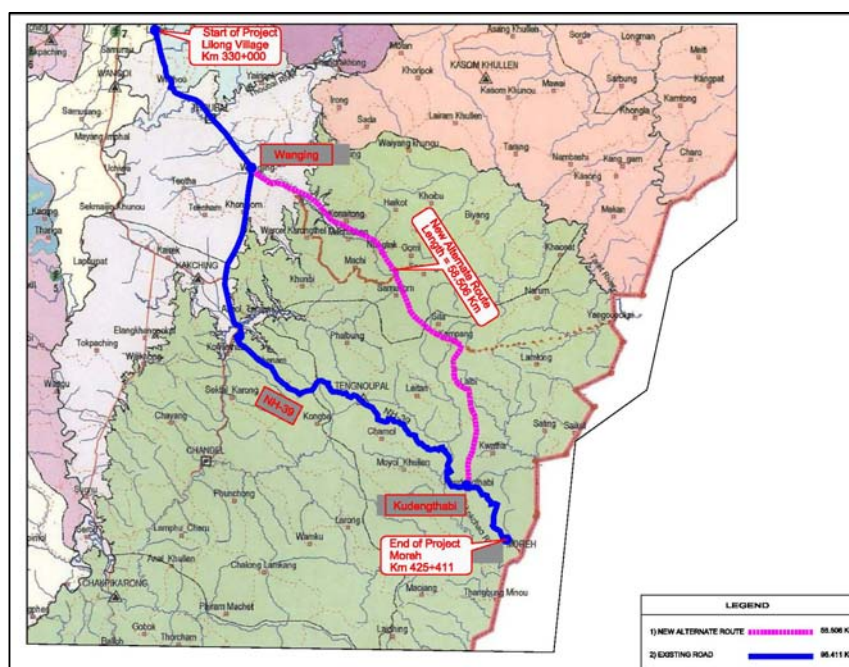
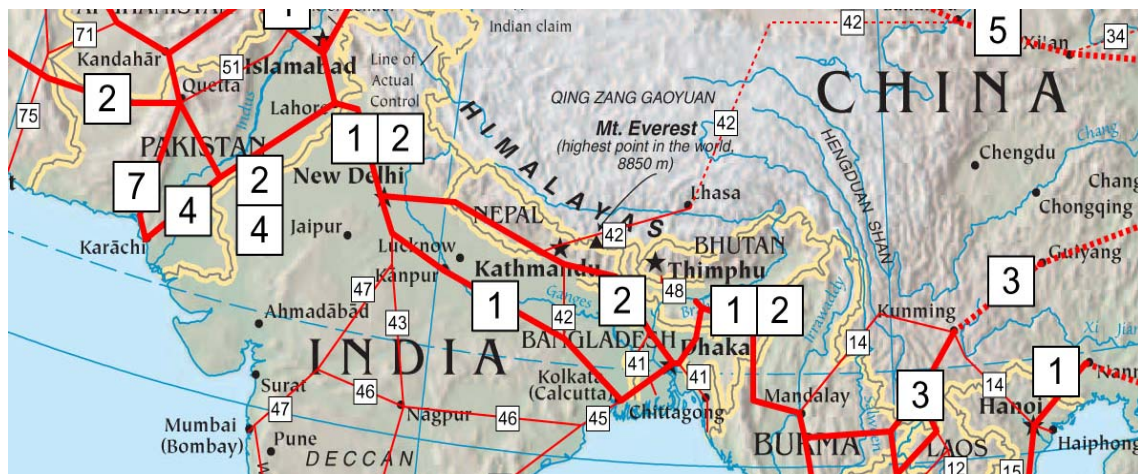


INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH ON NH-39



Funded by:

Asian Development Bank

Implementation Agency:

MORT&H / PWD Govt of Manipur

Detailed Project Report

Volume - I Main Report



April, 2015

SHELADIA Associates Inc. USA

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1 INTRODUCTION

1.1 BACKGROUND

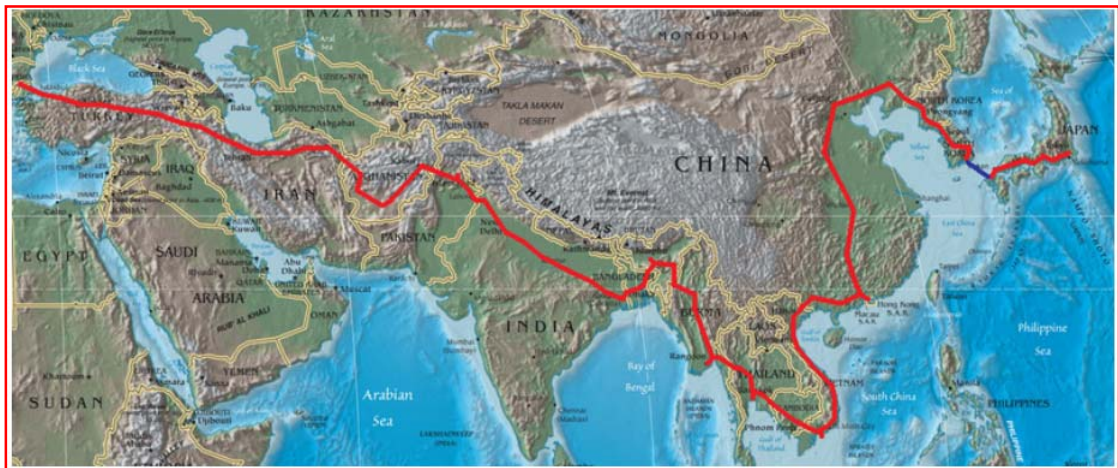
Manipur is one of the eight North Eastern States in India. The geographical area of the state 22,327 sq km constitutes less than 0.70% of the entire country. It lies between latitude of 23°83'N – 25°68'N and longitude of 93°03'E – 94°78'E. the State capital, Imphal is located at an elevation of 790 m above mean sea level. Geographically the state is bounded on all sides by ranges of hills and particularly land blocked.

The total population of the state is 27, 21, 756 as per 2011 census. Of the total area, only 17 % is in valley and balance in hills and hilly/mountain terrain. The state border totals 854 km of which 352 km is international border with Myanmar to the east and south east. The remaining 502 km separate Manipur to rest of India. The road transport infrastructure in the state of Manipur is far below the all India Standards in terms of road length per sq.km. It is imperative to improve the road transport infrastructure in the state.

The national highway corridors namely NH 53, NH 39 and NH 150 are linking the state with the other parts of the country. The NH 39 (recently renamed as NH 102) Imphal Moreh is linking India and Myanmar. Surfaced road in hill districts are mainly limited to National Highways, State Highways and Major District Roads. Majority of the other district roads and village roads are not surfaced. The existing road system suffer from various types of deficiencies such as inadequate crust thickness, inadequate cross drainage works, weak and narrow bridges and pavement failures etc.

The present study section, Imphal – Moreh is part of Asian Highway AH1 in Manipur state in India. AH 1 is the longest route of the Asian Highway Network (see figure on next page), running 12,845 miles (20,557 km) from Tokyo, Japan via Korea, China, Southeast Asia, India, Pakistan, Afghanistan and Iran to the border between Turkey and Bulgaria west of Istanbul where it joins end-on with European route E80. In India AH 1 passes through Numaligarh - Golaghat - Garampani - Barpathar - Naojan - Bokajan - Dimapur - Kohima - Tadubi - Senapati - Kangpokpi - Imphal - Thoubal - Tengnoupal – Moreh (Myanmar border).

The present project is aimed to widen and improve about 95+411 km of existing national highway into 2/4 lane configuration between Imphal and Moreh (NH-39) in the state of Manipur. The road stretch is a critical section of the UNESCAP Asian Highway No. 01 (AH01), paving the way for India and other South Asian countries to Myanmar, and further to ASEAN countries.



Looking at the benefits of the project, the Government of India requested for a project preparatory technical assistance (TA) from the Asian Development Bank (ADB) to prepare an ensuing loan for the international trade corridor in Manipur State (the project). The Asian Development Bank (ADB) is supporting the preparation of the Sub regional Road Connectivity Project in the state of Manipur, which is programmed for implementation in 2014 with funding support from ADB. In order to facilitate the implementation of the project, the ADB has engaged Sheladia Associates Inc. (SHELADIA) as Technical Assistance (TA) Consultant to prepare Detailed Feasibility Study and preliminary engineering design to define the project scope for implementation through Engineering, Procurement and Construction (EPC) contract.

The Feasibility Study Report as per the submission schedule is presented in this report. This Report presents the surveys and investigations carried out, analysis of Surveys and investigations, study of project options and improvement alternatives and project costing and feasibility analysis and recommendations of the TA Consultants.

1.2 THE PROJECT

The Project Road start in Imphal city, first 10 km section has already been undertaken by MORTH for upgrading to 4 lane carriageway and 6 km from start is already upgraded and remaining 4 km section has been sanctioned for upgradation to 4-lane and is in advance stage of Implementation. Hence the project start has been considered as km 330+000. The project concerns upgrading about 95+411 kilometers of existing National Highway 39 in the State of Manipur. The project corridor starts from Lilong village at its Km 330+000 and ends at Moreh (Myanmar Border) at its km 425+411. The road run through plain terrain up to Pallel (36 kms) and remaining road section passes through hilly/rolling terrain (from Pallel to Moreh). The corridor traverses through agriculturally rich area for first 30 kilometers length but with fair to poor surface condition (refer *Figure 1.1 – Index Map*).

The available ROW for the section from Km 330+000 to 330+150 is 60 m and from 330+150 to Km 425+411 is 15 m only. The terrain is plain from Km 330 to Km 366+200 and hilly/rolling terrain from 366+200 to 425+411 that is end of project road corridor. The major settlements along the project corridor are Lilong, Thoubal, Khangabok, Wangjing, Khongjom and Pallel. Due to the connectivity, additional route has been included in the present study by MORTH.

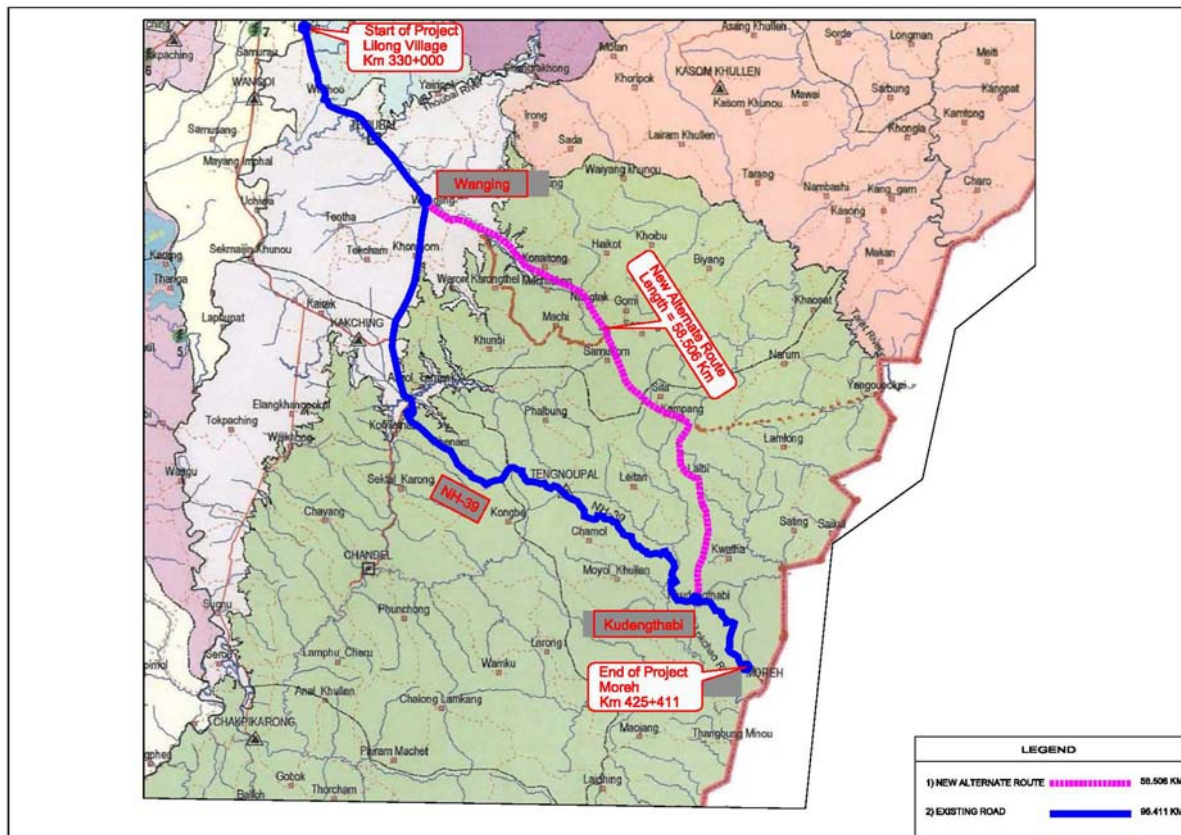
Alternatives including bypass/alternative routes may need to be examined. The flood pattern along the corridor up to Pallel town need to be explored and studied to design the project corridor taking into account the impact of long term climate change effects in the project design.

1.3 OBJECTIVES OF CONSULTANCY SERVICES

The following are the primary objectives of the consultancy services assigned to SHELADIA.

- To examine the feasibility of developing NH 39 corridor from Lilong village to Moreh town as a better connectivity to International trade between South and South East Asia;
- Study and prepare the detailed project report, including the alternate state highway route between Wangjing and Khudengthabi and various bypass options for major towns along the project corridor;
- If found feasible, to prepare the engineering design and bid documents for implementation of the project through EPC contract mode;

Figure 1-1 Index Map



1.4 STUDY SCOPE AND STAGES

Major tasks based on the Consultants understanding of the TOR are:

- To conduct traffic and engineering studies, develop project design options and economic viability for the road corridor development taking into account cost effective project road development options. Develop most appropriate and cost effective project road development option;
- To prepare engineering design of the project components sufficient to prepare the engineering, procurement and construction (EPC) mode of bidding; and
- Prepare project cost estimates;
- Prepare drawings and bid documents for the EPC mode;
- To decide on contract packaging and prepare bid documents;
- To prepare project reports incorporating outcomes of the study. The following reports are planned:
 - Inception Report
 - Feasibility Report
 - Detailed Project Report
 - EPC Bid Documents

1.5 STRUCTURE OF DETAILED PROJECT REPORT

The DPR is composed of the following volumes;

Volume 1: Main Report

Volume 2: Design Report

Volume 3: Material Report

Volume 4: Technical Specifications

Volume 5: Rate Analysis

Volume 6: Cost Estimate

Volume 7: BOQ

Volume 8: Drawings

The report in hand is the Main report which is divided into the following chapters;

2 EXISTING ROAD CORRIDOR AND NETWORK

2.1 PROJECT CORRIDOR

The project road section from Imphal to Moreh on NH 39 starts from Lilong village and ends at Moreh town (Myanmar border). As per site visit, length of this section is found to be about 95+411 km. Existing NH 39 (now NH 102) passes through three districts i.e. Imphal, Thoubal and Chandel. The road runs through flat terrain up to Pallel (46 km) and remaining road section in hilly terrain (from Pallel to Moreh).

The project road running north to south east between Longitudes $24^{\circ}48'8.9''$ N & $24^{\circ}14'16.46''$ N and lies between Longitude of $93^{\circ}56'18.44''$ E & $94^{\circ}18'2.23''$ E within the state of Manipur.

The land use along this section is agricultural mixed with road side development up to Pallel (km 46) with some of urban & semi urban centers like Lilong, Thoubal, Khudengthabi, and Moreh. Clusters of settlement are also noticed in between urban areas. From Pallel to outskirts of Moreh, the land use is mix of open/barren land with thin vegetation and patches of agricultural activities on hillocks. These hills are mostly owned by village communities. The vegetation on hilly terrain is mostly mixed bushes and thin forests owned by communities.

The project corridor however passes through some congested urban areas where widening or even minimum improvement of road geometry is not possible. At the same time, the existing constricted condition cannot be allowed to remain if the corridor is to attain a uniform acceptable level of service. Therefore, the solution at these locations is to provide bypass for the major bottle necks near Lilong village, Thoubal town, Pallel town and Moreh Town.



1. Lilong Village



2. Thoubal



3. Pallel Town



4. Moreh Town

2.2 CHAINAGE REFERENCE SYSTEM

Since Kilometer stones are available along the project road, the same is followed from Km 330+000 to Km 425+411.

2.3 CORRIDOR SECTIONS

Considering the nature of traffic, geometric features as observed during the preliminary visits, a segmental approach is appropriate to describe the project road features. Accordingly, the corridor can be divided into four broad sections as given below in Table 2.1.

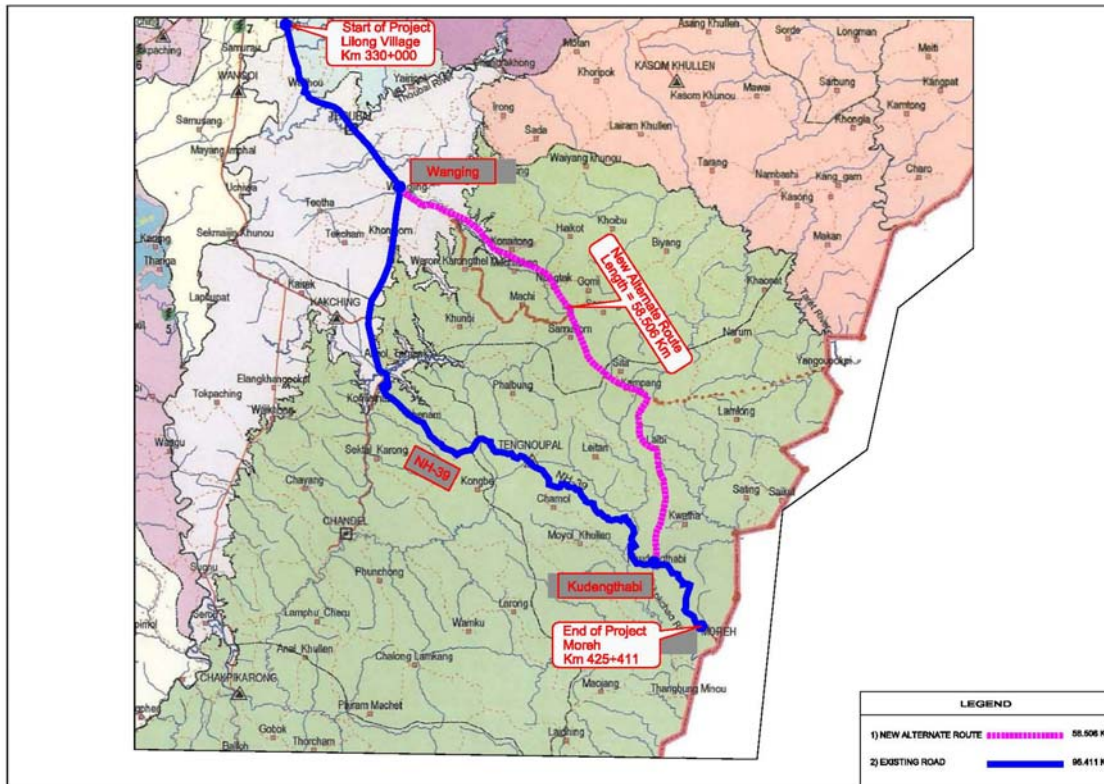
Table 2.1 Project Road Sections

Sl.No	Section	Length (km)
1	Lilong Village – Thoubal (From Km 330 to Km 342+600)	12.60
2	Thoubal – Pallel (From 342+600 to Km 365+900)	23.30
3	Pallel – Khudengthabi (From Km 365+900 to Km 417)	51.10
4	Khudengthabi – Moreh (From Km 417 to Km 425+411)	8.411
Total Length		95.411

