Detailed Project Report

Vol-III

DLI/CON/776/644

For

Construction of Two Lane Road
on NH Specification Starting from Kaletwa Chainage from km 60.700 to km 70.700 in Chin State of Myanmar

Engineering Projects (India) Ltd.

(A Government of India Enterprise)
CONTENTS

S.no.   Description                                           Pages

0.0     EXECUTIVE SUMMARY                                    3-9

1.0     INTRODUCTION                                         10-14

1.1     General                                             
1.2     Project Background                                   
1.3     Scope of Consultancy                                 
1.4     Project Objectives                                   
1.5     Report Structures                                   

2.0     METHODOLOGY ADOPTED                                  16-19

2.1     Introduction                                         
2.2     Highway Planning/Design                              
2.3     Topographic Map Study                                
2.4     Traffic Study                                        
2.5     Pavement Option Study                                
2.6     Geotechnical & Material Investigation                
2.7     Environmental Impact Assessment                      
2.8     Bridges & Culverts                                   

3.0     PROJECT DESCRIPTION                                  20-28

3.1     General                                             
3.2     Project Road                                         
3.3     Geology                                             
3.4     Rivers/Streams/Water Crisis                          
3.5     Climate                                             
3.6     Socio Economic Profile                              

4.0     ENGINEERING SURVEYS AND INVESTIGATIONS               29-39

4.1     General                                             
4.2     Reconnaissance                                      
4.3     Population                                          
4.4     Topographic survey                                   
4.5     Material Investigations                             
         Sub – Soil Investigations for Bridges
5.0  DESIGN STANDARDS AND PROPOSED CROSS SECTIONS

5.1 Design Standards for Road
5.2 Design standards for Bridges
5.3 Technical Specifications
5.4 Proposed Cross Sections

6.0  ENGINEERING DESIGN AND PROPOSALS

6.1 Length of the Project Road
6.2 Traffic Demand Estimate
6.3 Pavement Design
6.4 Cross Section Elements & Alignment
6.5 Drainage
6.6 Protective Works
6.7 Road Fixtures
6.8 Road side Amenities
6.9 Structures

7.0  RATE ANALYSIS

7.1 General
7.2 Material Rates
7.3 Material Lead Charges
7.4 Machinery Hire Charges
7.5 Labour Rates
7.6 Characterization of unit Rates

8.0  COST ESTIMATE

8.1 General
8.2 Cost Estimating Methodology
8.3 Estimation of Quantities
8.4 Earth Works
8.5 Pavement Material(Flexible)
8.6 Cross Drainage Structures
8.7 Drainage and Protective Works
8.8 Bus Stops and Truck Lay Byes
8.9 Road Furniture and Safety Works
8.10 Contingencies & Escalation charges
Detailed Project Report

For

Construction of Two Lane Road
on NH Specification Starting from Kaletwa Chainage from km 60.700 to km 70.700 in Chin State of Myanmar
EXECUTIVE SUMMARY
Executive Summary

0.0 General

Under the bilateral agreement between Government of India and Government of Myanmar, there is a proposal to develop a trade route between the two countries along the river Kaladan known as “Chhimtuipui” river inside Indian border (Mizoram State). River Kaladan (Chhimtuipui) emanates from central Mizoram and flows into Bay of Bengal at Sittwe, a port located in the State of Rakhine, Myanmar. For connectivity from Sittwe Port to India-Myanmar border, the trade route is proposed to provide transportation by two modes of transport i.e. from Sittwe port to Paletwa by waterway and from Paletwa to India-Myanmar border by road. The proposed road link from Paletwa to Zorinpui (India-Myanmar Border) in Chin State of Myanmar forms a part of the proposed development of trade route along the river Kaladan (Chhimtuipui) between Mizoram (India) and Chin State in Myanmar.

0.1 Project Road

The project road runs, in the South - North direction in the Chin State of Myanmar, parallel to Kaladan River. The project road takes off from Eastern bank of Kaladan River, where jetty of waterway terminal has been proposed as part of “Waterway Project” between Sittwe port and Paletwa and end at India Myanmar Border. The total length of the proposed alignment of the Project Road has been estimated at 109.200 km (Package I (Paletwa to Kaletwa) is 60.700 km and package II( Kaletwa to Zorinpui /India-Myanmar Border) is 48.500 km). Package –II is under the scope of Engineering Projects (India) Limited (EPIL) i.e. from Kaletwa to Zorinpui, total length in this package is 48.5 Km, whereas the length of 10 Km (starting from Km 60.700 to Km 70.700) is the scope under this tender.

The alignment passes through hilly terrain. There are twenty four villages situated nearby the proposed alignment of the project road. The hills are covered with jungles and thick undergrowth of evergreen bush, bamboo and kail. The hills are steep and separated by rivers Kaladan, Milewa chaung, Daletme and Dalesta chaung, paron Chaung, Kaletwa River, Niiti Chaung, Kannu Chaung, Twoase Chaung, Kun Chaung, Thala Chaung, Sat Chaung Chaung, Do Chaung, Tangbel Chaung, Sulahi Chaung, Sulewvi Chaung and Tapu Chaung, creating valleys between hill ranges.

The project road is traversing at altitude between 20m and 300m height from mean sea level. The annual rainfall is between 300-400cm. The project area is thinly populated and cultivation is the main source of income.

0.2 Engineering Surveys and Investigations

Topographical Survey

The topographic survey consisting of running an open traverse along the alignment. The topographic surveys have been carried out using sophisticated and precision instruments like Total Station, Auto level and Global Positioning System. The survey covered a strip of 48m width (24m on either side of alignment) with cross sections taken at 10 meter intervals to form a Digital Terrain Model (DTM). Spot levels, typical features, habitation and streams etc. have been mapped during topographic surveys. Similar details have been picked up for streams /rivers, crossing the proposed alignment. Data are stored in electronic format. Control points/ Reference pillars, consisting cement concrete pillars with central nail point, have been fixed at every 100 m intervals.
Material Investigations

The Survey and Investigations of subgrade soil and materials along project road have been conducted to identify suitable materials for the construction of embankment, subgrade, sub-base, base and other system of the road pavement. The other aim of the survey is to determine the engineering properties of the following materials, which are to be used during the execution of the project.

- Soil characteristics at proposed road alignment level.
- Borrow area materials for use in the embankment and subgrade.
- Quarries for hard stone aggregates for use in Wet Mix Macadam (WMM), Dense Bituminous Macadam (DBM), Bituminous Concrete (BC) and Cement Concrete works. Sand for use in bituminous mixes and cement concrete and other construction works. Water for use in cement concrete works.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Location</th>
<th>Soil Classification</th>
<th>Unified Soil Group</th>
<th>Atterberg Limit LL</th>
<th>PP</th>
<th>OMC</th>
<th>MDD</th>
<th>Soaked CBR 4 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Km 0.00</td>
<td>Brown Clayey</td>
<td>CI</td>
<td>50</td>
<td>25</td>
<td>15</td>
<td>1.80</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Km 5.00</td>
<td>Brown Clayey</td>
<td>CI</td>
<td>48</td>
<td>27</td>
<td>15.2</td>
<td>1.73</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Km 10.00</td>
<td>Brown Clayey</td>
<td>CL</td>
<td>32</td>
<td>21</td>
<td>13</td>
<td>1.92</td>
<td>7</td>
</tr>
</tbody>
</table>

Test Results for Soil Samples

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Location</th>
<th>Specific Gravity</th>
<th>Absorption (%)</th>
<th>Clay Lump (%)</th>
<th>Crushing Value (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kwan Chaung</td>
<td>2.44</td>
<td>1.5</td>
<td>&lt;1.0</td>
<td>35.0</td>
<td>Suitable for Sub-base, Base &amp; Surface Courses</td>
</tr>
<tr>
<td>2</td>
<td>Twaose Chaung</td>
<td>2.52</td>
<td>1.4</td>
<td>&lt;1.0</td>
<td>28.3</td>
<td>Suitable for Sub-base, Not Suitable Base &amp; Surface Courses</td>
</tr>
<tr>
<td>3</td>
<td>Thalan Chaung</td>
<td>2.48</td>
<td>4.0</td>
<td>&lt;1.0</td>
<td>28.4</td>
<td>Suitable for Sub-base, Not Suitable Base &amp; Surface Courses</td>
</tr>
<tr>
<td>4</td>
<td>Water Fall (Thalan Chaung)</td>
<td>2.41</td>
<td>3.8</td>
<td>&lt;1.0</td>
<td>29.4</td>
<td>Suitable for Sub-base, Not Suitable Base &amp; Surface Courses</td>
</tr>
<tr>
<td>5</td>
<td>Satchaing Chaung</td>
<td>2.36</td>
<td>5.9</td>
<td>&lt;1.0</td>
<td>26.6</td>
<td>Suitable for Sub-base, Not Suitable Base &amp; Surface Courses</td>
</tr>
<tr>
<td>6</td>
<td>Tangbel Chaung</td>
<td>2.34</td>
<td>5.6</td>
<td>&lt;1.0</td>
<td>48.4</td>
<td>Suitable for Sub-base, Not Suitable Base &amp; Surface Courses Suitable for Sub-base,</td>
</tr>
<tr>
<td>7</td>
<td>Sulahi Chaung</td>
<td>2.54</td>
<td>1.8</td>
<td>&lt;1.0</td>
<td>24.7</td>
<td>Not Suitable Base &amp;</td>
</tr>
</tbody>
</table>

Water Fall
0.3 Engineering Design and Proposals

The detailed design for the project road has been adopted with the objective of preparation of detailed engineering report for two-lane road as per codes and practices, based on the findings of survey and investigations and design standards. The proposals include provision for the following items:

- Traffic Demand Estimate
- Horizontal and Vertical Alignment design;
- Pavement Design;
- Culverts and Bridges;
- Protection work; and,
- Road appurtenances

Cross Section Elements

The cross-section of any road is governed by the traffic volume expected on the road. The project road takes off from terminal of IWT at Paletwa, on the right bank of Kaladan River, and it would serve as a cross-border route connecting India and Myanmar. The traffic along the project road would use the National Highway NH-54 to reach its destination anywhere in north-eastern region of India or vice-versa. The carriageway width of NH-54 varies from single lane (3.75m) to two lanes (7.0 m). At Myanmar end, the supply of traffic is linked up with proposed design traffic capacity of Inland Water Transport (IWT) route along Kaladan
River at Paletwa. As per IWT study, vessel cargo handling would be equivalent to maximum 200 trucks per day. Besides, there would also be some local commercial and passenger traffic along the project road.

The proposed design standards in respect of various cross-section elements for the Project Road are from category of “Two Lane”. The summary of design standards, for hill roads, for different road lanes are given below

**Design Standards for Cross-section Elements of Hill Roads**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Design Elements</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carriageway width</td>
<td>7.0 m</td>
</tr>
<tr>
<td>2.</td>
<td>Shoulder width</td>
<td>2.5 m both side including drain</td>
</tr>
<tr>
<td>3.</td>
<td>Formation width</td>
<td>12 m</td>
</tr>
<tr>
<td>4.</td>
<td>Cross-slopes/camber (%)</td>
<td>2.5 %</td>
</tr>
<tr>
<td></td>
<td>Maximum Super elevation</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Traffic Estimate**

Traffic volume data is one of most important information for decision-making related to planning, design, management, operation, and control of transportation system.

The project road would serve as trade route and Study of Inland Water Transport (IWT) along river Kaladan in Myanmar has indicated that there would be maximum traffic (commercial traffic only) of 200 trucks per day. Besides, there would be some passenger vehicles also. The passenger traffic of the project road had been estimated based on the population served by the Project road and general trip making behaviour in the area. Based on the preliminary study it has been estimated that about 3-5 minibuses and about 5-6 cars and about 10 two wheelers would use the project road beside the movement of the army in the area (assumed as 10 trucks per day). Based on the above assumptions the traffic estimated for the project road is presented in below table.

**Estimated traffic on the Project road**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trucks (International trade)</th>
<th>Cars</th>
<th>Mini Buses</th>
<th>Two Wheelers</th>
<th>Trucks (Local)</th>
<th>Trucks (Army)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>200</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>232</td>
</tr>
</tbody>
</table>

**Pavement**

The details of pavement thickness proposed for the project road is given in below table.

**Proposed Pavement Structure**

<table>
<thead>
<tr>
<th>Homogeneous Sections (KM)</th>
<th>Pavement Composition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paletwa to Zorinpui (India Myanmar Border)</td>
<td>BC  40</td>
</tr>
</tbody>
</table>
Total 34 culverts have proposed along the project road based on the requirement. The summary of type of culvert provided in given below.

