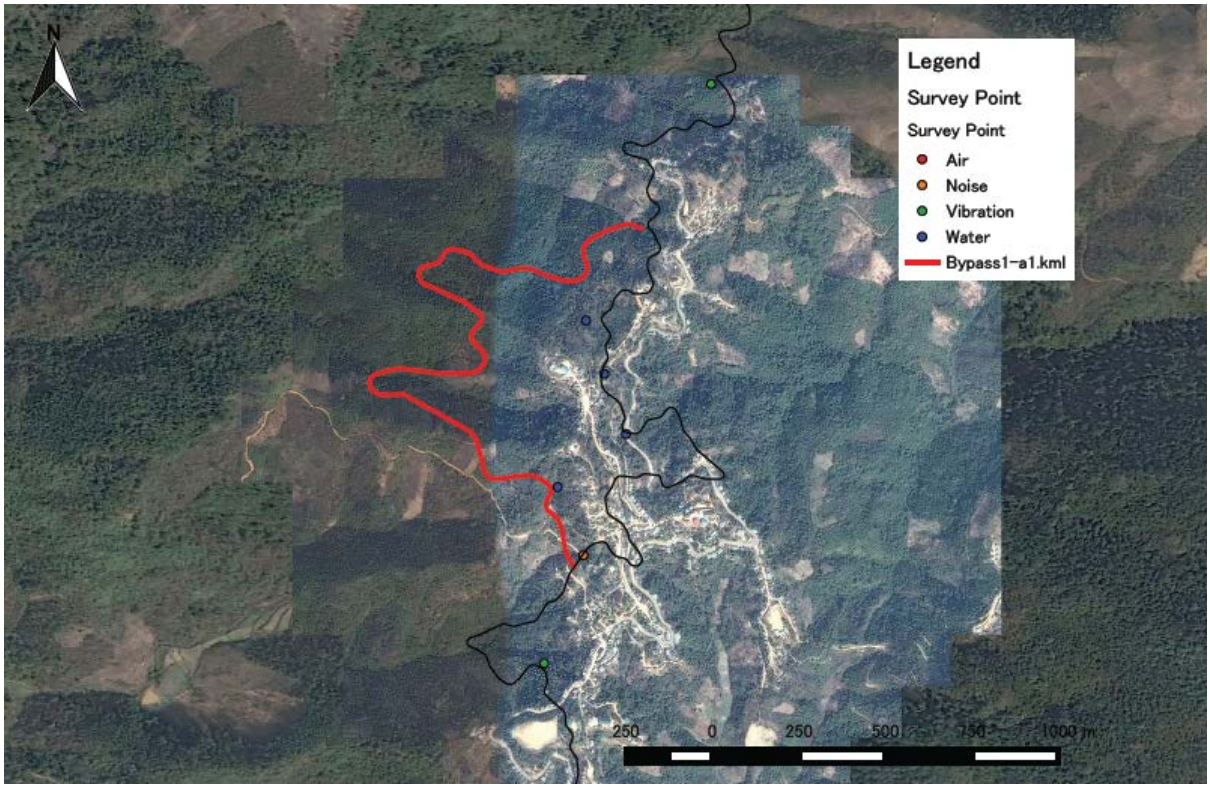
**Table 8.3-7 District-wise Number of Quarry Permit Issued and Mineral Production, 2010-11**

| 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

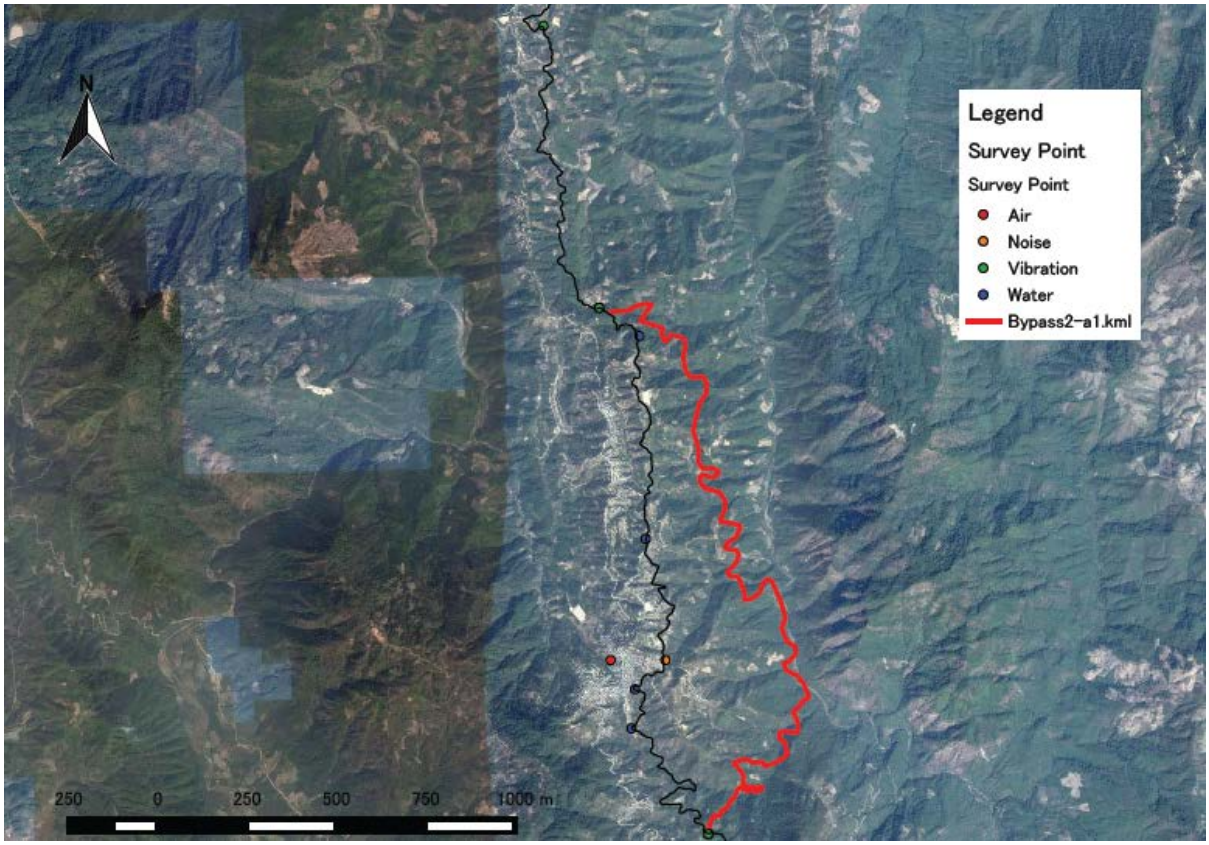
### 8.3.2 Living Environment

The survey points for air quality, water quality, noise, and vibration are shown through Figure 8.3-3 to Figure 8.3-6.



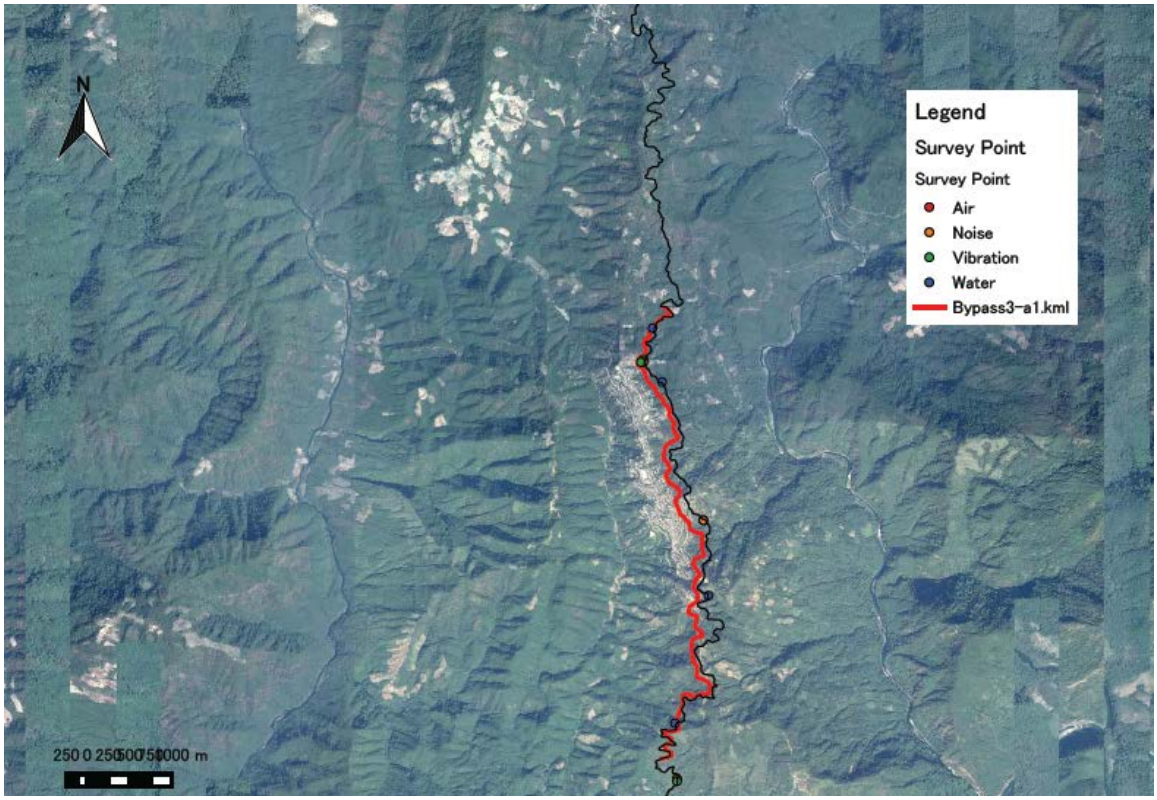

Source: JICA Study Team

**Figure 8.3-3 Survey Points for** Chhiahthlang **Bypass (BP1)**



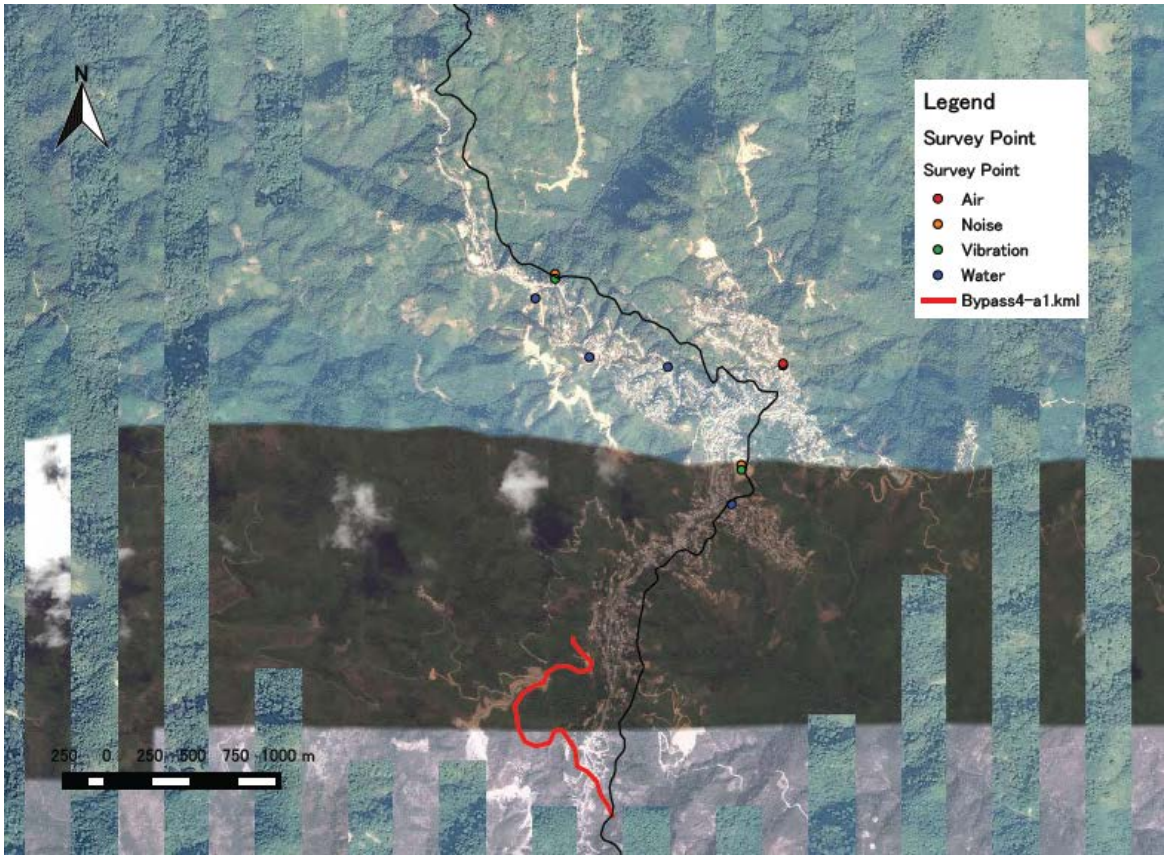

Source: JICA Study Team

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




Source: JICA Study Team

**Figure 8.3-5 Survey Points for Hnahthial Bypass (BP3)**




Source: JICA Study Team

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

The sections below present the summary of the 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 the baseline air quality scenario. The NAAQS Monitoring & Analysis Guidelines Volume-I, CPCB was followed for collection and analysis of the 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 Hnahthial 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 Table 8.3-8. On the basis of the tabulated data, it can be inferred that the concentrations of the measured parameters comply with the limits of the National Ambient Air Quality Standards, CPCB notification dated November 18, 2009.

**Table 8.3-8 National Ambient Air Quality Standards**

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

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

(i) Chhiahtlang (Bypass One)

Two ambient air quality stations were selected in the Chhiahtlang 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 Chhiahtlang ranged from 36 $\mu g/Nm^3$ to 52 $\mu g/Nm^3$ in the dry season, and ranged from 27 $\mu g/Nm^3$ 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 17 $\mu g/Nm^3$ to 32 $\mu g/Nm^3$ in the dry season, and ranged from 15 $\mu g/Nm^3$ to 20 $\mu g/Nm^3$ in the monsoon season

C) Sulphur dioxide ($SO_2$): The concentration of $SO_2$ ranged from 6 $\mu g/Nm^3$ to 12 $\mu g/Nm^3$ in the dry season, and ranged from <5 $\mu g/Nm^3$ to 7 $\mu g/Nm^3$ in the monsoon season.

D) Nitrogen oxide ($NO_x$): The concentration of NOx ranged from 12 $\mu g/Nm^3$ to 18 $\mu g/Nm^3$ in the dry season, and ranged from 7 $\mu g/Nm^3$ to 11 $\mu g/Nm^3$ 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.

(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 μg/Nm$^3$ to 12 μg/Nm$^3$ in the dry season, and ranged from <5 μg/Nm$^3$ to 9 μg/Nm$^3$ in the monsoon season.

D) Nitrogen oxide ($NO_x$): The concentration of NOx ranged from 12 μg/Nm$^3$ to 17 μg/Nm$^3$ in the dry season, and ranged from 8 μg/Nm$^3$ to 14 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.

(iii) Hnahthial (Bypass Three)
Three ambient air quality stations were selected in the Hnahthial 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 Hnahthial ranged from 37 μg/Nm$^3$ to 52 μg/Nm$^3$ in the dry season, and ranged from 29 μg/Nm$^3$ to 34 μg/Nm$^3$ in the monsoon season.

B) $PM_{2.5}$: The concentration of $PM_{2.5}$ at the AAQM station ranged from 18 μg/Nm$^3$ to 32 μg/Nm$^3$ in the dry season, and ranged from 15 μg/Nm$^3$ to 22 μg/Nm$^3$ in the monsoon season.

C) Sulphur dioxide ($SO_2$): The concentration of $SO_2$ ranged from 6 μg/Nm$^3$ to 9 μg/Nm$^3$ in the dry season, and ranged from 6 μg/Nm$^3$ to 8 μg/Nm$^3$ in the monsoon season.

D) Nitrogen oxide ($NO_x$): The concentration of NOx ranged from 12 μg/Nm$^3$ to 16 μg/Nm$^3$ in the dry season, and ranged from 9 μg/Nm$^3$ to 14 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.

(iv) Lawngtlai (Bypass Four)
Two ambient air quality stations were selected in the Lawngtlai bypass (near the 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 μg/Nm$^3$ to 62 μg/Nm$^3$ in the dry season. The $PM_{10}$ concentration at AOC Veng, Lawngtlai crossed the permissible limit of 60 μg/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 μg/Nm$^3$ to 35 μg/Nm$^3$ in the monsoon season.

B) $PM_{2.5}$: The concentration of $PM_{2.5}$ at the AAQM station ranged from 32 μg/Nm$^3$ to 41 μg/Nm$^3$ in the dry season, and ranged from 18 μg/Nm$^3$ to 23 μg/Nm$^3$ in the monsoon season.

C) Sulphur dioxide ($SO_2$): The concentration of $SO_2$ ranged from 7 μg/Nm$^3$ to 9 μg/Nm$^3$ in the dry season, and ranged from 6 μg/Nm$^3$ to 8 μg/Nm$^3$ in the monsoon season.

D) Nitrogen oxide ($NO_x$): The concentration of NOx ranged from 13 μg/Nm$^3$ to 16 μg/Nm$^3$ in the dry season, and ranged from 9 μg/Nm$^3$ to 14 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.

**(2) Ground and Surface Water Quality**

Under natural conditions, the water quality reflects the 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. In addition to this, 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, grease, and fluoride were below the detectable limit. Hardness of water, determined by the dissolved salts calcium and magnesium, was found to be in the range from 18 mg/l 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 with 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) Chhiahtlang (Bypass One)

One surface water sample, three ground water sample and one sample from community water tank were collected from different locations of Chhiahtlang. 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 the total coliform was detected in the community water tank (Chhiahtlang Sample 1) and surface water sample (Chhiahtlang 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 were well within the limits as per IS 10500:2012. The 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) Hnahthial (Bypass Three)

One surface water sample and three samples from community water tank were collected from different locations of Hnahthial. 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 were traces of total coliform in the surface water sample (Hnanthial Sample 1) and in one of the community water tank ((Hnahthial Sample 2).