2.3.1 SEGMENT 1: LILONG TO THOUBAL (FROM KM 330 TO KM 342+600)

The project road starts near Lilong village at Km 330 and passes through the Lilong village for a length of 2 kilometers. This segment has two lane carriageway configurations throughout and passes through the plain terrain up to Thoubal connecting several villages and the details are given below:

1. Lilong Hanganthobi Village at km 333+000
2. Ushopokpi Village at km 334+100
3. Sangomsang Village at km 335+000
4. Waithou Village at km 336+000

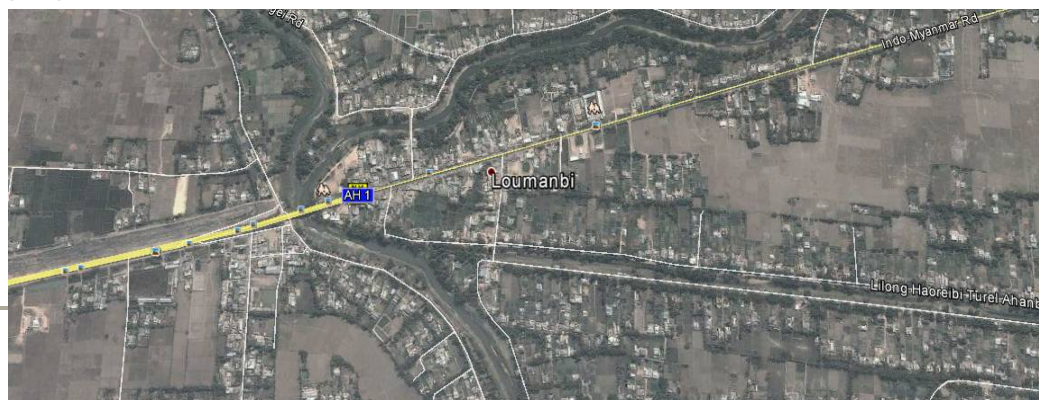
Figure 2.1-Project Alignment and Alternative Route

There are 2 minor bridges and 2 major bridges situated in this segment. The details of ROW collected from the PWD Manipur are given below:

Table 2.2 Details of ROW

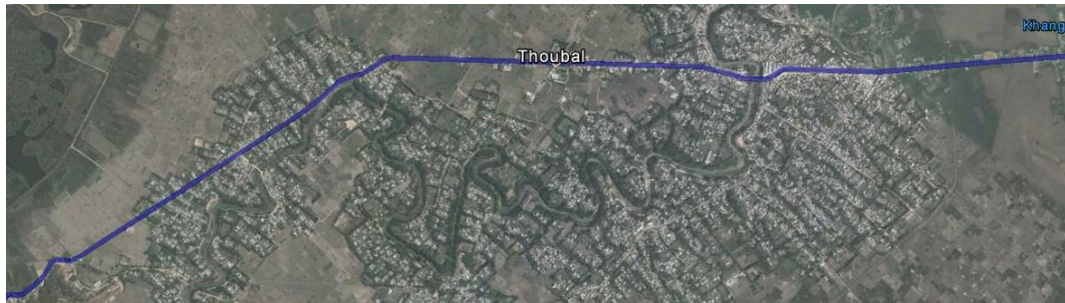
Chainage		Width of C/W (m)	Width of Formation (m)	ROW (m)	Condition
From	To				
330+000	330+150	7	30	60	Fair
330+150	334+000	7	10	15	Fair
334+000	341+000	7	10	15	Fair

Aerial view for the Built up areas of Lilong village snapshot collected from the google earth is shown below.



2.3.2 SEGMENT 2: THOUBAL TO PALLEL (FROM 342+600 TO KM 365+900)

This segment of the project road has two-lane carriageway that runs through Thoubal, Khangbok, Wangjing ad Pallel, out of which Thoubal and Pallel are two major built up areas. The length of urban section through Thoubal town is about 5 kilometers and through Pallel it is 1.5 kilometers. Four lane carriageway is observed in Thoubal town for a length of 900 meters (shown in photo). Entire section of this segment except at the ribbon development areas passes through the paddy fields where embankment heights vary from 1.0 m to 1.5 m. Aerial view for the Built up areas of Thoubal town snapshot collected from the google earth is shown below.



The ROW available is 15 m and the formation width is 10 m for the entire segment. There are 6 bridges existing out of which 1 is a major bridge. There is a new bridge under construction near Pallel town on Sekmai River, which will be ready by end of this year. This new bridge is on new alignment which bypasses the entire town portion, therefore further bypass study may not be required for Pallel town but the study of bypass may be required for Thoubal town. The view of new bridge near Pallel town is shown below.



This segment has two lane carriageway configuration throughout and passes through the plain terrain up to Pallel town connecting several village and the details are given below:

1. Khangabok Village at km 342+200
2. Wangbai Village at km 346+000
3. Wangjing Village at km 348+000
4. Khongjom Village at km 351+500
5. Sora Village at km 357+300
6. Kakching Lamkhai at km 360+000
7. Bijoypur Village at km 363+000



Pallel Town



Existing bridge in Pallel

2.3.3 SEGMENT 3: PALLEL TO KHUDENGTHABI (FROM KM 365+900 TO KM 417)

This segment from Pallel runs towards south east through the hilly terrain where the formation width is 10 m only and passes through Thamlapokpi, Bongyang, Sinam and Tegnoupal villages. Two army check post are at present located near start of ghat section and at highest altitude point near Tegnoupal village where all the vehicles are being checked. Majority of passenger/commercial traffic terminates near Pallel town. In hilly terrain isolate slipouts were noticed where the formation widening have been taken up by the department, and the protection works in the form of breast walls will be included in the improvement proposals, in many of the locations of old formation breast walls have been constructed for majority of it length in hill side. There are 3 minor bridges existing in this segment. Pavement condition varies from fair to good. The



segment passes on the ridges of the hills for majority of its length. The ROW of is 15 m only.

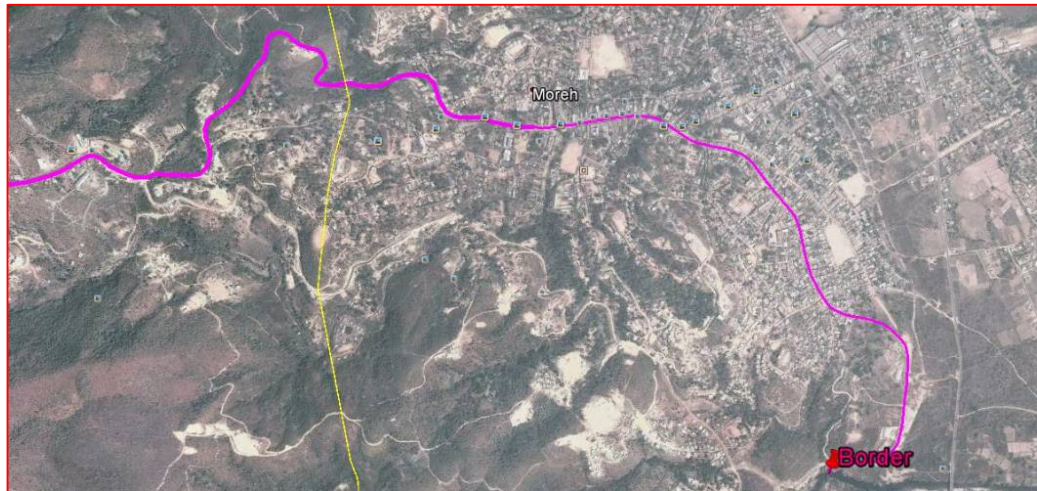
There is a steel minor bridge existing at Km 407 on a sharp curve over Lokchao River. Detailed Engineering Design Project Report (DPR) has already been prepared by PWD for improvement of this bridge and approaches. The same is in advance stage for its implementation. Geometrics improvements proposed in the PWD DPR will be considered for the present study. This segment ends near Khudengthabi village junction with PMGSY road.

The list of villages along this segment is listed below:

1. Bangjing vilage at km 373+700
2. Senam village at km 377+500
3. Salvom village at km 32+200
4. Tengnoup village at km 389+700
5. Chahmol village at km 392+800
6. Khonckhang village at km 398+100

2.3.4 SEGMENT 4: KHUDENGTHABI - MOREH (FROM KM 417 TO KM 425+411)

This segment starts from Khudengthabi village and end near international border in Moreh town. The section passes through rolling terrain for its total length and



the carriageway widths varies from 7.0 m to 8.0 m. Formation width of 10 m is observed and available right of way is 15 m only. Pavement is mostly in fair condition. This segment passes through the Moreh town for about 4 km length. There is a LCS (Land Customs office) located near km 429. The length of urba section observed is around 2.3 kilometers. Moreh town is shown in google earth image below.

There are 2 minor bridges existing in this segment out of which one bridge is located on the border at Km 430+400 which is a Bailey steel bridge and only half length maintained by India. The design scope for this bridge is not considered in the present study because 50% of length (shown yellow in color) maintained by Myanmar government.



2.4 ALTERNATIVE ROUTE ALIGNMENT

As part of the project, possible alternative alignments were studied and it is found that there is an alternative alignment existing on western side of the project corridor which starts from Wangjing town and finally merges with the project corridor near Khudengthabi village (Figure 2.1).

There is common portion of an alternative alignment for the MDR (Tengupoal-Machi) as well as the alternative alignment from the Machi junction to Sita village junction and the width of carriageway is varies from 3.0 to 4.0 m only. Further the alternative route takes left turn from the Sita village check post and passes through track on hill section and finally merges with NH 39 near Khudentahbi.



Alternative alignment passes on the mountain ridge for majority of its length, the requirement of either bridges or culverts are very less. The track is not in use for motorized traffic except few motor cycles from the adjacent villages. There is a land slide observed in between Machi village and Sita village.



List of villages along the alternative alignment is listed below:

1. Heirok town
2. Enganglok (Konaitong) village
3. Thabikeithel (Machi loukon) village
4. Charawanpham village
5. Machi Junction
6. Samukom village
7. Sita village
8. Kampangkhulen village
9. Wapur village
10. Leibi village
11. B.Molhoi village

In this alignment there is requirement 5 minor bridges and culverts. The available road formation is varying from 5.0 m to 7.0 m approximately including drains and in many sections it is only a track. The length between Wangjing and Khudengthabi along this alternative alignment is about 58+506 kms which is same as the case of project corridor on NH 39. The development of this road helps to provide access the population along the proposed alignment for marketing the agricultural products. The major portion of this road travels on the ridge portion there by reducing the necessity of major structures. The cost benefit analysis will examine the development of this alternative alignment to provide all year accessibility to the hinterlands and to provide an alternate route through the hilly region where further capacity augmentation of NH 39 in the long term is not feasible. This alternate route being of same length and characteristics will provide additional capacity. Alternative alignment is shown in Figure 2-1.

2.5 NETWORK

The corridor identified for development is situated in south eastern part of Manipur state and offers excellent potential to become a major traffic corridor

connecting international traffic from Myanmar. At present the traffic from Myanmar is low due to regulations not permitting vehicle travel between the countries. Goods are transported from Myanmar to Moreh (India) through porters and further loaded in mini trucks for further transportation to various places in India and same thing is in practice in Myanmar also. Once the regulations for free travel are implemented and international trade corridor opens, then the project corridor will become an important trade corridor with large potential for traffic and will provide the Manipur state and the region opportunities for trade development and also access to import from south east Asian countries.

3 SOCIO ECONOMIC PROFILE OF MANIPUR

3.1 INTRODUCTION

Manipur is situated in the eastern-most corner of Northeast India. The state shares borders with other north-eastern states of Nagaland, Mizoram and Assam and the neighbouring country of Myanmar.

Manipur in northeast India is a small state with the capital at Imphal. The word Manipur literally means “a jeweled land” and the state was described as the “Jewel of India” by the late Prime Minister Pandit Jawaharlal Nehru. The state attained full state hood on 21st January 1972 with a Legislative assembly of 60 seats.

Manipur has a geographical area of 22,327 sq km. Manipur is situated at an altitude of 790 meter. To the north of Manipur lays Nagaland, to the south lays the state of Mizoram, to the west lays Assam and to the east it is bordered by the international boundary of Burma. The state is surrounded by mountain ranges all around. The Barak river, the largest river of Manipur, originates in the Manipur hills. The state is blessed with lush green beauty and is surrounded by blue hills with an oval shaped valley. Manipur enjoys moderate climatic condition.

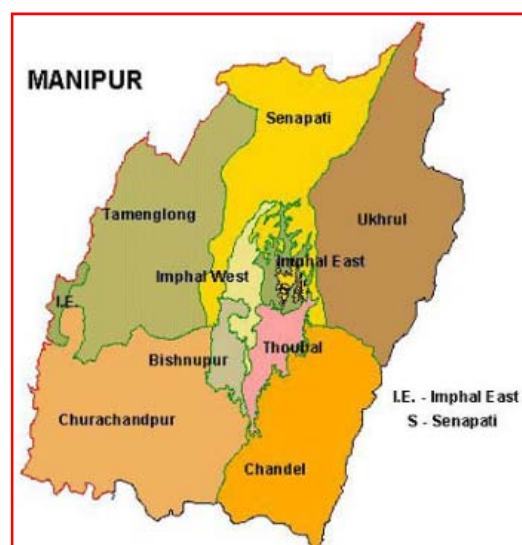
Manipur is a land with a proud history, and rich potential to transform the available national and state resources into economic growth and well being for the common man. The state is also a salad-bowl of multiple ethnicities, faiths and languages – underlining the pluralistic character of its population (27.22 lakhs by 2011 Census). There are no large waterways or effective rail transport systems, much of the reliance for inter-state communication being on the national highway system (made up of NH-39 now renamed as NH-2, NH-53 renamed as NH-37 and NH-150). Political unrest greatly



affects transportation of goods and people in and out of the state, as also within the State. Imphal is connected to Guwahati, Kolkata and Delhi by air, but air transport is costly and beyond the reach of common people, and not an option for

bulk transport of goods. Availability of power and telecommunication network is equally problematic, severely limiting infrastructure available for productive enterprise. Limited infrastructure means limited ability to convert the state's potentials – such as in horticulture, tourism, and forest produce – into commercial benefits.

Agriculture is the main mode of living of the people. People of Manipur are also engaged in handloom sector. Handloom industry is the largest cottage industry in Manipur. The state is the birth place of the game Polo and is also famous for its Manipuri dance the Ras Lila created by Rajashree Bhagyachandra.



This chapter gives an overview of the general features of the state economy relevant to the study, viz. demography, economic performance, major economic sectors, and the transport infrastructure, with special focus on the road sector. The influence area of the project corridor (PIA) comprises the districts that generate traffic for it. The socio-economic characteristics of the districts in the influence area are used to determine their relative economic performance vis-à-vis that of the state and for projecting the future growth.

3.2 GEOGRAPHY

Manipur is located at the coordinates 23°28'N 81°42'E / 23.46°N 81.7°E / 23.46; 81.7. It has an average elevation of 393 meters (1292 feet). The nine districts of Manipur state are given in Table 3.1.

Table 3-1: List of Districts

Sl.No	Name of District	Headquarters
1	Bishnupur	Bishnupur
2	Churachandpur	Churachandpur
3	Chandel	Chandel
4	Imphal East	Porompat
5	Imphal West	Lamphelpat
6	Senapati	Senapati
7	Tamenglong	Tamenglong
8	Thoubal	Thoubal
9	Ukhrul	Ukhrul

3.3 DEMOGRAPHIC PROFILE

3.3.1 POPULATION GROWTH

According to 2011 Census, the Manipur State had a total population of 2.57 million which accounts for 0.21 percent of the nation's total population.

In Manipur, Census 2011 covered 9 districts, 38 Sub districts, 51 towns (Statutory towns 28, Census town 23) and 2581 villages. In census 2001, the corresponding figures were 9 districts, 38 Sub-districts, 33 towns (28 Statutory towns, 5 Census towns) and 2391 villages. There is no specific increase in both districts, Sub-districts and Statutory towns but there is an increase of 18 Census towns and 191 villages in Census 2011 as compared to Census 2001

As per census 2011, the total population of Manipur is 2,570,390. Of this, the rural population is 1,736,236 and the urban population 834,154. In absolute numbers, out of the total increase of 403,602 added in the last decade, the contribution of rural is 145,416 and urban area is 258,186.

The growth rate of population in Manipur in the last decade is 18.6% (Rural 9.1%; Urban 44.8%). Chandel has recorded the highest decadal growth rate in rural population (23.2%) and Imphal East (69.2%) the highest decadal growth rate in urban population during 2001-2011. Senapati (96.1%) has the largest proportion of rural population, while Imphal West (62.3%) has the highest proportion of urban population. Demographic features for all the districts in Manipur as per census of India 2011 are given in Table 3-2 below.

Table 3-2: Demographic Features of Manipur

S. No	Name of District	Area in Sq.Km	Total	Literacy %			Sex Ratio	Density
				Male	Female	Total		
1	Imphal west	519	514683	92.93	80.71	86.70	1029	992
2	Imphal East	709	452661	89.86	75.92	82.81	1011	638
3	Thoubal	514	420517	85.90	67.57	76.66	1006	818
4	Bishnupur	496	240363	85.52	76.35	76.35	1000	485
5	Senapati	3271	354972	80.85	68.80	75.00	939	109
6	Tamenglong	4391	140143	76.74	63.76	70.40	953	32
7	Churachandpur	4570	271274	88.34	80.13	84.29	969	59
8	Ukhrul	4544	183115	86.05	77.47	81.87	948	40
9	Chandel	3313	144028	77.93	63.26	70.85	932	43
	Manipur	22327	2721756	86.49	73.17	79.85	987	122

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17)

3.3.2 POPULATION DENSITY

The decadal growth rate of population during 2001-2011 was 18.65% as compared to 21.35% during 1991-2001. This is as against a growth rate of 29.29% during 1981 – 91 periods. The population distribution is skewed with 14.12 lakhs (61.55%) person living in the Valley areas – that constitute only 1/10 of the total geographical area of the State - and 8.82 lakhs (38.45%) persons thinly dispersed all over the Hills, making up 9/10 of the total area of the State.

Urban and Rural Population: The State continues to be predominantly rural, with rural population being 73.82 % of the total (number 27, 10,051), urban areas making up on 26.18 % (2011 Census) the State. The following table gives growth of population in the State during 1971 and 2011.

Table 3-3: Growth of Population (in lakhs)

Year	Population	Rural	Urban
1971	10.73	9.31	1.42
1981	14.21	10.45	3.76
1991	18.37	13.32	5.05
2001	22.94	17.18	5.76
2011	27.22	18.99	8.23

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17)

Population density (persons per sq.km), in 2011 works out to be 115 showing an increase of 18 points from 2001. Imphal West (998 per sq.km) turns out to be the most densely inhabited followed by Thoubal (821 per sq.km), among all districts in 2011 census. Likewise among the major districts Imphal West occupies the first position with a density of 708 per sq.km during 2001. The minimum population density works out to Tamenglong district (25 per sq.km during 2001 and 32 per sq.km during 2011) for both census.

3.4 EDUCATION AND HEALTH

Education and Health indices throw up a mix of the good and not so good. Literacy rate, at 70.50% in 2001 (as against All India average of 64.80%) has improved significantly to 79.85% in 2011 (All India, 74.04%). Overall, Manipur stands sixteenth among all states in terms of literacy performance. Male literacy rate has increased by about 6% to 80.33% in 2011 while female rate has gone up by 12.64% from 60.53% during the same period.

The State Literacy Mission Authority (SLMA), Manipur was constituted as per the directive of National Literacy Mission (NLM) Authority. The project is funded on sharing basis by the Government of India and the State Government.