**Culvert Details**

<table>
<thead>
<tr>
<th>S.no</th>
<th>Type of Culvert</th>
<th>Package II (From Km 60.700 to Km 70.700)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Pipe (1.2 ø)</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Box 2m x 2m</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Slab 4m</td>
<td>04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slab 5m</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34</td>
</tr>
</tbody>
</table>

**Bridges**

Total 02 (Two) bridges have proposed along the project road (From 60.700 to Km 70.700) based on the requirement. The summary of type of bridges provided in given below.

**Details of Bridges (From Km 60.700 to Km 70.700)**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Section</th>
<th>No. of Major Bridges (≥60 m)</th>
<th>No. of Minor Bridges (&lt;60m)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Package II- Kaletwa to Zorinpui / Indian – Myanmar Border</td>
<td>-</td>
<td>02</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0</td>
<td>02</td>
<td>02</td>
</tr>
</tbody>
</table>

**Kaladan River**
**Proposed Minor Bridges**

There are 02 New minor bridges (<60 m) along the project length (i.e. for 10 km, from Km 60.700 to Km 70.700), the type of structure, location and span details are listed below:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Chainage (km)</th>
<th>Span Arrangement (m)</th>
<th>Superstructure</th>
<th>FRL</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2+910</td>
<td>1x20.0(R230)</td>
<td>RCC I-beam with cast-in-situ deck slab</td>
<td>262.000</td>
<td>Kannu Chaung</td>
</tr>
<tr>
<td>2</td>
<td>7+275</td>
<td>1x30.0</td>
<td>PSC I-beam with cast-in-situ deck slab</td>
<td>249.000</td>
<td>Kan Chaung</td>
</tr>
</tbody>
</table>

**Retaining wall**

For the proposed road, using digital terrain model (DTM), provisions have been made for retaining walls for the following areas.

- Places where the valley side gets saturated in monsoon and slips.
- Where there is a likelihood of damages caused by streams.
- Places on the valley centered curves where rainwater flows towards the valley because of super-elevation being on the hillside.

The retaining walls are proposed to be as given below:

- Random rubble dry stone with strengthening bands of stone in cement mortar of 1:6 mix; and

For the stone masonry retaining walls, the front face of the wall is kept vertical when the height is small. For larger heights, a nominal slope of 1 in 50 is given to avoid the feel of overhang when seen from the top.

**Details of Retaining wall**

Along the project length (i.e. for 10 km, from Km 60.700 to Km 70.700)

<table>
<thead>
<tr>
<th>Project Road Package</th>
<th>Length of Proposed Retaining Wall (in m)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package II- Kaletwa to Zorinpui / Indian – Myanmar Border</td>
<td>LHS</td>
<td>RHS</td>
</tr>
<tr>
<td></td>
<td>3444</td>
<td>988</td>
</tr>
</tbody>
</table>
### Details of Breast Walls

<table>
<thead>
<tr>
<th>Project Road Package</th>
<th>Length of Proposed Breast Wall (in m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LHS</td>
</tr>
<tr>
<td>Package II- Kaletwa to Zorinpui / Indian –</td>
<td>538</td>
</tr>
<tr>
<td>Myanmar Border</td>
<td></td>
</tr>
</tbody>
</table>

#### 0.4 Labour and Equipment

**Labour and Equipment**

Sufficient local labour, for road construction work, is not available. Further, the cultivation and harvesting season clash with the working season. Since this is a highly malaria prone area, imported labourers are not willing to work in such remote area. Helipads & emergency evacuation mechanism, dispensaries, well equipped to combat malaria, need to be established at few convenient places before commencement of the project. Therefore, it is envisaged that equipment / machine intensive methods would be adopted for proposed construction works.

**Transportation of Construction Items and Equipments**

The project is located in remote area of the hilly areas of Chin State. Access to the area is poor and limited through mode of water-transport and on foot only. In the present scenario, the river Kaladan in the stretch from Paletwa to Kaletwa is navigable from middle of June to middle of November (5 months).

#### 0.5 Unit Rates and Cost Estimate

The cost estimates for the proposed construction works have been based on the quantities derived from the design drawings and unit rates for different items of works.

**Unit Rate**

No construction activity (road / bridge / structure) has ever been carried out in the project area. The project road is located in the hinterland, without any proper road connectivity. The currency used for rate analysis is Indian Rupee. In order to workout the unit rates of construction items following standard documents have been referred to:

- Schedule of Rates (for Southern Mizoram) of PWD, Mizoram
- Schedule of Rates (For Rakine Region) in Myanmar
- Standard Data Book of MoRTH 2003

The rates given in Schedule of Rates have been enhanced, as recommendation given by the respective department/ agency, to obtain current rates.
CHAPTER 1
INTRODUCTION
CHAPTER 1

1.0 INTRODUCTION

1.1 General

The Consultancy for Detailed Engineering Project Report for Two Lane Road from Paletwa to Setpyitpyin (Kaletwa) (Package-I) and Setpyitpyin (Kaletwa) to Zorinpui/ India Myanmar Border (Package II) in Chin State of Myanmar was awarded to IRCON Infrastructure & Services Ltd and the EPI-C&C JV is the contractor (Known as Employer in bidding documents) for the “Construction of Two Lane Kaladan Road Project.”

1.2 Project Background

North Eastern region of India comprises of seven states viz., Assam, Meghalaya, Manipur, Tripura, Nagaland, Arunachal Pradesh and Mizoram. This region is connected by land with the rest of India through West Bengal. The surface transport system for movement of cargo/passengers to and from the northeastern states consists of road, rail and waterways. As far as cargo movement is concerned, most of the cargo originates from Kolkata and terminates at Guwahati and vice-versa. From Guwahati, the cargo gets distributed to various destinations of northeastern states. The transport links to states particularly Mizoram, Tripura, Manipur and Nagaland are affected many a time by floods, landslides, blockages of roads and local agitations.

Under the bilateral agreement between Government of India and Government of Myanmar, there is a proposal to develop a trade route between the two countries along the river Kaladan known as “Chhintuipui” river inside Indian border (Mizoram State). River Kaladan (Chhintuipui) emanates from central Mizoram and flows into Bay of Bengal at Sittwe, a port located in the State of Rakhine, Myanmar. For connectivity from Sittwe Port to India-Myanmar border, the trade route is proposed to provide transportation by two modes of transport i.e. from Sittwe port to Paletwa by waterway and from Paletwa to India-Myanmar border by road. The proposed road link from Paletwa to Kaletwa forms a part of the proposed development of trade route along the river Kaladan (Chhintuipui) between Mizoram (India) and Chin State in Myanmar. The location of this proposed trade route has been shown in Figure. 1.1 “Key Map”.

The connectivity would boost the trade between India and Myanmar. While India trades in cement, bicycle parts, medicines and horticulture products of Mizoram. From Myanmar handicrafts and clothes, apart from electronic goods and shoes, arrive in plenty. Two existing waterway routes are connecting northeastern state of Assam through the waterways in Bangladesh (Figure 1.2). Navigation through Bangladesh is governed by the Protocol Agreement between India and Bangladesh. The first route is from Kolkata to Guwahati (1439 km) through River Brahmaputra and the second route is between Kolkata and Karimganj (1233 km.) through River Kushia & Barak.
Figure 1.1: Key Map
Circuitous land link with the rest of the country and the difficult hilly terrain which impose great restrictions in the development of surface transport facilities led to exploration of new transport system (routes / modes) to connect farther states of Mizoram, Tripura, Manipura and southern parts of Assam. One such identified route is movement of cargo from Kolkata to Sittwe Port by sea and there on wards by waterway / Roadway to Mizoram.

Figure 1.2: IWT Route

1.3 Scope of Consultancy/ Employer

The project road is a new alignment to be developed taking into consideration of the technical and economic viability of the project. The scope of work covers the following:

1. Preparation of Detailed Project Report for Two lane road from Setpyitpyin (Kaletwa) to Zorinpui/ India Myanmar Border (Package II) in Chin State of Myanmar.

2. Examine suitability of all new materials / technologies accredited by authorities, approved/ accredited in the country of origin and those based on best global practices in the industry and their suitability with respect to site conditions, their initial cost and life cycle cost.


4. Preparation of bidding documents.
1.4 Project Objectives

The objectives of the study are as follows:

1. To establish the technical and economic viability of the project and prepare detailed project reports for new alignment for Two lane road from Setpyitpyin (Kaletwa) to India Myanmar Border (Package II) in Chin State of Myanmar.

2. Study the various options for project road and finalization of alignment based on engineering aspects, safety, quantities of various items of works and cost estimates. To prepare detailed project report including bidding documents, required for tendering the project for international / local competitive bidding.

3. Incorporate aspects of value engineering and quality audit requirement in design and implementation.
CHAPTER 2

METHODOLOGY ADOPTED
2.0 METHODOLOGY ADOPTED

2.1 Introduction

The Detailed Engineering Design essentially aims at working out the best/optimum alignment and various technical improvements of the project stretch after considering relevant environmental and social impacts, effectiveness, economic, international best practices including the use of state-of-art techniques, within the limited time and cost frame. This necessarily leads to inter-play of various competing demand and an inter-disciplinary treatment. Thus multi-disciplinary approach has to be adopted involving:

- Traffic Estimation
- Highway Planning/Design
- Pavement Option and Drainage Study
- Bridge Design
- Material Engineering & Geo-technical Investigation
- Topographical Survey
- Environmental Impact Assessment
- Estimation of Bill of Quantities
- Rate Analysis & Costing

Considerable amounts of field investigations have been carried out for different study components throughout the stretch and the consultant maintained liaison offices at Delhi and Myanmar to ensure effective communication with client and take help of its well-equipped design office at New Delhi for preparation and delivery of the projects.

The Consultant’s approach to the project will be in accordance with the “Scope of Services” given in the Contract Document, understanding of the project objectives and discussions with the Client during progress of the project study. Flow chart showing the methodology adopted is furnished below in Figure 2.1.
Figure 2.1: Flow Chart of Study Methodology

**DETAILED ENGINEERING DESIGN**

- **Mobilization & Reconnaissance**
  - Secondary Data Collection
  - Alignment Option Study
  - Traffic Studies

- Engineering Surveys
  - Alignment Finalization
  - Detailed Engineering

- Environmental & Social
  - Estimation of Quantities
  - Rate Analysis
  - Cost Estimation
  - Reports & Drawings

**Client Approval**

2.2 **Highway Planning/Design**
Strip plans with the help of Topographical maps of each kilometer showing all the physical elements of the project stretch for 30m width on either side has been prepared. On the basis of strip maps, knowledge of the existing problems and constraints and the inputs from the traffic Engineer, Highway Engineer, Material, Bridge Engineer, Geometric Design Standards has been prepared keeping in view the requirements of TOR. Different alignment options have been examined and provided wherever it is felt that the additional cost will be offset by the benefits. While finalizing the scheme, the social impact due to acquisition and resettlement and environmental impact has been considered.

2.3 **Topographical Map Study**

A reconnaissance survey has been initially conducted with Survey of Myanmar maps in scale 1:50000. The total project road has been divided in various stretches to expedite the work and forestall the delay that may occur due to monsoon. Open traverses with total station have been used for surveying 24m on each side of the proposed carriageway with a cross section points at every 10m interval. Final drawings showing all surface features and utilities have been prepared in 1:1000 scale, using benchmark (GTS) & Global co-ordinates.

2.4 **Traffic Study**

The traffic on the project road consists primarily of the internal trade between India and Myanmar. AADT, Design Service Volume and Capacity of road have been derived as an input for pavement design.

2.5 **Pavement Option Study**

The recommended design has been based on Indian Road Congress publications and relevant codes.

Traffic has been estimated for the project road based on the secondary information obtained from IWT office in India and Myanmar. Traffic projection over the design period has been done using secondary data. For the VDF it has been assumed as 3.5 as prescribed in the codes.

However, based on the payment composition as proposed for the Lawngtlai-Indo-Myanmar Border has been adopted for the project road.

2.6 **Geo-technical & Material Investigation**

Methodology of investigation adopted for the project has been arrived from reconnaissance survey of the terrain, comparison with geo-morphological aspects of similar terrain, TOR and the guidelines of Codes and specification for Roads & Bridges from Ministry of Road Transport and Highways (MoRT&H). Final bore locations for conducting Geotechnical investigations has been identified based on the bridges proposed and with consultation/approval with client. The geo-technical investigation has been tackled under: The pavement sub-grade studies and investigation for major and minor bridges.

For pavement design, a CBR sample tests has been undertaken at proposed alignment at every five km interval. Soil sample collected from each test pit for determining Grading, Atterberg Limits, Standard/Modified Proctor limit and CBR. All soil samples have been
tested in the laboratory of Ministry of construction, Myanmar to derive the soil parameters for the design of pavements, embankments and bridge foundations.