(iv) Lawngtlai (Bypass Four)

Three ground water samples and one surface water sample were 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 were within the limits as per IS 10500:2012. The surface water sample (Lawngtlai Sample 4) showed the presence of the 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 the 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.

The 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 the Lutron SLM 4013. The sound levels in the study area are given in Table 8.3-9. The ambient standards with respect to the noise both for $Leq_{day}$ and $Leq_{night}$ and also with respect to the noise applicable for commercial areas were considered in the present study because the start and end points of the bypasses are mainly commercial areas.

**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) Chhiahthlang (Bypass One)

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

(ii) Serchhip (Bypass Two)

In the dry season, the maximum $L_{eq}$ was 64.5 and minimum was 61.7 during the day time, and the maximum and minimum $L_{eq}$ are 52.7 and 49.6, respectively, 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 $L_{eq}$ was 72.1 and minimum was 59.5 during day time. During night time the maximum and minimum $L_{eq}$ are 53.1 and 42.1, respectively. The sampling locations are in the commercial area with activities during the daytime so the ambient sound level is found to be higher.

(iii) Hnahthial (Bypass Three)

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

(iv) Lawngtlai (Bypass Four)

In the dry season, the maximum $L_{eq}$ was 65.4 and minimum was 61.5 during the day time, and the maximum and minimum $L_{eq}$ are 56.8 and 48.2 during night time. Since the study point (start and end points of the area) was near a busy commercial area, the ambient sound levels are slightly higher at Lawngtlai 2 AOC Veng during the daytime and night time. In the monsoon season, the maximum Leq was 68.4 and minimum was 56.3 during the day time. During night time, the maximum and minimum

Leq are 54.5 and 43.4, respectively. Since the study point (start and end points of the area) was near a busy commercial area, the ambient sound level is slightly higher at Lawngtlai 2 AOC Veng during daytime and night time.

2) **Vibration**

Vibration surveys were implemented at two points (the start point and the end point) for every bypass area and the summary of the results after two seasons are as follows:

(i) Chhiahthlang (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) Hnahthial (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).

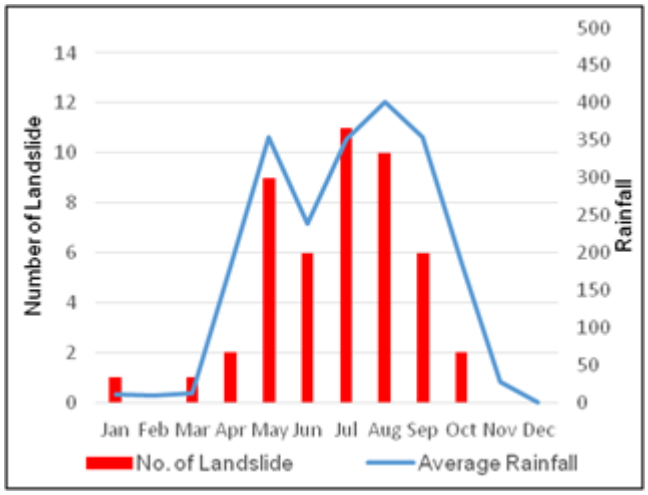
(iv) Lawngtlai (Bypass Four)
In the dry season, the maximum vibration is 1.85 mm/sec (rms). On the other hand, in the monsoon season, the maximum vibration is 1.98 mm/sec (rms).

There is no standard for vibration in India. While Japanese vibration standard is based on vibration acceleration, the baseline data above is based on vibration velocity. Due to the different measurement modes, the two figures cannot be directly compared, but the current baseline data is mostly below the level in which nuisance due to vibration is likely to start (maximum vibration velodcity amplitude 0.1 [in/s]) and thefore, it can be said that at the moment, vibration level is not likely to cause impacts to structures or trigger grievance. Meanwhile, Japanese standard of vibration and calculation method are used in the prediction of vibration impact in the construction and operation phase in section 8.6.2 (4) due to the lack of Indian standard.

**(4) Hazards**

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

In addition to the field identification of landslides, information on past landslide disasters in and around Mizoram states have been collected to ascertain the trend of natural hazards in the area. The number of landslide reported in the newspapers and academic papers from 1992 to 2015 is summarized in Figure 8.3-7. The figure clearly indicates an elevated risk of landslide during the monsoon season. In September 2014, a large landslide occurred near a PWD office in Laipuitang in Aizawl, killing 17 people and destroying 15 structures including the 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's name is 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 five major tribes and 11 minor tribes. The five major tribes are Lushai, Ralte, Hmar, Paite, and Pawi. Mizo is the official language and most widely used language for verbal interaction, 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, the total population of Mizoram was 1,097,206 with the Lushai tribes constituted the majority of the Mizo population. The population density of Mizoram is 52 per km$^2$. The literacy rate in Mizoram was 91.3% as per the 2011 census. District-wise and tribe-wise population of Mizoram is shown in Table 8.3-10. Out of the eight districts, four bypasses are located in the highlighted districts as shown in the table below.

**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 the four towns where the bypasses are located is shown in Table 8.3-11.

**Table 8.3-11 Population of Bypass Area**

| Town | No. of Household | No. of Population |
|---|---|---|
| Chhiahtlang | 815 | 4,071 |
| Serchhip | 4,085 | 21,158 |
| Hnahthial | 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 groups Bnei Menashe and a modernized traditional Mizo religion called Hnam sakhua, a religion that puts a particular emphasis on Mizo culture and seeks to revive traditional Mizo values. There are also a few tribal religions such as Lalchhungkua, Lalhnam, and Nunna Lalchhungkua.

**(2) Mizo Economy**

As per the available data, the Net State Domestic Product (NSDP) for the year 2012-2013 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 2004-2005 to 2012-2013 the economy of the state grew at a compound annual growth rate of 9.3%, with the 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%. These are summarized in Table 8.3-12.

**Table 8.3-12 Economic Growth of Mizoram**

| Sector | CAGR (2004-05 to 2012-13) |
|---|---|
| Agriculture and 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
Source: JICA Study Team

The main occupation of the people is agriculture. About 80% of the population are agriculturists. Rice is the main crop of Mizoram. 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, who 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 one of the most primitive types 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 change to the practice of 'jhum' by introducing 'terrace cultivation' which is ideal for hilly slopes. 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 are also grown. Anthurium is being sent for sale 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 Alternatives for Widening and Improvement of NH54 (1st Step)

The analysis of alterntives has been carried out in two stages. First, alternatives for widening of NH54 between Aizawl and Tuipang were carried out during the feasibility study in Phase I. The scope for alternatives was limited due to the hilly nature of the terrain and the nature of the project, which essentially aims to improve and widen the existing road. In developing a proposed preliminary road design, three concepts of alternatives have been considered and are shown in Table 8.4-1.

**Table 8.4-1 Concepts of Alternatives**

| No. | Option | Contents |
|---|---|---|
| 0 | Zero-Option (without the 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 will also undermine positive benefits of ongoing Kaladan Multimodal Transport Project, which provides an additional network from Mizoram to Haldia/Kolkata ports through the NH54 and the 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 the forest and will lead to higher project implementation costs. The number of traffic accidents will also increase due to the increased speed of vehicles passing through the built-up areas. |
| 2 | Selective widening considering social impacts | The level of widening will be minimized in heavily built-up areas to reduce the scale of resettlement. This option is desirable from a 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 an open forest. The bypass will be required in the longer-term to accommodate the project's increase in future traffic demand, but its environmental impact as well as economic feasibility will have to be studied in more detail. |

Source: JICA Study Team

The illustrative images of widening concepts are shown in Figure 8.4.-1 through Figure 8.4-3

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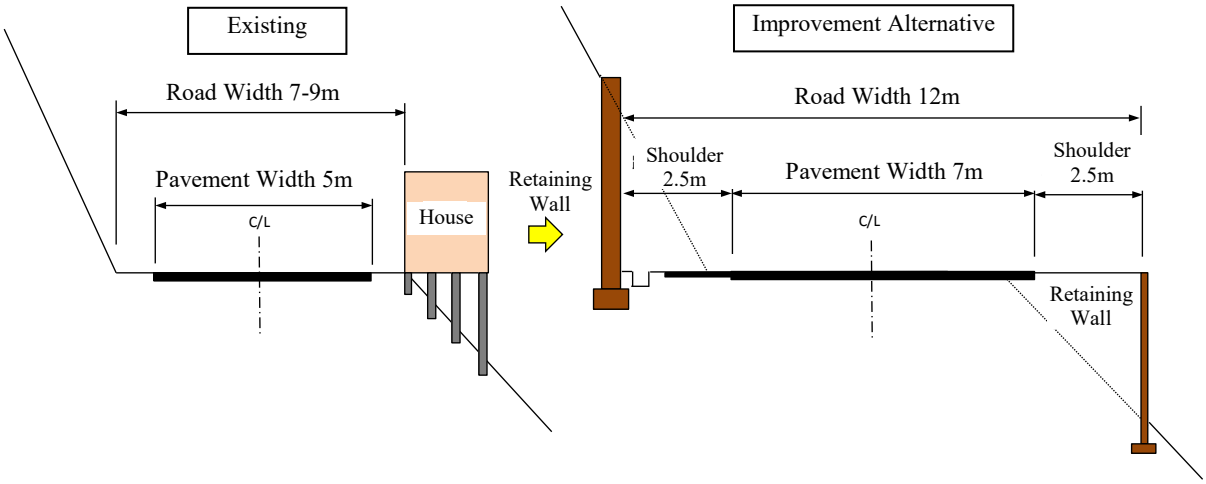
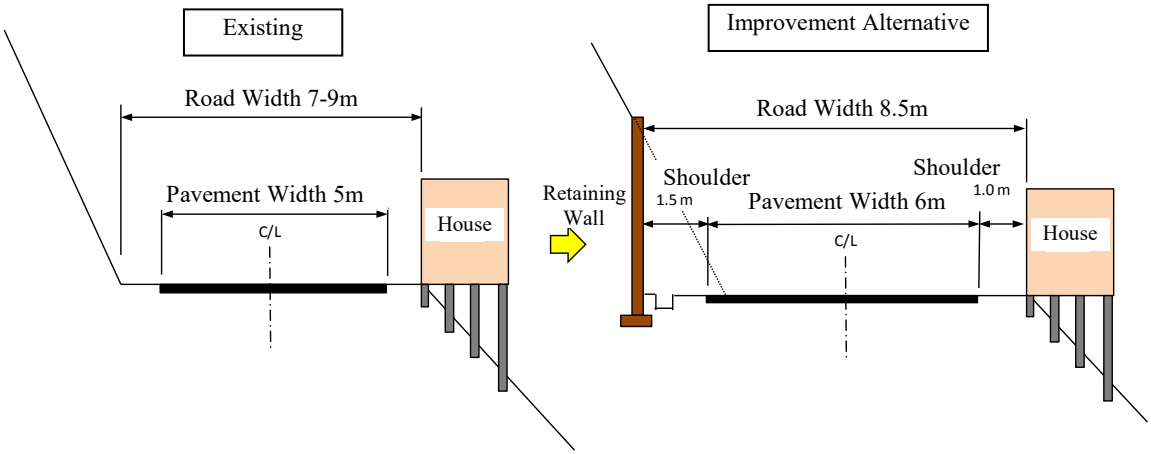


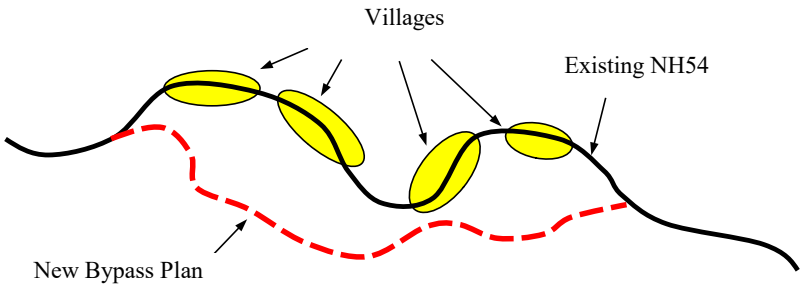

Source: JICA Study Team

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




Source: JICA Study Team

**Figure 8.4-2 Alternative Two (Limited Widening)**




Source: JICA Study Team

**Figure 8.4-3 Alternative Three (New Bypass)**

A comparison of the three options is provided in Table 8.4-2.

**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 suggests that expansion beyond 15 m can result in resettlement of more than 5,000 households. | △ ROW 12 m 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 (about 200 households) |
| Impact on Natural Environment | △ No immediate impact, but slope failure and soil erosion without proper management will eventually degrade the natural environment. | ◎ Limited impact as the engineering work will be limited in the side of the existing road | ◎ Limited impact as the engineering work will be limited on the side of the existing road | × A more detailed analysis is needed to assess the potential impact for a new bypass to be constructed in the 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 may result in traffic jams, which may offset some positive impacts. | ○ Widening will create a positive impact but greater traffic volume in major towns/villages may result into traffic jams, which may offset some positive impacts. | ◎ The positive impact will be biggest as the road is widened without causing traffic jams in major towns. |
| Pollution | × No immediate impact, but poor road condition and growing level of congestion will lead to elevated pollution level in the long-run, particularly in the built-up area. | ○ The option leads to the least level of congestion and thus least to relatively small increase in vehicular emissions. | △ More congestion will be expected compared with option one, but this will still lead to a better situation compared with without project scenario. | ◎ Traffic will not pass through the densely built up area and thus the health impact associated with the greater vehicular emission will be minimized. |
| Traffic Safety | × Likely to deteriorate further as no safety measures will be implemented. | ○ Proper safety measures including traffic signs will be required as the speed of vehicles passing through the built-up area is likely to increase. | ○ Proper safety measures including traffic signs will be required as the speed of vehicles passing through the built-up area is likely to increase. | ◎ The traffic does not pass through the densely built-up area and thus the risk of accident will be reduced. |

| Alternative | Zero Option | One | Two | Three |
|---|---|---|---|---|
| Technical Consideration | N/A | × The hilly side is expanded by cutting. Technically very difficult because in some areas, cutting of over 100 m hill is needed. | ◎ The direction of expansion (hilly side, slope side or both) is decided based on the condition of the slope and socio-economic situations. Efforts made to balance the volume of cut and fill as much as possible to reduce residual soil. | ◎ The bypass route is selected to minimize the risk of slope failure and soil erosion. Efforts made to balance the volume of cut and fill as much as possible to reduce residual soil. |
| 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 the three options, cost of constructing a new bypass will be significant. |
| Overall Evaluation (Ranking in bracket) | **4** | **3** | **1** | **2** |
| | Given the vulnerability of the existing road against landslide, and given the importance of infrastructure as key in the state, it is not recommended to keep the condition as it is. | The option will trigger significant resettlement. Given the limited availability of open and flat land, preparation of new resettlement site will be necessary. | The scale of widening is compromised in some areas, but this level of widening will be sufficient for carrying existing and projected traffic volume in the mid-term. | The scale of resettlement will be minimum, but the high cost associated with the bypass construction will undermine the economic viability of the project. |

Note: ◎: most desirable, best among the options; ○: 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 point of view, four major villages with over 4,000 population, namely: Chhiahtlang, Serchhip, Hnahthial and Lawngtlai, have been selected for bypass construction. Then, the 2nd step of analysis of alternative was conducted to select the optimal route for each bypass.

### 8.4.2 Analysis of Alternative for NH54 Bypasses (2nd Step)

The 2nd step of analysis of alternatives is for the four bypasses that have been identified in the feasibility study for widening and improvement of NH54. As discussed in Section 4.1, a total of ten 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 alternative has been assessed based on 1) the scale of land acquisition and resettlement, 2) impacts to natural environment (including the volume of spoil); 3) socio-economic impacts of project; 4) pollution; 5) traffic safety, including the risk of hazard; and 6) construction cost. Regarding the item 1), the number in the blacket shows the number of PAHs to be resettled. No blacket means that there will be only land physical resettlement (land acquisition only).

No land acquisition and resettlement are needed for zero-option and thus it has highest score for resettlement. The short-term impact to natural environment is also small in zero-option, but in the long-term, the congestion will have negative impacts on the environmenta and the limited road capacity will also become bottleneck for economic development. Poor geometry and slope condition are linked to low scores in pollution and traffic safety.

Due to the nature of the project, construction of new bypasses will have negative impacts on natural environment. But in the long-term, it will reduce congestion and the improved road network is expected to contribute to region's economic growth. Better geometric design, and road signs and slope protection to be introduced will improve road safety. The results of the alternative analysis are showin in Table 8.4-3.