Table 3-4: Literacy Rate

Sl.No	Literacy Rate	
1	Literacy Rate	79.80%
2	Male Literacy	86.50%
3	Female Literacy	73.20%

(Source: Census 2011 (Provisional data))

Several programs including the National Programmes of Nutrition (mid-day meals scheme), support primary education. The state also promotes education for girls. Under the Union Government's National Literacy Mission (NLM), the State Government has implemented the Total Literacy Campaign (TLC) for the non-literate population in the age group of 15 to 35 years.

Health indicators are good with Crude Birth Rate (CBR) and Crude Death Rate (CDR) estimated at 14.9 and 4.2 respectively as against 22.1 and 7.2 respectively at All- India average (SRS-2010), and Infant Mortality Rate (IMR) of 14 per thousand at (SRS- 2010) as against 47 at All-India average. Life Expectancy rate, however, appears to be low at 62 years, as against the national average of 66.8 years (Census 2011). The table below presents major health indicators.

Table 3-5: Health Indices

Parameters	Reference Year	Manipur	All India
Infant Mortality Rate	(SRS)	14	
Crude Birth Rate	(SRS)	14.9	
Crude Birth Rate	(SRS)	4.2	
Maternal Mortality Rate		160 (SRS-05) 110(Figure at RIMS-09)	212 (SRS - 07-09)
Total Fertility Rate (TFR)	NHFS -3	2.8	
Intuitional Delivery (%)		68.3 (HMIS-10)	47.0 (DLHS-3)
Fully Immunised Children 12-23 Months		81.4 (HMIS-10)	61.0(CES-09 Unicef)

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17))

The health service in the state is primarily under the government sector, although there are a few private hospitals/nursing homes to reckon with.

The health system under the State Health Department is organized at three levels, each level supported by a referral centre. The levels are:-

- a) Primary care level comprising of Primary Health Sub-Centers (PHSC), Primary Health Centers (PHC) and Community Health Centers (CHC). Essential basic health care are provided at this level.

- b) Secondary care level comprising of CHCs and District Hospital, which act as referral centers and where comparatively better services are provided with basic specialist facilities.
- c) Tertiary care level where specialist and super specialist care are provided. The State Level Hospital (JN Hospital) is providing the service.

Table 3-6: Number f Health Institutions with Bed Strength

Sl.No.	Category of Institution	Number	Sanctioned bed Strength	Actual bed in position	General hospital
A.	Under the State Health Department				
1.	State General Hospital	1	500	376	376
2.	State TB Hospital	1	100	100	0
3.	State Leprosy Hospital	1	30	6	0
4.	District Hospitals	7	450	295	295
5.	Sub-district Hospital	1	50	50	50
6.	CHC	16	480	344	344
	Sub-total Secondary		1610		1065
7.	PHC	80	432	370	0
8.	PHSC	420	0	0	0
9.	Allopathic Dispensary	20	0	0	0
10.	AYUSH Dispensary	10	0	0	0
	Total: A	557	2042	1541	1065
B.	Under Ministry of Health GoI				
1.	RIMS Hospital	1	1074	1074	1074
C.	Under Private Sector		0		
	Regd.Hospital and Nursing Home	26	807	807	807
	Grand Total(A+B+C)	569	3923	3422	2946

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17)

Generation of Health manpower in the State: The State has per capita one of the highest concentrations of Health Manpower among the North-Eastern States. The State has two tertiary Health Care Centers (Two Medical Colleges RIMs and JNIMS and their attached hospitals), 7 District Hospitals (against 9 districts in the State). Further there are 26 private Hospitals and Nursing Homes which are registered under the “Manipur Nursing Home and Clinic Registration Act.1992”. among the private hospitals one hospital namely Shija Hospital is rendering tertiary health care. Due to unwillingness of non-locals to join the medical colleges almost all the doctors in the two medical colleges (having 100 intake capacities each) and their attached hospitals are manned by local doctors. As on June 2011 there were 786 medical doctors serving under the State Health Department of which 119 are specialists. The number of medical doctors in the State Health Department plus those employed in RIMS and JNIMS together is 1257.

Table 3-7: Status of Medical Doctors in Manipur State as on June 2011

Sl. No		*RIMS	JNIMS	@State H&FW Dept	#Private Hospital	Remarks
A.	Core Specialties	69	33	53		155
B.	Other Clinical Specialities	33	10	35		78
C.	Para-clinical specialities	30	21	30		81
D.	Non-Clinical Specialities	28	15	1		44
E.	Doctors not included above	159	73	667	#172	1071
	Grand Total:(A-D)	319	152	786	172	1429

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17)

3.5 AGRICULTURE PRODUCTION

Agriculture and allied activities is the only mainstay of the State's economy where about 70% of the population depends on it. The State has two distinct topographical zones – valley and hill. The valley that is also known as “Rice bowl” of the State has an average altitude of 790 meters above MSL and its climate is sub-tropical to tropical to sub temperate. The hills, which constitute 9/10th of the total area, have sub temperate to temperate climate with an average altitude of 3000 m above MSL. The State has distinct winter, warm humid and rainy season.

The average rainfall during the last 10 years was 1482.20 mm with heavy precipitation during the month of June, July and August. The growth of Agriculture in the State has been quite uneven and unsatisfactory for the reason that its production still depends on seasonal rainfall.

Agriculture in the State is confined to 10.48% of the total geographical area. The percentage of agricultural land in valley districts is 47% and that in the hill districts is 53%. The irrigated area is 42,000 ha. i.e. 17.95% of the net agricultural land.

The State is marginally deficit in cereals and highly deficit in the production of oilseeds and pulses. Therefore, the per hectare production of all food grains and other commercial crops have to be increased to meet the food requirements as well as the economic development. The food grain requirement of the projected population including floating population and customary uses of 20112-13 has been estimated as 763.03 thousand tones. The consumption of fertilizers (NPK) in the State was 95.28Kg/ha. during 2011-12. The following are the facts and figure of crop production in the State.

Table 3-8: Facts and Figures of Crop Production

<u>Particular</u>	<u>State average</u>	<u>National Average</u>
Productivity of Rice	: 2494 Kg/ha (2011-12)	2177 Kg/ha (2010-11)
Food grain	: 2288 Kg/ha (2011-12)	1660 Kg/ha (2010-11)
Maize	: 1856 Kg/ha (2010-11)	1959 Kg/ha (2010-11)
Pulses	: 897 Kg/ha (2010-11)	537 Kg/ha (2010-11)
Wheat	: 2500 Kg/ha (2010-11)	2830 Kg/ha (2010-11)
Rapeseeds & Mustard	: 774 Kg/ha (2010-11)	1159 Kg/ha (2010-11)
Cropping Intensity	: 149% (2011-12) -	
Consumption of Fertilizer	: 95.28(NPK) Kg/ha (2011-12)	

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17))

Horticulture and Soil Conservation: Topographically the state is hilly and mountainous with a small central valley of only about 10% of the geographical area. Agro-ecologically the state is situated in the hot and warm humid/per-humid agro-eco region. The soil of Manipur is acidic as an indication of high rainfall area and 80% of the farmers are small and marginal. Most of the cultivated area is rain fed except some area in central valley. In such scenario of agriculture, some of the points for enhancing productivity, profitability, sustainability and competitiveness of horticulture sector in Manipur are:

- Horticulture is specially orchards and floriculture has high potential
- Poor infrastructure and poor road connectivity to the main agriculture potential area is a bottleneck.
- Poor marketing infrastructure and poor marketing network is the bottleneck for disposing the agriculture produce.
- Need for development of crop specific, region specific technology which are accessible and simple to the farmers.
- Need for creation of an environment for attracting youths in agriculture by adopting new technologies like protected cultivation, farm mechanization, etc.
- Need for enhancing activities of food processing and post harvest technology.

Natural forest covers about 64 per cent of the total geographical area of Manipur. Agriculture has significant share in the state domestic product and provides employment to about 52.2 per cent of the total workers in the state.

Teak, pine, oak, uningthou, leihao, bamboo, cane, etc., are important forest resources. In addition rubber, tea, coffee, orange, and cardamom are grown in the hill areas. Food and cash crops are grown, mainly, in the valley region. Major fruits grown in the state are pineapple, lime, lemon, banana, orange, papaya, plum, and passion fruit.

Rice is the staple food of Manipur and is grown in both the hills and the plains. In 2008-09, total production of rice was 473,380 tonnes in the state. Annual production of crop year 2009-10 is given below.

Table 3-9: Crop Annual Production Year 2009-10

Sl.No	Crop	Annual Production ('000 tonne)
1	Rice	473.3
2	Pineapple	103.5
3	Banana	33.7
4	Potato	15.2

(Source: Indian Horticulture Database 2010, National Horticulture Board, Department of commerce & Industries, Government of Manipur as of 2009-09)

3.6 FOREST AND WILD

Forests of Manipur are rich in biological and genetic diversity, and also the most abundant resource in the State. As per reports of Forest Survey of India, broadly forests of Manipur include Wet Temperate Forests, Pine Forests, Wet Hill Forests, Semi Evergreen Forests, Teak-Gurjan Forests, Bamboo brakes and Grass brakes.

As per latest State of Forest Report (SFR) 2009 published by Forest Survey of India, the forest cover in the State, based on interpretation of satellite data of December 2006 – January 2007, is 17,280 sq Kms. this is 77.4% of the State's geographical area. In terms of forest canopy density classes, the State has 701 sq.km (3.14%) very dense forest, 5474 sq. km. (24.52%) moderately dense forest and 11,105 sq km (49.74 %) open forest.

3.7 VETERINARY AND ANIMAL HUSBANDRY

Veterinary and Animal Husbandry sector plays a vital role in the socio-economic upliftment of rural masses of the state. According to the 18th quinquennial Livestock Census 2007 more than 4 lakhs household are depending on Animal Husbandry for their livelihood out of States total population of about 25 lakhs.

Fisheries: The total water area of Manipur was around 56,461 ha. in 1993 and still remain so comprising of lakes, reservoirs, tanks, canals, swamps and other water logged low lying areas.

Table 3-10: Detailed Fisher Resources in the State

S.No	Items/Particulars	Water area (in ha.)
1	Lakes, reservoirs, tanks, canals etc.	13,221.45
2	Water-logged marshy and swampy lands, etc.	11,536.23
3	Biomass.	8,596.50
4	Submerged crop lands.	3,480.50
5	Rivers and streams.	13,888.27
6	Water logged areas converted into agricultural lands.	1,738.10
7	Low-lying paddy fields.	4,000.00
Total		56,461.05 ha.

(Source: Land Survey Report, Manipur Remote Sensing Satellite)

The annual requirement of table fish by the end of 11th Five Year Plan period (2007-2012), calculated as per the Standard nutritional requirement of 11 kg per capita consumption of fish for about 27.21 lakh population of the State (as per Census 2011) is estimated at 29,931 M.T. against the present production of 22,200 M.T. (up to 11th Plan) showing a shortfall of about 7,731 M.T. of table fish..

In the hill areas, there exists a vast and varied scope for development of cold water fisheries, aquaculture programmes, paddy-cum-pisciculture etc. through adoption of seed farms, riverine and running water fisheries and other infrastructure etc. for optimization of fish production in the hill districts of the State.

3.8 MAJOR AND MEDIUM IRRIGATION

The state has about 2, 30,000 ha. of net cultivated area. By the end of Eight Plan period, only about 67,546 ha has been brought under irrigation of which major & medium irrigation projects contributed 28,150 ha. (29.38%) and Minor Irrigation contributed 39,396 ha. At present, three major and medium irrigation projects having large irrigation potential are ongoing and also eight major and medium and multipurpose river valley projects have been taken up. Five projects namely Loktak Lift Irrigation Project, Khoupum Dam project, Imphal Barrage project, Sekmai Barrage project and Singda Multipurpose Project have been completed and irrigation benefits have accrued to the State. One ongoing major multipurpose project, viz Thoubal Multipurpose project have been partially completed and irrigation potential of 14,861 ha have been created upto the end of 11/2011. Khuga Multipurpose Project is a medium on-going project. Constructions of Khuga Project except for some portion of canal system and Hydro Power component have been completed. The head work of the Khuga Project was inaugurated on 12th November, 2010 and in operation with a partial Irrigation benefit of 10000 ha. up to the end of 11/2011. Dolaithabi Barrage project is also ongoing project. It will give an Irrigation potential of 7550 ha. after its completion. On completion of the ongoing projects with modernization of the completed projects an ultimate annual irrigation of 99,590.00 ha, water supply of 19 MGD and power generation of 9.75 MW will accrue to the state.

Minor Irrigation: The net area under Minor Irrigation is to the tune of 74,540 hectares. In the hills, nearly 70,000 Ha are under Jhum cultivation which is to be discouraged due to its unsustainable land use practice. In the valley, 1, 40,000 Ha, of cultivable land is more or less situated in groups of compact area, while in the hills, the cultivable fields are situated in isolated and smaller pockets of arable lands. Still in many hill districts, nearly 1,00,000 Ha. of land can be brought under wet terraced cultivation. Further, nearly 60 p.c. of the whole cultivable area of the state is utilized for agriculture in the flat lands of valley. Though the average annual rainfall is to the tune of 1600 mm. to 2000 mm, it is confined mainly to the

monsoon months of June to September. Therefore the creation of potential irrigation facilities and achievement of targeted potential are important.

3.9 POWER

Electricity is one of the key infrastructures required for sustained economic growth and for improving quality of life. The power supply of the State of Manipur depends upon the Central Sector Generating Stations located in the North Eastern Region. Against a peak demand of 184 MW (as per the 17th Electric Power Survey of India) during 2010-11 the maximum availability of power from all the Central Sector Generating Stations including the unallocated share of the Central Sector Generating Stations, which varies from time to time at the peak hour was around 105 MW and around 1 MW of power from state source during 2010-11. There has been always a shortfall of about 42 p.c. of the peak power in the State. Peak demand and availability: Peak demand and availability of power for Manipur are shown below. The Peak Demand is based on the 17th EPS of India.

Table 3-11: Summary of Peak Demand Based on the 17th EPS of India

Sl.no	Year	Peak Demand (MW)	Availability(MW)	Shortfall
1	2009-10	170	110	35%
2	2010-11	184	160	42%
3	2011-12	203	92.3 as on Dec 2011	
4	2012-13	223		
5	2013-14	234		
6	2014-15	246		
7	2015-16	258		
8	2016-17	270		

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17)

The State has no sufficient generation of power of its own. The power supply of the State of Manipur depends upon the Central Sector Generating Stations located in the North Eastern Region. And there is also a wide gap between the demand and availability of power in the State. To fill up the gap to some extent it is proposed to start implementation of Loktak Down Stream Hydro Electric Project and Tipaimukh Hydro Electric Project as Joint Venture. Investigation of Irang and Tuivai hydroelectric projects are proposed to be completed. Similarly, survey and investigation of Maklang-Tuyungbi, Pabram and Nungleiban hydro electric projects are in planning.

3.10 COMMERCE AND INDUSTRIES

The Plan proposals attempted to evolve strategy for creation of basic infrastructure, generation of more employment opportunities, consolidation of achievement and completion of continuing schemes within schedules, identification of the critical areas and putting things in the right perspective, taking advantage of

the border trade carried on with Myanmar, The State Government recognize VSE Sector as the main thrust area of the industrial development since it provides largest employment next to agriculture. Particular emphasis is on Handloom & Handicrafts, and Food Processing and Bamboo based industries. A new Industrial Policy is being formulated to facilitate rapid and substantial industrial development. The Policy shall also provide for several incentives for the entire Industry Sector as well as specific to each selected sub-sectors. A policy on Mining Sector will also be separately framed.

The major achievements during the 11th Five Year Plan and Annual Plan 2011-12 are shown briefly as under:

- (i) Training programme: During 11th Five Year Plan 2,669 persons were imparted training in various trades in different training centers of the Department..
- (ii) Small Scale Industries: 13 small-scale industrial units were granted financial assistance in the form of Subsidy under the existing Industrial Policy of Manipur, for an amount of Rs.11.91 lakh during 11th Plan Period.
- (iii) Handloom Industries: During XI Plan 4027 societies have been given various benefit, organized 29 Melas, 1100 trainees, 70 clusters were developed, 29 Cluster Development Executives were engaged, 25 Designers have been appointed, 273 sewing and embroidery machines were provided for production of diversified items, 300 Nos. of handloom fabrics was identified for registration under GI Act, 1999 and filed 03 applications for GI on handloom fabrics to the Registrar of GI, 06 sales depots were assisted for opening outside the State, sponsored 10 nominees for undergoing Diploma in Handloom & Textile Technology.
- (iv) Handicrafts: Under the handicrafts 177 Master Crafts-persons residing in different Districts of the State are being honoured under State Award. 260 artisans under assistance to Individual artisans, 130 artisans under Kouna Development scheme, 120 under Mordernisation scheme, 50 under Original works, 90 under EDP and another 28 artisans are being benefited during 11th Fiver year Plan with an expenditure of Rs.78.500 lakh. One Craft Museum is also constructed within the building of the Directorate.
- (v) Food Processing Industries: Substantial progress was made in the implementation of various schemes, such as Food Processing Training Centre, Regional Extension Service Centre, Training on FPI, Research & Development on FPI, Mobile Food Processing unit for Fruit & Vegetables, Preparation of Project Report, Publicity & Campaign, and Support to FPI units, Quality Control and Codex Cell, Promotional Activities in FPI, Assistance to Ex-Trainees of FPI, etc. Other activities in promotion of Food Processing Industries are (a) Training on Food Processing Industries (b)

Seminar/Workshop on Modernization of Huller Rice Mills and (c).Awareness/Workshop on Implementation of APEDA schemes.

- (vi) The Department has also taken up for the establishment of (1) Food Processing Training Institute at Porompat, Imphal East, by upgrading existing Food Processing Training Centre and amalgamation with the existing Regional Extension Service Centre (RM). Integrated Cold Chain, Value Addition and Preservation Infrastructure towards the development of Food Processing Industries at Senapati District has also taken up.

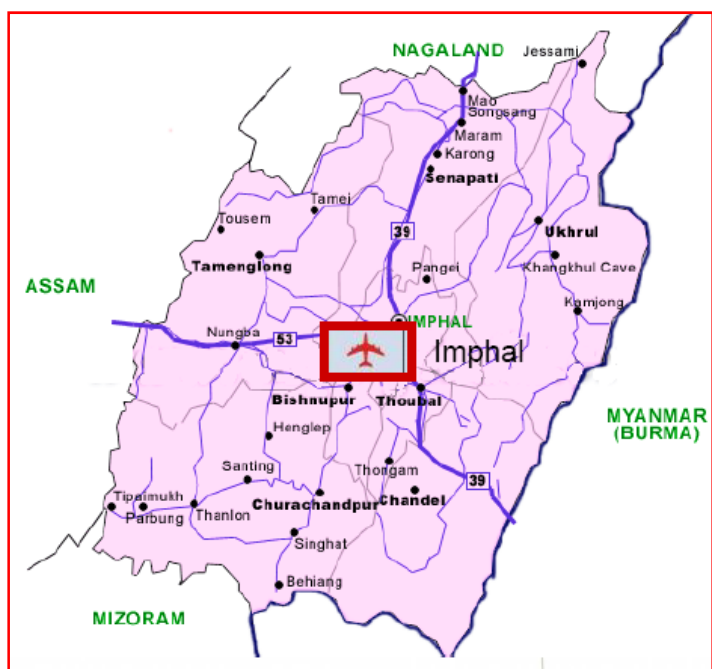
Food Park at Nilakuthi - the State established a Food Park at Nilakuthi to provide common facilities, like, cold storage, are house, and quality control labs. Packaging, toll room, power and water supply, sewerage treatment etc... This park will provide facilities to set up 50 – 60 Food Processing Units which will directly employed to 200-300 persons and 3000 persons indirectly including farmers, traders, businessmen, etc.

The State PWD has started construction of Bailey bridge connecting NH-39 and Food Park, Nilakuthi.