In order to investigate the sources and availability of materials and to compute the unit cost of selected materials for road construction namely, stone, sand, and other locally available materials like moorum, late rites & other soft aggregates etc. and water for construction. Information regarding the source, unit cost, quality, etc. has been gathered from locals, local suppliers and contractors. A preliminary investigation to determine the yield and quality have been carried out before sending for detailed laboratory investigation at laboratory. The market rate for unit costs of materials has been rationalized by adding carriage, royalty, cess and taxes.

A detailed project report from Kaletwa to India Myanmar border in Chin state of Myanmar was prepared by RITES with carriageway width of 3.75m. However Ministry of External Affairs has decided to submit the detailed project report with carriageway width of 7.0m with a change in exit point at India-Myanmar border.

Geo-Technical and Material Investigation reports prepared by RITES have been used for this section for the preparation of GAD and BOQ of structures for Package II (Kaletwa to India Myanmar border)

### 2.7 Environmental impact assessment

The Environmental Assessment Study, valued environmental components has been identified in consultation with local habitants, and experts. Initial environmental survey has been carried out and strip map of the entire route of the highway has been prepared. The environmental survey concentrated on the primary impact areas of the proposed highway, which was within 30m on either side of the highway. Sources of information have been based on primary and secondary level information including topographic sheets of Survey of Myanmar. An environmental Screening report has been prepared.

Environmental Assessment Study analysis aimed at screening of important and major environmental issues. Main output of the report was to identify major areas of environmental concern, to work out and develop probable alternatives that should be tried at the preliminary design and feasibility assessment stage of the Report.

Various alternatives have been analyzed to arrive at the selection of proposed alignment, which would be the most appropriate and environmental feasible proposition.

### 2.8 Bridges & Culverts

After a detailed reconnaissance survey the number and type of culverts and bridges have been identified. Based on the detailed investigations carried out, span arrangements for bridges have been determined considering the hydraulic characteristics of the channel.

Hydrological survey for each drain and channel in order to determine scour depth, discharge, velocity, HFL etc. have been carried out. Based on geotechnical investigation report, design of the foundation has been proposed.
CHAPTER 3
PROJECT DESCRIPTION
CHAPTER 3

3.0 PROJECT DESCRIPTION

3.1 General

Myanmar is situated in Southeast Asia and is bordered on the north and northeast by China; on the east and Southeast by Laos and Thailand; on the south by the Andaman Sea and the Bay of Bengal; and on the west by Bangladesh and India. It is located between latitudes 09°32’N and 28°31’N and longitudes 92°10’E and 101°11’E. The country covers an area of 677,000 square kilometers (261,228 square miles) ranging 936 kilometers (581 miles) from east to west and 2,051 kilometers (1,275 miles) from north to south.

The border between two countries (India and Myanmar) is demarcated by a natural water stream “Tapu Chaung” (known as “San Lui” in India). The proposed trade route, would cross the India-Myanmar International Border, as finalised during the “Technical Feasibility report on Road connectivity from Sittwe to India-Myanmar border in Myanmar”, at 22°0-6.43’ Northing and 92°0-46.5’ Easting. Besides, the study also recommended the proposed route to be adopted for connectivity from border crossing point to National Highway (NH54) in Mizoram state of India.

3.2 Project Road

The project road runs, in the South - North direction in the ChinState of Myanmar, parallel to KaladanRiver. The project road takes off from Eastern bank of Kaladan River, where jetty of waterway terminal has been proposed as part of “Waterway Project” between Sittwe port and Paletwa and end at India Myanmar Border. The total length of the proposed alignment of the Project Road has been estimated at 10 Km Kaletwa to Zorinpui India-Myanmar Border.

The road passes through Hilly terrain. There are three (03) villages situated nearby the proposed alignment of the project road.

The hills are covered with jungles and thick undergrowth of evergreen bush, bamboo and kail. The hills are steep and separated by rivers Kaladan, Milewa chaung, Daletme and
Dalesta chaung, paron Chaung, Kaletwa river, Niiti Chaung, Kannu Chaung, Twoase Chaung, Kun Chaung, Thala Chaung, Sat Chaing Chaung, Do Chaung, Tangbel Chaung, Sulahi Chaung, Sulewvi Chaung and Tapu Chaung, creating valleys between hill ranges. The project road is traversing at altitude between 20m and 300m height from mean sea level. The annual rainfall is between 300-400 cm. The project area is thinly populated and cultivation is the main source of income.

3.3 Geology

The geological map of Myanmar shows that in the region of project road, hills are tertiary formations and consist of predominantly sandstones. The sandstone vary from semi-hard blue and green textured stone, fair to good for road construction works. These friable stones are liable to disintegrate on exposure to the weather. The availability of good quality of stone is very limited.

3.4 Rivers / Streams /Water courses

The Kaladan, Milewa and Kaletwa Rivers are flowing from north to south as the hills are also in north-south direction whereas Dalesta and Dalema rivers are flowing south to north. The alignment of project road traverses parallel to Milewa Chaung (river), Dalesta, Dalema Chaung and Kaletwa. As a result, a number of water courses/ streams have been formed across the proposed alignment. These streams flow mainly in east-west direction.

3.5 Climate

Myanmar has three main seasons, hot season, rainy season and cold season. Hot season is from March to May, rainy season is from June to October and cold season is from November to February. The tropical monsoon is usually cloudy, rainy, hot, humid summers and less cloudy, scant rainfall, mild temperatures, lower humidity during winter. April and May are the hottest months in the project area, while the extreme temperature varies but mean maximum temperature works out to be 20°C in Sittwe Town. During the rainy season, from May to September, climateremains very humid. During winter season and particularly rainy season, thick, low lying clouds reduce visibility, impede movement and hold up work. Depending on the variation in temperatures and general weather conditions, three different types of seasons are observed in Project Influence Area (PIA):

Winter: Starts from November and lasts till February. The temperature is comparatively lower (11°C – 23°C), but not too low to make human habitation difficult. The season receives very little rainfall.

Spring: Season begins from March and lasts till first half of May and merges with rainy season. The temperature rises up to a range of 19°C to 29°C being aggravated by rainless days.

Rain: This is the longest season; hold out for nearly five months from second mid of May till late September. Rainfall is very heavy from May to September, with about 40 per cent of the annual rainfall received during July and August.

Elevation and distance from the sea affect temperature as well. Although Myanmar generally is a tropical country, temperatures are not uniformly high throughout the year. The daily temperature range is greater than that in nearly all other parts of Southeast Asia, but no locality has a continental type of climate (i.e., one characterized by large seasonal differences in average temperature). Mandalay, in the centre of the dry zone, has some of the greatest daily temperature ranges, which span about 12 °C annually. In broader
perspective, however, average daily temperatures show little variation, ranging from 26 °C to 28 °C between Sittwe (Akyab) in the Rakhine region, Yangon near the coast, and Mandalay in the northern part of the central basin. At Lashio, on the Shan Plateau, the average daily temperature is somewhat cooler, around 22 °C.

### 3.6 Socio Economic Profile

#### Area and Population

The total area of Myanmar is 678,500 sq km where 657,740 sq km occupies the land and 20,760 sq km occupies the water. The bordering countries are Bangladesh 193 km, China 2,185 km, India 1,463 km, Laos 235 km, and Thailand 1,800 km. The central lowlands ringed by steep, rugged highlands The lowest point is the Andaman Sea (0 m) and the highest point Hkakabo Razi (5,881 m).

Myanmar is made up of 135 national races, of which the main national races are Kachin, Kayah, Kayin, Chin, Bamar, Mon, Rakhine and Shan. Population is estimated to be over 60 million. The nationality is Myanmar. There are more than 100 ethnic groups in Myanmar. Some of the Ethnic groups are listed as Akha, Palaung, Padaung, Naga, Taron, Eng and many more near extinct tribes. The religions are Buddhist, Christian and Muslim. The major language is Myanmar, but minority ethnic groups have their own languages. English is widely spoken and understood.

The majority of Myanmar’s population is rural, with the density of settlement in each region related to agricultural production, particularly of rice. Thus, the most populous regions are the Irrawaddy delta and the dry zone, and the highest densities are found in the upper delta, between Yangon and Hinthada (Henzada). Settlement in the Sittang delta, the sedimented hinterland of Sittwe, and the regions of both sides of the lower Chindwin River is moderately dense. The Rakhine region (except the Sittwe area), the west bank of the Irrawaddy at the base of the Rakhine Mountains, Tenasserim, and the less accessible parts of the western and northern mountains and the Shan Plateau are sparsely inhabited. Although city populations have been growing, the pace of urbanization has not been as rapid in Myanmar as it has been in most other countries of Southeast Asia.

The population of Myanmar remains fairly youthful, with roughly one-fourth of the people under age 15. However, the proportion of young people has been decreasing steadily since the late 20th century, as the birth rate has dropped from notably above to significantly below the world average. Life expectancy, on the contrary, has been on the rise, with most men and women living into their 60s.

#### Economy

Myanmar’s economy, based on the kyat (the national currency), is one of the least developed of the region and is basically agricultural. Much of the population is engaged directly in agricultural pursuits. Of those who are employed in other sectors of the economy, many are indirectly involved in agriculture through such activities as transporting, processing, marketing, and exporting agricultural goods.

Nearly half of Myanmar’s economic output—notably all large industrial enterprises, the banking system, insurance, foreign trade, domestic wholesale trade, and nearly all the retail trade—was nationalized in 1962–63. Agriculture and fishing were left in the private sector. In 1975–76, however, the government reorganized nationalized corporations on a more commercial basis and instituted a bonus system for workers. The overall economic objectives of self-sufficiency and the exclusion of foreign investment also were revised. Foreign investment was permitted to
resume in 1973, although only with the government. Following a military coup in 1988, both foreign and indigenous private enterprise was encouraged. Myanmar also has an extensive informal economy. Considerable quantities of consumer goods are smuggled into the country, and teak and gems are exported both legally and illegally. In addition, northern Myanmar is one of the largest producers of opium in the world.

**Agriculture, forestry, and fishing**

Agriculture, forestry, and fishing together constitute the largest contributor to Myanmar’s economy. About half of all agricultural land in Myanmar is devoted to rice, and to increase production the government has promoted multiple cropping (sequential cultivation of two or more crops on a single piece of land in a single year), a system that is easily supported by the country’s climate. As a whole, the sector accounts for nearly one-half of the country’s gross domestic product (GDP) and employs about two-thirds of the labour force.

Myanmar may be divided into three agricultural regions: the delta, where cultivation of rice in flooded paddies predominates; the largely irrigated dry zone, an area primarily of rice production but where a wide variety of other crops also are raised; and the hill and plateau regions, where forestry and cultivation of rice and other crops through shifting agriculture are most important.

Although the dry zone was Myanmar’s most important agricultural region in the past, the rice production of the Irrawaddy River delta now provides much of the country’s export earnings and the staple diet of the country’s people. The delta’s traditional agriculture consisted primarily of rice in normal years, with the substitution of millet in drier years when there was insufficient moisture for rice; both grains yielded good returns on the alluvial soils.

Crops raised in the dry zone, in addition to rice, include sugarcane, fruits (such as plantains), legumes, peanuts (groundnuts), corn (maize), onions, sesame, rubber, and allspice. To cultivate much of this land successfully, however, irrigation is required. The earliest known irrigation works were constructed in the 1st century and greatly improved in the 11th century; though their maintenance lapsed somewhat after the fall of the monarchy in the late 19th century, many are still in active service. As in the delta, the arrival of the British in the dry zone led to increased commercial and public-works activities. British authorities repaired and extended parts of these ancient systems during the early 20th century. Most of Myanmar’s irrigated land is in the dry zone, and almost all of it is planted in rice. The portions of the dry zone that are not irrigated are utilized for the production of crops that are less sensitive to the seasonality or irregularity of rainfall than rice. In addition to the crops mentioned above, cotton and millet are cultivated, although neither is of considerable significance. Cattle also are raised there.

The third agricultural zone, the hill and plateau country, occupies perhaps two-thirds of the area of Myanmar. This land has less economic significance than the other two zones; it is the home of many of the country’s non-Burman ethnic groups, most of whom are engaged in shifting cultivation. More-sedentary modes of agriculture also exist, however, and have been imposed with the advance of agricultural technology, increased population, and central planning. Outside the forest areas of these highlands, the principal crops raised are rice, yams, and millet, and large numbers of pigs and poultry are kept. Bullocks and buffalo are used as draft animals, and goats, pigs, and poultry are raised for food in all parts of the country.