**Table 8.4-3 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 | Resettlement | ◎ | △ (19 PAH) | △ (19 PAH) | -- | -- |
| | | Natural Environment | △ | × | × | -- | -- |
| | | Socio-economic | △ | ○ | ○ | -- | -- |
| | | Pollution | × | △ | △ | | |
| | | Traffic Safety | × | ○ | ○ | -- | -- |
| | | Construction Cost | N/A | × | ○ | | |
| | | **OVERALL RANKING** | **3** | **2** | **1** | **--** | **--** |
| 2 | Serchhip Bypass | Resettlement | ◎ | × (11 PAH) | △ (1 PAH) | △ (1 PAH) | × (4 PAH) |
| | | Natural Environment | △ | × | × | × | × |
| | | Socio-economic | △ | ○ | ○ | ○ | ○ |
| | | Pollution | × | × | △ | △ | △ |
| | | Traffic Safety | × | △ | ◎ | ○ | ○ |
| | | Construction cost | N/A | × | ◎ | △ | ○ |
| | | **OVERALL RANKING** | **5** | **4** | **1** | **2** | **3** |
| 3 | Hnahthial Bypass | Resettlement | ◎ | △ | △ | -- | -- |
| | | Natural Environment | △ | × | × | -- | -- |
| | | Socio-economic | △ | × | × | | |
| | | Pollution | × | △ | △ | | |
| | | Traffic Safety | × | ○ | ◎ | -- | -- |
| | | Construction cost | N/A | ○ | ◎ | -- | -- |
| | | **OVERALL RANKING** | **3** | **2** | **1** | **--** | **--** |
| 4 | Lawngtlai Bypass | Resettlement | ◎ | × (2 PAH) | △ (0 PAH) | -- | -- |
| | | Natural Environment | △ | × | △ | -- | -- |
| | | Socio-economic | △ | 2 | 1 | -- | -- |
| | | Pollution | × | △ | △ | | |

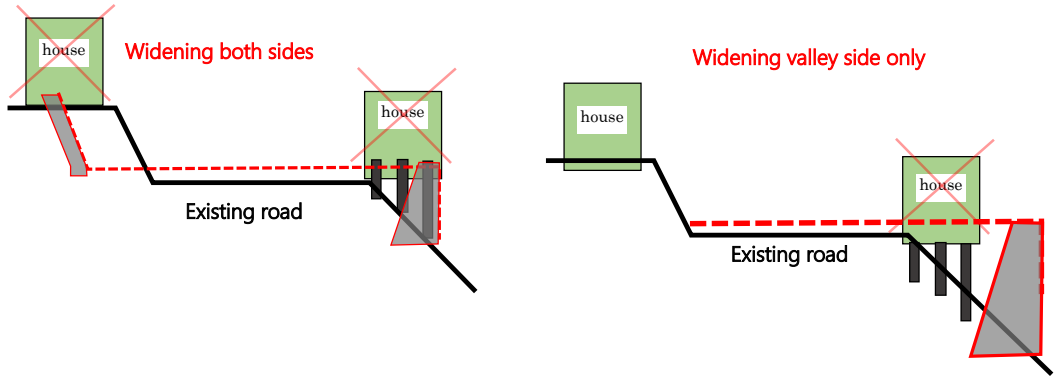
| Bypass No. | Bypass Name | Items for Analysis | Ranking for Each Alternative | | | | |
|---|---|---|---|---|---|---|---|
| | | | Alternate-0 | Alternate-1 | Alternate-2 | Alternate-3 | Alternate-4 |
| | | Traffic Safety | × | ○ | ◎ | | |
| | | Construction cost | N/A | ○ | ◎ | -- | -- |
| | | **OVERALL RANKING** | **3** | **2** | **1** | **--** | **--** |

The highlighted cells are for the Optimum Route, which is Alternative-2 for each bypass.

Source: JICA Study Team

The comparison in the 1st step (Table 8.4-2) targets the entire stretch of NH54 (approx. 350 km) while the comparison in the 2nd step (Table 8.4-3) targets the four bypasses (approximately 25 km) only. Involuntary resettlement of around 200 households is expected in alternative No. 3 of Step 1. This is a preliminary figure estimated based on the assumption that all 48 villages along NH54 will be bypassed. Meanwhile, the number of resettled Project Affected Households (PAHs) in Step 2 analysis was reduced from the initial 60 PAHs to 20 PAHs as a result of route selection that minimizes the scope of resettlement.

Bypass one passes through the existing community road near the ending point. As shown in Figure 8.4-4, widening both sides of the community road will result in the demolishment of houses and other structures in both sides. In contrast, widening of the 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. See Chapter 4 for more detailed comparison of the bypass routes.




Source: JICA Study Team

**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 the 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, naturalenvironment and social environment, health and safety, emergency risk, and others were classified through 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 8.5-1. Scoping was conducted toward the construction of the four bypasses. Description of resettlement-related items are for bypasses 1 and 2 only because there will be no resettlement in bypasses 3 and 4. 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, these are referred to as P, C, and O, respectively.

**Table 8.5-1 Scoping Matrix for NH54 Bypass Construction**

| Sl. No. | 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: Impacts on topographic condition during the operation phase is not expected. |
| **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 the 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 culverts 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 mainly near the existing road. However, construction work will affect the mountain ecosystem and local flora and fauna including jhum and plantation. |

| Sl. No. | Item | Scoping Result | | | Rational of Assessment |
|---|---|---|---|---|---|
| | | P | C | O | |
| | | | | | O: Increases in emissions due to the greater traffic volume will negatively affect the forest and surrounding ecosystem. Monitoring shall be carried out to check the impact of increased emissions on the forest/plantation (e.g. additional plantation) shall be undertaken to mitigate negative impacts as necessary. |
| **1.8** | Protected Areas | C | C | C | P/C/O: The bypasses do not traverse or border with national parks or protected forests. Meanwhile, potential indirect impacts on nearby protected areas will need to be assessed continuously. |
| **1.9** | Coastal Zone | D | D | D | P/C/O: No impacts are expected, because the alignment is far from the coastal zone and the planned alignment will not pass through the tidelands and the mangrove forests which are peculiar to the coastal region. |
| **1.10** | Landscape | D | D | D | P: No impact is expected since the project at this stage does not alter existing conditions. |
| | | | | | C: Changes in landscape during the construction work will be minor and temporary. |
| | | | | | O: No impact is expected since the project at this stage does not alter existing conditions. |
| **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 disasters. |
| **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 conditions. |
| | | | | | C: Some negative impacts are expected due to the 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 authorities 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 conditions. |
| | | | | | 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. |

| Sl. No. | Item | Scoping Result | | | Rational of Assessment |
|---|---|---|---|---|---|
| | | P | C | O | |
| **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 the 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 the soil along the road is already polluted. |
| | | | | | O: No impact is expected except for the risk of accidental spillage of oil and lubricants, 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 the 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 during parts of the day. |
| | | | | | O: Noise and vibration levels are likely to increase due to the 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. Construction of workers' camp may also result in temporary impact. |
| | | | | | C: Resettlement will be completed before the 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 the 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 the land clearance for construction yards and workers camps is temporary. |
| | | | | | No impact is expected as sufficient slope protection/ stabilization measures are set up 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 the utilization by the local people for other purposes. |
| | | | | | O: No impact is expected as use of the local resources is not expected during operation. |

| Sl. No. | Item | Scoping Result | | | Rational of Assessment |
|---|---|---|---|---|---|
| | | P | C | O | |
| **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 centers and public halls may be used as venues 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 yards 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 a 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. Impacts on jhum cultivation will also need to be assessed. |
| | | | | | C: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economic and livelihood. Impacts of construction work on jhum cultivation will also need to be assessed. On the other hand, construction work will have a positive impact on local economy by creating employment and business opportunities in the project area. |
| | | | | | O: The project will have a 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 damages between groups who are directly affected by the project and as well as those who are not. |
| | | | | | C: While resettling households bring 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: Overwhelming majority of the population in the area are Mizo and there is no ethinic conflict nor communication problem due to language. The proposed bypasses have broad community support and thus it is unlilely that the project will triger local conflicts of interest. |
| **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- | B- | P: The local graveyard is located near the proposed bypass alignment (BP1), and memorial stones located at the existing road (BP2) may be affected. Small religious facilities in built-up areas may also be affected. |

| Sl. No. | Item | Scoping Result | | | Rational of Assessment |
|---|---|---|---|---|---|
| | | P | C | O | |
| | | | | | C: Roadside religious facilities may be affected by noise and vibration during construction and operation due to construction work and greater traffic volume. |
| | | | | | O: Increases in traffic volume and speed and/or congstion may affect roadside religious facilities. |
| **3.13** | Sensitive Facilities (ex. hospital, school, precision machine factory) | B- | B- | B- | P: The 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. Adequate mitigation measures should 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 the 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 | B- | C | D | P: Resettlement may affect children's acces to school. |
| | | | | | C：Child labor is unlawful according to article 24 of Indian Constitution. Only adults are eligible for potential employment opportunity created by the project. |
| | | | | | O: No impact is expected. |
| **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 a 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 an 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 conditions. |

| Sl. No. | Item | Scoping Result | | | Rational of Assessment |
|---|---|---|---|---|---|
| | | P | C | O | |
| | | | | | C: Increase risk of accidents associated with construction activities is expected due to the operation of heavy equipment and vehicles. |
| | | | | | O: Risk 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 forests 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 the 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

The project is likely to trigger posive and negative impacts in many forms. This section will discuss likely impacts in each stage of the project and how they are mitigated. The assessment has been carried out based on the review of existing literature and field surveys. The TOR for the environmental surveys is shown in Table 8.6-1.

**Table 8.6-1 TOR of Environmental Survey**

| | Issues | Tasks | Data Collection Methodology | Evaluation Method |
|---|---|---|---|---|
| Natural Environment | Topography | ① Selection of spoil soil dumping sites | ①Topographic survey | Evaluation the impact by field survey and comparison with relevant projects (e.g. road project in Mizoram funded by World Bank), and based on the proposed design of the bypass (e.g. cut and fill volume). |
| | Soil Erosion | ① Confirmation of soil data of the project area | ①Collection of existing data | Evaluation the impact by field survey and comparison with relevant projects (e.g. road project in Mizoram funded by World Bank), and based on the proposed design of the bypass (e.g. cut and fill volume). |
| | Hydrology | ① Confirmation of the river and | ①Collection of existing | Evaluate the impact by field survey and study of |

| | Issues | Tasks | Data Collection Methodology | Evaluation Method |
|---|---|---|---|---|
| | | streams information of the project area | information<br>②Field survey | hydrological assessment, based on which the design of culvert will be decided. |
| | Groundwater | ① Confirmation of the use of groundwater | ①Interview at site | Field survey and literature review |
| | Ecosystem, Flora, Fauna and Bioderversity, Forest | ① Field study of local ecosystem | ①Collection of existing information<br>②field survey | Following will be reviewed:<br>・ Typical ecosystem of the project area, flola and fauna in different land use (settlement, jhum, natural forest and plantation) will be assessed.<br>・ Field survey in four bypass sites in two seasons<br>・ Interviews with officers and local leaders about the presence of vulnerable species<br>・ Types, size and distribution of roadside trees<br>・ Existing literature about the local ecosystem and assessment of relevant projects |
| | Protected Area | ① Confirmation of protected area and forest reserves in the project area | ①Collection of existing data (government statistics) | ・ Interviews with officers and local leaders about the conditions of nearby protected area (WLS) and surrounding environment.<br>・ Review of existing literature and assessment of relevant project to assess likely indirect impacts |
| Living Environment | Air Pollution | ① confirmation of the Indian standards<br>② Collection of baseline data<br>③ Confirmation of sensitive receptiors such as school and churches | ① Collection of existing data<br>②Baseline survey<br>③Field serveys and interviews | ・ Baseline survey along the monitoring points<br>・ Evaluation agaist the Indian standard |
| | Water Pollution | ① Confirmation of the Indian standards<br>② Collection of baseline data (surface water and ground water) | ① Collection of existing data<br>②Baseline survey | ・ Baseline survey of surface and ground water quality<br>・ Evaluation agaist the Indian standard |
| | Soil Contamination | ① Confirmation of wastes and hazardous materials which might cause soil contamination | ① Review of relevant projects | Literature review |
| | Noise and vibration | ① Confirmation of Indian (noise) and the Japanese | ① Collection of existing data<br>②Baseline survey | ・ Baseline survey of noise and vibration<br>・ Evaluation against the Indian |

| | Issues | Tasks | Data Collection Methodology | Evaluation Method |
|---|---|---|---|---|
| | | (vibration) standards<br>②Baseline survey<br>③ Confirmation of sensitive receptiors such as school and churches<br>④ Assessment of likely impacts in the future | ③Field survey<br>④ Prediction of impacts based on the future traffic demand | and International standards (no vibration standard in India). |
| | Wastes/Hazardous Materials | ① Confirmation of wastes and hazardous materials which might cause soil contamination<br>② Selection of soil dumping sites | ① Topographic survey<br>②Local interview | Review of existing waste treatment mechanismand assessment of likely volume and types of wastes to be generated |
| Social Environment | Involuntary Resettlement | ① Confirmation of affected PAH<br>② Confirmation of demand and asipirations of PAH | ①Baseline survey<br>② Consultation and interviews | Census survey, interviws and consultation meetings |
| | Land Use | ① Confirmation of existing conditions in the project area | ①Local interviews<br>②Field survey | Assessment based on the field survey and review of similar projects |
| | Utilization of local resources | ① Confirmation of likely impacts due to project | ①Field survey<br>② Collection of existing information | Assessment based on the economic condition of Mizoram and likely impacts of the project (inc. necessary materials extraction, workers to be employed) |
| | Social Infrastructure and Services | ① Confirmation of existing conditions in the project area | ①Local interviews<br>②Field survey | Field survey to count/assess the number of electric poles, water pipes, well and other social infrasctures, to be completemend by hearing with relevant local authorities. |
| | Unequal Distribution of Benefit and Damage | ① Confirmation of existing conditions in the project area | ①Local interviews | Interviews with local leaders and field survey and review of assessment in similar projects |
| | Religious Facilities and other sensitive facilities | ① Confirmation of existing conditions in the project area | ①Local interviews<br>②Field survey | ・ Field survey to identify road site religious and sensitive facilities<br>・ Evaluate likely impacts based on the assessment of noise and vibration impact |
| | Poor People | ① Confirmation of existing conditions in the project area | ①Baseline survey | Comparison of census data with Indian poverty line |
| | Ethnic Minorities/ Indigenous People | ① Confirmation of existing conditions in the project area | ①Baseline survey | Field survey and comparison with relevant projects |
| | Gender | ① Confirmation of existing conditions in the project area | ①Baseline survey | Field survey and interview with local NGO |

| | Issues | Tasks | Data Collection Methodology | Evaluation Method |
|---|---|---|---|---|
| | Children's Right | ① Confirmation of actual condition of child labor in the project area | ①Field survey<br>②Literature Review | Conform the actual condition of child labor in Mizoram based on the field survey and literature review |
| | Public Health (sanitation and infectious diseases) | ① Review and proposal of mitigation measures | Comparison with relevant projects | Review of literature and comparison with similar projects |
| | Accidents | ① Review and proposal of mitigation measures | Comparison with relevant projects | Consider mitigation measures (to be included in road design) based on the review of literature and comparison with similar projects |
| | GHG Emissions | ① Confirmation of existing conditions in the project area<br>② Assessment of impacts due to forest clearing and reforestation | ① Collection of existing data | Consider adaptation measures such as compensatory plantation based on the review of literature and comparison with similar projects |

Source: JICA Study Team

### (1) Topography and Geology

Pre-Construction and Construction Phase

The change in topography (that of existing) is envisaged in the sections where new bypasses are constructed particularly in hilly and mountaneous slopes. The change in topography will also happen due to the 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 the monsoon season, the change in the topography will also be visible due to landslides and damage to the 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 from road and bridge construction standard. The borrow areas shall be filled with the rejected waste/material, spoils and then finally a layer of topsoil shall be spread over the areas before carrying out the plantation and turfing.

During the operation phase, maintenance of the 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.

### (2) Soil Erosion

Pre-Construction and Construction Phase

Site preparation will involve demolition of buildings, 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 the 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 the operation stage may take place during operation at side slopes of road and near the interchanges. The risk is higher during monsoon season.

Mitigation Measures

To control the roadside soil erosion, turfing with grasses and shrubs will be carried out in accordance with the recommended practice in the 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 the road is designed as concrete lined ditch for all sections of the cut side to prevent damage from water runoff.

**(3) 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 the increase in impervious surface and sediments and this in turn will be accumulated in nearby water bodies.

Mitigation Measures

The new drainage system is designed by basing it on hydrological calculation results. Based on the obtained location of water crossing and water discharge, dimension and locations for the drainage system are determined. For cross drainage structures, appropriate culvert type is selected by taking account of economy, construction workability, and maintenance ability. In principle, a pipe culvert is used where the water discharge is comparably small. A box culvert is proposed where the water discharge is comparable large. The size is determined to satisfy the water discharge obtained by hydrological calculation.

**(4) Groundwater**

No tunnel is proposed in this project and as such, the project will not affect the groundwater level or quality in the area. If the contractor proposes to use water from under the 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.

**(5) Ecosystem, Flora, Fauna and Biodiversity**

Pre-Construction and Construction Phase

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 the natural parks 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 fields, fallows or plantations. Natural vegetation grow in fallow areas but they are to be burned in the next cycle of jhum farming.

Flora and fauna assessments 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 10 m x 10 m, for shrubs 5 m x 5 m and for herbs 1 m x1 m 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, while secondary data were gathered 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 the 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 the spoil bank.

Deforestation is one of the main causes of climate change. The project clears forests 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 are jhum fields, which is regularly burned yearly with considerable GHG emissions, the impact of the project in terms of GHG emission volume will be minimal. Yet, as per the requirement of the Forest Act, the project will undertake reforestation to compensate for 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 a net increase in carbon sequestration capacity in the state in the long-term. The detailed terms and conditions of reforestation will be finalized in cooperation with the Environment and Forest Department of the State.

Operation Phase

Increases in emission resulting from greater traffic volime will negatively affect the ecosustem and forest. In addition, improved road network may trigger poaching.

Mitigation Measures

In the process of finalizing the 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 cleared 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 locations (either degraded forests or vacant/abandoned jhum areas).

During the operation stage, monitoring shall be carried out to check the impact of increased emissions on the forest/plantation and measures (e.g. additional plantation) shall be undertaken to mitigate negative impacts as necessary. All data related to the increased traffic volume and emissions shall be shared with relevant state authorities.

At the moment, educational activities and removal of traps by rangers are undertaken to reduce poaching. While the NHIDCL is not responsible for the control of poaching, a proposal shall be made to relevant authorities regarding the potential increase in poaching and the necessity of adequate management systems, such as restriction of precious wildlife trade.

**(6) Protected Areas**

Pre-Construction and Construction Phase
The project road does not traverse or border with national parks, wildlife sanctuaries or reserved forests. As discussed above, however, three wildlife sanctuaries are located near the area (but more than 10 km away).

Operation Phase
Increase in traffic volume are likely to have negative impact on the forest ecosystem.

Mitigation Measures
The conditions of these WLS are periodically monitored by the Governemnt of Mizoram. NHIDCL will review this information, and in case it is likely that these WLS are negatively affected by the bypasses, discuss with relevant State authorities to develop effective mitigation measures.

**(7) Hazards**

Construction and Operation Phase
Land slide are common hazard of the existing NH54. Given the topographic nature and climatic condition of the bypass route, the new bypasses are also prone to the risk of landslide.

Mitigation Measures
First of all, the areas that are of high risk of land slide will be avoided when bypass route is selected. The risk of landslide will be mitigated by installation of proper slope protection and drainabge, and their maintenance. The details of the slope protection and drainage are described in section 5.2.4 and 5.2.6 respectively.