- (vii) Mineral Development: Four projects/programs were approved and reviewed which include (i) exploration of Limestone Deposits of Shokpau-Yongphu Block of Ukhrul District, (ii) exploration of Chromite in Khangkhui-Singcha Block, Ukhrul District, (iii) prospecting of Nickel in the Ophiolite Belt at Pushing area, Ukhrul District and, (iv) Sampling in Ophiolite Belt at Khudengthabi-Kwathta area in Chandel District.

3.11 ROADS AND BRIDGES

Manipur being a land locked state with almost 90% of the area under difficult hilly terrain; the road transport is the only means of mass transport system in the state presently. Because of this terrain condition, presently there is no alternative means of transportation. Consequently the movement of passenger and goods traffic is solely dependent on the Road Transport. Hence development of the road infrastructure is of paramount importance to ensure connectivity and progress of the State and to ensure that the administrative set up reaches these isolated and remote habitats. In fact this



sector is the backbone for the Socio-Economic development of the state. The successful implementation of the schemes under the different Sectors is also dependent on this sector.

The total lengths of road under various categories at the end of the 11th Five Year Plan and at the beginning of 12th Five Year Plan are as below:

Table 3-12: Summary of Total Length of Roads.

Item	3/2012 (km)	12th Plan Target (km)
i) National Highway	959	959
ii) State Highways	1137	1137
iii) Major district Roads	1179	1179
iv) Other District Roads	1013	1063
v) Inter Village Roads	8330	8280
Total	12618	12618

(Source: Draft Annual Plan (2012-13) and 12th Five Year Plan (2012-17)

The road density in the State of Manipur at the end of Tenth Five Year Plan is 57.00 km (including all roads under BRO, NEC & NH) per 100 sq.km. Whereas the road density on all India standard is 62 Kms per 100 sq.km. There is immediate need for increasing the road length as well as for improvement of existing roads. However, the emphasis of the state government during the 12th Five Year Plan is on improvement of the existing infrastructure, and providing of all weather roads to all the Divisional and Sub Divisional Head quarters ensuring their connectivity with the State Capital throughout the year. No additional construction is proposed during this Plan period.

3.12 OVER VIEW OF STATE ECONOMY

The economy of Manipur is characterized by high rate of unemployment and poverty; low capital formation, in-adequate infrastructure facilities, geographical isolation and communication bottlenecks, practically no industrialization to speak of. More than 60 per cent of the population depends on agriculture for sustaining their livelihood. Whereas, contribution of Agriculture & Allied Sector to the GSDP was 24.70% during 2011-12 (P), the contribution of Secondary & Tertiary sectors was 29.73% and 45.57% respectively. The lower contribution from agriculture and allied activities to the Gross State Domestic Product (GSDP) was primarily because of un-sustainable and non-viable nature of the sector and its low capital base.

Agriculture continues to be the mainstay of the economy, although the reliance of the population on the sector has been going down. The backwardness of the economy is further evident from the fact that there has been virtually no diversion from agriculture to other activities such as plantation and forestry, although significant potential exists for that. Settled form of agriculture is concentrated in the Valley and jhum cultivation continues to be pre-dominant in the Hills. Further,

agriculture continues to depend on monsoon rain and the state continues to be a net importer of food grains.

The per-capita income in 2011 at current prices was Rs.36, 085. A comparative statement of per capita income of the State and All India Average is given below:

Table 3-13: Per Capita Income with 2004-05 Base

Year	Manipur	India
2004-05	18640	24143
2005-06	19479	26015
2006-07	19431	28067
2007-08	20106	30332
2008-09	21169	31754
2009-10	22359	33843
2010-11	23298	35993
2011-12	24327	38005

(Source: Directorate of Economics & Statistics 2011-12)

Annual average growth rate of the State vis-à-vis all India is presented in the following Table.

Table 3-14: Growth Rate in Per Capita Income

Year	Annual average Growth Rate Manipur	Annual average Growth rate all India
2005-06	4.5	7.75
2006-07	-0.24	7.89
2007-08	3.48	8.07
2008-09	5.29	4.69
2009-10	5.62	6.58
2010-11	4.20	6.35
2011-12	4.42	5.59

(Source: Directorate of Economics & Statistics 2011-12)

Table 3-15: NSDP at Constant prices (2004-05 Prices)

{(At Constant 2004-05 Prices) (2004-2005 to 2012-2013)}									
									(Rs. Lakh)
Sector	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
I. Primary									
(i) Agriculture and Allied	115476	116574	115490	127728	141237	161300	163883	177524	195476
Agriculture	86500	86878	85797	98061	111722	131442	133810	147319	165162
Forestry & Logging	18830	19233	19036	18947	18755	18919	18936	18876	18845
Fishing	10146	10463	10657	10720	10760	10939	11137	11329	11469
(ii) Mining & Quarrying	0	0	0	0	0	0	0	0	0
Total Primary	115476	116574	115490	127728	141237	161300	163883	177524	195476
II. Secondary									
Manufacturing	18894	20126	22950	27440	26146	27662	27787	29585	31330
(i) Manu-Registered	468	816	403	728	956	1061	1148	1181	1498
(ii) Manu-Unregistered	18426	19310	22547	26712	25190	26601	26639	28404	29832
Construction	140754	150792	152487	152716	156398	161186	166486	170578	174456
Electricity Gas and Water supply	10048	12082	11560	10576	12856	19402	22779	25298	29974
Total Secondary	169696	183000	186997	190732	195400	208250	217052	225461	235760
Industry (Mining & Quarrying + Secondary)	169696	183000	186997	190732	195400	208250	217052	225461	235760
III. Services									
Transport Storage & Communication	13021	15110	17896	20275	22125	24311	27460	31807	36076
Railways	0	0	0	0	0	0	0	0	
Transport by other means	8174	8631	9093	9466	10120	10259	10864	11513	12072
Storage	106	107	121	132	149	162	178	198	219
Communication	4741	6372	8682	10677	11856	13890	16418	20096	23785
Trade Hotels and Restaurants	36977	37734	39468	43475	44613	49574	52772	56606	60863
Banking & Insurance	9009	9771	11573	13023	12938	16446	19625	22613	25939

{(At Constant 2004-05 Prices) (2004-2005 to 2012-2013)}									
									(Rs. Lakh)
Sector	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Real estate ownership of dwellings and business services	16145	16913	18058	18256	18567	18103	18613	19309	19574
Public administration	48289	54833	49537	52971	60458	56982	57998	58861	61049
Other services	51717	56770	60200	60206	69879	68983	76470	84110	90105
Total Services	175158	191131	196732	208206	228580	234399	252938	273306	293606
State domestic product (Rs. Lakh)	460330	490705	499219	526666	565217	603949	633873	676291	724842
Population	2469600	2519200	2569200	2619400	2670000	2720800	2772000	2823400	2875800
State Per Capita Income (Rs.)	18640	19479	19431	20106	21169	22197	22867	23953	25205

Source: www.Indiastat.com

3.13 VEHICLE REGISTRATION DATA

Regional Transport Office (RTO): Vehicle registration data for I Manipur state for the year from 2004-05 to 2010-11 along with CAGR is given below in Table 3-16.

Table 3-16: Vehicle Registration Growth (%)

Year	Car	Scooter Motor cycle	Three Wheeler	LMV Goods	Trucks	Bus	Tractor & Trailer
2004-05	18,840	80,557	2,630	1490	6,314	3,150	1,935
2005-06	20,979	86,931	2,721	1854	6,746	3,371	2,058
2006-07	20,819	93,595	3,787	2005	7,078	3,549	2,230
2007-08	21,635	105,465	4,071	2245	7,216	3,977	2,350
2008-09	21,635	105,465	4,071	2245	7,216	3,977	2,350
2009-10	28,180	139,650	7,266	2871	7,639	4,293	3,835
2010-11	30,816	145,286	9,954	3207	8,249	4,376	3,900
CAGR (%)	8.55	10.33	24.84	13.63	4.56	5.63	12.39

(Source: Road Transport Year Book, Govt of India from 2004-05 to 2010-11)

3.14 ECONOMIC INDICATORS FOR PIA

Economic Indicators growth (%) like Net State Domestic Product, Per Capita Income and Population for all the above mentioned states as well as for overall India is given in the below table and the collected data has been arranged along with their linear growth is set out in Annexure 3.3.

Table 3-17: Economic Indicators Growth (%) at Constant (2004-05) Prices

Year	NSDP (millions)	PCI (Rs)	Population (millions)
2004-05	4,603	18,640	2,469,421
2005-06	4,907	19,479	2,519,123
2006-07	4,992	19,431	2,569,091
2007-08	5,267	20,106	2,619,616
2008-09	5,652	21,169	2,669,942
2009-10	6,083	22,359	2,720,605
2010-11	6,458	23,298	2,771,912
2011-12	6,868	24,327	2,823,201
Growth (%)	5.88	3.88	1.93

Source: Directorate of Economics & Statistics of respective State Govt and for all India Central Statistics

3.15 ELASTICITY VALUES

The elasticity method relates traffic growth to changes in the related economic parameters. According to IRC-108-1996, elasticity based econometric model for highway projects could be derived in the following form:

$$\text{Log } e(P) = A_0 + A_1 \text{Log } e(EI)$$

Where:

P = Traffic volume; EI = Economic Indicator; A_0 = Regression constant; T Stat; A_1 = Regression co-efficient (Elasticity Index).

Elasticity values for car/van/jeep/taxi, bus and trucks were developed using the econometric model for Manipur State. Economic independent parameter of PCI has been used as one parameter against dependent parameter for car/van/jeep/taxi, 2wheeler and 3 wheeler, and Bus. Whereas for commercial vehicles, NSDP has been considered as independent variable.

Table 3-18: Estimated Elasticity Values for Manipur State

Vehicle Type	R ²	Parameter	e
Car/Van/jeep/Taxi	0.909	PCI	2.10
Two Wheeler	0.946	PCI	2.70
Bus	0.876	PCI	1.43
All Trucks & LMV	0.942	NSDP	1.00

3.16 GROWTH RATES

For traffic projection, vehicle growth rates are used as a proxy of traffic growths and traffic growth rates are calculated from the econometric relation developed. The national growth rate have come down substantially in the last 2 years and is expected to be continuing on the current growth trend. The state growth rate is well below national growth rate in the past but considering the developments happening such as railhead coming upto near Imphal and trade opening up with Myanmar and expecting an improving security situation, the state economy is expected to grow close to the recent past trend. The state has observed an economic growth rate of 5.9% in recent years and considering the overall economic slowdown, a growth rate of 5.3% is considered for the next 5 years and reducing by 0.5% every 5 years thereafter. The population growth also will slow down over the time. The traffic growth rates are computed based on this growth assumption and the recommended growth rates for all the vehicles are given below. Where abnormally high growth rates are observed, for example in case of three wheelers and LCV's, the growth rates are adopted same as car in case of three wheelers and 15% higher than truck growth rates in case of LCV's.

Table 3-19: Summary of Recommended Growth Rates for Project Corridor

Vehicle Type	2013-18	2018-23	2023-28	2028-33	2033-38
Car/Van/Jeep	7.2	6.4	5.8	5.0	4.0
2 Wheeler	9.0	8.0	6.5	5.6	4.0
3 Wheeler	6.5	5.8	5.2	4.5	3.6
Bus	5.0	4.3	4.0	3.4	3.4
All Trucks	5.5	5.0	4.5	4.0	3.5
LCV	6.1	5.5	5.0	4.4	3.9

4 TRAFFIC STUDY AND ANALYSIS

4.1 INTRODUCTION

Traffic surveys are an essential task to assess the likely quantum and composition of traffic over the design period on the project road. The details of various traffic surveys conducted, methodologies adopted for collection of data in understandable formats and analysis, including possible traffic diversions have been discussed in detail in this chapter. Traffic surveys have been carried out on Imphal-Moreh road to the level required for feasibility study and design. No traffic survey was carried out on the alternate state highway route as the route was not motorable.

4.2 OBJECTIVES OF THE TRAFFIC SURVEYS

The main objectives of the traffic surveys are to assess:

- The volumes of traffic flows and their characteristics.
- The trip distribution and travel characteristics.
- The through traffic characteristics.
- The commodities distributions.

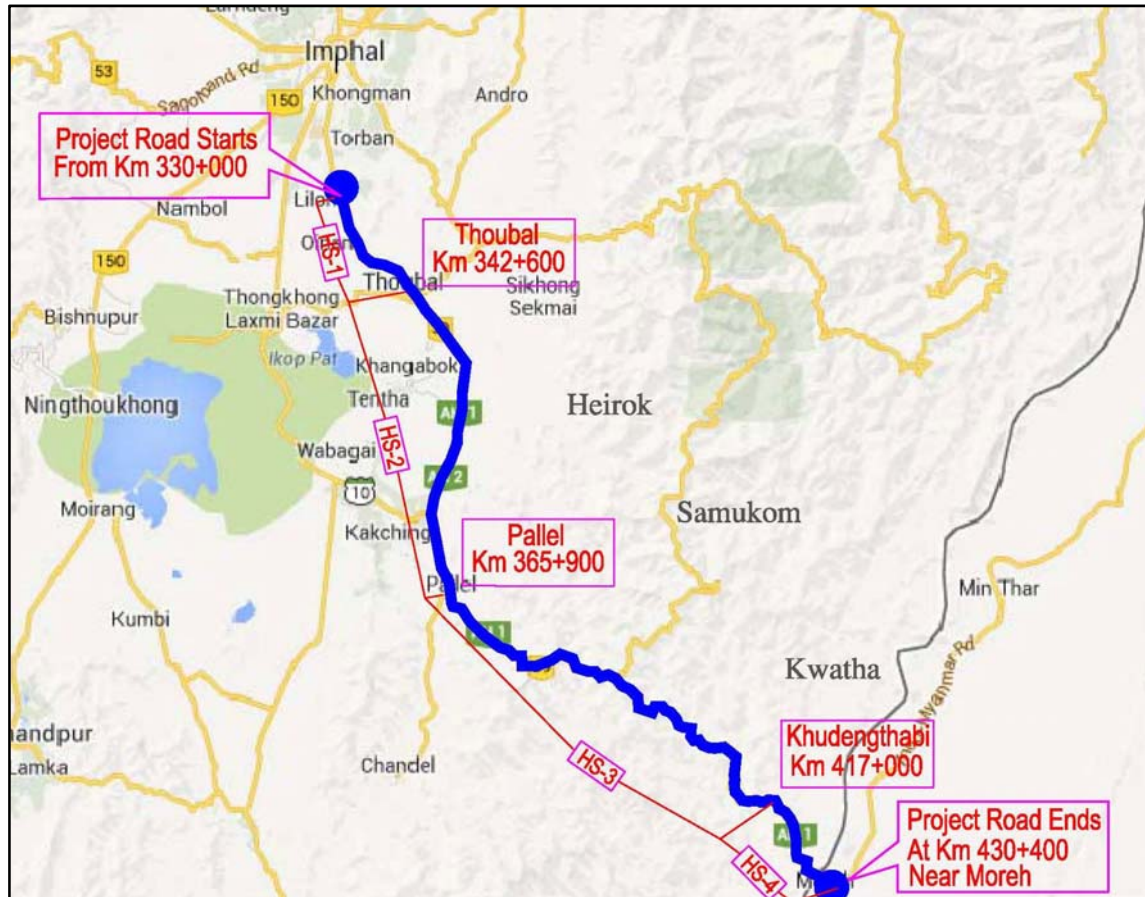
4.3 HOMOGENOUS SECTIONS

The project road corridor has been divided into four homogenous sections based on the traffic flow characteristics. The defined homogeneous sections have been referenced with the existing chainages from km 330+000 to km 430+400. The details of project corridor homogenous sections defined are set out in Table 4-1.

Table 4-1: Homogenous Sections

Sl.No	Homogenous Section Details	Description of Homogenous Section
1	HS 1: Start of project corridor (from Governor Bungalow) to Thoubal	Starts at 330+000 chainage at Imphal Junction and ends at km 342+600 near Thoubal Junction. The total length of HS 1 is 12.6 km.
2	HS 2: Thoubal Town to Pallel Town	Starts at Thoubal Junction at Km 342+600 and ends at km 365+900 near Pallel Junction. The total length of HS 2 is 23.3kilometers.
3	HS 3: Pallel Town to Khudengthabi Junction	Starts at Pallel Junction at km 365+900 and ends at km 417+000 near Khudengthabi Junction. The total length of HS 3 is 51.1 km.
4	HS 4: Khudengthabi Junction to Moreh Bridge (end of Project corridor)	Starts at Khudengthabi Junction at km 417+000 and ends at km 430+400 near Moreh Bridge. The total length of HS 4 is 13.411km.

Figure 4-1: Homogeneous Sections on Project Corridor



4.4 TRAFFIC SURVEY LOCATIONS AND PERIOD

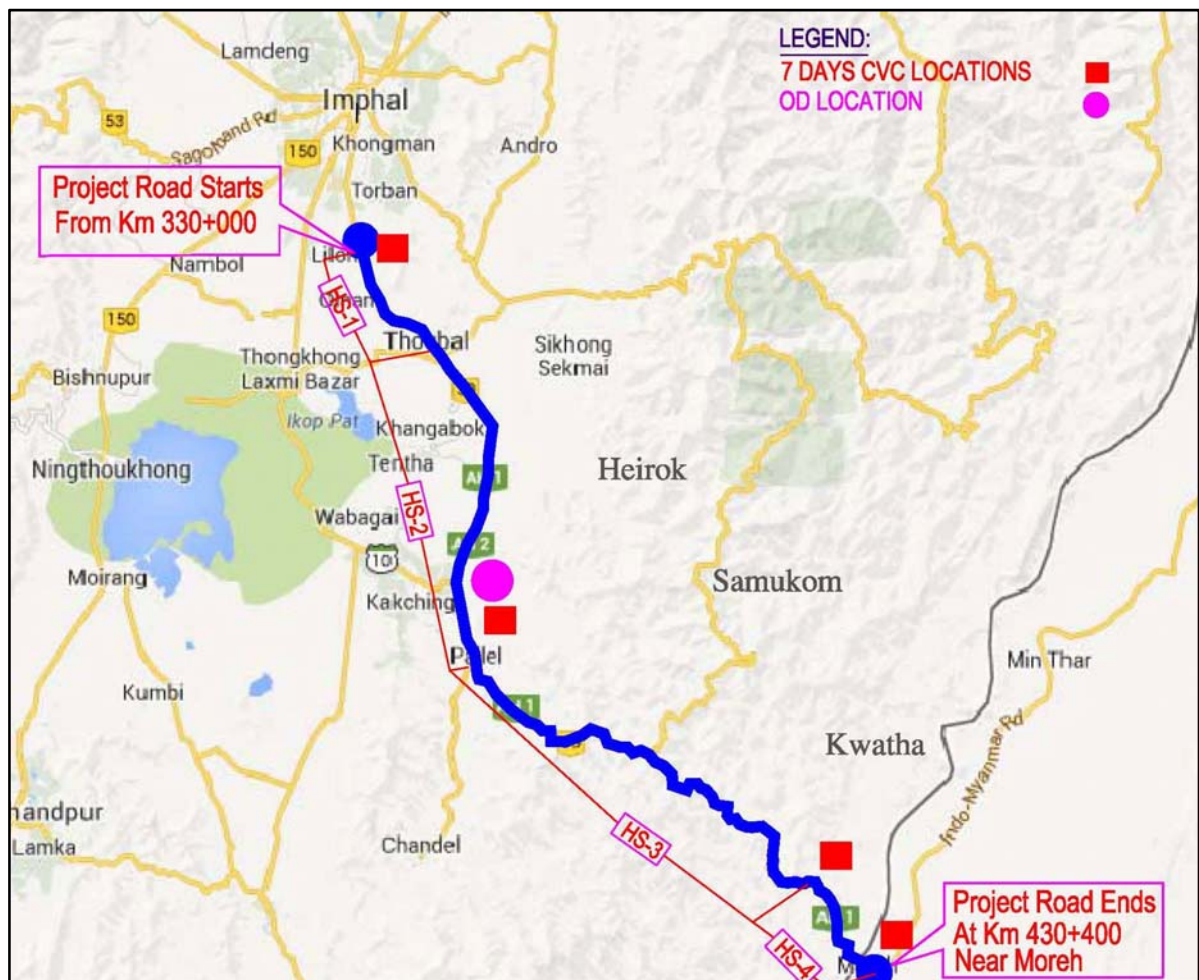
In order to understand the traffic characteristics and the volume of traffic using the project road, primary surveys were carried out to know the existing travel pattern. A detailed reconnaissance survey had earlier been conducted to identify the appropriate locations for the mid-block traffic volume count survey. The traffic on the project corridor is a mixture of through and local types because, the land use along the route is both rural and residential. To achieve the stated objectives, the traffic following locations were selected for the traffic surveys and the details are given in Table 4-2 and the graphical representation of the survey locations are set out in Figure 4-2.