The second most important element in the diet, after rice, is fish—fresh or in the form of *ngapi*, a sort of nutritional paste that is prepared in a variety of ways and eaten as a
condiment. Much private, noncommercial fishing is provided, however, in virtually every type of permanent, seasonal, or artificial body of inland water of any size. Nonindigenous fish, including the European carp and the tilapia (originally brought from Thailand), have become the focus of a growing aquaculture industry.

Forestry has been particularly important as a source of foreign exchange. Myanmar is estimated to have the bulk of the world’s exploitable teak supplies. Teak is found in the tropical-deciduous forests of the hills. Although the forests are owned and regulated by the state, concern has been raised about indiscriminate and illegal logging.

Resources and Power

Myanmar is rich in minerals, including metal ores, petroleum, and natural gas, and also has significant deposits of precious and semiprecious stones. Although production has been increasing from last few decades still mining sector accounts for small portion of country’s GDP having small share of workforce.

Large-scale exploitation of Myanmar’s mineral deposits began in the mid-1970s. Deposits of silver, lead, zinc, and gold are concentrated in the northern Shan Plateau, tin and tungsten in the Tenasserim region, and barite around the town of Maymyo in the central basin. Copper mining at the town of Monywa began in the early 1980s and has been growing, despite intermittent setbacks caused by shortages of fuel and supplies as well as by economic sanctions imposed by foreign governments.

Rubies and sapphires have been mined in the northern Shan Plateau since precolonial times. Jade is mined in the northern mountains. The country also produces smaller quantities of spinels, diamonds, and other gemstones. When Myanmar was colonized by the British in the late 19th century, the extraction of petroleum from the country’s central region already was an established local practice. The industry was expanded by the British and, since the mid-20th century, by the government of independent Myanmar. Although exploration for onshore petroleum resources since independence has not proved particularly fruitful, exploration for natural gas has been especially productive. Exploitation of onshore gas fields began in the 1970s, and in the 1990s extensive gas fields were opened offshore—especially in the Gulf of Martaban—and a pipeline was constructed to serve Thailand. There are oil refineries at Chauk, Syriam, Mann, and other locations.

Myanmar also has major deposits of coal, and production rose sharply in the early 21st century. Coal is mined primarily in the upper Irrawaddy and Chindwin valleys. The demand for electricity chronically has outstripped capacity. Although much of the country’s energy is drawn from fossil fuels, hydroelectricity accounts for a significant and rapidly expanding segment of Myanmar’s total power supply. The government has built several hydroelectric power plants, including those on the BaluRiver (a tributary of the Salween), at Taikkyi near the city of Bago (Pegu), in the northern Rakhine region, and near Mandalay.

Manufacturing

There was little industrialization in Myanmar until the mid-20th century, when a limited program was initiated after the country achieved independence. Yangon, Myingyan (in the dry zone), and the Rakhine area were selected to become the new industrial centers. Although the manufacturing sector has expanded, it has not grown as rapidly in Myanmar as it has in other countries of the region.
A major enterprise in Myanmar is tobacco production, consisting of government-owned factories, which manufacture cigarettes, and cottage industries, which produce cheroots (a type of small cigar). Other important industries include steel processing, the manufacture of nonelectrical machinery and transportation equipment, and cement production. Textile factories have been established in Yangon, Myingyan, and other cities, but growth of the industry has been hindered since the late 20th century by intermittent sanctions by foreign governments. Myanmar also produces lumber, paper, processed foods (mainly rice), and some pharmaceuticals. Cottage industries are encouraged by subsidies.

**Trade**

The government’s decision in the early 1960s to limit foreign trade reversed the export orientation of the British colonial period. However, the subsequent relaxation of trade restrictions, notably the legalization of trade with China and Thailand in the late 20th century, allowed trade again to become a significant component of the national economy. Natural gas is Myanmar’s primary export, followed by pulses (mostly dried beans), teak, and minerals and gems. Its principal imports include machinery and equipment, industrial raw materials, and consumer goods. Owing largely to the sanctions imposed by the United States and members of the European Union since the end of the 20th century, Myanmar’s Asian neighbours—including Thailand, Singapore, China, Hong Kong, India, and Japan—have become its chief trading partners.

**Transportation**

The country’s trade in rice is dependent on water transport. The Irrawaddy River is the backbone of Myanmar’s transportation system. The Irrawaddy is navigable year-round up to Bhamo and to Myitkyina during the dry season, when there are no rapids. The Chindwin is navigable for some 500 miles (800 km) from its confluence with the Irrawaddy below Mandalay. The many streams of the Irrawaddy delta are navigable, and there is a system of connecting canals. The Sittang, in spite of its silt, is usable by smaller boats, but the Salween, because of its rapids, is navigable for less than 100 miles (160 km) from the sea. Small steamers and country boats also serve the coasts of the Rakhine and Tenasserim regions.

The first railway line, running from Yangon to Pyay (Prome) and built in 1877, followed the Irrawaddy valley. The line was not extended to Mandalay; instead, after 1886 a new railway from Yangon up the Sittang valley was constructed, meeting the Irrawaddy at Mandalay. From Mandalay it crossed the river and, avoiding the Irrawaddy valley, went up the Mu River valley to connect with the Irrawaddy again at Myitkyina. A short branchline now connects Naba to Katha on the Irrawaddy below Bhamo.

The Yangon-Mandalay-Myitkyina railway is the main artery, and from it there are branchlines connecting the northern and central Shan Plateau with the Irrawaddy. Other branches run from Pyinmana across the Bago Mountains to Kyaukpadaung and from Bago to Mawlamyine to Ye. The Pyay-Yangon railway has a branchline crossing the apex of the delta to Hinthada and Pathein (Bassein).

The road system, until independence, was confined to the Irrawaddy and Sittang valleys, duplicating the railway route. A road goes from Pyay along the Irrawaddy to the oil fields, and many roads extend into the rural areas. These rural roads, however, are often impassable during the wet season. There were originally three international roads in use during World War II: the Burma Road from Lashio to Kunming in China; the Stilwell, or Ledo, Road
between Myitkyina and Ledo in India; and the road between Kengtung, in the southeastern Shan Plateau, and northern Thailand. These roads subsequently became neglected but more recently were rebuilt and extended.

The state-run Myanmar Airways International runs frequent domestic flights between Yangon and other cities; it also has international service from Yangon to several major Southeast Asian cities. There are also small privately owned airlines that offer domestic and very limited international service. International airports are located in Yangon and Mandalay.

Yangon, as the terminus of road, rail, and river-transport systems, is the country’s major port, with up-to-date equipment and facilities. Pathein, Mawlamyine, and Sittwe are also important ports.

**ChinState**

ChinState is located in the north-west of Myanmar between 20° 40' N and 24° 06'N latitudes and 92° 37'E and 94° 09'E longitudes. To the north and east of ChinState is Sagaing Division, to the south are Magway Division and RakhineState, and to the west are Bangladesh and India. The area of the State is 13,907 square miles and capital is Hakhar.

**Area & population**

Chin State is inhabited by different Chin tribes, Nagas, Rakhines and Myanmarns in nine Townships and 505 Wards and Village-Tracts. It has a population of about 368,985. Main agricultural crops are paddy, maize and millet although wheat, groundnut, chilli, cotton and sugar-cane are also grown. Apples, oranges, damsons and other garden fruits are produced in large quantities and grapes are being cultivated on an experimental basis. Cultivable acreage has increased as the State has built irrigation works, introduced terrace cultivation, distributed pedigree seeds and insecticides and provided tractor ploughing.

**Resources**

The 605 square miles of Forest Reserves in Chin State produce valuable scented woods, teak, pine and cane. Hilly though the State is, the hills are not rocky but made up of shale and earth. Some coal is found in west Kabaw valley. In livestock breeding, sericulture is the principal industry.

**Ecotourism**

There is a beautiful heart shape lake called "Reh" close to the Indian border. Mt.Victoria can also be climbed. Tourists can also visit the Nat-Ma-Taung or the Mt.Victoria nature park in the ChinState.

**Pictorial Description of the Site**

**Package II : Kaletwa to India Myanmar Border**
Detail Project Report for Package –II
(from Km 60.700 to Km 70.700)

Setpyitpyin Village

Kaladan river

Ch 0+500

Ch 1+100

Rake Village

Ch 4+000

Kaun Village

Ch 10+000
CHAPTER 4
ENGINEERING SURVEYS AND INVESTIGATIONS
CHAPTER 4

4.0 ENGINEERING SURVEYS AND INVESTIGATIONS

4.1 General

The project road is located in Chin State of Myanmar. The project road takes off from left bank of Kaladan River, where the road from Paletwa would meet the project road. The entire project road traverses through hilly terrain and virgin lands.

The consultants carried out detailed engineering surveys and other associated surveys and investigations as given below:

- Reconnaissance;
- Topographic surveys;
- Environmental Impact;
- Construction material surveys and investigations; and
- Hydrological survey;

This chapter describes details and findings of detailed engineering surveys carried out for preparation of project report.

4.2 Reconnaissance

The main objective of reconnaissance survey is to examine the general character of the area for the purpose of identification of the most feasible route for further investigations and detailing. Prior to taking up the ground reconnaissance survey, the following maps and secondary data, pertaining to project influence area, have been collected and studied:

- Topographic survey sheets collected from Survey of Myanmar (Scale 1:50,000)
- Proposed alignment of RITES (for Package II i.e from Kaletwa to Indian/Myanmar Border).
- The ground reconnaissance consisted of general examination of the ground by walking along all the probable route(s) and collected information necessary for evaluating the same.
- Geological information regarding project area.
- Environmental and Social issues.

4.3 Population

The Chin state is sparsely populated. The details of villages which are situated in the vicinity of the project road are given below:

Table 4.1: List of villages on the Project Road for Whole Project Length from Km 0.00 to Km 109.200

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Village</th>
<th>Population (Numbers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Paletwa</td>
<td>5481</td>
</tr>
<tr>
<td>2</td>
<td>Milawa</td>
<td>121</td>
</tr>
<tr>
<td>3</td>
<td>Leik kon</td>
<td>350</td>
</tr>
</tbody>
</table>
### Detail Project Report for Package –II
(from Km 60.700 to Km 70.700)

<table>
<thead>
<tr>
<th>No</th>
<th>Village</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Mang khoil</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>Mang Ta</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Tuki Alog</td>
<td>135</td>
</tr>
<tr>
<td>7</td>
<td>Urin Wa</td>
<td>190</td>
</tr>
<tr>
<td>8</td>
<td>Dalet Sa</td>
<td>104</td>
</tr>
<tr>
<td>9</td>
<td>Ye Lawa</td>
<td>350</td>
</tr>
<tr>
<td>10</td>
<td>Dong Lawa</td>
<td>505</td>
</tr>
<tr>
<td>11</td>
<td>Ke Kuwa</td>
<td>295</td>
</tr>
<tr>
<td>12</td>
<td>Uwfu Wa</td>
<td>270</td>
</tr>
<tr>
<td>13</td>
<td>We Kuwa</td>
<td>129</td>
</tr>
<tr>
<td>14</td>
<td><strong>Setpyitpyin</strong></td>
<td><strong>364</strong></td>
</tr>
<tr>
<td>15</td>
<td><strong>Rake</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>16</td>
<td><strong>KaunChaung</strong></td>
<td><strong>240</strong></td>
</tr>
<tr>
<td>17</td>
<td>Kwan Taung</td>
<td>528</td>
</tr>
<tr>
<td>18</td>
<td>Laung Gyaing</td>
<td>400</td>
</tr>
<tr>
<td>19</td>
<td>Sat Gyaing</td>
<td>395</td>
</tr>
<tr>
<td>20</td>
<td>Kyauktan</td>
<td>108</td>
</tr>
<tr>
<td>21</td>
<td>Do Chaung</td>
<td>1118</td>
</tr>
<tr>
<td>22</td>
<td>Yechantha</td>
<td>189</td>
</tr>
<tr>
<td>23</td>
<td>Sun Laung Pwi</td>
<td>303</td>
</tr>
<tr>
<td>24</td>
<td>Samai</td>
<td>147</td>
</tr>
</tbody>
</table>

**Photographs of villages**

*(India Myanmar Border) in Chin State of Myanmar*
4.4 **Topographical Survey**

The topographic surveys have been carried out using sophisticated and precision instruments like Total Station, Auto level and Global Positioning System. The survey covered a strip of 48m width (24m on either side of alignment) with cross sections taken at 10 meter intervals to form a Digital Terrain Model (DTM). Spot levels, typical features, habitation and streams etc. have been mapped during topographic surveys. Similar details have been picked up for streams /rivers, crossing the proposed alignment. Data are stored in electronic format. Control points/ Reference pillars, consisting cement concrete pillars with central nail point, have been fixed at every 250m intervals.