### 8.6.2 Living Environment

**(1) Air Quality**

Hills, towns and villages along the 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 the major built-up area. This leads to vehicular exhaust emissions and deterioration for which the proposed bypasses will have a positive impact.

Pre-Construction and Construction Phase
The short-term and localized degradation of air quality will occur from dust generation due to the 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 the 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 the construction camps. During the construction of the roads, the movement of different types of construction machinery and vehicles will increase. This increases 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 the construction period but for a 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 be felt downwind of the site rather than on-site due to the local wind pattern.

Operation Phase
The project road is mostly passing through the rural areas with alluvial soil. Dust generation due to the movement of vehicles is envisaged along the project road, but not in a significant amount. Due to the increase in speed and volume of vehicular traffic on the project corridor, marginal increase in the air pollutant levels is expected but it is not significant enough to cause a big impact. The widening of

the road will attract larger communities to use this corridor which in-turn increase the fuel consumption and would therefore have a direct impact on the 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 a 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 sites and temporary service and access roads. After compacting the earthwork, water will be sprayed to prevent dust emission. The vehicles delivering construction materials 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, the projected increase in traffic volume, particularly ones of heavy trucks, may pose health threats in the roadside community. The peak hourly estimated traffic volumes for the years 2020 and 2035 have been considered to project the future air quality scenarios to provide an indication of long-term variations in the 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 $NO_x$ levels) will remain below the standard during the projected period (2035). Nevertheless, mitigation measures such as introducing a speed limit and other measures to control congestion in the 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 campaigns may include distribution of facemask to mitigate the risk of air pollution as well as distribution of other information kits will be taken up.

### (2) Water Quality

Pre-Construction and Construction Phase

The bypasses may marginally lead to increased run-off during the 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 the 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, the 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, canals and rivers. The 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 purposes.

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 the water bodies will be avoided during the monsoon period. All necessary precautions will be taken to construct temporary or permanent devices to prevent water pollution due to the 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 the 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 the contamination of water.

**(3) Soil Contamination**

Pre-Construction and Construction Phase

The contamination of soil during the construction stage is primarily due to construction and allied activities. The soil contamination may take place due to the solid waste from the labor camps set-up during the 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 the 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 low but potentially disastrous to the receiving environment, should they occur. These impacts can, in the long-term, be 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 do 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 earthworks 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 the highway.

In the operation stage, the petrol pumps and vehicle washing areas located along the ROW will be monitored regularly for any spillages and corrective remedial measures like spread of sand, provision of oil and greases separators for passing wash water of petrol pumps and 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 which are both organic and inorganic, hazardous waste (like used batteries). The wastes will be treated in accordance with the Municipal Solid Waste (Management and Handling) Rule and Hazardous Waste (Management, Handling and Transboundary Movement) Rules.

**(4) Noise and Vibration**

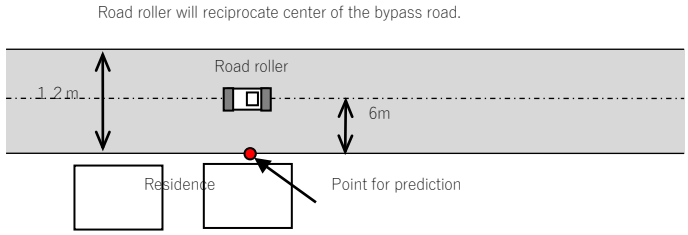
Pre-Construction and Construction Phas Impact

The short-term impact of noise and vibration will occur for local residents near the construction area. Most of the construction areas are far from residential areas excluding start/end points, then only the persons who live near start/end points may be affected. Bypass construction includes civil works (e.g.,

drilling and filling), pavement works, drainage works, bridge works and slope protection works, however, significant construction works (e.g., civil work, slope protection work, etc.) will not be implemented. Therefore, the prediction targetsonly pavement work.

- Method of prediction and evaluation
  Prediction of noise during construction were calculated based on the propagation theory and compared with environmental standards in India. Prediction of vibration were calculated by using the Bornitz formula and compared with the Vibration Regulation Law in Japan because there is no related regulations in India.
- Condition of prediction
  The prediction condition for noise and vibration are shown in Table 8.6-2.

**Table 8.6-2 Prediction Condition for Noise and Vibration by Construction Machines**

| Item | Condition | Remarks |
|---|---|---|
| Target | Pavement Work | |
| Construction Machine | Roller | |
| Construction Condition | Velocity 5 km/hour<br>Frequency 10 times/day | |
| "A" weighted sound power level | 104 dB<br>(Road Roler) | Source: Acoustical Society of Japan (ASJ) Prediction Model 2007 for Construction Noise Report |
| Vibration Level at Standard Position | 59 dB<br>(Asphalt pavement work, upper and under layer) | Source: Environmental Impact Assessment Technique for Road Project edition of FY 2012 (National Institute for land and infrastructure management) |
| Attenuation Coefficient of Ground Vibration | 0.01 | |
| Construction Location |  | |

Source: JICA Study Team

- Result of prediction
  The result of prediction and evaluation are described in Table 8.6-3. Both impacts of noise and vibration fall within the standards.

**Table 8.6-3 Prediction Result for Noise and Vibration by Construction Machines**

| Item | Prediction Result | Evaluation Criteria |
|---|---|---|
| Noise ($LA_{eq}$) | 53.9 dB | 65 dB (day time) |
| Vibration ($L_{10}$) | 57.7 dB | 70 dB |

Source: JICA Study Team

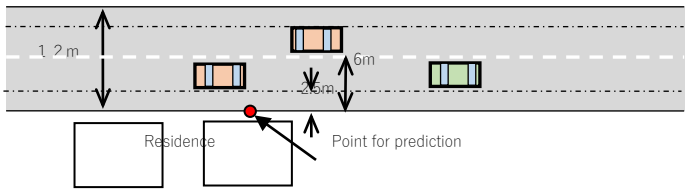
Most of the construction area are passing in the forest far from residential area. Therefore, it is necessary to consider the impact of noise and vibration for sensitive facilities near start/end points. Regarding the start point of Chhiahtlang bypass, one elementary school is located 50 m to the south and one church named Presbyterian Kohhran Chhiahtlang is located 170 m to the south. These facilities are not remarkably close to the construction site, but it is necessary to consider the time of class or event.

Operation Stage Impacts

Noise and vibration from vehicles passing by new bypasses and its impact for to local residents near bypasses will occur.

- Method of prediction and evaluation
  Prediction of noise during operation was calculated based on ASJ-RTN Model 2013 by Acoustical Society of Japan which was developed based on energy and compared with noise standard in India. Prediction of vibration was calculated based on the proposed formula by the Public Works Research Institute in Japan based on the results of driving tests and compared with the limit value of request to road manager defined in the Vibration Regulation Law in Japan.
- Condition of prediction
  Prediction condition for noise and vibration are shown in below table.

**Table 8.6-4 Prediction Condition for Noise and Vibration during Operation**

<table>
<tr><th>Item</th><th>Condition</th><th>Remarks</th></tr>
<tr><td>Basic Information</td><td>Two-lane</td><td>Width 2.5 ＋ 3.5 ＋ 3.5 ＋ 2.5 = 12.0 m</td></tr>
<tr><td>Design Speed</td><td>40 km/h</td><td></td></tr>
<tr><td>Running Condition</td><td>Non-steady</td><td></td></tr>
<tr><td>“A” weighted sound power level</td><td>Large Vehicle: $88.8+10\cdot\log_{10}V$<br>Compact Vehicle: $82.3+10\cdot\log_{10}V$</td><td>Source: Acoustical Society of Japan (ASJ) Prediction Model 2013 for Road Traffic Noise Report</td></tr>
<tr><td>Natural Frequency of Ground</td><td>8 Hz</td><td>*Assumption</td></tr>
<tr><td>Target Year</td><td>2040</td><td></td></tr>
<tr><td>Volume of Traffic</td><td colspan="2">Volume of Traffic for Bypass (2040)
<table>
<tr><th>Line</th><th>Standard</th><th>Bus</th><th>Auto Rickshaw</th><th>Two-wheeled</th><th>Compact (Commerce)</th><th>Truck</th></tr>
<tr><td>Chhiahtlang (No.1)</td><td>2052</td><td>38</td><td>29</td><td>885</td><td>580</td><td>63</td></tr>
<tr><td>Serchhip (No.2)</td><td>2049</td><td>0</td><td>264</td><td>988</td><td>649</td><td>131</td></tr>
<tr><td>Hnahthial (No.3)</td><td>1469</td><td>0</td><td>99</td><td>754</td><td>542</td><td>115</td></tr>
<tr><td>Lawngai (No.4)</td><td>1783</td><td>0</td><td>169</td><td>654</td><td>592</td><td>145</td></tr>
</table></td></tr>
<tr><td>Running Location</td><td colspan="2"> 
</td></tr>
</table>

Source: JICA Study Team

- Result of Prediction
  The results of the prediction and evaluation are described in Table 8.6-5. Both impacts of noise and vibration will fall within the standards.

**Table 8.6-5 Prediction Result for Noise and Vibration by Construction Machines**

| Item | Prediction Result | | Evaluation Criteria |
|---|---|---|---|
| Noise (LAeq) | Chhiahtlang bypass (No.1) | 64.4dB | 65dB (Day time) |
| | Serchhip bypass (No.2) | 64.6dB | |
| | Hnahthial bypass (No.3) | 63.5dB | |
| | Lawngtlai bypass (No.4) | 64.3dB | |
| Vibration ($L_{10}$) | Chhiahtlang bypass (No.1) | 42.9dB | 70dB |
| | Serchhip bypass (No.2) | 43.4dB | |
| | Hnahthial bypass (No.3) | 42.3dB | |
| | Lawngtlai bypass (No.4) | 43.3dB | |

Source: JICA Study Team

Mitigation Measures

The high noise and vibration levels may cause discomfort to local residents and workers. 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 the 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 90 dB(A);
- In construction sites within 150 m of human settlements, noisy construction will be stopped between 10:00 PM and 6:00 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 should be scheduled so as to 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 a 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 8.6-6.

**Table 8.6-6 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 of the composition of construction waste will depend on the final design and the schedule of the construction, and thus generic mitigation measures proposed in the 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 the NH54 Bypass, the necessary volume of spoil banks has been calculated as below.

**Table 8.6-7 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 the NH-54 Bypass with the following conditions;
  - 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 30 m in 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 creation of playgrounds. The proper measure will be applied to each spoil bank to prevent soil erosion (and damage to the jhum fields), which was one of the key concerns raised during consultation meetings.

### 8.6.3 Socio-Economic Environment

#### (1) Involuntary Resettlement

Pre-Construction Phase Impact

As per the preliminary ROW design, the project will affect 257 houholds (1,485 persons). Out of those, 20 households (133 persons), which include four houses including shops, will be resettled. The baseline condition of PAH is presented in section 8.10.

Mitigation Measures

Compensation will be provided at replacement cost prior to the commencement of the construction work. Support to restore the livelihood and additional assistance to vulnerable group will also be provided. Two rounds of consultations showed their strong support towards the project. Also, it was confirmed that they prefer cash compensation over land-for-land compensation. The proposed compensation package is presented in the Entitlement Matrix in section 8.11.

#### (2) Land Use

Pre-Construction Phase Impact

The construction of the bypass and spoil bank will cause changes in the land use pattern, affecting existing agricultural and plantation activities.

Mitigation Measures

For sections where the proposed alignment passes through the forest, jhum area and plantation, engineering work should be scheduled in a way to minimize the disruption of access of the local people. At the same time, proper management of effluent and soil erosion shall be carried out to avoid negative impacts on such resources.

**(3) Utilization of Local Resources**

Construction Phase Impact

Significant volume of local resources such as sand may be used for construction work. This could cloud the use of such resources for other purposes in the short-term.

Mitigation Measures

While the project overall will have significant positive impacts on the local and regional economy, the short term negative impact due to extensive use of local resources should be avoided by careful planning of material extraction.

**(4) General, Regional /City Plans**

The project will create new opportunities for village and district-level development planning. In particular, the construction of the spoil bank will create a large area of flat land where such surface is a scarce commodity. The development of the spoil bank, therefore, should be coordinated with the village/district development plan so that the land will benefit the community.

**(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**

Construction Phase Impact

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. There is a small pre-school near the starting point of BP1. Also, one water point and two public toilets exist near the ending point of BP1, and one water point, one public toilet, and one memorial stone near the ending point of BP2 will be affected

Mitigation Measures

The pre-school can be shifted since there is an open space behind it. Water points, public toilets, and a memorial stone will be relocated prior to the commencement of construction work to minimize the disturbance to the local community. The water points are not permanent structure (the water from outside of the affected area is brough to a convenient place for the resident via hose) and thus can be shifted easily by extending the hose. 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 an alternative plan accordingly.

**(7) Local Economy and Livelihood**

Pre-Construction, Construction and Operation Phase Impact

There will be loss of livelihood due to resettlement. Also, significant impact is expected for shops/business located near the starting/end points of the bypasses which will be relocated. Jhum cultivation along the proposed bypass route will be directly affected. In addition, the access to farmald may be restricted due to resettlement. When the existing farmlad is bisected by the new bypass, there is a risk of damage due to soil erosion or water runoff from the road.

Mitigation Measures

State and village land are available near the proposed bypass route and thus PAHs should be able to purchase or to be allocated the residential land or jhum land near not far from their original locations. For avoidance and mitigation of damage due to erosion, mitigation measures described in section 8.6.1(3) will be implemented.

**(8) Unequal Distribution of Benefit and Damage**

Pre-Construction and Construction Phase Impact

Roadside or near-road location offers critical advantages for local business (tea stalls, restaurant, petty shops). Resettlement to the inner part of the village may significantly undermine the viability of these businesses, and therefore, business owners that are affected may be worse off compared with farmers to be relocated.

Mitigation Measures

Compensation should be provided at the replacement cost prior to the commencement of the construction work (and before the resettlement for to be relocated PAH). Also, R&R activities will be implemented to ensure that PAHs will be able to, at least, restore their livelihood to the pre-project level. Sound arbitration and conflict resolution mechanism by local leaders should be in place for smooth implementation of the RAP and R&R activities.

**(9) Religious and Sensitive Facilities**

Pre-Construction and Construction Phase Impact

A local cemetery is located near the proposed alignment of BP1. One pre-school with about 20 students is located near the starting point of BP1. Also, one memorial stone (commemorating the inauguration of the road) will be affected near the end point of BP2. Meanwhile, there are no sacred forest in or near the proposed bypass locations.

Mitigation Measures

While the alignment is designed so as not to affect the cemetery itself, extra efforts should be paid to minimize negative impacts during the construction, including noise and vibration and the disruption of access of the local people. Construction activities near the ceretery should be avoided during funerals and other religious ceremonies. More stringent standards for noise and vibration and air quality should be adopted where sensitive facilities such as school and hospitals are located. 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. While the memorial stone itself does not have significant religious or cultural importance, it should be relocated to an appropriate location prior to the start of the construction work.

**(10) Poor People**

Pre-Construction and Construction Phase Impact

The poor people have limited capability to cope with negative impacts and thus likely to be significantly affected.

Mitigation Measures

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

**(11) Ethnic Minorities/ Indigenous People**

Pre-Construction and Construction Phase Impact

The World Bank OP4.10 defines the indigenous people as follows:

a) self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;

b) collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories

c) customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture; and

d) an indigenous language, often different from the official language of the country or region.

The PAP partly meets the above definition in the sense that they share the same identity as Mizo and uses the common language. However, in the state of Mizoram, the tribal (Scheduled Tribe: ST) population constitutes about 95% of the total population, and as such, their livelihood and culture are not considered as "separate from those of the dominant society and culture".

Mitigation Measures
In India, Scheduled Tribes including Mizo are considered as indigenous people. Given that the majority of the affected people are Mizo, the project incorporates the requirements of World Bank OP4.10 in preparation of RAP. In particular, the principle of Free Prior and Informed Consent is adhered to during the preparation of the RAP to ensure meaningful participation of the PAPs, and the project has broad community support.

**(12) Gender**

Construction Phase Impact
In general, tribal and non-tribal women in the northeast 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 counterparts.

Mitigation Measures
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. Having said that, however, these measures shall be undertaken in consideration with local gender structures and customs so that such measures result in an unintended impact. In addition, efforts should be made to ensure participation of women in consultation meetings to be carried out during the implementation of the RAP.

**(13) Children's Right**

Pre-Construction and Construction Phase Impact
In the pre-construction phase, access to education may be undermined due to resettlement. During construction, construction work may also undermine accsss to School and pre-school. Although child labor is prohibited in India, child labor to support the parents are still relatively common and there is a risk that children are employed in construction work.

Mitigation Measures
If children need to change the school due to resettlement or commute longer distance to school, adequate assistance (e.g. to register to new school) should be provided. During the construction phase, the policy of no tolerance to child labor should be strictly adhered to.

**(14) Public Health and Occupational Health and Safety (OHS)**

The health and safety measures at design, construction and operation phases are shown in Table 8.6-8.

**Table 8.6-8 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.<br>● Adequate drainage, sanitation and waste disposal shall be provided at workplaces.<br>● 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 labourers to standards and scales approved by the resident engineer.<br>● 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.<br>● 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.<br>● 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 measures 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.<br>● 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.<br>● 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 |
| HIV and AIDS | ● Information brochures of HIV/AIDS will be distributed to the local community, construction workers and truck drivers. Mizoram is ranked second in India in terms of HIV/AIDS prevalence. Integrated Counseling and Testing Center and Anti Retroviral Therapy Center have been established by the state government (Mizorm State AIDS Control Society) where counseling, checking and therapy are provided. International organizations and NGO also implement various programs. Given the availability of existing program within Mizoram, the project will focus on awareness raising. Actitivies of the NGO include: empowerment of women by Mizo Hmeichhe Insuihkhawm Pawl and support to alcoholic and drug addicts by Agape Moral Reformation Organization. (Red Ribbon Club in universities provide similar service as Agape Moral Reformation Organization). |
| ***Operation Phase*** | |
| Safety Measures | ● Traffic management plan shall be developed especially along congested locations.<br>● Traffic control measures including speed limits will be enforced strictly.<br>● 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, are generally the causes of road accidents. Similarly, in operation stage, increase in traffic and increase in speed would tend lead to an increase in accidents. It is likely that there will be some concern of safety for highway users during the 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 the operation stage, increase in traffic and increase in speed would lead to an increase in accidents. In-spite of these, the social benefits from the project are quite significant.