Midblock classified traffic volume count surveys were carried out at 4 locations for seven consecutive days each from morning 6:00 AM to 6:00 PM due to security issues and traffic beyond 6:00 PM is almost negligible. Origin and Destination survey carried out at one location near Kakching village for 12 hours during day time.

Table 4-2: Traffic Survey Details:

Sl.No	Description of Location	Dates of Survey
Traffic Volume Count Survey		
1	TVC 1- Near Imphal University (km 330+000) for 7 days	05.10.2013 to 11.10.2013
2	TVC 2- Near Kakching city (km 362+000) for 7 days	05.10.2013 to 11.10.2013
3	TVC- 3 Near Khudengthabi village (km 416+000) for 7 days.	05.10.2013 to 11.10.2013
4	TVC- 4 Near Moreh Central Bazaar (km 428+500) for 7 days.	05.10.2013 to 11.10.2013
Origin & Destination Survey		
1	OD at Kakching village(Km 362+000) for 12 hours	19.10.2013

Figure 4-2: Traffic Survey Locations



4.5 SURVEY METHODOLOGY

Trained enumerators were used for counting traffic under the supervision of qualified and experienced traffic engineers. The vehicle classification system was adopted to capture all type of vehicles using project road. For the purpose of analysis of the data, IRC: 64 – 1990 was used to convert the classified traffic volume in to equivalent passenger car units (PCU). Table 4-3 and 4-4 show the vehicle classification and the PCU values respectively.

Table 4-3: Vehicle Classification System Adopted

Sl.No	Vehicle Type	Sl.No	Vehicle Type
	Passenger Traffic Motorized		Commercial Vehicles
1	Car/Jeep/Van	12	3 Tyre LCV
2	Taxi	13	Other Slow Moving If any
3	Two Wheeler	14	3 Tyre
4	Three Wheeler	15	Mini LCV (Ace)
5	Mini Bus	16	4 Tyre LCV
6	Standard Bus	17	6 Tyre LCV
	Passenger Non-Motorized	18	2 Axle Truck
7	Ambulance, Fire tender, Funeral vans	19	3 Axle Truck
8	Trucks	20	MAV
9	Bicycle	21	7 or more Axle Trucks
10	Cycle Rickshaw	22	Tractor with Trailer
11	Animal Drawn Carts	23	Tractor without Trailer
12	Hand Carts		

Table 4-4: Recommended PCU as per IRC: 64-1990

Sl.No	Vehicle Type	PCU
	Fast Moving	
1	Motor Cycle or Scooter	0.5
2	Passenger Car, Pick-up Van or Auto Rickshaw	1.0
3	Agriculture Tractor, Light Commercial Vehicle	1.5
4	Truck or Bus	3.0
5	Truck Trailer, Agriculture Tractor-Trailer	4.5
	Slow Moving	
6	Cycle	0.5
7	Cycle-Rickshaw	2.0
8	Hand Cart	3.0
9	Horse Drawn Vehicle	4.0
10	Bullock Cart*	8.0

Note: * For smaller Bullock Carts a value of 6 will be appropriate.

4.6 TRAFFIC CHARACTERISTICS

The data collected from the traffic volume count survey were coded and processed in order to analyze the results with respect to existing traffic intensity, flow pattern, hourly variation and composition of traffic on the road sections under study. The following traffic characteristics have been presented in the chapter:

- Average Daily Traffic (ADT)
- Hourly variation and Peak Hour Percentage
- Directional distribution
- Traffic composition
- Annual Average Daily Traffic (AADT).

Each of the above is discussed in detail in the following subsections.

4.6.1 AVERAGE DAILY TRAFFIC (ADT)

The traffic volume data collected for seven consecutive days selected 4 locations averaged out to arrive at the average daily traffic (ADT) on the project road sections. The summary of ADT in terms of vehicles and PCU is given in Table 4-5.

Table 4-5: Average Daily Traffic (ADT)

S.No	Vehicle Type	TVC 1	TVC 2	TVC 3	TVC 4
		HS 1	HS 2	HS 3	HS 4
1	Car/Jeep/Van	4954	886	1087	1142
2	Taxi	3436	341	0	0
3	2- Wheeler	6220	734	15	1509
4	3- Wheeler	5305	327	0	1617
5	Mini Bus	5	10	1	1
6	Std Bus	192	24	2	3
7	Ambulance, Fire tender, Funeral vans	18	6	1	2
8	Govt Trucks	32	26	18	29
9	Cycle	353	230	0	84
10	CRK	40	6	0	1
11	AC	0	1	0	0
12	HC	0	0	0	0
13	Others	0	0	0	0
14	3- Tyre	99	4	13	15
15	Mini LCV (Ace)	174	47	4	4
16	4-Tyre	218	47	62	64
17	6-Tyre	166	44	31	43
18	2-Axle	101	56	22	25
19	3-Axle	34	7	7	7

S.No	Vehicle Type	TVC 1	TVC 2	TVC 3	TVC 4
		HS 1	HS 2	HS 3	HS 4
20	MAV	0	0	0	0
21	7 Axle or more Axle/HCM/EME	6	1	0	0
22	Trailers	4	3	0	0
23	Tractor	0	0	0	0
Total Fast Vehicles		20964	2563	1263	4461
Total Fast PCU's		18802	2487	1401	3889
Total Slow vehicles		393	237	0	85
Total Slow PCU's		257	133	0	44
Grand Total Vehicles		21357	2800	1263	4546
Grand Total PCU's		19058	2620	1401	3933

From the above it is revealed that the maximum vehicles observed in homogeneous section 1 due to proximity to Imphal town and the minimum traffic observed in homogenous section 3 in the hilly region. Security issues are another major concern and is affecting the traffic. Another serious issue is the frequent strikes and shortage of fuel which again affect the economy and the potential traffic. Homogeneous section 3 has moderate traffic being close to Moreh town. Commercial traffic for HS 3 and HS 4 is almost same as present project road corridor is only link between Imphal and Moreh.

Daily variation of traffic for all the 4 locations shows uniform trend for all the seven days and the graphical representation of daily variation for four homogeneous sections set out in the figures below.

Figure 4-3(a): TVC 1: Daily Variation at Imphal University on HS-1

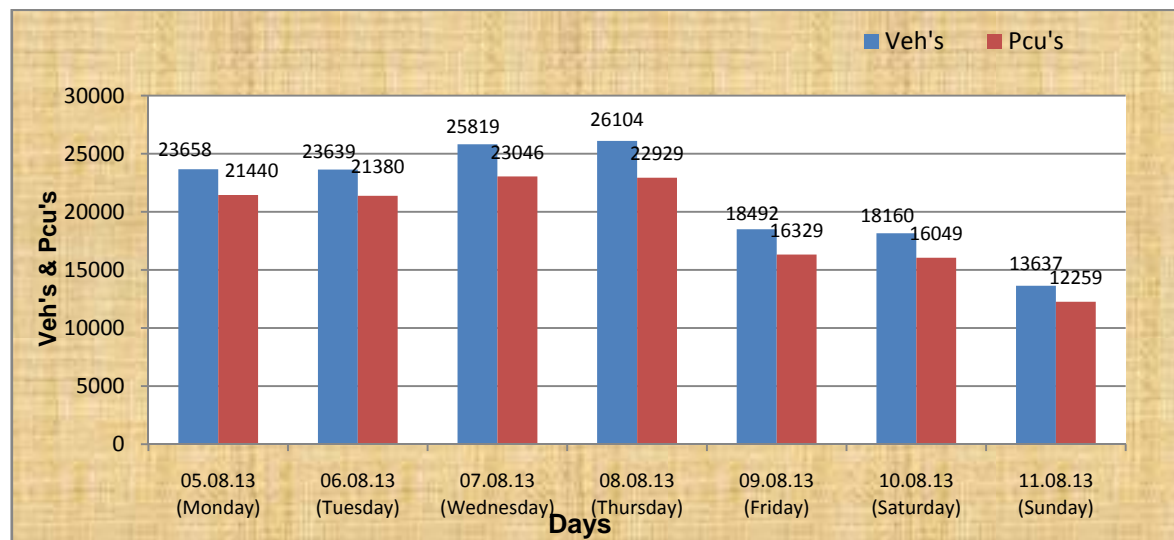


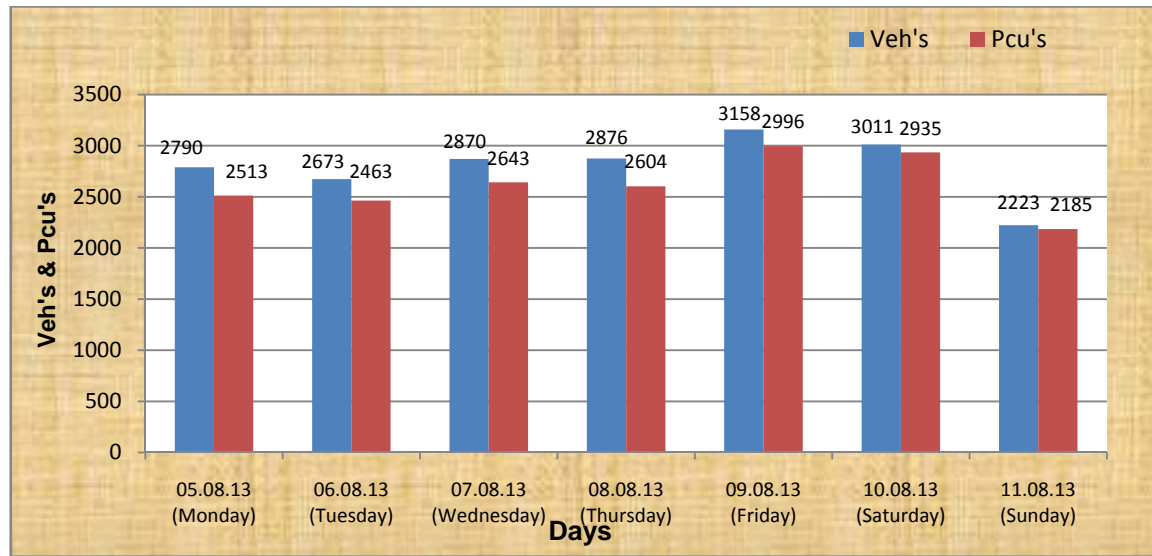
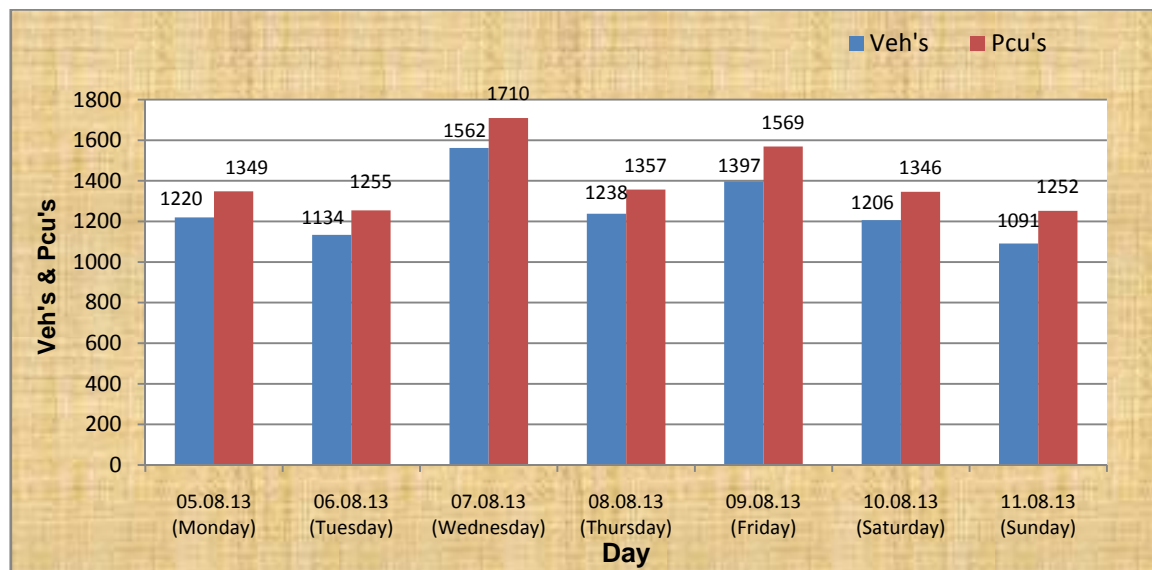
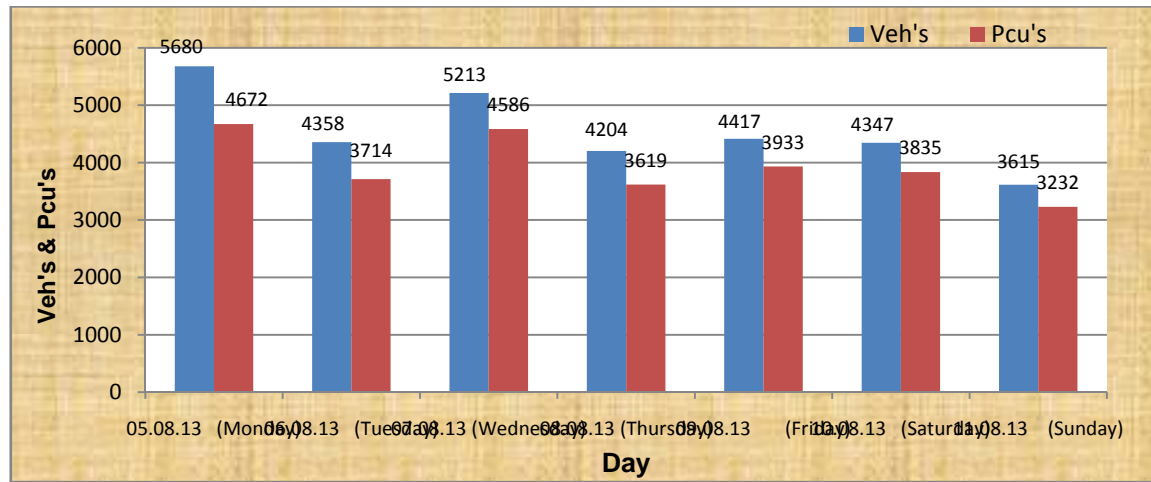
Figure 4-3(b): TVC 2: Daily variation at Kakching city on HS-2Figure 4-3(c): TVC 3: Daily variation at Khudengthabi Village on HS-3

Figure 4-3(d): TVC 4: Daily variation at Moreh Central Bazar on HS-4



4.6.2 HOURLY VARIATION AND PEAK HOUR PERCENTAGE

The hourly variation of traffic illustrates the distribution of traffic over a period of 12 hours from 6:00 AM to 6:00 PM. Within this distribution the peak hour percentage is the maximum percentage of the total traffic that uses the project highway in one single hour of the day. It is of significance as highway capacities and design calculations are based on peak hour volumes and percentage. Maximum peak hour percentage of 10.32% was observed in between 1:00 PM to 2:00 PM in homogeneous section 3.

Table 4-6: Peak Hour Percentage

Survey Location	Peak Hour (Vehicle)	Peak Hour Percentage	Observed Peak Hour
TVC 1 (HS1)	1,937	9.07%	9:00AM-10:00AM
TVC 2 (HS 2)	255	9.11%	3:00PM-4:00PM
TVC 3 (HS 3)	124	10.32%	1:00PM-2:00PM
TVC 4 (HS 4)	449	9.85%	8:00AM-9:00AM