The survey maps have been prepared in 1:1000 scale, using the engineering design software MOSS / MXRoad and Auto-Cad, and given in *Volume-II: Drawings* of this Report.

### Topographical Survey

<table>
<thead>
<tr>
<th>Total Station</th>
<th>Differential Global Positioning System</th>
</tr>
</thead>
</table>

4.5 **Material Investigations**

The Survey and Investigations of subgrade Soil and materials along Project Road have been taken-up to identify suitable materials for the construction of embankment, subgrade, sub-base, base and other system of the road pavement. The aim is to determine the engineering properties of the materials, which are to be used during the execution of the project.

- Soil characteristics at proposed road alignment level.
- Borrow area for use in the embankment and subgrade
- Quarries for hard stone aggregates for use in Wet Mix Macadam (WMM), Dense Bituminous Macadam (DBM), Bituminous Concrete (BC) and cement concrete works
Detail Project Report for Package –II
(from Km 60.700 to Km 70.700)

- Sand for use in bituminous mixes and cement concrete and other construction works
- Water for use in cement concrete works.

The investigations comprised testing of soils and other materials, both in the field and laboratory. The tests included checking field density, moisture content, Atterberg Limits etc. The samples after collection have been sent to the laboratory for detailed investigations. The following tests were conducted in the laboratory.

- Sieve Analysis
- Atterberg Limits
- Modified Proctor Compaction (MDD) test and Optimum Moisture Content (OMC)
- Unsoaked and Soaked CBR Value at Three Energy Levels

Extensive survey have been conducted to identify borrow areas for locating suitable soil/soil aggregates mixes to be used in the construction of embankment and subgrade. Details of the test results are provided in Table 4.2 a & b. Efforts have been made to locate borrow areas near the project road to avoid long haulage of the materials. Similarly, detailed survey has been carried out to identify stone metal quarries of hard stone for use in Granular Sub-base (GSB), Wet Mix Macadam (WMM), bituminous and cement concrete works.
Table 4.2: Test Results for Soil Samples

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Location</th>
<th>Soil Classification</th>
<th>Unified Soil Group</th>
<th>Atterberg Limit</th>
<th>Compaction Test</th>
<th>4 days Soaked CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LL</td>
<td>PP</td>
<td>OMC</td>
</tr>
<tr>
<td>1</td>
<td>km 0.00</td>
<td>Brown Clayey</td>
<td>CI</td>
<td>50</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Km 5.00</td>
<td>Brown Clayey</td>
<td>CI</td>
<td>48</td>
<td>27</td>
<td>15.2</td>
</tr>
<tr>
<td>3</td>
<td>Km 10.00</td>
<td>Brown Clayey</td>
<td>CL</td>
<td>32</td>
<td>21</td>
<td>13</td>
</tr>
</tbody>
</table>
Site Photograph

Package II: Kaletwa to Zorinpui / Indian – Myanmar Border
Stone Metal Quarries

Extensive survey has been conducted to locate the availability of stone metal near the project site. As a result of local enquiries and discussions with the local officials, stone metal quarries have been identified at riverbed and rock quarries close to the project road. The samples from all these quarries have been collected and tested in the laboratory. Test results of the stone aggregate samples are provided in Table 4.3 a & b.

Table 4.3: Test Results for Stone Aggregates

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Location</th>
<th>Specific Gravity</th>
<th>Absorption (%)</th>
<th>Clay Lump (%)</th>
<th>Crushing Value (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lymyo</td>
<td>2.62</td>
<td>1.2</td>
<td>&lt;1.0</td>
<td>19.3</td>
<td>Suitable for Sub-base, Base &amp; Surface Courses</td>
</tr>
<tr>
<td>2</td>
<td>Sin Ma (Yellow)</td>
<td>2.58</td>
<td>3.1</td>
<td>&lt;1.0</td>
<td>38.3</td>
<td>Suitable for Sub-base, Not Suitable Base &amp; Surface Courses</td>
</tr>
<tr>
<td>3</td>
<td>Sin Ma (Blue)</td>
<td>2.77</td>
<td>1.2</td>
<td>&lt;1.0</td>
<td>15.4</td>
<td>Suitable for Sub-base, Base &amp; Surface Courses</td>
</tr>
</tbody>
</table>

Do Chaung

Sulai Chaung
Sand

Sand is available from two sources, Kaladan River and Limyo River. The samples have been tested for suitability for construction. The results are provided in Table 4.4. Sand collected from Kaladan river is of fine variety having fineness module of 0.9 to 1.5, and is not suitable for concrete works. Sample collected from Lemyo was found suitable for concrete.

Table 4.4: Test Results for Sand

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Specific Gravity</th>
<th>Absorption (%)</th>
<th>Clay Lump</th>
<th>Fineness Modulus</th>
<th>Loose Density(Kg/m³)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample No. – 1 (Kaladan River)</td>
<td>2.5</td>
<td>2.5</td>
<td>&lt;3.0</td>
<td>1.5</td>
<td>1427.38</td>
<td>Not Suitable for concrete work</td>
</tr>
<tr>
<td>Sample No. – 2 (Kaladan River)</td>
<td>2.4</td>
<td>2.8</td>
<td>&lt;3.0</td>
<td>1.2</td>
<td>1251.16</td>
<td>Not Suitable for concrete work</td>
</tr>
<tr>
<td>Sample No. – 3 (Kaladan River)</td>
<td>2.6</td>
<td>2.6</td>
<td>&lt;3.0</td>
<td>2.0</td>
<td>1385.73</td>
<td>Not Suitable for concrete work</td>
</tr>
<tr>
<td>Sample No. – 4 (Kaladan River)</td>
<td>2.5</td>
<td>2.3</td>
<td>&lt;3.0</td>
<td>0.9</td>
<td>1291.21</td>
<td>Not Suitable for concrete work</td>
</tr>
<tr>
<td>Sample No – 5 Lemyo</td>
<td>2.5</td>
<td>2.2</td>
<td>&lt;1.0</td>
<td>2.8</td>
<td>1424.18</td>
<td>Suitable for Concrete work</td>
</tr>
<tr>
<td>B.S Specification for Concrete</td>
<td>2.6 - 2.8</td>
<td>3.0</td>
<td>3.0</td>
<td>2.2 – 3.6</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
4.6 **Sub – Soil Investigations for Bridges**

As per the scope of work following activities have been carried out for Geo-technical evaluation of bridge locations from Paletwa to Kaletwa (Package I). Secondary data information obtained from the RITES report has been considered for the geotechnical investigations for Package II from Kaletwa to Zorinpui.

**Boring / Drilling**

The boreholes of 150mm diameter at the specified locations have been drilled by deploying hydraulic feed rotary drilling techniques as per IS: 1892. The depth of soil overburden varies from 1.0 m to 4.5m. Rock Core drilling was carried out by hydraulic feed rotary machine using diamond bit. The rotary core drilling equipment and procedure for drilling was as per IS: 6926. The drilling equipment was provided with necessary facilities to regulate the spindle speed, bit pressure and water pressure during core drilling to get good core recovery. The borehole depths, description of soil, N-values from SPT and the depth at which ground water table was encountered are given in Material Investigations Report.

**Standard Penetration Test**

Standard penetration tests have been conducted in each borehole at specified depth as per IS: 2131- 1981 to establish the penetration resistance of the soil.

These tests were conducted in all types of soil deposits met within a bore hole, to find the variation in the soil stratification by correlating with the number of blows required for unit penetration of a standard penetration. This test was conducted at 1.50m intervals and every change of strata. The standard split spoon sampler is lowered at the bottom of bore hole and allowed to sink under its own weight along with the weight of connecting drill rods, then the split spoon sampler is driven 15 cm. by 63.5 kg hammer falling freely through 75cm. Thereafter, the sampler is further driven by 30cm. The number of blows required for every 15cm of penetration is recorded. The first 15cm of drive is considered as seating drive. The total number of blows required for last 30 cm of penetration is termed as SPT ‘N’. On removal of sampler, the soil entrapped in the sampler was taken out and visually classified and representative soil sample is preserved as disturbed sample in polythene bags to avoid the loss of fines, moisture content.

**Collection of Soil Samples**

Undisturbed soil samples are collected from each borehole at specified depths in thin wall sampling tubes of 10 cm in diameter and 45cm long with area ratio not more than 10% as per specification of IS: 2132: 1986. The tubes were sealed with paraffin wax at both ends, labeled depth wise and dispatched to the laboratory.

**Rock Core Samples**

Core samples were extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores were extracted from the barrel directly into a suitable sized half round plastic channel section. Proper care has been taken to maintain the direction of extrusion of sample same as that while coring to avoid stress reversal. Immediately after withdrawal from the core barrel; the cores samples were placed in a tray and transferred into boxes specially prepared for the purpose. The boxes were
made from seasoned timber material and indexed on top of the lid as per IS: 4078. The cores were numbered serially and arranged in the boxes in a sequential order. The description of the core samples recorded as per IS: 4464.

Geo-Technical Investigations at Kaladan Bridge
CHAPTER 5
DESIGN STANDARDS AND PROPOSED CROSS SECTIONS
CHAPTER 5

5.0 DESIGN STANDARDS AND PROPOSED CROSS SECTIONS

5.1 Design Standard for Road

Guiding Principles
For the design of a good highway, guiding principles are:

- Horizontal and vertical geometry should be accorded due importance to avoid rectification at a later date.
- Road formation levels should be such so as to avoid recurring expenditure from the effect of flood waters.
- Safety should be the criteria for adopting design standards.
- Design standards should minimize the use of 5Ms (money, men, material methods & machinery).
- Optimum efficiency in traffic operations with maximum safety at reasonable cost to road users.
- Minimum maintenance cost.

Geometric Design Standards

Terrain Classification
The terrain classification has been adopted for the Project Road is given in Table 5.1.

<table>
<thead>
<tr>
<th>Terrain</th>
<th>% Cross-slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Rolling</td>
<td>10 – 25</td>
</tr>
<tr>
<td>Mountainous</td>
<td>25 – 60</td>
</tr>
<tr>
<td>Steep</td>
<td>&gt; 60</td>
</tr>
</tbody>
</table>

The project road traverses through hilly terrain comprising mountainous and steep terrain, as per classification given above. The standards have been classified separately for mountainous and steep terrain. Generally, the standards for steep terrain take lower value of design speed, radii of curve etc. At quite a few locations, the terrain change from mountainous to steep or vice versa, may be within short distance. It is nor desirable to change standards frequently. As per standard practice, stretches will be classified, as Mountainous or steep depending on pre-dominant terrain in the stretch and accordingly standards would be adopted for that stretch. The same standards should, generally, continue for maximum distance possible / practicable.

Design Speed
The proposed design speeds for hilly terrain are given in Table 5.2.

<table>
<thead>
<tr>
<th>Mountainous Terrain</th>
<th>Steep Terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruling</td>
<td>Minimum</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Ruling</td>
<td>Minimum</td>
</tr>
<tr>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>
Road Land Width

The desirable width of road land (right of way) for the stretches of project road, located in open areas and built up areas is given in Table 5.3

<table>
<thead>
<tr>
<th>Open areas</th>
<th>Built up area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Exceptional</td>
</tr>
<tr>
<td>24</td>
<td>18</td>
</tr>
</tbody>
</table>

Alignment Design

Horizontal Alignment

Horizontal alignment essentially comprises three major elements: tangent section, circular curve and transition curve. A balanced control on the above elements is required to provide safe and continuous flow of vehicles under general traffic conditions. The design parameters governing the curve elements are given in Table 5.4. Super-elevation \( (e) \) is calculated by the formula:

\[ e = \frac{V^2}{225R} \]

Where, \( V \) = design speed in km/h
\( R \) = radius of horizontal curve in m.

Maximum super-elevation, however, would be restricted to a value of 0.07. A maximum side friction factor of 0.15 would be taken into account and that is very likely to be available with the coarse texture of proposed premix carpeting / asphalt concrete wearing course.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Design Elements</th>
<th>Design Speed, km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hilly Terrain (not bound by snow)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>Radius of Horizontal curve (m)</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>• Minimum</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>• No transition curve</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Transition curves in a form of spiral between the tangent section and circular curve element are designed to satisfy the requirements of allowable rate of change in experiencing centrifugal acceleration by the user and attaining super-elevation on carriageway for the circular curve.