Mitigation Measures

During pre-construction and construction phases, large vehicles carrying construction materials may block the view and cause congestion. Appropriate measures need to be taken to prevent the accidents due to the operation of construction vehicles. Also, it is necessary to make construction workers aware of the location of nearby hospitals so that immediate actions can be taken in case of accidents. The first aid kit should be available in all construction work sites. When construction work is carried out near the settlement, the residents should be informed of the type of construction work and schedule, as well as the risk and precaution checklists. Other measures to be taken during the construction phase include:

- Arrange of flagmen at road construction sites
- Make construction workers aware of the construction activities and the risk of accidents
- Conduct safety meeting before starting the work
- Use appropriate protective gears (such fall prevention equipment)
- Make the first aid kit available in all construction sites all the time

During the operation, the risk of accidents due to increases in traffic volume and speed will be mitigated by the use of traffic signs, road marking, retro-reflective road delineators and guard rail. See section 5.2.7 for the details of the traffic signs and markings to be installed.

### (2) GHG emissions

Construction and Operation Phase Impacts

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 increased due to the increase in traffic volume. The increase will be mitigated by keeping good road conditions that 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 are jhum fields, which is regularly burned yearly with considerable GHG emissions, the impact of the project in terms of GHG emission volume will be minor.

Mitigation Measures

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

## 8.6.5 Matrix of Impacts Based on the Assessment

Matrix of environmental and social impacts based on the assessment results is shown in Table 8.6-9.

**Table 8.6-9 Results of Assessment**

| Item | Scoping Result | | | Assessment Result | | | Rational of Assessmnet |
|---|---|---|---|---|---|---|---|
| | P | C | O | P | C | O | |
| **Natural Environment** | | | | | | | |
| Topography | D | A- | D | N/A | A- | N/A | 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 surplus soil. |
| Soil Erosion | D | A- | B+/ B- | N/A | A- | B+/ B- | C: Soil erosion is expected particularly during the monsoon period. Construction work should avoid the monsoon period.<br>O: Poor condition of drainage causes soil erosion in the 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. |
| Hydrology | D | B- | B- | N/A | B- | B- | C: Construction work may cause minor, temporary impacts on hydrology.<br>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. |

| Item | Scoping Result | | | Assessment Result | | | Rational of Assessmnet |
|---|---|---|---|---|---|---|---|
| | P | C | O | P | C | O | |
| Ecosystem, Flora, Fauna and Biodiversity, Forest | D | A- | B- | N/A | A- | B- | C: The project will not affect the pristine ecosystem as the work will be carried out along the existing road. However, construction work will affect the mountain ecosystem and local flora and fauna including the jhum areas and plantation.<br>O: Increases in traffic volume will have a negative impact on the ecosystem and flora and fauna along the road. Clearing of the forest will also lead to greater $CO^2$ emissions. |
| Protected Areas | C | C | C | D | D | D | P/C/O: The bypasses do not traverse or border with national parks or protected forest and therefore no direct impact is expected. |
| Natural Disaster | D | B- | B- | N/A | B- | B- | 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.<br>O: The risk is likely to increase in the rainy season. |
| **Living Environment (Pollution Control)** | | | | | | | |
| Air Pollution | D | B- | B- | N/A | B- | B- | C: Some negative impacts are expected due to the 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. Meanwhile, bypasses are expected to reduce air pollution in urban centers by diverting traffic and reducing congestion. |
| Water Pollution | D | B- | B- | N/A | B- | C | 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 the surrounding water bodies are expected due to the water discharge from road users and wastewater from maintenance activities. |
| Soil Contamination | C | C | C | D | B- | C | C: Impact on soil from deposition of pollutants from construction materials in the construction site are expected. |
| | | | | | | | C/O: Accidental spillage of oil and lubricant will cause soil contamination. Altough the risk is not very small, potential negative impact can be high. |
| Noise/ Vibration | D | B- | B- | N/A | B- | B- | C: Noise and vibration are generated by operation of construction equipment and vehicles, although they are temporary. The 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 levels 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. |
| Wastes/Hazardous Materials | D | B- | B- | N/A | B- | B- | C: Waste from construction workers' camps are expected to be generated. Waste generated from the construction and demolition work may include hazardous materials that must be treated before final disposal. |
| | | | | | | | O: Waste will be generated from the road users and workers of maintenance works. |

| Item | Scoping Result | | | Assessment Result | | | Rational of Assessmnet |
|---|---|---|---|---|---|---|---|
| | P | C | O | P | C | O | |
| **Social Environment** | | | | | | | |
| Involuntary Resettlement | A- | D | D | A- | N/A | N/A | 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. Minor and short-term resettlement may be necessary for construction of workers camp. |
| Land Use | A- | A- | D | A- | A- | N/A | P: Land acquisition and involuntary resettlement are likely to cause changes in the existing land use pattern.<br>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. |
| Utilization of Local Resources | D | A- | D | N/A | A- | N/A | C: Mass-scale use of local resources such as sand and quarrying for the construction activities may obstruct their utilization by the local people for other purposes. |
| Social Infrastructure and Services | D | A- | B+ | N/A | A- | B+ | C: Access to social infrastructure and services, such as water point in BP1, may be temporarily affected due to construction of the construction yard and accommodation for workers as well as traffic jams due to the operation of construction vehicles.<br>O: The project is expected to improve access to social infrastructure and services by providing a better road network. |
| Local Economy and Livelihood | A- | A- | B+ | A- | A-/B+ | B+ | P: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economy and livelihood.<br>C: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economy and livelihood. On the other hand, construction work will have a positive impact on the local economy by creating employment and business opportunities in the project area.<br>O: The project will have a positive impact on the local economy as improved road network ensures a more stable supply of essential goods. In the long-term, this will lead to regional economic development with more job and business opportunities. |
| Unequal Distribution of Benefit and Damage | A- | A- | D | A- | A- | N/A | 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.<br>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. |
| Cultural and Historical Heritage | C- | D | D | D | N/A | N/A | P: No impact is expected as the project will not affect cultural and historical heritages |
| Religious Facilities | A- | A- | B- | A- | A- | B- | P: Small-scale facilities may be affected due to the scope of the expansion.<br>C: Roadside religious facilities may be affected by noise and vibration during construction and operation due to the construction work and greater traffic volume.<br>O: Greater traffic volume is expected to increase noise and vibration level. Adequate mitigation measures should be implemented. |

| Item | Scoping Result | | | Assessment Result | | | Rational of Assessmnet |
|---|---|---|---|---|---|---|---|
| | P | C | O | P | C | O | |
| Sensitive Facilities (ex. hospital, school, precision machine factory) | B- | B- | B- | B- | B- | B- | P: Pre-school near the starting point of BP1 may be affected.<br>C: Noise and vibration during construction work may affect the school and hospitals near community roads<br>O: Greater traffic volume is expected to increase noise and vibration level, but adequate mitigation measures will be implemented. Traffic jam may undermine the access to these facilities. |
| Poor People | A- | A- | D | A- | A- | N/A | 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 the rehabilitation plan.<br>C: The poor may bear disproportionally burdened due to their limited coping capacity, although they can benefit from employment opportunities during the construction work. |
| Ethnic Minorities/ Indigenous People | A- | A- | D | A- | A- | N/A | P/C: 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. |
| Gender | D | C- | B+ | N/A | B- | B+ | C: Equal opportunity should be sought for employment during construction work while giving preferencial access to women for light duty and part-time work. Prevailing social and cultural norms must be carefully studied to avoid gender-related conflict.<br>O: Better road condition is expected to reduce the burden of girls and women who carry water and fuel wood and improve their safety. |
| Children's Rights | C | C | D | B- | B- | N/A | P: Children's right to go to school may be compromised.<br>C : Child labor is unlawful according to article 24 of the Indian Constitution, but it still exists in the region. |
| Public Health (sanitation and infectious diseases) | D | B- | B- | N/A | B- | B- | 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.<br>O: An increase in traffic volume and road users may have a negative impact on public health. |
| Occupational Health and Safety (OHS) | D | B- | B- | N/A | B- | B- | C: Occupational health and safety of construction work should be properly managed through an adequate Environment Management Plan.<br>O: Maintenance and repair work should take into account the occupational health and safety of the workers. |
| ***Others*** | | | | | | | |
| Accidents | D | B- | B+/ B- | N/A | B- | B+/ B- | C: Increase of risks of accidents associated with construction activities is expected due to the operation of heavy equipment and vehicles.<br>O: Risk 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. |

| Item | Scoping Result | | | Assessment Result | | | Rational of Assessmnet |
|---|---|---|---|---|---|---|---|
| | P | C | O | P | C | O | |
| GHG emissions | D | B- | B+/ B- | N/A | B- | B+/ B- | C: $CO_2$ emissions will increase due to the clearance of forest for the 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.<br>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

N/A: Not applicable (items that were assessed as D during the scoping are not assessed.

Source: JICA Study Team

## 8.7 Environmental Management Plan

Descriptions of the environment management measures during different stages of the project are provided in Table 8.7-1 to Table 8.7-3.

**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 | Involuntary resettlement | ● All requirements of the RAP as applicable shall be completed before the start of the construction works. The activities broadly include the 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 only) | Before construction begins | Government of Mizoram, District Revenue authorities, Village Councils, NGO | PIU, SC |
| P2 | Land Use<br>➢ Removal of vegetation | ● Minimize the scale of vegetation clearing/damage to jhum fields by factoring in vegetation/forest cover in the final design of the bypass route alignment process<br>● Removal of trees to be carried out after the forest clearance is obtained<br>● Reforestation/replantation of trees at a term as instructed by the Forest Department<br>● Activities 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. |
| | ➢ Setting up construction camps | ● Construction camps shall be located reasonably away from the nearest built-up area to avoid nuisance<br>● Sewage system for the construction workers camp shall be designed, built and operated to prevent pollution to ground or adjacent water bodies. 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.<br>● In relation to the underground water resources, the contractor shall take all necessary precautions to prevent interference with such water resources.<br>● 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 campsites identified by the contractor and approved by the SC | During establishment, operation and dismantling of such camps | Contractor | PIU, SC |
| | ➢ Setting up hot mix plants | ● Hot mix plants and batching plants shall be located sufficiently away from habitation and agricultural operations.<br>● 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 |
| | ➢ Finalizing sites for surplus soil dumping | ● Location of the 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 |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| P3 | 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.<br>● Implement additional slope protection measures as necessary | All areas | During mobilization | Contractor | PIU, SC |
| P4 | Local economy and livelihood | ● Implementation of income restoration program | Project affected households | Before the start of construction work | State Government | State Government |
| P5 | Unequal distribution of costs and benefits | ● Implementation of income restoration program | Project affected households | Before the start of construction work | State Government | State Government |
| P6 | Religious facilities | ● Selection of routes that avoids/minimizes negative impacts | All areas | Detailed deesign | NHIDCL | State Government |
| P7 | Sensitive facilities | ● Selection of routes that avoids/minimizes negative impacts | All areas | Detailed deesign | NHIDCL | State Government |
| P8 | Poor people | ● Implementation of income restoration program | Project affected households | Before the start of construction work | State Government | State Government |
| P9 | Ethinic minority and indigenous people | ● Implementation of income restoration program | Project affected households | Before the start of construction work | State Government | State Government |
| P10 | Children's rights | ● Provision of commuting assistance to children who needs to commute longer due to resettlement | Resettled students | Before the start of construction work | State Government | State Government |

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 |
| ***Natural Environment*** | | | | | | |
| C1 | Topography | ● Proper management of spoiled soils | Soil dumping site | Construction Stage | Contractor and Supervision Consultant | PIU |
| C2 | Soil Erosion<br>➢ Erosion in Borrow Pits<br>➢ Loss of top soil in Borrow pits<br>➢ Compaction of Soil<br>➢ Soil erosion in embankments | ● The depth of the 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 |
| | | ● Agricultural fields or productive land shall be avoided for borrowing earth. If unavoidable, the topsoil shall be preserved and used for tree plantation | On approved locations of borrow pits. | Construction Stage | Contractor and Supervision Consultant | PIU |
| | | ● Construction equipment and vehicles shall be restricted to move only within a designated area to avoid compaction of productive soil | All areas | Construction Stage | Contractor and Supervision Consultant | PIU |
| | | ● 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 |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| C3 | Hydrology | ● Install appropriate drainage based on the hydrology analysis to minimize impacts<br>● | All areas | Construction Stage | Contractor and Supervision Consultant | PIU |
| C4 | Ecosystem<br>➢ Tree cutting | ● Three trees shall replace each tree cut for the purpose (as suggested by Environment and Forest Dept. Mizoram).<br>● The engineer shall approve such felling only when the NHIDCL receives a "clearance" for such felling from the MOEFCC, as applicable.<br>● 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<br><br>Forest Dept. | PIU |
| | ➢ Damage or loss of important flora and fauna | ● 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 |
| C5 | Natural disaster | ● Implement preventive measures for fire and water hazards<br>● Keep first-aid kit and updated list of local hospitals and access | Throughout the project area | Construction Stage | Contractor and Supervision Consultant | PIU |
| ***Living Environment*** | | | | | | |
| C6 | Air Pollution<br>➢ 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.<br>● 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 |
| | ➢ 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 |
| | ➢ 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 |
| | ➢ 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 |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| C7 | Water Pollution<br>➢ Contamination of water from fuel and lubricants | ● Construction vehicles and equipment shall be operated and maintained in such a manner so that water contamination due to its spillage shall be minimum<br>● Fuel storage shall only be done on a 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 |
| | ➢ Sanitation in construction camps | ● The construction of camps will be located with sufficient buffer from habitation.<br>● At the construction sites and labor camps sufficient numbers of latrines shall be provided<br>● The sewage generated from the camps will be properly disposed of so that it does not pollute water bodies<br>● The labor camp shall not be allowed near any of the water bodies<br>● The proper sanitation facilities shall be provided | Wherever the labor camp is located | Construction Stage | Contractor and Supervision Consultant | PIU |
| | ➢ Deposition of dust in open wells near construction site | ● The mouth/opening of the well shall be covered with a 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 |
| C8 | Soil contamination | ● At construction yards, the vehicles/equipment will be maintained and re-fuelled in a way that prevents oil/diesel spillage<br>● fuel storage and re-fuelling sites are kept away from drainage channels and important water bodies.<br>● The fuel storage and re-fuelling areas shall not be located on agricultural lands or productive lands to avoid topsoil contamination.<br>● The construction waste generated will be reused in the construction of the highway as much as possible | Construction site, labor camp | Construction Stage | Contractor and Supervision Consultant | PIU |
| C9 | Noise and Vibration<br>➢ Noise from vehicles. Asphalt plants and equipment | ● The plants and equipment used for construction shall conform to CPCB norms.<br>● Vehicles and equipment used shall be fitted with silencers.<br>● Any vehicle and machinery shall be kept in good working order and engines should be turned off when not in use.<br>● All equipment and plants shall strictly be placed away from educational institutes and hospitals.<br>● Regular monitoring of noise parameters ($L_{eq}$) during the construction period as envisaged in the Environmental Monitoring Plan. | Wherever the plants are setup. | Construction Stage | Contractor and Supervision Consultant | PIU |
| | ➢ Blasting | ● Blasting as per Indian Explosives act will be carried out.<br>● People living near such blasting operation sites shall be informed before the operational hours.<br>● 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 |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| C10 | Waste | ● Debris generated due to the dismantling of the existing pavement and culverts shall be reused as much as possible<br>● Debris and other waste 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<br>● Spoiled soil shall only be dumped at the pre-selected dumping sites | Soil dumping site and solid waste dump site identified and approved by the SPCB or competent authority | Construction Stage | Contractor and Supervision Consultant | PIU |
| | ➢ Demolishion of comstruction camp | ● 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 and to the entire satisfaction of the engineer. | Construction camp | Upon completion of construction work | Contractor and Supervision Consultant | PIU |
| Social Environment | | | | | | |
| C11 | Land use | ● The contractor | At | Construction Stage | Contractor and Supervision Consultant | PIU |
| C12 | Utilization of Local resources | ● The contractor shall make arrangements for water required for construction in such a way that water availability and supply to nearby community is unaffected<br>● Wastage of water shall be kept minimum during construction | At respective planned construction sites | Construction Stage | Contractor and Supervision Consultant | PIU |
| C13 | Social infrastructure and service | ● 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 the side roads and existing accesses shall not be undertaken without providing adequate provisions to the prior satisfaction of the engineer.<br>● 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.<br>● Prior arrangement/traffic diversion for safe passage of vehicles shall be made with proper direction and signage at the construction site. | Near built-up areas | During Construction. | Contractor | Engineer |
| | | ● 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. | Near built-up areas | During Construction. | Contractor | Engineer |
| C14 | Local Economy and livelihood | ● Plan construction work time and schedule to minimize disruption to local livelihood (e.g., access to jhum field) | Near built-up area | Construction Stage | Contractor | Enginner |
| C15 | Unequal distribution of costs and benefits | ● Plan construction work time and schedule to minimize disruption to local livelihood (e.g., access to jhum field) | Near built-up area | Construction Stage | Contractor | Enginner |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| C16 | Religious facilities | ● Schedule construction work to avoid impacts on religious ceremonies, particularly Sunday masses | Near built-up area | Construction Stage | Contractor | Enginner |
| C17 | Sensitive facilities | ● Minimize disruption of access to hospitals and schools<br>● Schedule construction work to avoid impact during important events (e.g., school events and cultural events) | Near built-up area | Construction Stage | Contractor | Enginner |
| C18 | Poor people | ● Implementation of income restoration program | Project affected households | Before the start of construction work | State Government | State Government |
| C19 | Ethnic minority and indigenous people | ● Implementation of income restoration program | Project affected households | Before the start of construction work | State Government | State Government |
| C20 | Gender | ● Preferencial access of light-duty and part-time work to women<br>● Segregation of male and female areas in labor camp shall be executed. | Wherever labor camp is setup | Construction Stage | Contractor and Supervision Consultant | PIU |
| C21 | Children's rights | ● Child labor shall not be allowed. | Construction site and camp | Construction Stage | Contractor and Supervision Consultant | PIU |
| C22 | Public Health and Hygine<br>➢ Abandoned Quarry will accumulate water and act as a breading ground for disease vectors<br>➢ HIV/AIDS and sexually transmitted diseases | ● 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 |
| | | ● Information brochures will be distributed to local community, construction workers and track drivers to raise awareness. | Construction site and camp | Construction Stage | Contractor and Supervision Consultant | PIU |
| C23 | Occupational Health and Safety<br>➢ Health damage due to contaminated water | ● 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.<br>● Adequate drainage, sanitation and waste disposal shall be provided at workplaces.<br>● Preventive Medical care shall be provided to workers. | Construction site and camp | Construction Stage | Contractor and Supervision Consultant | PIU |
| | ➢ Accident and injuries | ● Personal protective equipment shall be provided to worker as per the Factories Act. | Construction site | Construction Stage | Contractor and Supervision Consultant | PIU |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | ➢ Hygine of construction camp | ● Proper sanitation facilities shall be provided at all construction camps<br>● The sewage generated from the camps shall be properly disposed of so that it does not pollute water bodies and create health hazard.<br>● Install gabage bins to reduce littering<br>● At every workplace, a readily available first aid unit including an adequate supply of sterilized dressing material and appliances will be provided. | Construction camp | Construction Stage | Contractor and Supervision Consultant | PIU |
| | ➢ 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.<br>● 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 |
| ***Others*** | | | | | | |
| C24 | Accidents<br>➢ Accidents during construction work | ● Prior arrangement/traffic diversion for safe passage of vehicles shall be made with proper direction and signage at the construction site.<br>● Detailed Traffic Control Plans shall be prepared and submitted to the Site Engineer/ Project Director, particularly in section where the bypass intersects with existing road. The traffic control plans shall include measures to reduce congenstion and prevent accidents, and should be announced to the local residents in advance.<br>● 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.<br>● 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. | Throughout the project area | Construction Stage | Contractor and Supervision Consultant | PIU |
| | ➢ Risk of 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.<br>● 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 sites | Construction stage | Contractor and Supervision Consultant | PIU |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | ➢ Hazardous materials | ● 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.<br>● 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 |
| | ➢ 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.<br>● 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.<br>● 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 |
| | ➢ First Aid | ● At every workplace, a readily available first aid unit including an adequate supply of sterilized dressing material and appliances will be provided.<br>● Provide training to construction workers on first aid | At the construction site /labor camp | Construction stage | Contractor | PIU |
| | ➢ Traffic safety | ● Take necessary precautionary and preventive measures for the safety pf pedestrials, such as installation of road signs and crossings<br>● Provide sufficient information about construction work and potential risks to local residents to raise awareness | Near built-up area | Construction stage | Contractor | Engineer |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| C25 | Climate Change | ● Implement reforestation | Sites as per guidance of Forest Department | Before the start of construction work | NGO, Contractor and Supervision Consultant | Forest Department |