Figure 4-4(a): TVC 1: Hourly Traffic Variation at Imphal University on HS-1

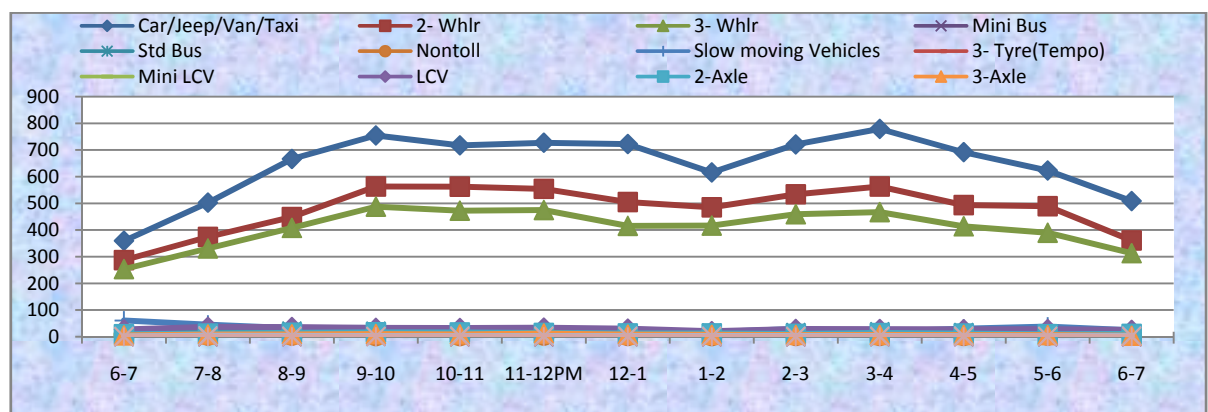


Figure 4-4(b): TVC 2: Hourly Traffic variation at Kakching city on HS-2

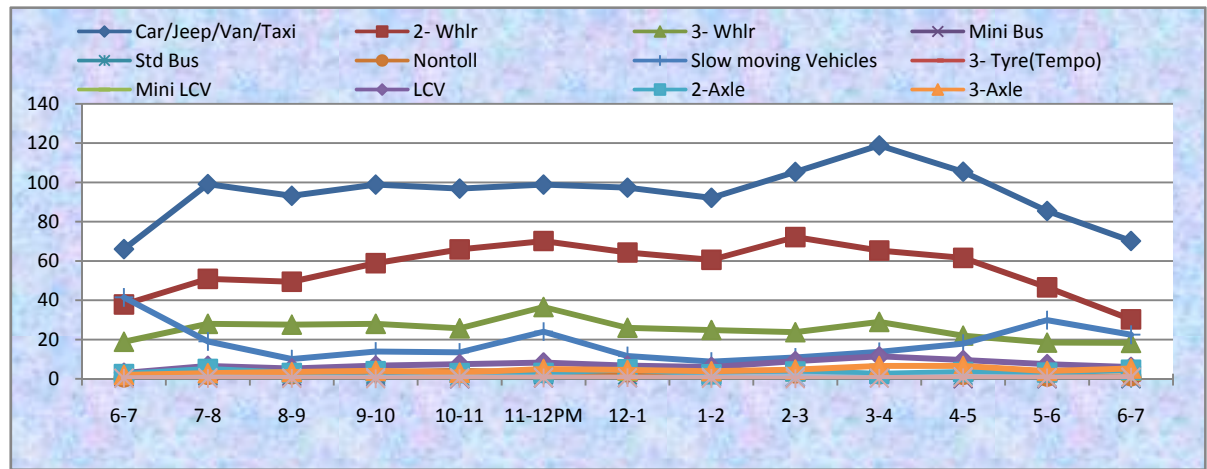


Figure 4-4(c): TVC 3: Hourly Traffic variation at Khudengthabi Village on HS-3

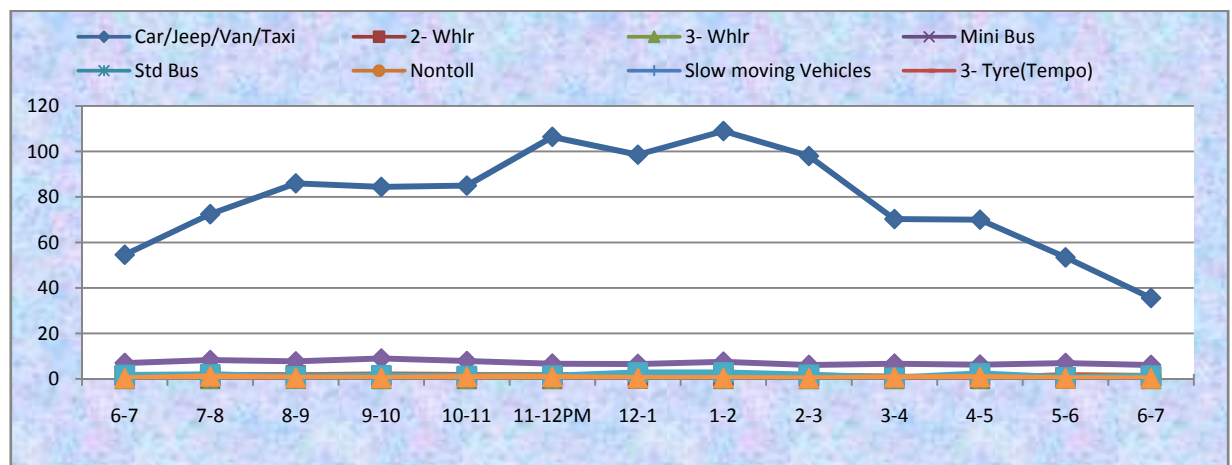
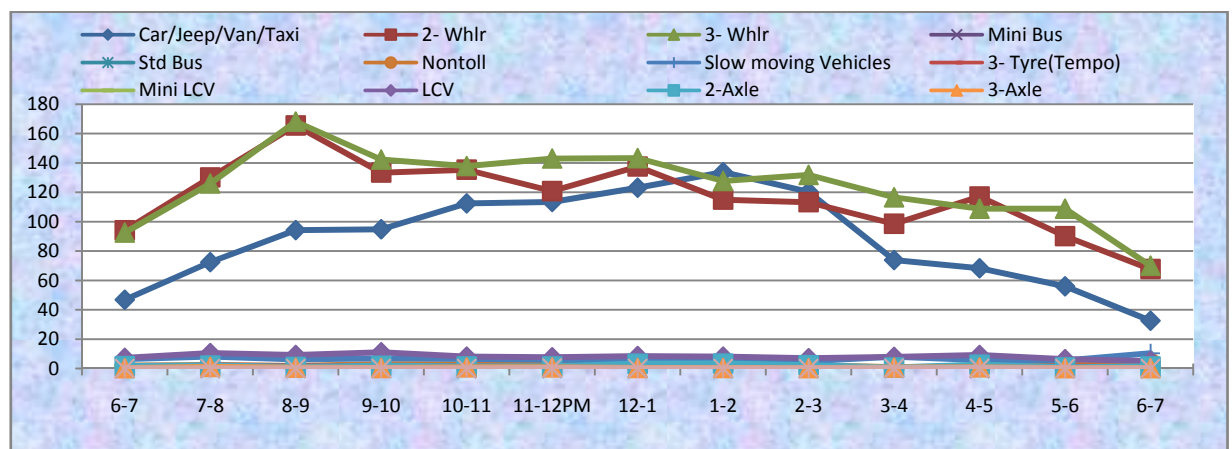


Figure 4.4(d): TVC 4: Hourly Traffic variation at Moreh Central Bazar on HS-4



The hourly variation for all the homogenous sections locations represents the similar trend. Traffic movement beyond 6:00PM observed is almost negligible and it is due to the following reasons:

- Due to the security reasons in Ghat area;
- No vehicles are allowed before 6:00 AM and after 6:00 PM, because check post near Moreh will be closed.

4.6.3 DIRECTIONAL DISTRIBUTION

Directional distribution has been established from the midblock classified traffic volume counts. The directional distribution along the project corridor has similar trend which is in the order of 49:51.

Table 4-7: Directional Distribution (DD)

Count Station	Directional Distribution (I to M:M to I)
TVC 1 (HS 1)	49.89%:50.11%
TVC 2 (HS 2)	49.14% : 50.86%
TVC 3 (HS 3)	49.25% : 50.75%
TVC 4 (HS 4)	48.13% : 51.87%

note:i-imphal, m-moreh

4.6.4 TRAFFIC COMPOSITION

The vehicle composition for all types of vehicles and for all homogenous sections is given along with the summary for passenger traffic, slow moving traffic and commercial traffic Table 4-8.

Table 4-8: Traffic Composition (%)

S. No	Vehicle Type	TVC 1	TVC 2	TVC3	TVC4
		HS 1	HS 2	HS 3	HS 4
1	Car/Jeep/Van	23.20	31.64	86.06	25.12
2	Taxi	16.09	12.18	0.00	0.00
3	2- Wheeler	29.12	26.21	1.19	33.19
4	3- Wheeler	24.84	11.68	0.00	35.57
5	Mini Bus	0.02	0.36	0.08	0.02
6	Std Bus	0.90	0.86	0.16	0.07
7	Ambulance	0.08	0.21	0.08	0.04
8	Govt Truck	0.15	0.93	1.42	0.64
9	Cycle	1.65	8.21	0	1.85
10	CRK	0.18	0.21	0	0.02
11	AC	0.00	0.04	0	0.00
12	HC	0.00	0.00	0	0.00

S. No	Vehicle Type	TVC 1	TVC 2	TVC3	TVC4
		HS 1	HS 2	HS 3	HS 4
13	Others	0.00	0.00	0	0.00
14	3- Tyre	0.46	0.14	1.03	0.33
15	Mini LCV (Ace)	0.81	1.68	0.32	0.09
16	4-Tyre	1.02	1.68	4.91	1.41
17	6-Tyre	0.78	1.57	2.45	0.95
18	2-Axle	0.47	2.00	1.74	0.55
19	3-Axle	0.16	0.25	0.55	0.15
20	MAV	0.00	0.00	0	0.00
21	7 Axle	0.03	0.04	0	0.00
22	Trailers	0.02	0.11	0	0.00
23	Tractor	0.00	0.00	0	0.00
Total Percentage		100	100	100	100
% of Passenger Veh's		94.17	82.93	87.49	93.97
% of Slow Moving Veh's		1.84	8.46	0.00	1.87
%of Commercial Veh's		3.97	8.50	12.51	4.16
% of Agriculture Veh's		0.02	0.11	0.00	0.00

Figure 4-5(a): TVC 1: Traffic Variation at Imphal University on HS-1

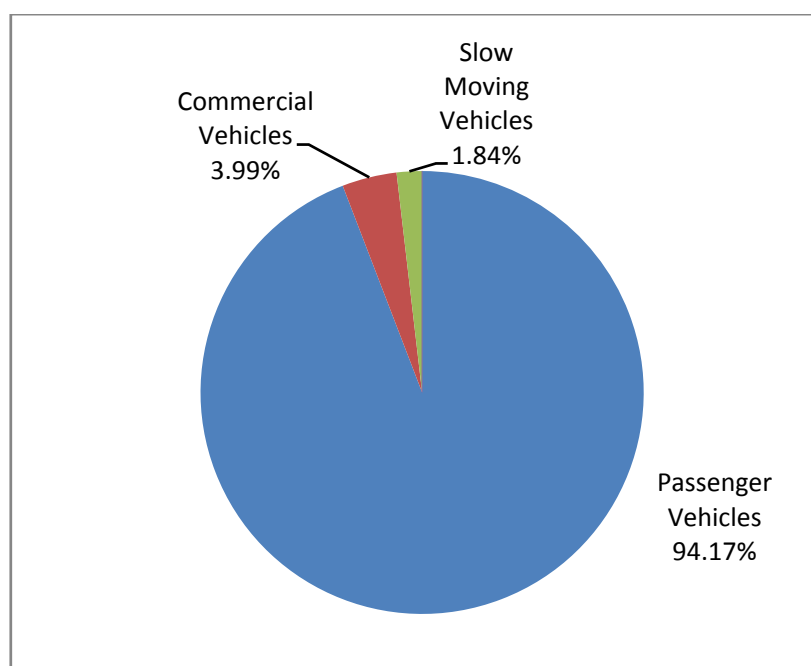


Figure 4-5(b): TVC 1: Traffic Variation at Kakching Town on HS-2

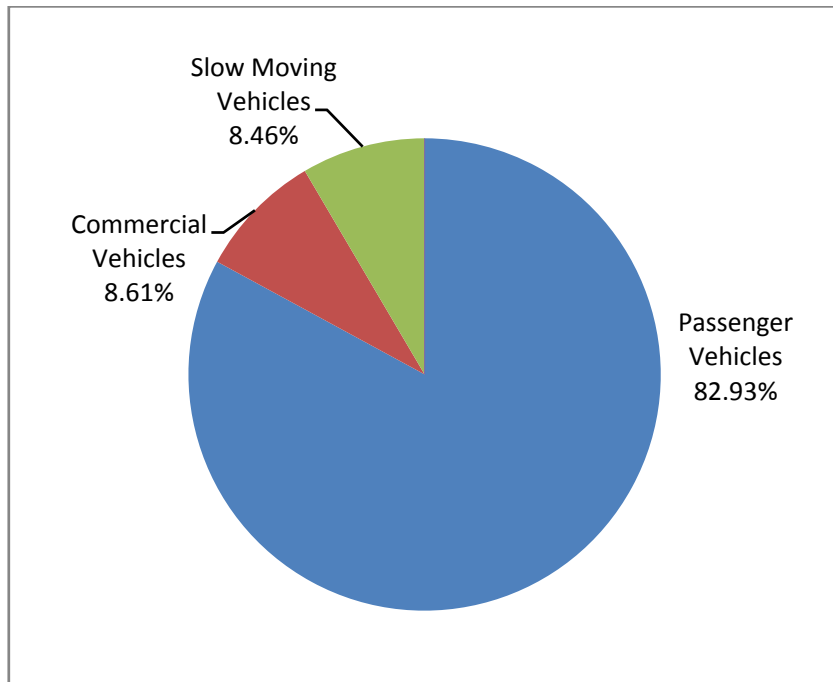


Figure 4-5(c): TVC 1: Traffic Variation at Khudengthabi Village on HS-3

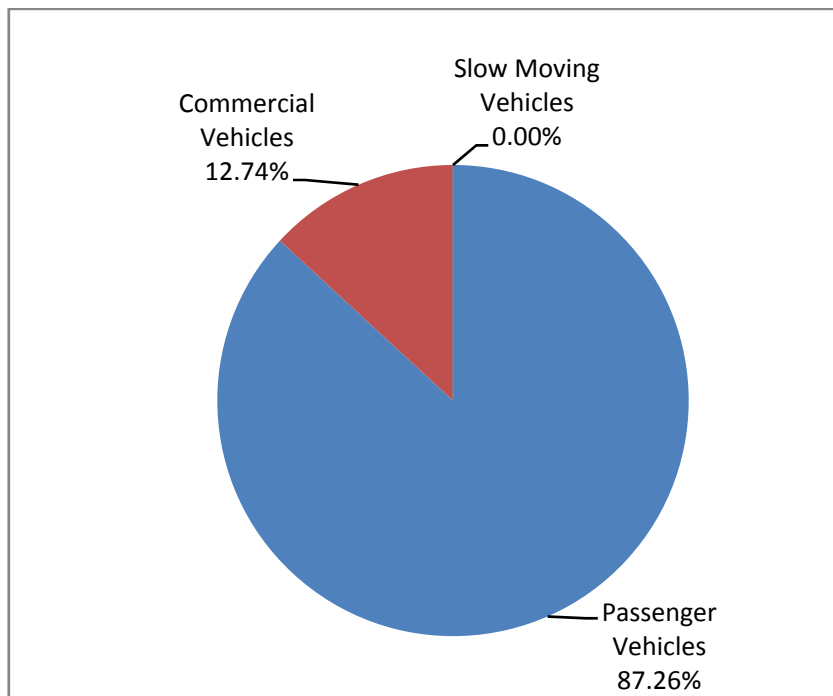
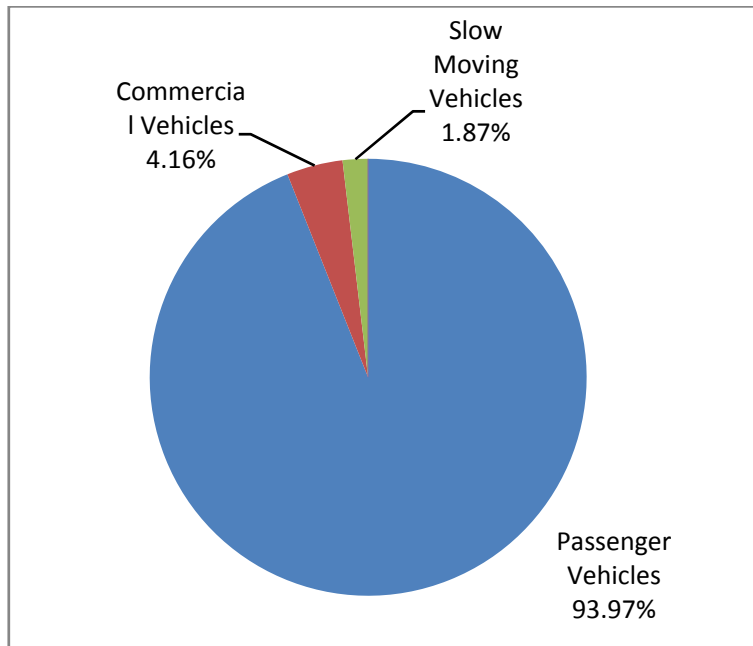


Figure 4-5(d): TVC 1: Traffic Variation at Moreh Central Bazaar on HS-4

Minimum slow moving vehicles and maximum commercial vehicles are recorded in HS 1 and HS 3.

4.6.5 ANNUAL AVERAGE DAILY TRAFFIC (AADT)

The traffic plying on any road generally varies over the different periods of the year depending on the cycle of different socio-economic activities in the regions through which it passes. Therefore, in order to have more realistic picture of the traffic on the project road, it is required to assess seasonal variation in traffic to estimate Annual Average Daily Traffic (AADT). In the absence of any reliable data on seasonal variation, no correction was carried out. The traffic survey was carried out for 12 hours from 6 AM to 6 PM and for the remaining time traffic is negligible. In order to account for the daily traffic the ADT observed for 12 hours is increased by 5% to arrive at the AADT.

Table 4-9: Annual Average Daily Traffic (AADT)-Normal Traffic

S. No	Vehicle Type	TVC 1	TVC 2	TVC 3	TVC 4
		HS 1	HS 2	HS 3	HS 4
1	Car/Jeep/Van	5202	930	1141	1199
2	Taxi	3608	358	0	0
3	2- Wheeler	6531	771	16	1584
4	3- Wheeler	5570	343	0	1698
5	Mini Bus	5	11	1	1
6	Std Bus	202	25	2	3
7	Ambulance, Firetender, Funeral vans	19	6	1	2

S. No	Vehicle Type	TVC 1	TVC 2	TVC 3	TVC 4
		HS 1	HS 2	HS 3	HS 4
8	Trucks	34	27	19	30
9	Cycle	371	242	0	88
10	CRK	42	6	0	1
11	AC	0	1	0	0
12	HC	0	0	0	0
13	Others	0	0	0	0
14	3- Tyre	104	4	14	16
15	Mini LCV (Ace)	183	49	4	4
16	4-Tyre	229	49	65	67
17	6-Tyre	174	46	33	45
18	2-Axle	106	59	23	26
19	3-Axle	36	7	7	7
20	MAV	0	0	0	0
21	7 Axle or more Axle/HCM/EME	6	1	0	0
22	Trailers	4	3	0	0
23	Tractor	0	0	0	0
Total Fast Vehicles		22013	2689	1326	4682
Total Fast PCU's		0	0	0	0
Total Slow vehicles		413	249	0	89
Total Slow PCU's		270	139	0	46
Grand Total Vehicles		22426	2938	1326	4771
Grand Total PCU's		20012	2746	1470	4125

The collected seven days traffic count data for various locations are set out in Annexure 4-1(a) to Annexure 4-1(d).

4.7 ORIGIN & DESTINATION SURVEY

4.7.1 METHODOLOGY

To estimate travel demand pattern in the region, Origin and Destination (O-D) surveys were carried out at 1 location on the project road section. Roadside interviews were carried out as described in IRC: 102-1988. Police assistance was arranged to ensure a successful completion of the survey. Both passenger and commercial vehicles plying on the project road were stopped on a random sampling basis and interviewed. Along with the OD survey, volume count survey has been carried out to observe the sample size and for expanding the sample OD matrices.

Enumerators under the supervision of senior traffic engineer collected the trip characteristics using survey forms specially designed for this purpose. Trip characteristics like origin, destination and frequency of trip and route prefers were collected for passenger vehicles. For goods vehicles, the survey elicited characteristics like origin, destination, frequency and commodity being transported. The collected data was analyzed to obtain the trip distribution based on a zoning system suitably designed for the present study.

4.7.2 SAMPLE SIZE

The vehicles during the OD surveys were interviewed on a random sample basis. Tables below show the sample size in terms of percentage and Expansion Factors (EF) for O&D survey location.

Table 4-10: Origin & Destination Survey Sample Size& Expansion Factor (EF):

S. No	Vehicle Type	OD at Kakching Km 362+000			
		ADT	Sample	Sample Size	Expansion Factor(EF)
1	Car/Jeep/Van/Taxi	1227	735	59.90	1.67
2	LCV	91	44	48.35	2.07
3	Trucks	64	23	35.94	2.78
4	Bus	34	26	76.47	1.31

Form the above table it is observed that the collected sample size is more than 35% for all the individual vehicles.

4.7.3 ZONING SYSTEM

Having collected the data through O-D survey, the next step was to analyze that to obtain traffic flows in the form of O-D matrix. It was done by dividing the study area into traffic zones and analyzing the data among these zones to form goods and passenger O-D matrix. These matrices were useful in understanding the passenger and

commodity flows, and on this basis, estimating the divertible traffic to the project roads from alternative routes where possible.

Zoning: The traffic zones were formed through considering the main economic centers/ attracting/ originating centers (urban areas, industrial area, mining areas etc.) located within the state as well as the inter-action of the state's economic centers with that located outside the state. The traffic zones include 'internal zones' (areas within the Project road section) and 'external zones' (areas outside project road sections). While identifying the internal traffic zones, the influence area of these zones were identified, and thus in a way, the name of the area identified as traffic zone is treated as 'centroid' of the area formed by its influence zone.

The travel characteristics obtained by O-D survey facilitate the identification of:

- Trip Distribution and Trip frequency.
- Commodity analysis.

A total of 10 zones system adopted for the present study is given in Table 4-11.