Since the entire length of the alignment is traversing through hilly to steep terrain, the design standards for relevant to hilly terrain have been given below. Minimum lengths of transition curve proposed for different speeds and radii are given in Table 5.5.
Table 5.5: Minimum Lengths of Transition Curve for Different Speeds and Radii

<table>
<thead>
<tr>
<th>Curve Radius (R) (m)</th>
<th>Transition Length (m) for speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 kmph</td>
</tr>
<tr>
<td>25</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>NA</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>70</td>
<td>NA</td>
</tr>
<tr>
<td>80</td>
<td>55</td>
</tr>
<tr>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>125</td>
<td>35</td>
</tr>
<tr>
<td>150</td>
<td>30</td>
</tr>
<tr>
<td>170</td>
<td>25</td>
</tr>
<tr>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>300</td>
<td>15</td>
</tr>
<tr>
<td>400</td>
<td>15</td>
</tr>
<tr>
<td>500</td>
<td>NR</td>
</tr>
</tbody>
</table>

Note: NA = Not Applicable; NR = Not Required

**Hair-Pin Bends**

The hair-pin bends, where unavoidable, would be designed either as a circular curve with transition at each end, or as a compound circular curve. The following criteria have been proposed to follow for their design:

- **a)** Minimum design speed = 20 km/h
- **b)** Minimum roadway width at apex = 11.5m
- **c)** Minimum radius for the inner curve = 14.0m
- **d)** Minimum length of transition curve = 15.0m
- **e)** Maximum gradient = 1 in 40 (2.5%)
  - Minimum gradient = 1 in 200 (0.5%)
- **f)** Superelevation = 10%

Where a number of hairpins bends have to be introduced, a minimum intervening distance of 60m has been provided between the successive bends to enable the driver to negotiate the alignment smoothly. At hairpin bends, the full roadway width has been surfaced.

**Grade Compensation at Curves**

At horizontal curves, the gradients should be eased by an amount known as the ‘grade compensation’ which is intended to offset the extra tractive effort involved at curves. This may be calculated from the following formula: Grade Compensation (per cent) = \( \frac{30 + R}{R} \)

Subjected to a maximum of 75/R,
Where, \( R \) = Radius of the curve in meters
Grade compensation is not necessary for gradients flatter than 4 percent.

**Widening at Curves**

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passage as provided in Table 5.6.

<table>
<thead>
<tr>
<th>Radius of Curve (m)</th>
<th>Extra Width (m) – Two lane road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 40</td>
<td>1.5</td>
</tr>
<tr>
<td>41 to 60</td>
<td>1.2</td>
</tr>
<tr>
<td>61 to 100</td>
<td>0.9</td>
</tr>
<tr>
<td>101 to 300</td>
<td>0.6</td>
</tr>
<tr>
<td>Above 300</td>
<td>Nil</td>
</tr>
</tbody>
</table>

**Table 5.6: Widening at curves**

**Vertical Alignment**

There are two major elements in vertical geometry of an alignment *i.e.* longitudinal gradient and vertical curve. The gradients for different terrain conditions except at hair-pin bend are given in Table 5.7.

<table>
<thead>
<tr>
<th>Classification of Gradient</th>
<th>Gradients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruling gradient</td>
<td>5% (1 in 20.0)</td>
</tr>
<tr>
<td>Limiting gradient</td>
<td>6% (1 in 16.3)</td>
</tr>
<tr>
<td>Exceptional gradient</td>
<td>7% (1 in 14.3)</td>
</tr>
</tbody>
</table>

Gradients up to the “ruling gradient” will be adopted for the design. The limiting gradients will be adopted where topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. Further, the steepest gradient or “exceptional gradient” is meant to be adopted only in very difficult situations and for short lengths not exceeding 100m at a stretch.

The vertical curve would be provided at all grade changes exceeding those indicated in Table 5.8.

<table>
<thead>
<tr>
<th>Design Speed (km/h)</th>
<th>Maximum grade change (per cent) not requiring a vertical curve</th>
<th>Minimum length of vertical curve (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 35</td>
<td>1.5</td>
<td>15</td>
</tr>
<tr>
<td>40</td>
<td>1.2</td>
<td>20</td>
</tr>
<tr>
<td>50</td>
<td>1.0</td>
<td>30</td>
</tr>
</tbody>
</table>

**Table 5.8: Minimum Length of Vertical Curves for Different Speeds**

**Cross-section Elements**

The cross-section of any road is governed by the traffic volume expected on the road. The project road takes off from terminal of IWT at Paletwa, on the right bank of Kaladan River, and it would serve as a cross-border route connecting India and Myanmar. The traffic along the project road would use the National Highway NH-54 to reach its destination any where in north-eastern region of India or vice-versa. The carriageway width of NH-54 varies from single lane (3.75m) to two lanes (7.0 m). At Myanmar end, the supply of traffic is linked up with proposed design traffic capacity of Inland Water Transport (IWT) route along Kaladan River at Paletwa. As per IWT study, vessel cargo handling would be equivalent to
maximum 200 trucks per day. Besides, there would also be some local commercial and passenger traffic along the project road.

The proposed design standards in respect of various cross-section elements for the Project Road are from category of “Two Lane”. The summary of design standards, for hill roads, for different road lanes are given in Table 5.9

| Table 5.9: Design Standards for Cross-section Elements of Hill Roads |
|------------------|-------------------|
| Sl. No. | Design Elements | Dimension |
| 1. | Carriageway width | 7.0 m |
| 2. | Shoulder width | 2.5 m both side including drain |
| 3. | Formation width | 12 m |
| 4. | Cross-slopes/camber (%) | 2.5 % |
| | Maximum Super elevation | 10% |

**Design Service Volume**
The recommended “Design Service Volume” (DSV) in Passenger Car Unit (PCU) per day in different terrain with low curvature (less than 50° per kilometer) is as given in Table 5.10.

| Table 5.10: Design Service Volume (DSV) Capacity |
|---------------------------------|-------------------|
| Road Category | Road Width | DSC in PCU / day (Hilly Terrain) |
| Single Lane (SL) | 3.75 m | 1800 |
| Intermediate Lane (IL) | 5.50 m | 5200 |
| Double Lane (DL) | 7.00 m | 7000 |

**Side Slope**
Side slope of embankment and cutting for the roadway formation has been based on the safety of travel, soil type, and stability of slope and economy of construction. Side slope has been kept as 2Horizontal: 1Vertical for fill and 1Horizontal: 1Vertical for cut.

For the excavation the soil is classified in three broad categories and accordingly cut slopes are proposed as given below:

a) **Ordinary / Heavy Soil:** This comprises organic soil, clay, sand, moorum and stiff clay which can be excavated manually by pick axes and/ or shovels or with dozers / excavators with normal efforts. This can be cut to side slopes of 1:1 to ½ :1 (H:V).

Soil mixed with boulders is also assumed to come under this category.

b) **Ordinary / Soft Rock:** This comprises soft varieties of rocks such as lime stone, sand stone, laterite, conglomerate or other disintegrated rocks, which can be excavated by crow bars and/ or pick axes without blasting or with casual blasting. This can be cut to side slope of ¼:1 to 1/8: 1 (H: V).

c) **Hard Rock:** This covers any hard rock, excavation of which involves intensive drilling, and blasting. This can stand vertical or even overhanging cut depending on the type /mass and dip of rock. Normally the cut may vary from 80° – 90° to horizontal.

5.2 **Design Standards for Bridges**
The following design parameters would be considered based upon the requirements of IRC codes, MORTH specifications and practice adopted internationally in the country for design and construction of highway bridges.

**Standards and Code of Practices**

**General Features of Design**

<table>
<thead>
<tr>
<th>IRC</th>
<th>Code</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRC:5</td>
<td></td>
<td>199</td>
</tr>
<tr>
<td>IRC:6</td>
<td></td>
<td>2000</td>
</tr>
<tr>
<td>IRC:78</td>
<td></td>
<td>2000</td>
</tr>
<tr>
<td>IRC:21</td>
<td></td>
<td>2000</td>
</tr>
</tbody>
</table>

**Design of Superstructure**

<table>
<thead>
<tr>
<th>IRC</th>
<th>Code</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRC:6</td>
<td></td>
<td>2000</td>
</tr>
<tr>
<td>IRC:21</td>
<td></td>
<td>2000</td>
</tr>
</tbody>
</table>

**Bearings**

<table>
<thead>
<tr>
<th>IRC</th>
<th>Code</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRC:83-Part-II</td>
<td></td>
<td>1987 for elastomeric bearings</td>
</tr>
<tr>
<td>IRC:83 Part-III</td>
<td></td>
<td>2002 for POT/PTFE bearings</td>
</tr>
</tbody>
</table>

**Expansion Joints**

Filler type joints for spans up to 10m and elastomeric strip seal type expansion joints for larger spans are proposed to be used. Ministry’s Interim Specifications shall be considered for design and detailing of the joints.

**Protection Works**

IRC: 89-1997

**Vertical Clearance:** A vertical clearance as per IRC –5: 1998 (Cl.106) above the affluxed HFL will be provided.

### Table 5.11: Discharge & Vertical Clearance

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Discharge (Cum/sec)</th>
<th>Min. Vertical Clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Up to 0.3</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>Above 0.3 to 3.0</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>Above 3.0 to 30.0</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>Above 30.0 to 300</td>
<td>900</td>
</tr>
<tr>
<td>5</td>
<td>Above 300 to 3000.0</td>
<td>1200</td>
</tr>
<tr>
<td>6</td>
<td>Above 3000</td>
<td>1500</td>
</tr>
</tbody>
</table>

**Carriageway**

The bridges are designed for 12.00 m total deck width with footpath of 1.50m, 0.45m crash barrier, 0.30m railing on both sides and the carriageway width is 7.50 m. The carriageway has been generally provided with a bi-directional camber of 2.5%. The section adopted for all bridges is in conformity to the latest guidelines of MORTH for 2 lane bridges in hill roads. The cross section at bridge location shall be suitably matched with road cross section.

**Protection Works:** In case of bridges with scourable beds, floor protection works are proposed.

**TMT Requirement:** Thermo Mechanically Treated reinforcement (TMT) conforming to IS: 1786, are used.

**Design Loading:** The design loading for the bridge will be considered in accordance with IRC-6:2000 (Loads and Stresses) so as to sustain the most critical combinations of various
loads, forces and stress that can co-exist. Dead loads of various members of the bridge will be adopted as per the relevant IRC codes and Indian Standards.

**Live Load**: For the design purpose either of the following IRC live load will be taken for worst effects:

- One lane of Class -70 R loading
- One lane of Class-A loading
- Two lanes of class A loading.

For Box Cell type bridges with fill, live load equivalent to 1.2m height of fill has been assumed for design.

**Tractive and Braking Force**: The tractive and braking forces will be considered in accordance with the provisions of IRC-6:2000, wherever applicable.

**Wind / Seismic Force**: The particular section of road is adjacent to Mizoram in India which is situated in Zone-V as per IRC-6:2000. Adequate provision for wind / seismic has been considered in the design. Box Cell structure being embedded within the enclosed soil mass, no effect of seismic forces has been considered in the design as per Clause 222.10 of IRC-6:2000.

**Buoyancy Effects**: The buoyancy effects to be considered during check for stability of various components of the bridge are as follows:

- For Foundations stability: 100% Buoyancy
- For Substructure check for stresses in section below water level: 15% Buoyancy

**Soil Parameters**: The sub-soil investigations will be carried out at the bridge locations and details of bore logs and soil parameters will be presented in the sub-soil investigation report.

The soil parameters taken for earth filling behind and above box structure & behind abutments will be as follows:

- Angle of internal friction = 30°
- Angle of wall friction = 20°
- Unit weight of fill material = 1.8T/m³

### 5.3 Technical Specifications

Ministry of Surface Transport specifications for Road & Bridge works, 1998 will be made applicable for various items of execution. In its absence, specifications will be drafted by using relevant codes such as BIS, AASTHO or any practice and incorporated in bid documents suitably.

**Material Specifications**

The following Indian Standards will be made applicable wherever appropriate.

- Ordinary Portland cement IS 269
- Coarse aggregate IS 383
- Fine aggregate IS 383
- Bricks IS 1077
- High strength ordinary Portland cement IS 8112
- High yield deformed bars IS: 1786
- High tensile steel Strands 19T13
- Sheathing “Dross batch” 0.4mm thick IRC-18:1985
- Water IRC-SP-33 1989 Clause 5.1(ii)

**Any Other Standards**
Where elements of design for project roads are not covered in the design standards, the same will be designed in accordance with the available IRC standards, BIS standards and AASHTO specifications. In case nothing is provided in all these standards, specifications for design will be drafted in consultation with Ministry of External Affairs and made applicable.