Source: JICA Study Team

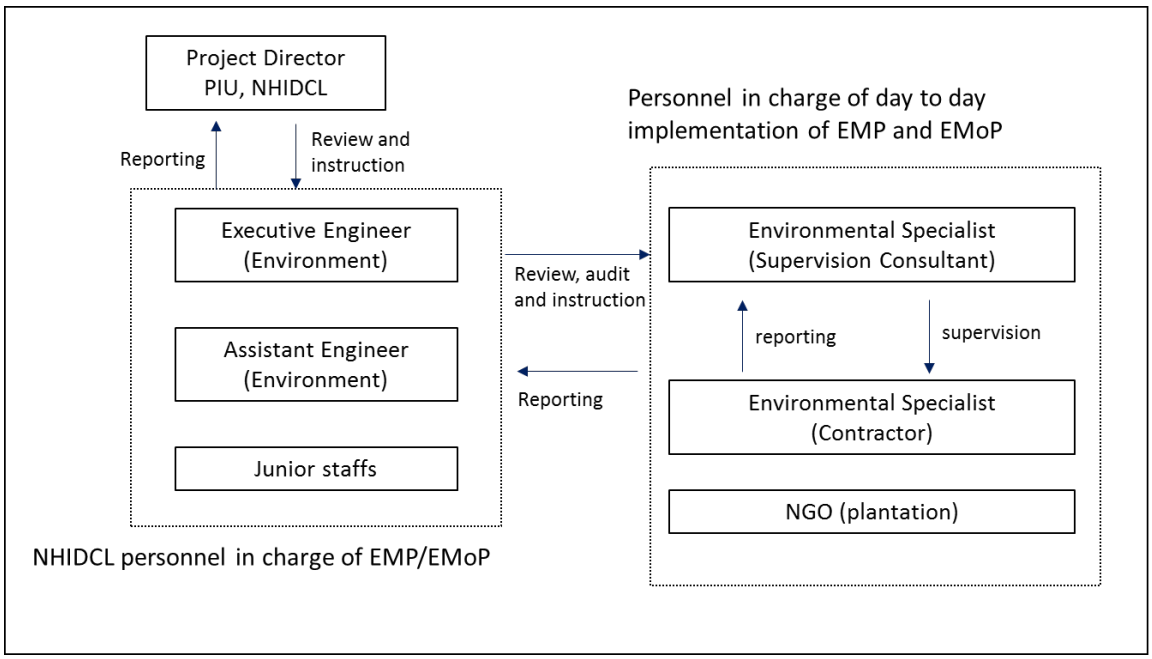
**Table 8.7-3 Environmental Management Plan for Operation Stage**

| 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.<br>● Monitoring shall be carried out as specified in the monitoring plan. | As specified in the monitoring plan | As per monitoring plan | PIU, SPCB | PIU |
| ***Natural Environment*** | | | | | | |
| O2 | Soil Erosion | ● Implement slope protection to ensure the stable condition can be maintained, and minimize erosion by greening of slopes. | Through the project area | Construction stage | Contractor and Supervision Consultant | PIU |
| O3 | Hydrology | ● Gabion and apron concreate will be installed at the outlet of culverts to minimize erosion. | Through the project area | Construction stage | Contractor and Supervision Consultant | PIU |
| O4 | Ecosystem and forest | ● 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.<br>● 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 |
| ***Living Environment*** | | | | | | |
| O5 | Air pollution | ● Monitoring shall be carried out as specified in the monitoring plan<br>● 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 |

| Sl. No | Environmental Impacts/Issues | Mitigation Measures | Location | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| O6 | Water pollution<br>➢ 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<br>● Monitoring shall be carried out as specified in the monitoring plan | As specified in the monitoring plan | As per monitoring plan | PIU, SPCB | PIU |
| | ➢ Soil and water contamination from accidental spills | ● Contingency plans to be in place for cleaning up of spills of oil, fuel and toxic chemicals<br>● Monitoring shall be carried out as specified in the Monitoring Plan | All areas 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 |
| O7 | Soil contamination | ● The petrol pumps and vehicle washing areas located along the ROW will be monitored regularly for any spillages and corrective remedial measures<br>● Monitoring of oil/fuel spilage in case of accident | All areas | Plan to be developed at state/district level by early operation stage | PIU, SPCB, Local Government Bodies | PIU |
| O8 | Noise and vibration | ● Monitoring shall be carried out as specified in the Monitoring plan<br>● Install noise barrier (wall etc.) in sensitive areas, if necessary | As specified in the monitoring plan | As per monitoring plan | PIU, SPCB | PIU |
| O9 | Hazardous materials | ● Compliance with the Hazardous Wastes (Management and Handling) Rules, 1989 | All areas | Manual/guideline to be prepared during early operation stage | PIU | PIU |
| ***Social Environment*** | | | | | | |
| O10 | Religious facilities | ● Monitoring shall be carried out (particularly for noise and vibration) | As specified in the monitoring plan | As per monitoring plan | PIU, SPCB | PIU |
| O11 | Sensitive facilities | ● Monitoring shall be carried out (particularly for noise and vibration) | As specified in the monitoring plan | As per monitoring plan | PIU, SPCB | PIU |
| O12 | Public health and hygine | ● Continued awareness raisinig about HIV/AIDs and sexually transmitted diseases | Through the project area | Construction stage | PIU/NGO | PIU |
| O13 | Occupational health and safety | ● As per measures during the construction stage | Through the project area | Construction stage | PIU | PIU |
| ***Others*** | | | | | | |
| O14 | Accidents | ● Traffic control measures including speed limits to be enforced strictly.<br>● Local government bodies and development authorities will be encouraged to control building development along the highway. | All areas | Throughout the operation stage | PIU, Local Government Bodies | PIU |
| O15 | Climate change | ● Monitoring of reforestation | As specified in the monitoring plan | As per monitoring plan | PIU, NGO | PIU |

Source: JICA Study Team

The institutional setup for EMP and EMoP implementation is shown below.




Source: JICA Study Team

**Figure 8.7-1 Institutional Setup of EMP and EMoP Implementation**

## 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 decisions may be taken during construction and operational phases. It provides the basis for evaluating the efficiency of mitigation and enhancement measures and suggests 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 in Table 8.8-1.

The schedule of EMP and EMoP implementation as of the preparation of this report is as follows. The overall schedule of the project implementation is presented in section 7.1.

1) Pre-construction phase: 2017 –
2) Construction phase: from 2019 to June 2022
3) Operation phase: from 2022 (monitoring by NHIDCL will continue for three years from the start of the operation)

**Table 8.8-1 Environmental Monitoring Plan**

| Sl. No | Item | Project Stage | Parameters | Guidance | Standards | Location | Frequency | Cost | Responsibility | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Implementation | Supervision |
| M1 | Air | Construction | SPM, RSMP, $SO_2$, NOx, CO, HC | • Dust sampler to be located 50 m from the plan in the downwind direction.<br>• Use method specified by CPCB for analysis | Air (P&CP) Rules, CPCB, 1994 | Hot mix plant/ batching plant | Twice a year for three years | Rs.6,000/ unit | Contractor through approved monitoring agency | PIU |
| M2 | | Construction | SPM, RSPM | • Dust sampler to be located 50 m 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 | Rs.6,000/ unit | 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 the EIA report | Twice a year for one year | Rs.6,000/ unit | PIU | PIU |
| M4 | Water | Construction | pH, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb | • Sample collected from the source and analyzed as per Standard Methods for Examination of Water and Wastewater | Water quality standards by CPCB | Sampling locations specified in the EIA report | Twice a year for three years | Rs.6,000/ unit | Contractor through approved monitoring agency | PIU |
| M5 | | Operation | pH, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb | • Grab sample collected From the source and analyzed as per Standard Methods for Examination of Water and Wastewater | Water quality standards by CPCB | Sampling locations specified in the EIA report | Twice a year for one year | Rs.6,000/ unit | 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 areas | Post-monsoon | Rs.6,000/ unit | PIU | PIU |

| Sl. No | Item | Project Stage | Parameters | Guidance | Standards | Location | Frequency | Cost | Responsibility | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Implementation | Supervision |
| M7 | Soil contamination | Construction | Spillage of fuel, oil and lubricants and other hazardous materials | • Visual observations during site visits | N/A | All areas | At the time of accident and routine maintanance | Part of civil work cost | Contractor through approved monitoring agency | PIU |
| | | Operation | Spillage of fuel, oil and lubricants and other hazardous materials | • Visual observations during site visits | N/A | All areas | At the time of accident and routine maintanance | Part of civil work cost | PIU | PIU |
| M7 | Noise and vibration | Construction | Noise levels on dB (A) scale | • Free field at 1 m from the equipment whose noise levels are being determined | Noise standards by CPCB | At equipment yard | Once every 3 months (max) for three years, as required by the engineer | Rs.5,000/ unit | 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 the EIA report for noise monitoring locations | Twice a year for one year | Rs.5,000/ unit | 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 | Part of civil work cost | Contractor | PIU |

| Sl. No | Item | Project Stage | Parameters | Guidance | Standards | Location | Frequency | Cost | Responsibility | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Implementation | Supervision |
| 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 | Part of civil work cost | PIU | PIU |
| M12 | Afforestation | Construction and operation | Plant survival | ● The success of the tree planting program. Monitor the rate of survival after six months, one year and 18 months in relation to the total numbers of trees planted | | All areas | Minimum three years after planting | Rs.300 per sapling | NGO, PIU | PIU |
| M13 | Flora and Fauna | Construction and Operation | Condition of ecosystem | ● Comparison to pre-project flora and fauna<br>● Regular checking of baseline condition of protected areas near bypasses | As specified in the TOR | As specified in the TOR | Twice a year for three years | Rs.80,000 per survey | PIU | PIU |

Source: JICA Study Team

## 8.9 Public Consultation during Environmental and Social Considerations

### 8.9.1 1st Consultation Meetings

The schedule and attendance of the 1st round of consultation meetings in February 2016 are shown in Table 8.9-1.

**Table 8.9-1 Schedule and Attendance of the 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 |

Source: JICA Study Team

In the 1st round of consultation meetings, the summary of the project was presented with the note that the bypass was being discussed in response to the request of the local people (bypass is preferable to avoid resettlement). The summary of the EIA for the expansion of NH54 was also presented together with the methodology of the environmental and social impact assessment for the bypass project, likely impacts and proposed mitigation measures that were envisaged at this point.

Major comments raised in the consultations and responses are summarized in Table 8.9-2.

**Table 8.9-2 Comments and Responses in the 1st Round of Consultation**

| Main Concerns/Comments | Responses |
|---|---|
| ● PAHs raised concerns about the treatment of surplus soil. Agriculral land was damaged due to residual soils in road projects in the past as contractors did not manage them properly (across all bypasses). | ● Proper sites for dumping are identified based on the calculation of necessary volume. The proposed site will be discussed in the 2nd consultation meeting to be held in July.<br>● If there is any demand for excess soil in villages, the project can provide the soil as well. |
| ● (asked if they are aware of any endangered species in the project area)<br>They are not aware of such species, and they have never saw them in the bypass area (across all bypasses). | ● Understood. Baseline survey and interviews with relevant insitutions will be done to confirm the status and appropriate mitigation measures will be developed. |
| ● (asked if there are any cultural heritage, cemetery, sites of historical importance)<br>No such sites are present (BP3 and BP4) | ● This issue will be discussed again in the 2nd meeting once the general design of the bypass has developed. |
| ● Consideration is necessary for access to water Bypass will affect well and access to the well (BP1 and BP2) | ● The design and construction work will be done in consideration with the well and access to it. |
| ● The proposed site is close to the the cemetery. Please design the bypass route to avoid impacts to the cemetery (BP1) | ● The location of the cemetery is already identified. The route design will be made in such a way that it will avoid the direct impact to the cemetery. |
| Other<br>● This project improves the infrastructure condition of the area and local community support of the project. (across all bypasses) | ● Appreciate the support to the project. The project will continue to disclose necessary information so that the local community will be kept informed. |

Source: JICA Study Team

### 8.9.2 2nd Consultation Meetings

There are villages with muiltiple Village Councils. The 2nd round of consultation meetings were organized per Village Council in response to the request from the community so that participants can discuss issues thoroughly. In addition, additional briefing sessions for the BP2 area were held in July 23rd and 25th for those who have missed the three official consultation meetings. The two meetings were attended by 12 and 17 people respectively. The schedule and attendance of the 2nd round of consultation is shown in Table 8.9-3.

To promote the participation of women, inputs from a local NGO which work for the empowerment of women is sought. The time of the meeting was set early in the morning or in the evening where women are more likely to attend (they are busy during the daytime). The possibility of women-only focus group was also explored, but it was concluded not necessary because in Mizoram, women can freely speak in front of men. While the participation of women remained low in the 2nd round of consultation, most of them did not participate because "one person from family is sufficient and if my husband goes, I don't think I need to go."

**Table 8.9-3 Schedule and Attendance of the 2nd Round of Consultation**

| Bypass | Date | Target VC | No. of Attendees | | |
|---|---|---|---|---|---|
| | | | M | F | Total |
| BP1 | 12 July 2016 | Chhiahtlang 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 | Hnahthiel N 1 | 28 | 7 | 35 |
| | 13 July 2016 | Hnahthiel 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

Results of the impact assessment including the environmental data of dry and monsoon seasons were presented in the second round. More importantly, presentations were made about the proposed mitigation measures and institutional mechanism to implement these measures. Key questions/comments and responses are shown in Table 8.9-4. In all meetings, participants showed their support to the project.

**Table 8.9-4 Comments and Responses in the 1st Round of Consultation**

| Main Concerns/Comments | Responses |
|---|---|
| *General*<br>• 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 (across all bypasses).<br>• Village Council members suggested that the vegetation be cleared so that villagers can clearly see the proposed alignment in hilly area (BP2) | • 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, the 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.<br>• It was confirmed that the clearance of vegetation and forest will be done after the forest clearance permit is obtained. Also, reforestation will be carried out to offset the loss of forest. |

| Main Concerns/Comments | Responses |
|---|---|
| *Environmental and Social Impacts*<br>• 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 (across all bypasses). | • In addition to the provisions in the EMP for properly managing surplus soil, monitoring will be undertaken both internally and externally so that any deviation or negligence of the environmental safeguards will be identified and rectified.<br>• Also, PAHs and village council members were encouraged to use surplus soil for local construction (for playground etc.) if appropriate. |
| • Some raised concerns if the construction of bypass will increase the risk of landslides. Also, they were worried about the potential impacts on their jhum land that will be bifurcated by the bypass (across all bypasses). | • Slope protection measures will be installed to reduce the risk of land slide and other hazards. The risk will actually decrease compared with the no-project scenario.<br>• The bypass is designed in a way to minimize impacts to the jhum land, for example by not disturbing natural waterways. |
| • PAHs asked if the local graveyard is affected by the project (BP1). | • It was confirmed that the local graveyard will not be affected by the project. Construction work schedule will also be developed to avoid impact on the use of the cemetery. If there are specific date/time to avoid the work, please inform us in advance. |

Source: JICA Study Team

## 8.10 Land Acquisition and Involuntary Resettlement

### 8.10.1 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 a total of 46 ha of land will have to be acquired for the four bypasses and in a limited stretch where the bypass uses an 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 census survey that collected the demographic and socio-economic information of the PAPs was carried out from February 16 to March 1, 2016 and from July 6 to 23, 2016. As per World Bank OP4.12, the cut-off date is provisionally declared on February 16, which was the start date of the census survey. The information is disseminated through relevant Village Councils. The information about the cut-off date was also distributed during the census survey and other interviews. In the meantime, the Mizoram Land Acquisition Act which was enforced after the study began stipulates that the census survey will be carried out once the Social Impact Assessment is carried out by the state government and premilinary notification on land acquisition was issued. The act does not include a specific reference to cut-off date, but it specifies the start date of the census to be undertaken by the state government and may also be used as the official cut-off date.