Table 4-11: O&D Zones

Zone No	Zone Description	Remarks
1	HS-1 (Imphal-Before Thoubal)	List of Villages in zone 1 along the Project Road Section: Imphal East, Kangla, Makhaleirak, SingjameimayengbamLeikai, LairembiLampak, Kakwa, WaikhomLeikai, Nagairangbam, Torban, Khongman, UchekonKhonou, NandeibamLeikai, Thongju, WangkheiLoumanbi, TakhokAwang, TurelAhanbiMathak, Loumanbi, Lilong, Haoreibi, Atoukhong, Nungei, chabok, ThoubalKhundou, Kshetrileikai, Wangmataba.
2	HS-2 (Thoubal- before Pallel)	List of Villages in zone 2 along the Project Road Section:Thoubal,Moijing, Charangpatmaning, ManingLeikai, Khangabok, MaisnamLeikai, Nepra company, Shanirou, MakhaLeikai, Wangbal, Wangjing, Kairembikhok, Wangkhei, Cherapur, Lamding, Heirol, Kang Samaram, Chingtham, Sapam, Tekcham, YaithibiKhunou, Loushipat, Kakching, Irengbang, laijing, Unapal, Aimol,Ngairong.
3	HS-3 & HS 4 (Pallel-Moreh)	List of Villages in zone 3 along the Project Road Section:Pallel, Chingnunghut village, AimolKhullen, AimolKhunou, Komlathabi, Leipuntampak, Sinam, Tegnoupal, Chandel
4	Rest of Imphal East, Rest of Imphal West, Senapati, Ukhrul, Tamenglong, Bishnupur and Chaurachandpur.	
5	Rest of Chandel and Rest of Thoubal District	
6	Mizoram State	

Zone No	Zone Description	Remarks
7	Assam State	
8	Nagaland State	
9	Rest of India	
10	Myanmar (Burma) Country	

Based on the zoning system, surveyed data has been coded and analyzed by using the computed expansion factors of various vehicle types, Expanded O-D matrix is developed for each type of vehicle for all the OD survey locations. The zone map is set out in Figure 4-5. The Frequency type, commodity type and Vehicle code used in the analysis are given in Table 4-12.

Table 4-12(a) Frequency Code

Frequency Type	Code
Single Trip	1
Return/Multiple Trips	2
Monthly Trips	3

Table 4-12(b) Commodity Code

Commodity type	Code
Food Material	1
Rice	2
Oil & Gas	3
Wood/Timber	4
Construction Material	5
Sand	6
Stone	7
Steel & Machinery	8
Empty	9
Others	10

Table 4-12(c) Vehicle Code

Frequency Type	Code
Car/van/Jeep	1
LCV	2
Trucks	3
Min Bus & Std. Bus	4

4.7.4 TRIP DISTRIBUTION

OD survey data has been analyzed and estimated the percentage of internal traffic, External-Internal & Internal-External traffic and External traffic for the O&D Survey

location for project road sections. External traffic zones have been defined as beyond the project road sections or other than internal traffic zones. The defined internal zones along the project road section and for other road network are given below:

Table 4-13: Internal zones

Location	Internal Zone	Homogenous Section
OD at Kakching village	1,2,3	HS1,HS 2& HS3

Based on the defined internal and external zones the trip distribution for Internal-Internal, External-External traffic and Internal-External & External-Internal zones were established and the summary is given in Figure 4-6 for the OD survey location.

Figure 4-6: Zone Map.

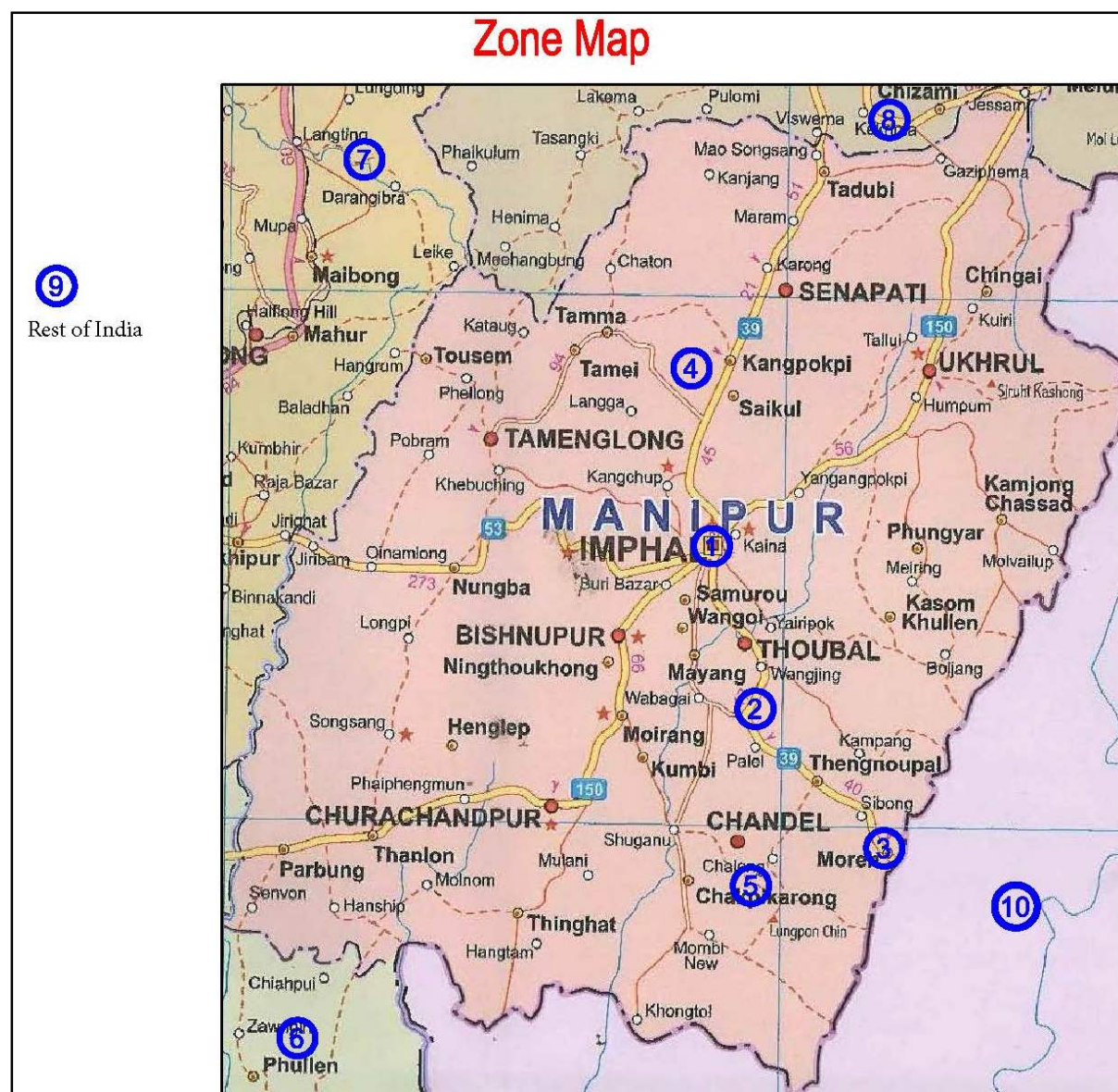
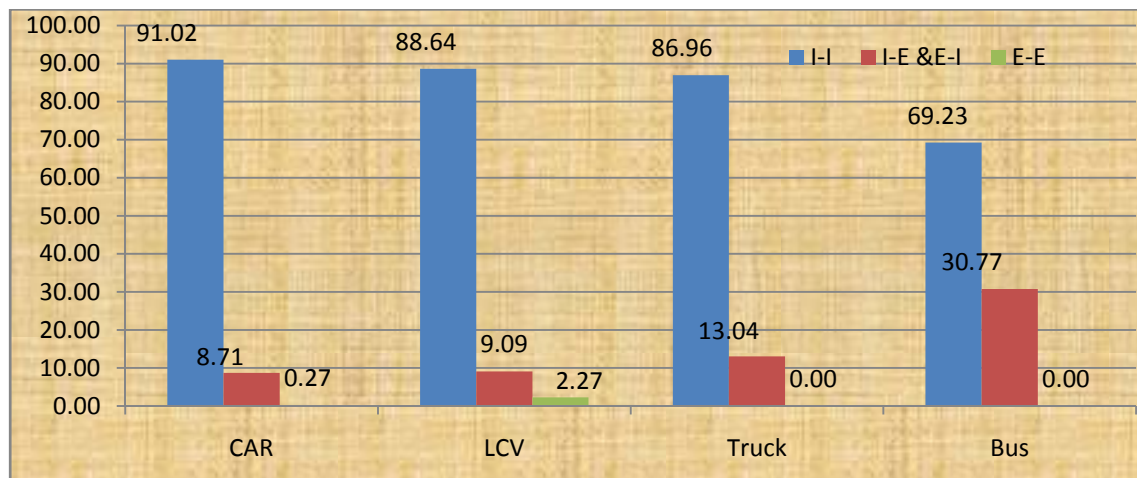
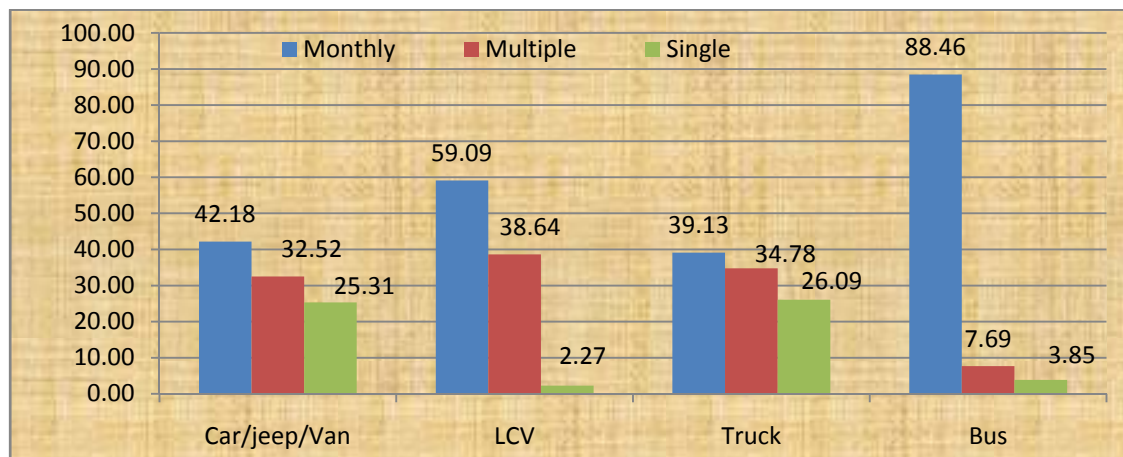


Figure 4-7 Trip Distribution at Kakching Village

Trip distribution on the project road observed that commercial traffic had major trips between internal to internal only except LCV where it is observed external to external but limited percentage.

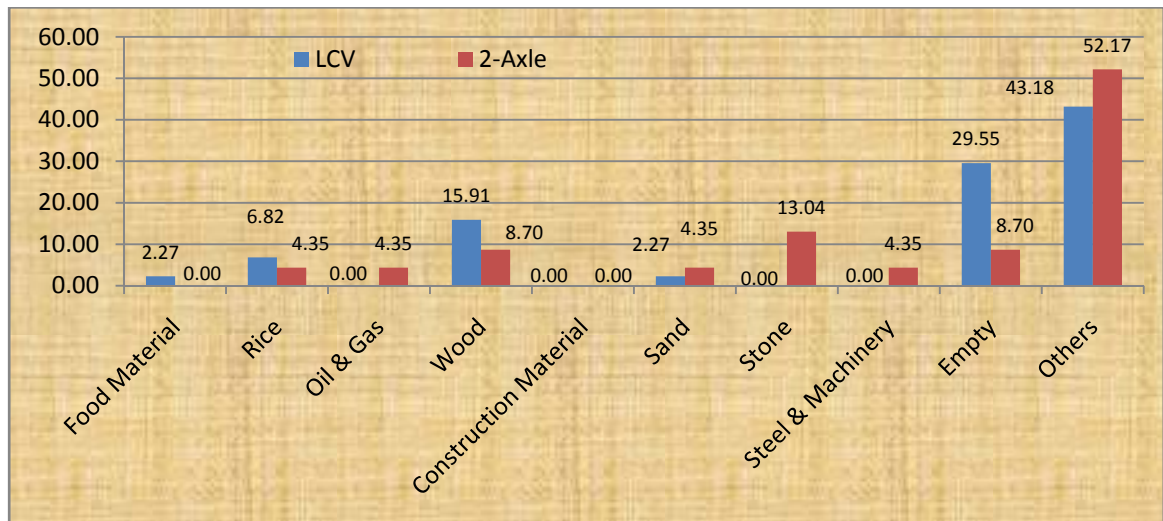
4.7.5 TRIP FREQUENCY

Trip Frequency for single trips, multiple trips and monthly trips have been analyzed from the O&D survey and summarized below in Figure 4-8 Trip frequency has been studied for single, return/multiple and monthly trips where it is observed that majority are monthly trips in nature for all the vehicle types.

Figure 4-8 Trip Frequency at Kakching Village

4.7.6 COMMODITY DISTRIBUTION

The commodity distribution has been analyzed for the 10 different types of commodities. Transportation of other materials including grocery and parcel are observed more and empty vehicles are also observed predominant. The graphical representation is given from Figure 4-11 for the OD survey location.

Figure 4-9: Commodity Share (%) at Kakching village on project road

From the above table & figure, the following observations were drawn.

- LCV are mostly carrying Food materials and wood (Timber).
- 2-Axle trucks are carrying Rice, Oil & Gas, Sand, Stone and others (Parcel and Grocery).
- Parcel and Grocery transportation is more due to imports from Moreh(Myanmar)

4.7.7 ZONE INFLUENCE

The observed major zone influence from the O&D survey combined is given below:

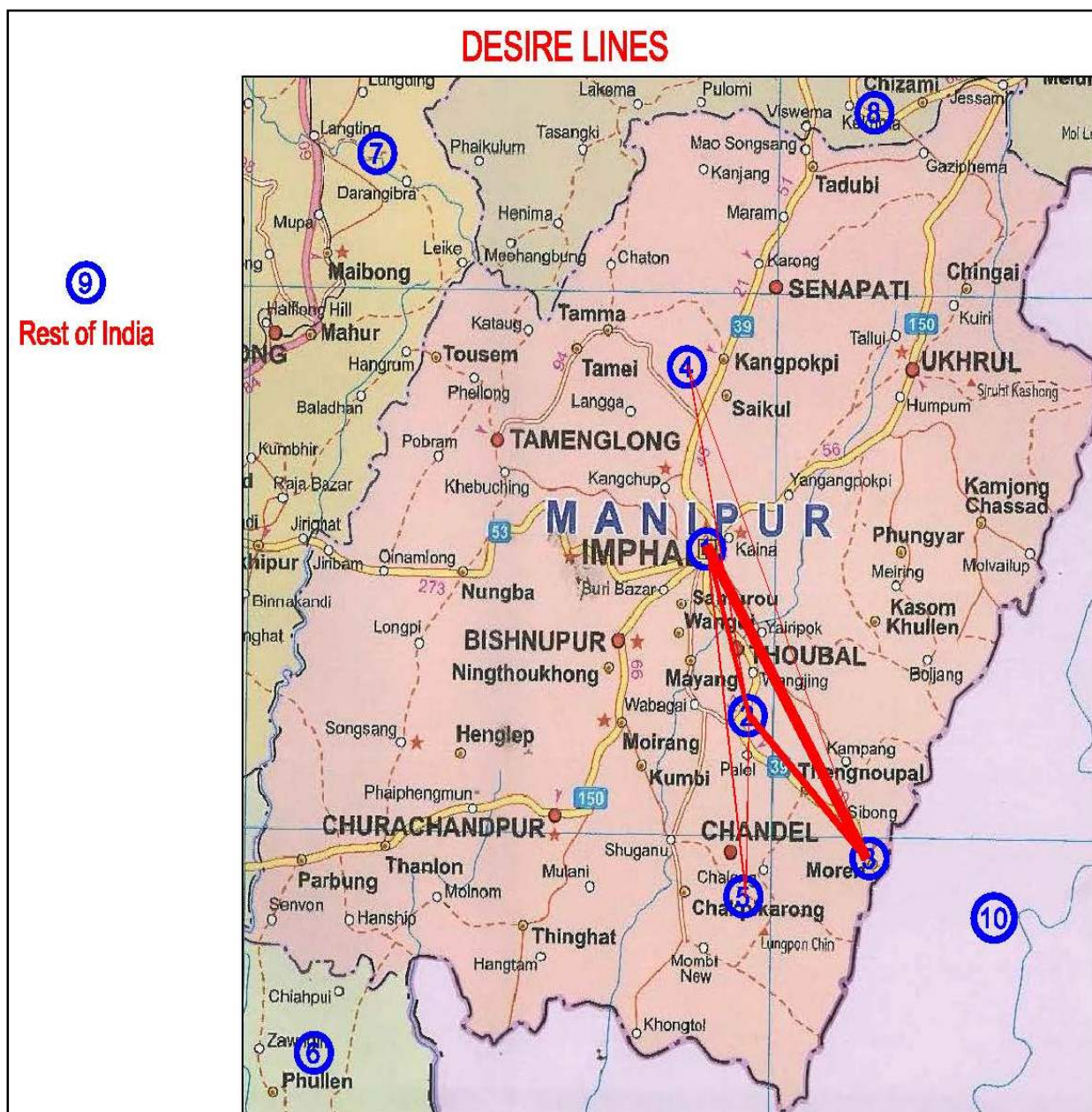
Table 4-14: Summary of Zone Influence.

Zone Code	All Trucks	LCV	Std Bus & Mini Bus	Car/Van /Jeep/Taxi
1	23.91	27.27	42.31	30.48
2	28.26	30.68	25.00	29.66
3	41.30	35.23	17.31	35.24
4	2.17	3.41	0.00	2.24
5	4.35	3.41	15.38	2.38

4.7.8 DESIRE LINES

Desire lines diagrams have been drawn for the O&D survey and are given in Annexure of O&D analysis. Whereas the desired lines were developed for combined analysis of the O&D survey location and is given in Figure 4-10. The O-D Data and analysis is given in Annexure 4-2.

Figure 4.10: Desire Line Diagram



5 ENGINEERING SURVEY INVESTIGATIONS & ANALYSIS

5.1 SURVEY AND INVESTIGATIONS

Surveys and investigations have been carried out to obtain data on the engineering parameters of the project road sections which are necessary for feasibility and design study. The field work methodology generally conformed to the guidelines laid down in IRC – SP 19.

The various engineering surveys and investigations for the roadway which have been carried out for the feasibility stage listed below:

- Road Inventory
- Pavement Investigation
 - Pavement Condition by Visual Inspection
 - Benkelman Beam Deflection Testing
- Material Investigation
- Inventory and Condition survey of bridges and culverts

The survey and Investigations carried out for Imphal-Moreh road (NH 39 corridor) is presented in the following sections. The description of alternate state highway route between Wangjing and Khudenthabi is described in Sections 5.6.

5.2 ROAD INVENTORY

A team of highway engineers collected road inventory data for every 100 m during August – September 2013 and compiled the same in the prescribed format of IRC: SP:19-200. (Ref Annexure 5.1). Data on the following parameters were collected.