### 5.4 Proposed Cross Sections

Based on the above factors, and on the terrain traversed, a total of four different typical sections are being considered for the project road. The selection of which typical to be used will be site-specific, taking into account various factors including resultant geometric, cost, ease of construction, access, and right-of-way and acquisition impacts. The proposed typical cross sections are shown in Figure 5.1 to 5.4.
Detail Project Report for Package –II
(from Km 60.700 to Km 70.700)
Detail Project Report for Package –II
(from Km 60.700 to Km 70.700)
Detail Project Report for Package –II
(from Km 60.700 to Km 70.700)
CHAPTER 6
ENGINEERING DESIGN AND PROPOSALS
CHAPTER 6

6.0 ENGINEERING DESIGN AND PROPOSALS

The detailed design for the project road has been adopted for two-lane road as per codes and practices, based on the findings of survey and investigations and design standards. The proposals include provision for the following items:

- Traffic Demand Estimate
- Pavement Design;
- Culverts and Bridges;
- Protection work; and,
- Road appurtenances

6.1 Length of the Project road

Total length of the project road 10.00 km (i.e from Km 60.700 to Km 70.00).

6.2 Traffic Demand Estimate

Traffic volume data is one of most important information for decision-making related to planning, design, management, operation, and control of transportation system.

The project road would serve as trade route and Study of Inland Water Transport (IWT) along river Kaladan in Myanmar has indicated that there would be maximum traffic (commercial traffic only) of 200 trucks per day. Besides, there would be some passenger vehicles also. The passenger traffic on the project road had been estimated based on the population served by the Project road and general trip making behavior in the area. Based on the preliminary study it has been estimated that about 3-5 minibuses and about 5-6 cars and about 10 two wheelers would use the project road beside the movement of the army in the area (assumed as 10 trucks per day). Based on the above assumptions the traffic estimated for the project road is presented in Table 6.1.

Table 6.1: Estimated traffic on the Project road

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trucks (International trade)</th>
<th>Cars</th>
<th>Mini Buses</th>
<th>Two Wheelers</th>
<th>Trucks (Local)</th>
<th>Trucks (Army)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>200</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>232</td>
</tr>
</tbody>
</table>

The capacity of three categories of road, in hilly terrain, in terms of Design Service volume, has been shown below in Table 6.2.

Table 6.2: Design Service Volume Capacity

<table>
<thead>
<tr>
<th>Road Category</th>
<th>Road Width</th>
<th>DSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lane (SL)</td>
<td>3.75 m</td>
<td>1400 PCU/day</td>
</tr>
<tr>
<td>Intermediate Lane (IL)</td>
<td>5.50 m</td>
<td>4500 PCU/day</td>
</tr>
<tr>
<td>Double Lane (DL)</td>
<td>7.00 m</td>
<td>6000 PCU/day</td>
</tr>
</tbody>
</table>
The above given capacity has also been converted into number of vehicles. Assuming the commercial traffic component to be 70% of total traffic volume capacities, the total number of commercial vehicle estimated for different category of roads are as given in Table 6.3.

Table 6.3: Design Traffic Volume

<table>
<thead>
<tr>
<th>Road Category</th>
<th>Design Service Volume(DSV)</th>
<th>Proportion of Traffic Volume (Vehicle Numbers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Commercial*</td>
</tr>
<tr>
<td>Single Lane (SL)</td>
<td>1400 PCU /day</td>
<td>325</td>
</tr>
<tr>
<td>Intermediate Lane (IL)</td>
<td>4500 PCU /day</td>
<td>1050</td>
</tr>
<tr>
<td>Double Lane (DL)</td>
<td>5000 PCU /day</td>
<td>1400</td>
</tr>
</tbody>
</table>

*Commercial Vehicles: Truck, Multi-Axle Vehicle, Bus (PCU factor =3)
**Non Commercial Vehicles: Car and Jeep (PCU factor=1)

The traffic volume of commercial vehicles given in the above Table 6.3 is the upper limit of respective road category. Keeping in view the expected opening traffic and DSV capacity, a single lane width would be adequate for the project road. However two lane configurations has been proposed for the project road keeping in mind the project road is a part of Kaladan multi-model transit transport project.

6.3 Pavement Design

The project primarily envisages construction of two lane road. Traffic has been estimated for the project road based on the secondary information obtained from IWT office in India and Myanmar. Traffic projection over the design period has been done using secondary data. The pavement investigations comprising of sub-grade testing, soil test and borrow area testing results are incorporated in pavement design. For the VDF it has been assumed as 3.5 as prescribed in the codes.

6.3.1 Design of Flexible Pavements:

Design Traffic:
The traffic demand estimate had been prepared for the project road, traffic data and its analysis for the project road stretch is discussed in traffic section.

Average Daily Traffic:
Based on the traffic study, the commercial traffic comprising of trucks and minibuses had been considered for pavement design and is presented in Table 6.4.

Table 6.4: Traffic (Pavement Design)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trucks</th>
<th>Mini Buses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>222</td>
<td>4</td>
<td>226</td>
</tr>
</tbody>
</table>

Design Life:
The flexible pavements for the project road have been designed for Ten (10) years.

Design Traffic:
Based on the projection of traffic and the Vehicle Damage Factor (VDF) of various types of commercial vehicles, Cumulative standard Axles (CSA) during the period of design life have been computed for project road.
The trend of CSA growth over the design life of pavement is given in Figure 6.1. Based on CSA computations, the design traffic (msa) adopted for 10 years of pavement life for the project road stretch under report is given in Table 6.5.

Table 6.5: Design Traffic for 10 Years

<table>
<thead>
<tr>
<th>Design Traffic (msa)</th>
<th>Adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Figure 6.1: CSA growth over the design life of Pavement.

Design CBR of Sub-grade:

Based on the initial results from investigations of the borrow area soils, following CBR values have been adopted for the sub-grade material selected for the pavement given in Table 6.6.

Table 6.6: CBR values for Subgrade Materials

<table>
<thead>
<tr>
<th>Section</th>
<th>CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Kaletwa to Zorinpui/ India-Myanmar border</td>
<td>4%</td>
</tr>
</tbody>
</table>

Thickness Design:

Following the design methodology described above, the flexible pavements have been designed for the design period as stated above. The pavement composition as evaluated from IRC: 37, 2001 for the project road are summarized in Table 6.7.

Table 6.7: Pavement Composition for new construction

<table>
<thead>
<tr>
<th>Homogeneous Sections (KM)</th>
<th>CBR (%)</th>
<th>Design Traffic(msa)</th>
<th>Pavement Composition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Paletwa to Zorinpui/ India-Myanmar border</td>
<td>4%</td>
<td>3</td>
<td>PC* 50 250 280 500</td>
</tr>
</tbody>
</table>

*PC: Premix Carpet, BM: Bituminous Macadam, WMM: Wet Mix Macadam; GSB: Granular Sub base.

The above pavement composition is based on the IRC guidelines & traffic estimated on the project section. However, based on the payment composition as proposed for the Lawngtlai-
Indo-Myanmar Border has been adopted for the project road. The adopted pavement composition for the project road is presented in **Table 6.7 A.**

**Table 6.7A: Pavement Composition adopted for project road**

<table>
<thead>
<tr>
<th>Homogeneous Sections (KM)</th>
<th>Pavement Composition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BC</td>
</tr>
<tr>
<td>From Paletwa to Zorinpui/ India-Myanmar border (109.200km)</td>
<td>40</td>
</tr>
</tbody>
</table>

*BC: Bituminous Concrete, DBM: Dense Bituminous Macadam, WMM: Wet Mix Macadam; GSB: Granular Sub base.

**Shoulders**

It is proposed to provide paved shoulders on either side of the carriageway with 25mm SD, 150mm WMM or 425mm excavated rock.

### 6.4 Cross Section Elements & Alignment

#### Cross-section Elements

Hill road cross-section has the usual components of carriageway, shoulder and longitudinal drain and parapet/ railing requirements. The carriageway and shoulder widths are governed by the traffic volume expected on the road. Other components are functions of traffic safety and surface run-off requirements. Roadway, however, is defined as the total width of carriageway and shoulder.

A single lane road is adequate to cater for above-mentioned traffic expected on the project road. However, based on the MoRTH guidelines vide letter no NH 12037/19/2010/IMG/SARDP-NE dated 5th May 2011, two lane configurations have been proposed for the project road.

The proposed standards in respect of various cross-section elements for the Project Road are summarized in **Table 6.8.**

**Table 6.8: Design Standards for Cross-section Elements**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Design Elements</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carriageway width</td>
<td>7.0 m</td>
</tr>
<tr>
<td>2.</td>
<td>Shoulder width</td>
<td>2.5 m both side including drain</td>
</tr>
<tr>
<td>3.</td>
<td>Formation width</td>
<td>12 m</td>
</tr>
<tr>
<td>4.</td>
<td>Cross-slopes/camber (%)</td>
<td>2.5 %</td>
</tr>
<tr>
<td></td>
<td>Maximum Super elevation</td>
<td>10%</td>
</tr>
</tbody>
</table>

#### Geometric Design

Geometric design involves the design of the visible elements such as horizontal alignment, vertical alignment and the cross-section of the project road. The design is governed by the design speed fixed up taking into account site conditions including the terrain in which the project road traverses.

The project road traverses through mountainous terrain and a design speed of 50kmph & 40kmph has been provided. At few locations 30kmph has also been provided to minimize the cut & fill quantities. However the minimum values have been applied only where serious
restrictions are placed by technical or economic considerations. General effort has been made to exceed the minimum values on safer side.
The entire geometric design has been based on the ground modeling by highway design software MOSS/MX Road.

**Horizontal Alignment**

The proposed design of all curves has been made as per the desired design standards and specifications given in Chapter-5. Except at few locations, generally project road has been designed for a speed of 50 kmph. Wherever design speed is 50 kmph, a minimum radius of 80 m has been provided and wherever the speed is 40 kmph, a minimum radius of 50 m has been adopted. The super elevation and the length of transition curves have been finalized with maximum super-elevation of 7%. No hair pin bends have been proposed.

**Vertical Alignment / Gradient**

The project road has been designed for ruling gradient. However, the “limiting gradients” have been used where the topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. In such cases, the length of continuous grade steeper than the ruling has been kept as short as possible. While the exceptional gradients, steepest gradient have been adopted only in very difficult situation and for short lengths.

**Table 6.9: Summary of Proposed Vertical Alignment**

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage Distribution and Gradient Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;4%</td>
</tr>
<tr>
<td>Package II- Kaletwa to Zorinpui / Indian – Myanmar Border</td>
<td>61.37</td>
</tr>
</tbody>
</table>

**6.5 Drainage**

**Side Drains**

The project road would envisage cutting on one/two side and part filling and in full cutting at certain locations. Longitudinal side drain (lined) has been proposed on the side of hill cutting.

**Table 6.10: Summary of Longitudinal Drains**

<table>
<thead>
<tr>
<th>Project Road Package</th>
<th>Length of Proposed Drain (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LHS of Road</td>
</tr>
<tr>
<td>Package II- Kaletwa to Zorinpui / Indian – Myanmar Border</td>
<td>5.06</td>
</tr>
</tbody>
</table>

**6.6 Protective Works**

Complete length of the project road passes through mountainous and steep terrain. Following structures have been proposed to effectively retain cut and fill slopes and to ensure a stable road:
- Retaining wall
- Breast Wall
- Parapet, Railing and edge stones Toe and Check Walls
Retaining walls

For the proposed road, using digital terrain model (DTM), provisions have been made for retaining walls for the following areas.

Places where the valley side gets saturated in monsoon and slips.

Where there is a likelihood of damages caused by streams.

Places on the valley centered curves where rainwater flows towards the valley because of super-elevation being on the hillside.

The retaining walls are proposed to be as given below:

Random rubble dry stone with strengthening bands of stone in cement mortar of 1:6 mix; and

For the stone masonry retaining walls, the front face of the wall is kept vertical when the height is small. For larger heights, a nominal slope of 1 in 50 is given to avoid the feel of overhang when seen from the top.

<table>
<thead>
<tr>
<th>Project Road Package</th>
<th>Length of Proposed Retaining Wall (in m)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package II- Kaletwa to Zorinpui / Indian – Myanmar Border</td>
<td>LHS 3444, RHS 988</td>
<td>4432</td>
</tr>
</tbody>
</table>

Breast walls

The uphill slopes and the slopes cutting would affect the stability of the road. Provisions have, therefore, been made for the breast walls for the stretches wherever there is a likelihood of a slip or slide on the road. A standard design of breast wall of 2 m and 3m in height in stone masonry with cement mortar has been adopted for the present study.

<table>
<thead>
<tr>
<th>Project Road Package</th>
<th>Length of Proposed Breast Wall (in m)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package II- Kaletwa to Zorinpui / Indian – Myanmar Border</td>
<td>LHS 538, RHS 1386</td>
<td>1924</td>
</tr>
</tbody>
</table>

Parapets

For defining the edge of the road and for safety of traffic, parapets are required on the valley side. Parapet wall of 0.45m thick of stone masonry in cement mortar in length of 2m to 6m with 0.75m gaps. The proposed height of wall is 0.6m.