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 the forest and jhum fields in the hilly area. The number has been estimated based on the confirmation meeting with the 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 in Table 8.10-1.

**Table 8.10-1 Number of PAH and PAP per Bypass**

| Bypass | To be resettled PAH (PAP) | No. of PAH (PAP) without resettled PAH (PAPs) | Total No. of PAH (PAP) |
|---|---|---|---|
| BP1: Chhiahtlang | 19 (131) | 30 (172) | 49 (303) |
| BP2: Serchhip | 1 (2) | 119 (698) | 120 (700) |
| BP3: Hnahthial | 0 | 77 (410) | 77 (410) |
| BP4: Lawngtlai | 0 | 11 (72) | 11 (72) |
| Total | 20 (133) | 237 (1352) | 257 (1485) |

Source: JICA Study Team

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 the forest and jhum fields in the hilly area. The number has been estimated based on the confirmation meeting with the Village Council and villagers who claim that their farmland or plantation are likely to be affected. The number of affected households and persons for each bypass are presented in Figure 8.10-1.

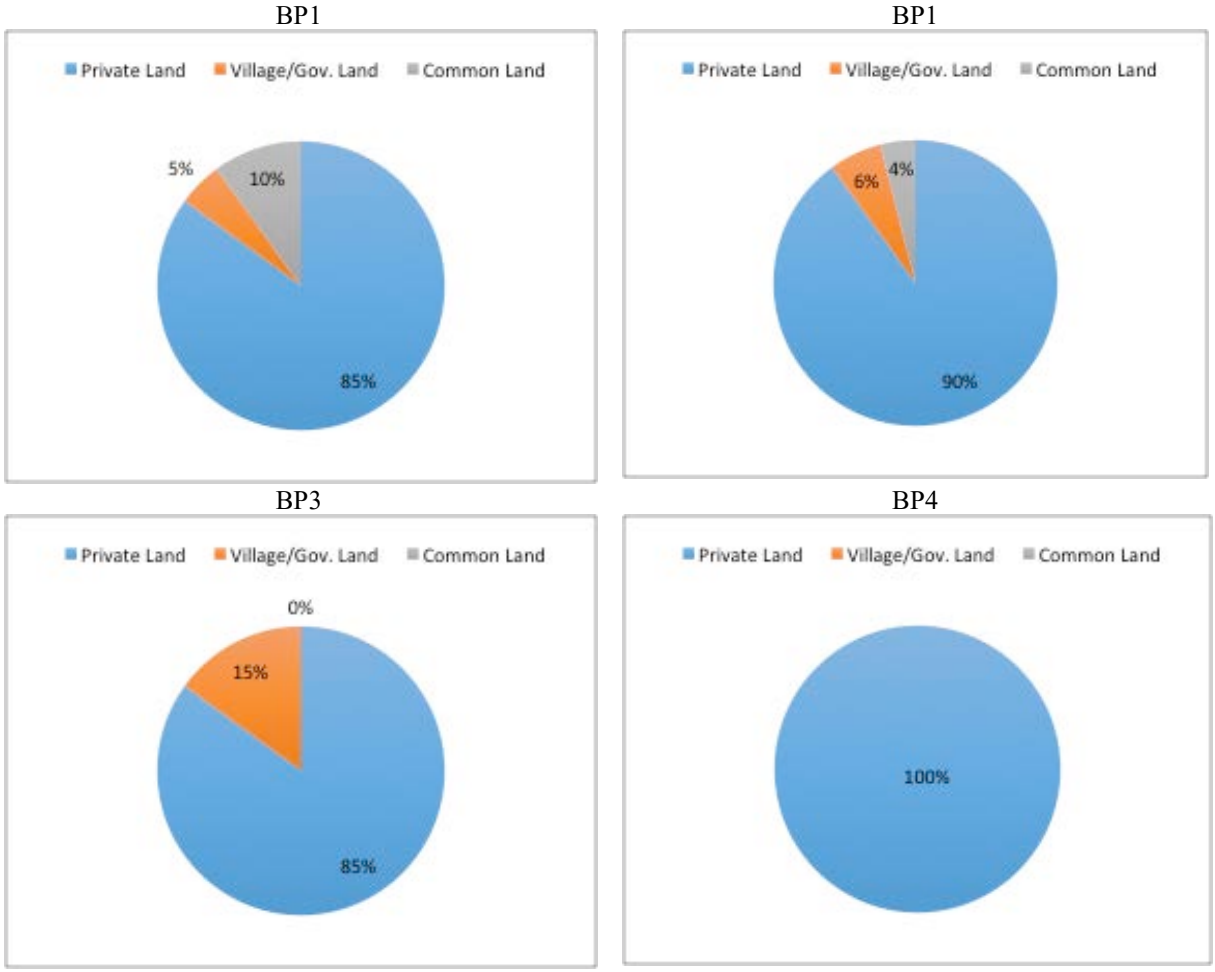
Land ownership and land use patterns of the PAHs are shown in Table 8.10-2 (see section 8.2.3 for land ownership and use patterns in Mizoram). While several PAHs do not have official document, most of them have certificates and other documents allowing land ownership or use such as LSC, Village Pass and Periodic Patta).

**Table 8.10-2 Land Ownership Patterns of PAH**

| Bypass | LSC | Periodic Patta | Garden Pass | Village Council Pass | Other | No document/ answer |
|---|---|---|---|---|---|---|
| BP1 (49 PAH) | 15 | 2 | 0 | 20 | 6 | 6 |
| BP2 (120 PAH) | 23 | 8 | 2 | 82 | 3 | 2 |
| BP3 (77 PAH) | 25 | 12 | 14 | 14 | 6 | 6 |
| BP4 (11 PAH) | 11 | 0 | 0 | 0 | 0 | 0 |
| Total (257 PAH) | **74** | **22** | **16** | **116** | **15** | **14** |

Source: JICA Study Team

As shown above, Village Pass is most common type of land ownership/use pattern in Mizoram than the LSC. The holders of Village Council Pass, Periodic Patta and Garden Pass are allocated specific plots in the village by the state government or the Village Council, and conduct farming there. Since the allotment is long-term custom (although the location of allocated land changes), this is customally understood as “private” land although on paper, it is owned by different levels of government. The land ownership pattern based on the interview of affected people (i.e. their perception) is shown below.



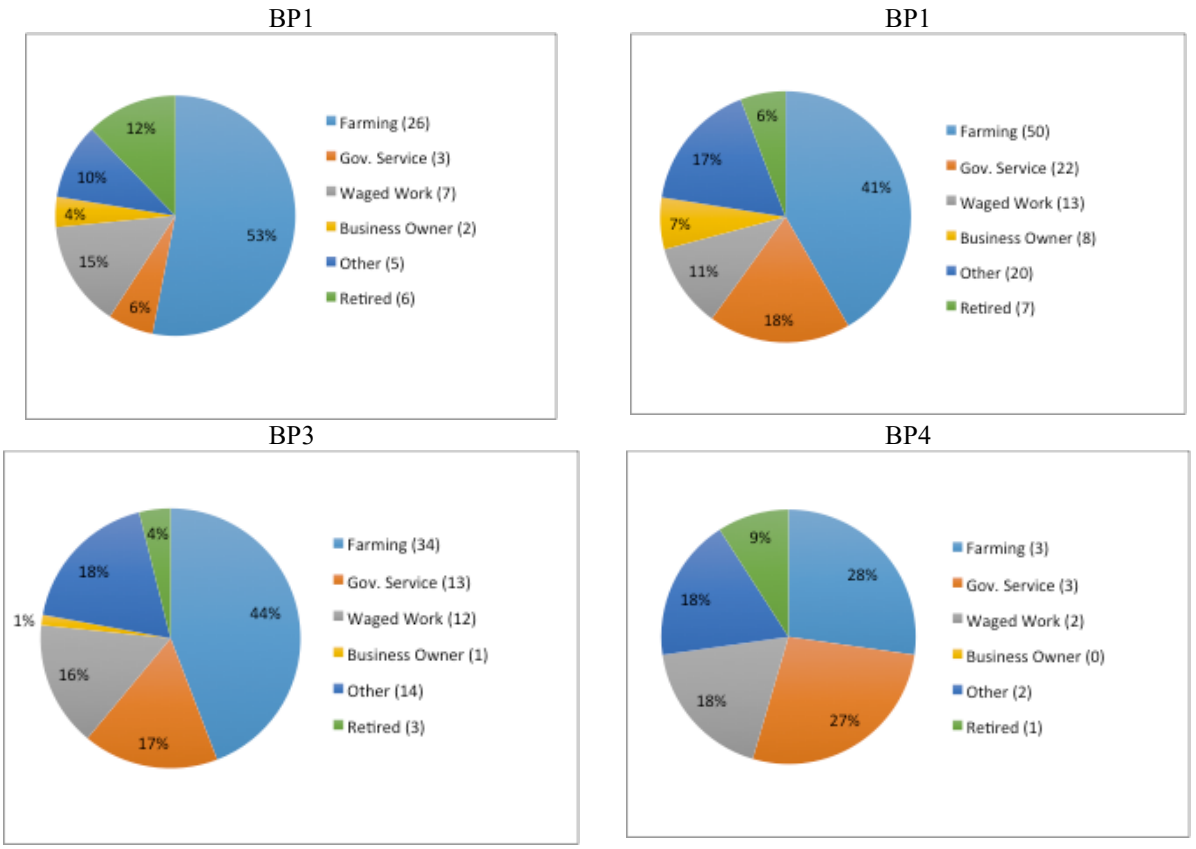

Source: JICA Study Team

**Figure 8.10-1 Land Ownership Pattern in Each Bypass as Perceived by PAH**

### 8.10.2 Profile of Project Affected Households/Persons

The overwhelming majority of PAHs are Mizo. Out of the 257 PAHs, there are only four non-Mizo PAHs. There are Asamese in the BP2 area and they are not going to be relocated. While there are different sub-tribes among Mizo, all of them, including the four Asamese PAHs, speak Mizo. About 20% of the 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.

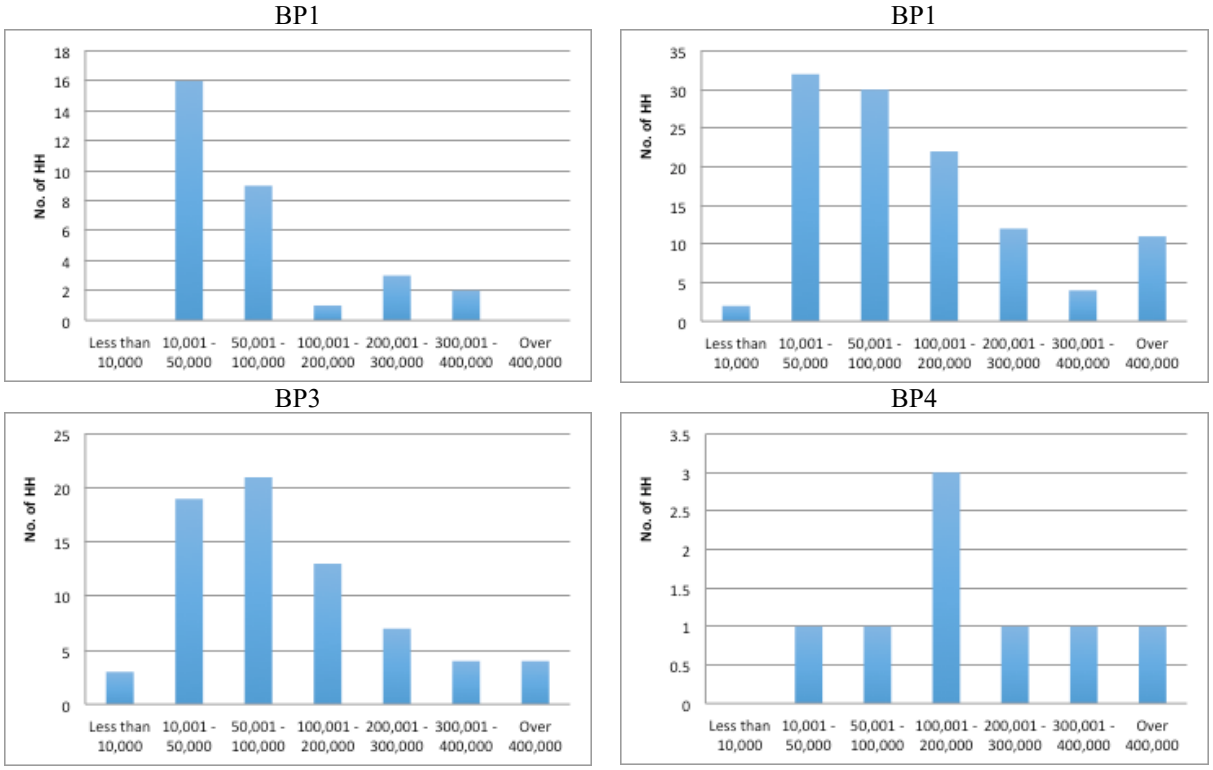
The primary sources of income of the household heads are shown in Figure 8.10-2. Farming is the most commong primary income source followed by government sector.




Note: Other includes driver, carpenters etc.
Source: JICA Study Team

**Figure 8.10-2 Primary Income Source of PAH**

The annual income of the PAHs is shown in Figure 8.10-3. It is important to note that the cash income may not reflect the true well-being of the PAHs engaged in the subsistence of agriculture. The minimum and maximum income as reported by the PAHs is Rs 4,000 and Rs 1,250,000 respectively. Meanwhile, 34 PAHs out of the 257 PAHs did not answer questions on income.




Source: JICA Study Team

**Figure 8.10-3 Annual Income of PAH**

According to the Reserve Bank of India, the share of the poor in Mizoram is 23% in the rural area sand 7.9% in urban areas in 2012[3]. However, the survey found that about 30% or 78 PAHs consider themselves as Below Poverty Line household, which may reflect their true coping capacity against negative impacts. The type and number of vulnerable PAH is shown in Table 8.10-2.

**Table 8.10-3 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.

Source: JICA Study Team

### 8.10.3 Land Use Pattern

Based on the interviews, field surveys and satellite imagery, the land use patterns of proposed bypass ROW area have been estimated. While some variations exist among the 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

**Table 8.10-4 Land Use Pattern (ha.)**

| Bypass | Forest | Plantation | Agriculture (Jhum) | Others (inc. residential) | Total (ha.) |
|---|---|---|---|---|---|
| BP1 | 2.4 (79%) | 0.6 (18%) | 0.06 (2%) | 0.03 (1%) | 3.09 |
| BP2 | 1.9 (15%) | 6.3 (45%) | 5.6 (40%) | 0.15 (0.1%) | 13.95 |
| BP3 | 3.2 (38%) | 2.5 (30%) | 1.25 (15%) | 1.4 (10%) | 8.35 |
| BP4 | 1.65 (65%) | 0.88 (35%) | 0 | 0 | 2.53 |
| **Total** | **9.15** | **10.28** | **6.91** | **1.58** | **27.92** |

Note: 1. The area of spoil dumping site (about 20ha) is not included as the location has not been finalized. However, the land use pattern in proposed spoil site and surrounding area are in genral quite similar with the land use pattern in each bypass shown above.

Source: Baseline Survey

### 8.10.4 Impact on Crop and Trees

Forest in the above land use pattern can be used for jhum cultivation or plantation in the future, but at the time of the survey, the area is just left as it is and used only for collection of firewood and other forest products.

In jhum farming, bananas, peppers, eggplants tomatos and various kinds of beans are commonly cultivated. However, due to the nature of jhum cultivation, the same crop is not usually harvested repeatedly in the same land. Also, after several rounds of harvest, the "forest" land can be cleared for new jhum cultivation while existing jhum is left for fallow. Likewise, bamboo and teak plantations also often change places. The crop compensation will have to be provided based on the crops that are cultivated at the time of land acquisition (handover of land), but due to the rotation of jhum farming, the current baseone cannot be used for this purpose. Therefore, another round of survey will have to be carried out once the detailed designs is completed and the affected land, including the spoil dumping site, is finalized in order to identify standing crops at the time of land acquisition.

## 8.11 Entitlement Matrix

The Entitlement Matrix showin in Table 8.11-1 has been developed in accordance with the 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 the preparation of compensation and resettlement packages.

**Table 8.11-1 Entitlement Matrix**

| Type of Loss | | Application | Entitlement | Details |
|---|---|---|---|---|
| *Fixed Assets* | | | | |
| Land | LSC | Holders of LSC | Compensation at replacement cost | a) Cash compensation for the land at replacement cost (market price plus solatium), which will be determined by the District Collector. (no request for land-for-land compensation from PAH) |
| | Periodic Patta, Village Pass (use permits) | Holders of Periodic Patta, Village Pass | Compensation at replacement cost or allotment of patta or pass equivalent in value | a) Cash compensation for the land at replacement cost (market price plus solatium), which will be determined by the District Collector. (no request for land-for-land compensation from PAH); or<br>b) Cash compensation to the Village Council as above, and the Village Council will allocate another Patta or Pass of land with the same quality (PAHs prefer direct cash compensation) |
| Structure (house, shop, Agricultural Hut) | House and shop | Owner of structure | Compensation at replacement cost | a) Compensation at the replacement cost including construction materials and cost of construction (cost for hiring labors), any fees and tax to register the new house<br>b) Two-month advance notice before demolishing the structure<br>c) If PAH continues to live partially affected structure, 25% of the structure's replacement cost will be provided as the cost of repair |
| | Agricultural Hut | Owner of structure | Assistance to relocating the hut or compensation at replacement cost | a) If the remaining land can be used for agriculture, cash assistance will be given to shift the agricultural hut<br>b) If all land will be acquired or remaining land is not viable for agriculture, compensation at the replacement cost shall be given |
| Public Utilities | Water point | Local user | Maintenance of access | a) Relocation of facilities or provision of alternatite means shall be done |
| *Loss of Income/Livelihood* | | | | |
| Vegetable and Crops | Crops | Farmers | Compensation at market price | a) 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.<br>b) Scheduled rate of Mizoram will be used as reference for unit price, but since the rate was published in 2013 (No.K.12011/10/2007-REV), inflation at the time of payment shall be considered. |
| Wage worker (driver etc) | Wage | Wage worker | Assistance for loss of income | a) Compensation for the loss of income and employment opportunity due to project (equivant to three-month wages)<br>b) Vocational training if changing jobs is necessary<br>c) Priority work opportunities in the project construction work |

| Type of Loss | | Application | Entitlement | Details |
|---|---|---|---|---|
| Owner of business | Income from Business | Business owner | Assistance for loss of income | a) Compensation for the loss of income and business opportunity due to the project<br>b) Vocational training if continuation of business is not feasible<br>c) Priority work opportunities in the project construction work |
| *Assistance for Resettlement* | | | | |
| House/Shop | | Owner of structures to be relocated | Moving assistance | a) Moving allowance of Rs 50,000/-<br>b) Shifting allowance of Rs 7500/- for installation of water and electricity etc.<br>c) Commuting assisntance for PAHs who need to commute longer due to resettlemnet |
| *Vulnerable Groups* | | | | |
| Vulnerable groups | | Poor people, women-headed households, household with orphan, widow, etc. | Additional assistance | a) One-time additional financial assistance of Rs 25,000<br>b) Preferencial access to income restoration and other publc services<br>c) Priority work opportunities in the project construction work (particularly ones that can be done by eldery and women) |

Source: JICA Study Team

## 8.12 Income Restoration

The socioeconomic survey of the PAPs indicates that the main sources of income in the project influence area are agriculture and small business enterprises. Because of this, there are a considerable number of PAHs with limited capacity to benefit from the livelihood opportunities created under the development projects or any government sponsored programs. 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 the 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 stages of the project, but three options are presented below for considerations. Keeping the 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 common livelihood activity in the 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 the project area can be enhanced through supply of quality saplings.

Shared Market Place

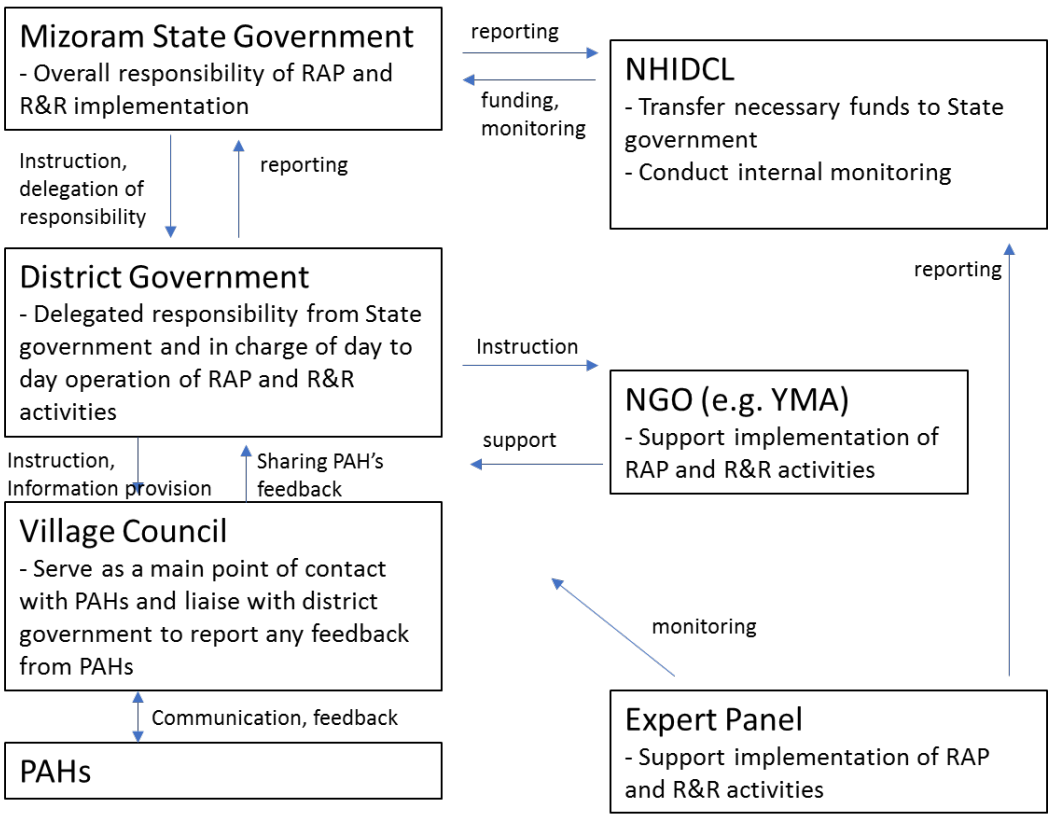
While the new bypass (and road widening and improvement of NH54) is expected to facilitate trade across borders, these roads also may have the potential to boost local level trade and improve linkages of the villages in the interiors with the local and regional markets. At the same time, relocation is likely to cause a negative impact on households who have benefited from the near-road location suitable for business. It is recommended that the project creates benefit sharing arrangements with communities along the project roads as well as building capacities for increasing the production and trade potential, for example, through improvement and/or construction of common market places 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 efforts may work to the benefit of the producer.

## 8.13 Institutional Arrangement for RAP Implementation

As per the 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 the village council and the traditional village leaders also play a major role in implementing the RAP. The 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 the NHIDCL) will work closely with the state and district/village officials to ensure that implementation of the RAP is in line with the JICA Guidelines for Environmental and Social Considerations. The institutional arrangement for the RAP implementation is shown in Figure 8.13-1.




Source: JICA Study Team

**Figure 8.13-1 Institutional Arrangement for RAP Implementation**

## 8.14 Grievance Redress Mechanism

According to the land Acquisition Act of Mizoram stipulates that the grievance redress procedures are as follows:

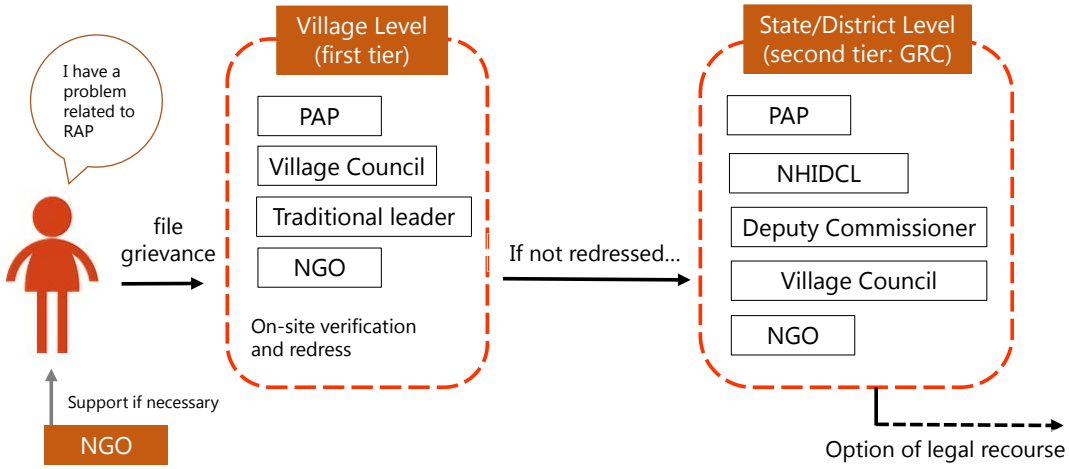
1. Objection to the land acquisition and/or contents of the Social Impact Assessment can be submitted within 60 days from the date of Preliminary Notification by the government. The objection must be made in writing to the collector (Article 15).
2. The state government will conduct public hearings in the process of preparing the rehabilitation and resettlement scheme. Comments and objections raised during the hearing will be submitted to the collector (Article 16 (6)).
3. Objection about the contents of compensation and assistance can be submitted to the collector between 30 days and six months from the issuance of the land acquisition notice (Article 21 (2)).
4. If the claimant refuses to accept the compensation, he or she can request the collector to bring the issue to court.

In this project, a two-tier Grievance Redress Mechanism (GRM) is established at the village level as well as the district/state level. The two-tier system aims to provide more accessible and easy-to-use mechanism for the PAHs. Yet, this does not provent the PAHs to have legal recourse.

The first tier of the GRM takes place at the village level. The first tier, as a window of contact for affected people, supports PAHs when/if they need assistance in making objections as per Mizo Act (e.g. prepare formal objection letter). The informal mechanism can also conduct physical verification and certification upon receipt of any grievance such as inaccurate measurement of impacted asset, loss of access, and 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 the PAPs who file the grievance, and such, 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 the GRC. A GRC will be formed by the project authority within one month from the date of mobilization of the RAP implementation agency at the site. The GRC will comprise of the 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 the RAP implementation agency. Grievances of PAPs in writing will be brought to the 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 meetings but may meet more frequently, depending upon the number and type of grievances. 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 the court of law. The flow of grievance redress mechanism is shown in Figure 8.14-1.




Source: JICA Study Team

**Figure 8.14-1 Grievance Redress Mechanism**

## 8.15 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 the 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 the RAP implementation are critical in order to measure the project performance and fulfillment of the project objectives. Summary of the specific tasks to be carried out in each type of monitoring activities is shown in Table 8.15-1.

**Table 8.15-1 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 of the schedule of grievance status; minutes of any stakeholder or affected people consultations or meetings. The format of internal monitoring is enclosed in Annex 8. |

| Type | Frequency | Prepared by | For | Report Contents |
|---|---|---|---|---|
| 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 to the 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 that the NHIDCL has complied with the undertakings defined by the RAP as well as land acquisition and compensation has been completed in accordance with the JICA Guidelines |

Source: JICA Study Team

To ensure that external monitoring be implemented in line with JICA Guideliens, an expert with experience of external monitoring in donor-funded projects will be monilized to lead the Panel. At the same time, given that the majority of the affected people are Mizo, experts in local university and NGO with knowledge of Mizo customs and culture will also participate in the Panel. The Extert Panel will be composed on these experts and will be supported by local assistants. The external monitoring will be conducted against the following indicators:

- ✓ Payment of Compensation: Whether the compensation has been provided at the replacement cost prior to the resettlement and prior to the commencement of construction work; whether the record of negotiation and payment are properly maintained.
- ✓ Staffing: whether the number of staff dedicated to RAP & R&D implementation and their skills/experiences are adequate
- ✓ Consultation: whether adequate consultation is carried out with PAPs for R&R assistance?
- ✓ R&R: Has the R&R been adequately and timely carried out for different types of losses?
- ✓ Grievance: whether the GRM is adequately functioning; whether the PAPs are happy with the GRM.
- ✓ Livelihood Restoration: A sample survey shall be conducted to measure whether the livelihood of PAHs have improved or at least restored compared with the pre-project level.
- ✓ Reporting: whether the contents of internal monitoring report is adequate; whether the reports are shared with relevant stakeholders: whether remedical actions are taken, if needed.

## 8.16 Public Consultation

### 8.16.1 1st Consultation Meeting

The schedule and attendance of the 1st round of consultation meetings are shown in Table 8.16-1.

**Table 8.16-1 Schedule and Attendance of the 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 |

Source: JICA Study Team

In the 1st round of the consultation meetings, the summary of the project was presented with the note that the bypass was being discussed in response to the request of the local people (bypass is preferable to avoid resettlement). The summary of census survey which started in February was also presented with request for cooperation. Major concerns and comments raised in the consultations and responses are summarized in Table 8.16-2.

**Table 8.16-2 Comments and Responses in the 1st Round of Consultation**

| Main Concerns/Comments | Responses |
|---|---|
| *General issues*<br>• 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. (across all bypasses)<br>• Participants expresss their support to the project. In terms of census survey, they requested to inform the schedule of the survey to the Village Council in advance so that they can stay home on the date of the survey (across all bypasses) | • The provisional route plan as per DPR was provided, and it was explained that another round of consultation will be held once basic design was developed.<br>• Appreciae the support and cooperation. The date and time of the survey will be shared with the Village Council. |
| • Would appreciate if this kind of meeting can be held for each Village Council, not each bypasss. (BP2) | • The 2nd round of meetings will be held in each Village Council. |
| *Land Acquisition and Resettlement*<br>• PAHs requested that compensation to be paid in cash and in advance from the start of the project implementation. (across all bypasses)<br>• 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 the JICA Guidelines.<br>• The project will be implemented in compliance with the Indian and Mizoram laws and the JICA Guidelines. Monitoring will be done to ensure compliance. |

Source: JICA Study Team

### 8.16.2 2nd Consultation Meetings

There are villages with muiltiple Village Councils. The 2nd round of consultation meetings were organized per Village Council in response to the request from the community so that participants can discuss issues thoroughly. In order to identify landowners on the proposed bypass area that were not identified in the 1st round of meetings, the proposed route map was shared with Village Council in advance to invite the target audience. To minimize the burden of PAHs to attend the meeting, the meeting was held in conjuction with the meeting for the EIA. In addition, additional briefing sessions for the BP2 area were held in July 23rd and 25th for those who have missed the three official consultation meetings. The two meetings were attended by 12 and 17 people respectively. The schedule and attendance of the 2nd round of consultation are shown below.

**Table 8.16-3 Schedule and Attendance of the 2nd Round of Consultation**

| Bypass | Date | Target VC | No. of Attendees | | |
|---|---|---|---|---|---|
| | | | M | F | Total |
| BP1 | 12 July 2016 | Chhiahtlang 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

To promote the participation of women, inputs from a local NGO which work for the empowerment of women is sought. The time of the meeting was set early in the morning or in the evening where women are more likely to attend (they are busy during the daytime). The possibility of women-only focus groups was also explored, but it was concluded not necessary because in Mizoram, women can freely speak in front of men. While the participation of women remained low in the 2nd round of consultation, most of them did not participate because "one person from family is sufficient and if my husband goes, I don't think I need to go."

During the 2nd round of meetings, the results of the socio-economic survey was presented. More importantly, the contents of the draft RAP report, particularly procedures of land acquisition and compensation packages and the grievance redress mechanism were explained. Main concerns, comments and responses are shown in Table 8.16-4. At the end of the meeting, the PAHs (for all four bypasses) expressed their support to the project and demanded that the project be implemented as soon as possible.

**Table 8.16-4 Comments and Responses in the 2nd Round of Consultation**

| Main Concerns/Comments | Responses |
|---|---|
| *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. (across all bypasses) | • 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. |
| • The Village Council members suggested that the vegetation be cleared so that villagers can clearly see the proposed alignment in the hilly area (BP2) | • Clearance of vegetation and forest will be done after the forest clearance permit is obtained. Also, reforestation will be carried out to offset the loss of forest coverage. |
| *Land Acquisition and Resettlement* | |
| • PAHs reiterated that it is essential that the compensation is to be paid in cash and in advance at the start of the project implementation. | • The compensation and replacement cost will be disbursed before the construction activity begins, as per the provisions in the JICA Guidelines. |
| • 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 proposed route is based on the comprehensive review of technical feasibility, environmental impacts such as the volume of residual soil and impact of resettlement, among others. |
| • A PAP asked why the valley side of the community road is planned to be widened for the bypass (BP1). | • PAHs were reminded not to negotiate with such middlemen, as all project related activities will be done directly by NHIDCL and/or the Government of Mizoram. If there are questions, PAHs were advised to contact with the district settlement officers. |
| • Some participants said they were approached by a "broker" who pretended to serve as a negotiator between PAHs and NHIDCL. Can we trust them? (BP1, 2, 3) | |

Source: JICA Study Team

# 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 NH54 bypass project by reviewing the contents of the 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 meets the SARDP-NE target of development of the region through improvement of connectivity as part of the NH54 mainline project. The possibility of access from the NH54 project to Kaladan Multimodal Transit Transport Project was confirmed. In this regard, the 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 the traffic study, project costs and economic analyses of the Project, the EIRR of the Project of the NH54 main road section plus the 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 the DPR, it was confirmed that design concept for alignment design does not consider well environmental impact and natural disaster prevention. The study team introduced the design concept for the environment and disaster prevention such as earth balanced alignment design and advanced slope protection design, which was introduced in developed countries. The team also introduced the spoil bank to provide flat land for the promotion of effective use and disposal of soil.
2) Since the preliminary design in the DPR has not carried out topographic survey and geotechnical survey, accuracy of the basis for the alternative route study is low. Therefore, the study team carried out topographic surveys and geotechnical surveys for the alternative route study and preliminary design to ensure accuracy of the design.
3) The study team prepared the preliminary project cost in reference to the SOR in 2015 and cost of advanced slope protection works which is introduced to the design.
4) The JICA Study Team examined the construction and implementation plans.
5) The study team conducted surveys on the NHIDCL's institutional structure, annual budget, and maintenance of the existing roads under their administration. As a result of the surveys, it was confirmed tha the NHIDCL has just started their organizational function and maintenance systems by the NHIDCL is still under consideration. Therefore, the study team proposed an institutional structure for maintenance of the project road in consideration of the importance of maintenance aiming for disaster prevention.
6) The survey team reviewed the EIA related to the activities of environment and social consideration, and confirmed the present condition of the environment (water quality, air, noise, vibration). In addition, the study team carried out the identification of PAPs based on site survey using design drawings, and social interview surveys along the project road to prepare the draft RAP. The draft EIA and RAP are prepared in accordance with the JICA Environmental Guideline. To ensure smooth implementation of RAP works during project implementation, preparation of accurate RAP drawings is essential.

## 9.3 Recommendations

Since implementation schedule of the NH54 mainline and the NH54 bypasses will be overlapped, efficient procurement of contractor and consultant for the NH54 bypass project is proposed with reference to the geographical condition.