Crash barrier

The Crash barrier has been provided on the valley side where every the height is more than 6 mts from the ground levels

Edge Stones / delineators

Where the road is extra width due to gully or through cut, the parapets are not required. At such locations edge stones have been proposed to demarcate the road edge. The edge stones are dressed stones embedded in earth and projecting about 0.3m above the road level, duly
white washed, for visibility. However, on sharp bends and accident prone areas, delineators with metallic pipes and reflective paint / tape have also been proposed for traffic safety.

**Toe and Check Walls**

When culverts are constructed and waterfalls above the retaining walls on the valley side to a considerable height, in the form of a free fall, there is considerable erosion at the toe of the retaining wall. In order to check this erosion, it is proposed to provide toe walls in order to break the water force so that the retaining wall does not get eroded.

The Gabion walls have also been proposed to use as toe wall or earth retaining structure. Gabion wall mark an improvement for use in place of dry masonry walls. It has number of advantages; unskilled labour can do the job, local stones can be used, and higher ability to tolerate subsistence and differential settlement and amenability to greater heights using modular construction.

**6.7 Road Fixtures**

The provision of following road fixtures has been considered for the project road:

- Kilometer Stone
- 5th Km Stone
- Direction / Destination Board
- Information Sign Board
- Mandatory Signs
- Cautionary Signs
- Road Delineators
- Solar lights/Blinkers/Road Studs

**6.8 Roadside Amenities**

The provision of roadside amenities in hill roads contributes to a large extent in ensuring safety besides making convenient and pleasant. Research in road safety has shown that a major cause of fatal accident is fatigue and or driver falling asleep at the wheel. To avoid such occurrences, it is desirable to provide rest area / parking facilities at every 2 hours driving time distance.

It has been proposed to provide bus lay-by for passenger traffic, at all villages located along the alignment of project road. Proposed bus bay locations are provided in Table 6.13. Truck lay bay has been proposed near Setpyitpyin.

<table>
<thead>
<tr>
<th>Table 6.13: Location of Bus bays</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Package II - Kaletwa to Zorinpui / Indian – Myanmar Border</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

**6.9 Structures**

The bridges are designed for 12.00 m total deck width with footpath of 1.50m, 0.45m crash barrier, 0.30m railing on both sides and the carriageway width is 7.50 m. There are 02
Minor Bridges proposed crossings over river, streams and deep valleys along the project alignment.

For package II i.e from Kaletwa to Zorinpui (India-Myanmar Border) in view of the site constraints like remoteness and rock available at 3 to 4.5 m depth and to adopt the simplicity of construction and execution, it is proposed to provide RC Girders and PSC Girders Superstructures with open foundations. Depends on the waterway discharge and existing ground longitudinal profile the number of spans and span lengths has been decided, these structures briefly detailed as listed below:

**PSC Girder Superstructures**

For Package II i.e from Kaletwa to Indian / Myanmar Border, the PSC Girders are designed as Cast In-Situ construction since these are proposed in sites where the construction is possible to do cast in-situ PSC Girders with deck slab.

**RC Girder Superstructures**

The RC Girders are designed as Cast In-Situ construction since these are proposed in sites where the construction is possible to do cast in-situ RC Girders with deck slab.

**RC Substructures**

For Package II i.e from Kaletwa to Indian / Myanmar Border, the Rectangular type abutment shaft to a width of 12m is proposed to cater the soil pressure and retain excess soil slopes to fall in river/stream waterway. The seismic arrestors are designed at abutment cap locations since the area is under high seismic influence as per the seismic map of Myanmar.

**Foundation**

For Package II i.e from Kaletwa to Zorinpui (India-Myanmar Border), open foundation is proposed due to hard rock at 3.0m to 4.5m below the lowest bed level. The founding level is kept at around 3m to 4m below the lowest bed level. Foundation is adequately protected against scour by providing rigid floor, flexible apron and curtain wall at both upstream and downstream sides of the bridge.

**RC Crash Barriers (Jersey Barriers)**

Crash Barriers have been proposed as per Indian Road Congress Standards (IRC:5-1998).

**Expansion Joints**

Strip seal type expansion joints are proposed for all the structures.

**Wearing Coat**

Asphaltic concrete wearing coat, 65 mm thick comprising of 50 mm thick bituminous concrete laid in 2 layers of 25 mm thickness each / over under layer of 15mm thick mastic asphalt as per MoORTH Standards has been proposed since the proposed bridges fall in high rainfall area.
Drainage Spouts

Drainage spouts have been proposed in accordance with MoRTH standards.

Approach Slab

Reinforced concrete approach slabs 3.5 m long and 300 mm thick in M30 grade concrete at either end of the bridge has been proposed with one end supported on reinforced concrete bracket projecting out from dirt wall and the other end resting over the soil in accordance with the guidelines issued by MoRTH India. A leveling course in M15 grade concrete has been provided under the approach slab.

Concrete grades

The grades of concrete for different bridge components are as follows.

- Retaining Wall: M35
- Deck Slab: M40
- Pile foundation: M35 & M40
- Substructure: M35
- Super structure of RCC Bridges: M35
- Super structure of PSC Bridges: M50

Reinforcement

Thermo Mechanically Treated Bars (TMT) conforming to IS: 1786 shall be used for reinforcement of super-structure, sub-structure and foundations. The minimum lap length of reinforcement bars shall be kept as 63 times the diameter of bar and not more than 50% of the bars shall be lapped at one location.

Structural Steel

The Structural steel is of Grade E250 (Fe410W, B) normalized and fully killed, as per IS: 2062-2006.

Bearings

Type of bearings to be adopted depends upon the length of the span, loads, forces, movement and seismic zone in which the project road falls. Since the proposed bridges fall in high seismic hazardous zone, POT/PTFE type bearings are proposed.

Protection Works

There is the requirement of protection to provide adequate protection work against scour. The floor protection work comprises of rigid flooring with curtain wall and flexible apron so as to check scour, washing away or disturbance by pumping action etc. The arrangement of floor protection work shall be as follows:

- **Rigid Flooring**
  The rigid flooring shall be provided under the bridge and it shall extend for a distance of at
least 3m on u/s side and 5m on d/s side of the bridge. In case of splayed wing wall the flooring shall extend up to the line connecting the end of wing wall on either side of the bridge.

- **Curtain Wall**
The rigid flooring shall be enclosed by curtain walls.

- **Flexible Apron**
Flexible apron, 1m thick comprising of loose stone boulders shall be provided beyond the curtain wall.

Break-up of structures according to length of structures is as under in Table 6.14

<table>
<thead>
<tr>
<th>Table 6.14: Details of Bridges (from Km 60.700 to Km 70.000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6.16: Detail of Minor Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
Culverts

Total 34 culverts have been proposed along the project road based on the requirement. The summary of type of culvert provided in given in Table 6.17.

**Table 6.17: Culvert Details**

<table>
<thead>
<tr>
<th>S.no</th>
<th>Type of Culvert</th>
<th>Package II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Pipe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.2ø)</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td>(2x1.2 ø)</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Box</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2m x2m</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>3m x3m</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Slab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4m</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5m</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>34</strong></td>
</tr>
</tbody>
</table>
CHAPTER 7
RATE ANALYSIS
CHAPTER 7

7.0 RATE ANALYSIS

7.1 General

Unit rates are applied to the quantities to get the direct cost of construction. Unit rates are arrived after carrying out the rate analysis based on "Standard data book for analysis of rates" published by MoRTH. The various components such as material cost at source, lead charges, labour cost and machinery hire charges are considered for the rate analysis. The rates and inputs for analysis of unit rates have also been based on the Schedule of Rates of Rakhine State, Myanmar and labor rates as prevailing in the vicinity of the project road.

7.2 Material Rates

The material rates adopted were based on the rates given in Schedule of rates for Rakhine State Myanmar and plus the transportation chargers based on the actual leads to the project road. Where the rates are not available in the SOR, market rates has been incorporated.

7.3 Material Lead Charges

The average lead for different construction materials is worked out based on the sources of the materials. The lead rates (transportation) are based on the standard data book.

7.4 Machinery Hire Charges

The machinery rates are adopted based on the contractor enquiry and prevailing rates in the vicinity of the project road.

7.5 Labour Rates

The labour rates adopted for the analysis are based on the schedule of rates for Rahike Division and prevailing market rates.

7.6 Characterization of Unit Rates

Following chapters have been formulated in conformity to “Latest Standard Data Book for Analysis of Rates” for detailed analysis of various items for roads & bridge works.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Works Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Clearance and Dismantling</td>
</tr>
<tr>
<td>2</td>
<td>Earthwork</td>
</tr>
<tr>
<td>3</td>
<td>Granular Sub Base</td>
</tr>
<tr>
<td>4</td>
<td>Culverts</td>
</tr>
<tr>
<td>5</td>
<td>New Bridges</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance, Drainage</td>
</tr>
</tbody>
</table>
CHAPTER 8
COST ESTIMATE
CHAPTER 8

8.0 COST ESTIMATE

8.1 General

The cost estimates for the project are extremely important as its entire viability and implementation depends on the project cost. Therefore, cost estimates and rate analysis of the items have been carried out with due care. The project cost estimates have been prepared considering various items of works and based on the rates calculated as per standard Data Book for analysis of rates (MoRTH) and rates based on the Manipur Schedule of Rate, Rakhine Region (Myanmar) Schedule of rates and prevailing market rates in the project vicinity.

8.2 Estimation of Quantities

The quantities of major items of work for the Project road have been estimated on the basis of Pavement design, geometric design and structural design as presented in drawing Volume of the Project Report.

The quantities of the following major items of works has been estimated separately.

- Site Clearance
- Earth Works
- Granular Sub-base and Base
- Courses Bituminous Courses
- Bridges, Culverts and Retaining Walls etc.
- Kerbs, Drainage and Protective Works
- Road Furniture and Safety Works
- Traffic Management and Miscellaneous.

8.3 Site Clearance

Site clearance quantity is estimated, as overall area requires clearance for construction of road. It includes the cutting of trees etc and reuse/re-fixing of usable material.

8.4 Earth Works

Earthwork quantities are calculated using the “MX Roads” software package. As the cross sections are uniform throughout the project road, common strings have been developed for the entire stretch. The positions of bus bays are also taken into account. The earthwork is calculated based on the amount of cut or fill with respect to the datum line defined in the vicinity.
template and the existing ground profile, which in turn is obtained from the DTM surface developed by the software.

The volumes of earthwork as well as materials have been calculated with the areas obtained at 10m intervals. Care has been taken for estimating additional earthwork quantities required at the approaches of bridges for back filling, around abutment stretches and same has been incorporated in roadwork items.

8.5 **Pavement Material (Flexible)**

The pavement work includes construction of proposed carriageway. The flexible pavement includes Bituminous Concrete (BC), Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM), Granular Sub-base (GSB), Subgrade and other related items like prime coat and tack coat etc. over road formation. The quantities of bituminous course are calculated for full width of carriageway.

8.6 **Cross Drainage Structures**

The construction of bridges and culverts are assessed on proposed length and the earthwork, pavement and shoulders for bridge approaches have been included as appropriate roadwork items. The other items like RCC and PCC work of bridges and culverts are calculated as per design and drawings.

8.7 **Drainage and Protective Works**

Drainage and protective works provides for the roadside drains in the rural and urban areas, drainage chutes and crash barriers for the embankments more than 3.0 m high and retaining walls where necessary to keep the road within R.O.W.

8.8 **Bus Stops and Truck Lay Byes**

The quantities for truck lay-byes and Bus Stops etc have been calculated based on the Design drawings provided in the Drawing Volume Report. No building construction work has been taken in the report.

8.9 **Road Furniture and Safety Works**

Provisions for road safety measures road signs, markings, road appurtenant have been made. Turfing like on embankment, earthen shoulder and hedges in median and roadside plantation and landscaping have been considered on the basis of traffic and other requirements.
**SUMMARY OF WORK COST**

<table>
<thead>
<tr>
<th>BILL No</th>
<th>Description of Items</th>
<th>Amount in Rs</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Site Clearance</td>
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<td>Earth Work</td>
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<td>Granular Sub- Base</td>
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<td>Cross Drainage Works (Culverts)</td>
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<td>New Bridges</td>
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<td>6</td>
<td>Maintenance, Drainage</td>
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<tr>
<td></td>
<td><strong>Total Cost of Civil</strong></td>
<td><strong>573941137.77</strong></td>
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