1. Spacing : @ 100 m interval
2. Terrain : Plain/Rolling/Hilly
3. Land Use : Built up/Agriculture/Forest/Barren
4. Name of the Village :If any
5. Formation type :Cut/Fill/Cut-Fill/Fill-Cut Level
6. Formation Width :in m
7. Carriageway type :BT/CC/GR/ER
8. Carriageway Width :in m
9. Carriageway Condition :Good/Fair/Poor/Very Poor
10. Shoulder type : BT/CC/GR/ER
11. Shoulder Width :in m
12. Shoulder Condition :Good/Fair/Poor/Very Poor
13. Embankment Height :in m

14. Details of Cross Roads :If any
 15. Remarks :If any generally on over topping, accidents etc.,
 16. Foot Path :Length in m
 17. Drain Details :Type and Length in meters
 18. Facilities :If any
 19. Constraints :If any
 20. Sharp Curves :Left/Right

The salient features of the project based on inventory data analysis are listed below:

1. Pavement (Bituminous) :100.400 km
2. Carriageway width :5 m for 0.5 km length, 9 to 12 m for 3.5 km length, 12.5 m for 0.2 km length, 16.5 m for 0.4 km length and rest is with 7 m.
3. Shoulder : Earthen verge of 0.5 m to 0.3 m

5.2.1 TERRAIN

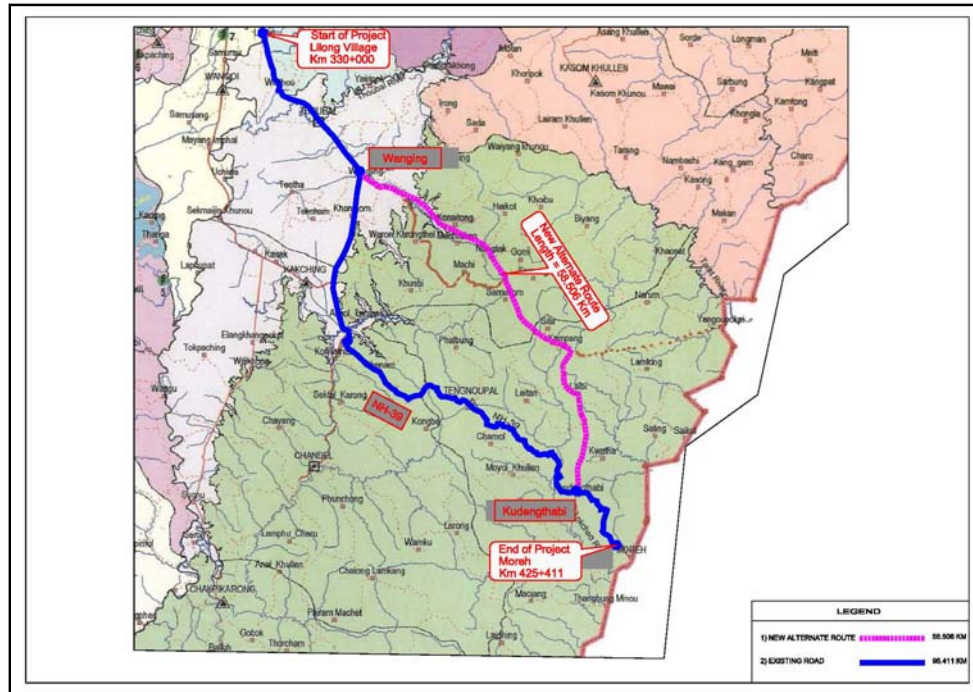
Terrain is classified by general Slope of the Country across the highway alignment as per IRC 73-1980. Based on these criteria the highway passes through the plain terrain and Hilly terrain along the entire stretch for NH 39. From Km 330+000 (start of the project road) to Km 366+300 project road passes through the plain terrain and rest from Km 366+300 to Km 430+400 project road traverse through the hilly/rolling terrain.

5.2.2 PATTERN OF LAND USE ALONG THE PROJECT AREA

The land use pattern for NH 39 is presented in Table 5.1. It may be noted that 17% of the project area is built up area, 18% is agricultural land and 65% is barren land. Length of the land use along the project corridor on either side is given below.

Table 5-1 Land use pattern along NH 39

Sl.No	Land Use	Length		
		Left Side	Right Side	%
1	Agriculture Land	17400	18500	18
2	Barren Land (Forest)	65200	65100	65
3	Built up Area	17800	16800	17

Figure 5-1: Project Road Section:

Some of the photographs of land use on NH 39 are presented below

**Lilong Bazar At Km 330+200****Thoubal town at km 342+000**

	
Wangjing village at km 348+000	Pallel town at km 365+900
	
Ghat Section at km 373+200	End of Project Road at Km 425+411

5.2.3 VILLAGES & TOWNS ALONG THE PROJECT ROAD.

The project corridor of NH 39 section passes through 24 villages / towns which aggregate to a length of 100+400 km. The details of the villages/towns area through which the project road traverses and length of each settlement details are given in Table 5-2.

Table 5-2 Details of Habitations along the Project Corridor

Sl. No	Existing Chainage		Name of the Village/Town	Length (m)
	Start	End		
1	330+000	332+400	Lilong bazar	2400
2	333+000	333+600	Lilong Hangamthobi	600
3	334+100	334+400	Ushopokpi	300
4	335+000	335+300	Sangomsang	300
5	335+900	336+200	Waiythou	300
6	338+000	343+100	Thoubal Town	5100
7	344+200	345+300	Khangabok	300
8	346+000	346+400	Wangbal	400
9	347+800	348+700	Wangjing	900

Sl. No	Existing Chainage		Name of the Village/Town	Length (m)
	Start	End		
10	351+500	353+100	Khongjom	1600
11	357+300	358+200	Sora	900
12	359+900	360+300	Kakching Lamkhai	400
13	362+900	363+200	Bijoypur	300
14	365+100	366+300	Pallel	1200
15	373+700	374+200	Bangjing	500
16	377+400	377+700	Senam	300
17	382+800	383+000	Saivom	200
18	389+600	390+600	Tengnoupal	1000
19	392+800	393+200	Chahmol	400
20	398+100	398+300	Khonckhang	200
21	416+600	417+000	Khudengthabi	400
22	424+000	424+300	Newmongiang	300
23	425+000	427+100	Chikim	2100
24	428+000	430+400	Moreh	2400

5.2.4 SUMMARY OF PUBLIC BUILDINGS AND PONDS.

The major road side public building / properties observed on the project road include:

- School
- Temples
- Government Offices
- Police Stations
- Ponds

These types of structures pose a constraint to improvement proposals. These road side amenities observed along the project corridor with reference to the existing kilometer are recorded during the road inventory survey. Govt offices include Panchayat Office, Post Office, Police station, BSNL office, Electrical Substation etc., observed are recorded and the summary of details are given in Table 5-3 (Ref Annexure 5-1).

Table 5-3 Summary of Public Amenities and Places along Project Corridor

Type	Distance from Road Edge on LHS					Distance from Road Edge on RHS				
	<3m	3-6m	6-10m	10-15m	>15m	<3m	3-6m	6-10m	10-15m	>15m
School	0	3	2	3	-	0	4	2	3	1
Temple	0	2	2	5	-	0	0	0	1	-

Type	Distance from Road Edge on LHS					Distance from Road Edge on RHS				
	<3m	3-6m	6-10m	10-15m	>15m	<3m	3-6m	6-10m	10-15m	>15m
Govt offices	0	0	1	6	1	0	2	0	3	3
Police stations	0	1	2	1	-	0	1	2	2	-
Hospitals	0	0	1	1	-	0	0	0	3	-
Bus Stops	0	2	1	0	-	0	2	2	0	-
Electrical Sub Stations	0	0	0	1	-	0	0	0	1	-

Summary of Public Amenities are shown below:

	
At CH 340+700, Fire Station on L/S	At CH 341+300 (NH-39) School on R/S
	
At CH 343+700, S.P. Office on L/S	At CH 344+800, Pond on L/S

	
At CH 345+200,School on L/S	At CH 362+000,Sub Station on R/S
	
At CH 424+050 Church on R/S	At CH 429+900 Cemetery on R/S

The details of ponds observed along the project road corridor are given in Table 5-4.

Table 5-4 Position of Ponds on the sides of NH 39

S.No.	Existing Chainage		Length (m)	Side
	Start	End		
1	333+100	333+200	100	LHS
2	333+200	333+300	100	RHS
3	344+800	344+900	100	LHS
4	352+300	352+300	100	LHS
5	357+900	360+200	300	LHS
6	363+200	363+300	100	LHS
7	363+900	364+000	100	LHS

5.2.5 AVAILABLE RIGHT OF WAY (ROW)

The details of available ROW collected from the PWD Imphal indicate that from Km 330+150 to Km 425+411, the available ROW is 15 m.

5.2.6 FORMATION TYPE AND WIDTH.

The available formation width from Km 330+150 to 425+411 based on the PWD Imphal records is 10 m only.

5.2.7 EXISTING CARRIAGEWAY / SHOULDER TYPE AND WIDTH

Type of pavement is bituminous for throughout its length with a varying carriageway width of 7 m for a length of about 95+800 m and rest of the length is with varying width of 9 to 16.5 m.

The existing shoulder on either side of the carriageway is of earthen type with a width varying from 0.5 m to 1.0 m for a majority road section of 96+900 m length, Hard Shoulder of 3.5m from 341+900 to 342+500 and at some stretches for a length of about 2900 m paved shoulders width varying from 0.5 to 2.0 m mostly in urban sections are observed. From the above it is reported that there is an urgent need to provide a uniform standard cross section for the entire project as required by the design traffic.

5.2.8 EXISTING EMBANKMENT HEIGHT

There is no embankment observed in between Lilong and Pallel except at the cross drainage structures. The existing heights on valley side in ghat section from Pallel and Moreh are presented in Table 5-5 below.

Table 5-5 – Height of Embankment

Embankment Height (m)	Project Length (%) (NH 39)
0- 1	26
1 - 2.	9
2 - 4.	4
4 - 6.	9
6 - 12.	17
>12.	35

It is noted that 26% and 35% of NH 39 are having an hill slopes height of less than 1m and greater than 12m (ghat section). Also road embankment may need to be raised to provide adequate clearance above the pipe culverts where needed.

5.2.9 EXISTING ROAD JUNCTIONS

There are 3 major junctions and 21 minor junctions situated along the project corridor and the details of the junctions are presented in Tables 5-6. The first three

junctions in the table below are major type junctions and special attention is required while designing.

Table 5-6 Details of Major/Minor Junctions

S. No	Existing Chainage	Type of junction	Classification
1	342+600	+	Major
2	360+000	T	Major
3	365+850	+	Major
4	322+900	Y	Minor
5	328+600	T	Minor
6	331+450	T	Minor
7	333+050	T	Minor
8	334+200	T	Minor
9	348+550	Y	Minor
10	351+700	T	Minor
11	352+550	T	Minor
12	352+600	T	Minor
13	353+050	T	Minor
14	353+650	T	Minor
15	353+100	T	Minor
16	354+400	T	Minor
17	357+550	T	Minor
18	357+750	T	Minor
19	360+150	T	Minor
20	365+850	T	Minor
21	416+750	T	Minor
22	424+750	T	Minor
23	426+850	T	Minor
24	428+800	+	Minor

Photos for the Major junctions are shown below:



5.2.10 SUBSTANDARD ROAD GEOMETRY

It is observed that the project corridor has straight alignment for a length of 30 km that is up to Pallel town (from km 330+000 to 366+300) and rest of the project corridor passes through the hilly/rolling terrain where many sharp curves are observed. The details of curves with existing chainage are given in Table 5-7.

Table 5-7 Sharp curve Locations

S. No	Chainage	Remarks	S. No	Chainage	Remarks
1	334+450	S-Curve	23	390+100	Left hand curve
2	335+450	S-Curve	24	391+800	S-Curve
3	335+750	Left hand curve	25	392+300	Left hand curve
4	336+550	Left hand curve	26	394+000	Right hand curve
5	367+000	Right hand	27	399+800	S-Curve
6	369+100	Left hand curve	28	400+100	Right hand curve
7	370+900	Left hand curve	29	400+300	S-Curve
8	373+600	Right hand	30	401+200	Left hand curve
9	375+800	S-Curve	31	401+700	S-Curve
10	377+100	S-Curve	32	402+500	S-Curve
11	377+400	Left hand curve	33	403+000	Left hand curve
12	379+100	Left hand curve	34	403+200	Right hand curve
13	381+400	Left hand curve	35	405+500	Right hand curve
14	383+000	S-Curve	36	405+800	S-Curve
15	384+000	S-Curve	37	406+800	Right hand curve
16	386+600	S-Curve	38	408+400	Left hand curve
17	387+100	Right hand	39	411+100	Left hand curve
18	387+200	Left hand curve	40	414+050	Left hand curve
19	387+800	S-Curve	41	415+300	Left hand curve
20	388+000	S-Curve	42	421+100	Left hand curve
21	388+800	Left hand curve	43	421+800	Left hand curve
22	389+000	S-Curve	44	422+200	S-Curve

5.2.11 BUS STOP LOCATIONS

A clear distinction is required between, passing places and bus stops. Bus stops are to be provided for specific purposes to allow buses to stop safely without impeding through traffic. The existing bus stop locations along the project road of NH 39 are presented in Table 5-8.

Table 5-8 Existing Bus stop Locations

S.No	Existing Chainage	Side
1	334+150	RHS
2	335+300	RHS
3	338+150	RHS
4	340+700	RHS
5	342+600	LHS

6	343+800	RHS
7	355+150	RHS
8	360+100	LHS
9	362+000	LHS
10	416+800	LHS

Some of the Photographs of existing bus stop types are shown below:

	
At CH 334+150, Ushopokpi	At CH 335+300, Thoubal
	
At CH 342+600, Thoubal	At CH 360+100, Kakching Lamkhai

5.2.12 GENERAL DRAINAGE CONDITIONS

The level of the water table beneath the carriageway is a major influence on the strength of the subgrade. The bottom of side drains should normally be maintained at a level at least one meter below formation level. This will generally help to effectively discharge water from culverts without inlet/outlet structures. A good road drainage system, which is effectively maintained, is vital to the successful operation ensuring the designed life of a road.

Along project corridor, as per inventory, Rectangular Cover Drain (RCD) and Rectangular Open Drain (ROD) have been observed for the urban areas and

earthen drain is observed for rural sections in plain terrain. Natural drainage has been observed in the hilly area. Rectangular Cover Drain -1+300 km length.

1. Rectangular Open Drain - 3+700 km length
2. Earthen drain - 3+800 km length
3. Natural drain - 91+600 km length

5.3 PAVEMENT INVESTIGATION

The project road has been investigated subjectively as well as objectively, for their structural and functional performance. The various surveys/investigations of the pavement are discussed below:

- Pavement Condition Survey
- Benkelman Bea Deflection Survey
- Test Pit Investigations

5.3.1 PAVEMENT CONDITION SURVEY

One of the most important activities of feasibility study on highway improvement project is assessment of the existing pavement condition. Detailed field studies were carried out to collect pavement, shoulder and drainage condition. The pavement condition data for the project stretch from Km 330+00 to 425+411 is presented in Annexure 5.2.

The visual condition survey has been carried out recording the data every 100 m intervals. This included information on visible deficiencies in terms of pavement deterioration, riding quality, cracking, rutting, incidence of potholes and patches, edge break, raveling, shoulder materials, embankment conditions etc. and ongoing/recent improvements; the visual condition survey represents the state of the pavement and has some bearing on the decision on type of rehabilitation to be adopted. The condition survey has been prepared by considering the following details:

1. Length of the section : Minimum of 100 m section
2. Surfacing Description : BT/CC/GR/ER
3. Rut Depth : in mm
4. Cracks : % of Area
5. % Area Covered by : Potholes, Raveling, Patching
6. Shoulder Condition : Good/Fair/Poor/Very Poor
7. Remarks : If any

Cracking: Visual distresses in the form of cracks have been recorded on every 100 m interval, with the % area.

Raveling: Raveling which indicates disintegration of the pavement from the surface downward due to the loss of aggregate particles has been noticed.

Rutting: Rutting is the deformation of pavement layers under the movement of loads along the wheel path.

The criteria considered for classification of pavement sections is according to IRC 81-1997 as, no cracking or rutting less than 10 mm is classified as Good, rutting observed between 10 mm to 20 mm is classified as Fair, and rutting more than 20 mm or cracking exceeding 20 percent is treated as Poor.

The pavement condition survey was conducted in July 2013 for NH 39 the summary of overall pavement condition is presented in Table 5-9.

Table 5-9 Overall Pavement condition along NH 39

Pavement Condition	Length (m)	Percentage of Length
Good	23900	24
Fair	44600	45
Poor	31900	31

5.3.2 HOMOGENOUS SECTIONS

Pavement Condition along the project Corridor has been recorded for the divided four homogeneous sections for better analysis and understanding of the project. Homogeneous sections are listed below:

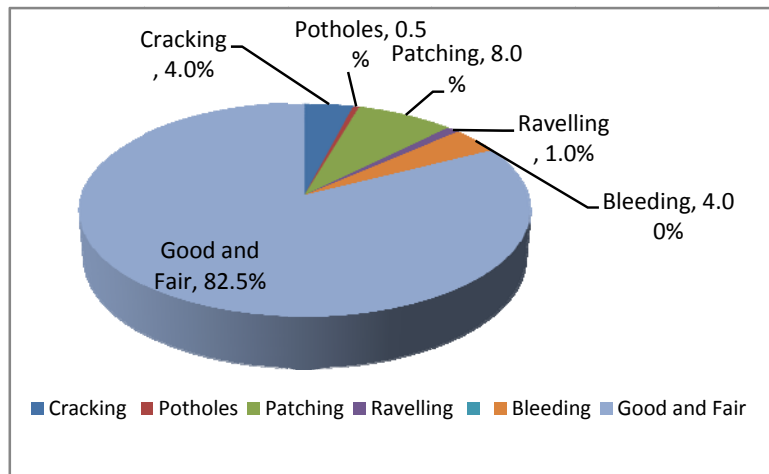
- i) Lilong village –Thoubal junction (km 330+000 to km 342+600)
- ii) Thoubal Junction to Pallell Junction (km 342+600 to km 365+900)
- iii) Pallell Junction to Khudengthabi (km 365+900 to km 417+00)
- iv) Khudengthabi to Moreh(Barma Border) (km 417+000 to km 425+411)

(a) Lilong Village –Thoubal Town (km 330+000 to km 342+600)

The overall condition from Lilong to Thoubal Junction on NH-39 for a length of 12600m is presented in Table 5.11 and the distresses such as cracking, patching, potholes and rutting percentages are presented below in Figure 5.3 in which “Good” indicate the portion of pavement with no distress observed.

Table 5-10 Pavement Condition Rating- Lilong to Thoubal Section

Pavement Condition	Length (m)
Good	4300
Fair	4700
Poor	3600

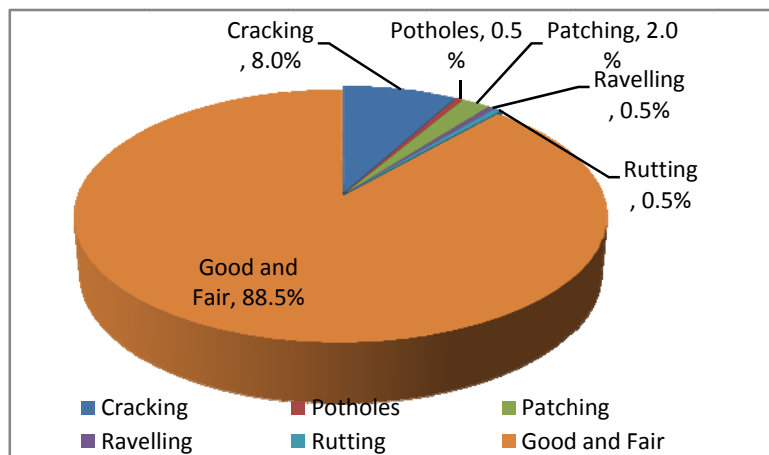
Figure 5-2 Pavement distress along Lilong to Thoubal Section

(b) Thoubal Junction to Pallel Junction (km 342+600 to km 365+900)

The overall condition from Thoubal Junction to Pallel Junction for a length of 23300 m is presented in Table 5-11 and the distresses such as cracking, patching, potholes and rutting percentages are presented in below in Figure 5-4.

Table 5-11 Pavement Condition for Thoubal to Pallel Section

Pavement Condition	Length (m)
Good	9600
Fair	10400
Poor	3300

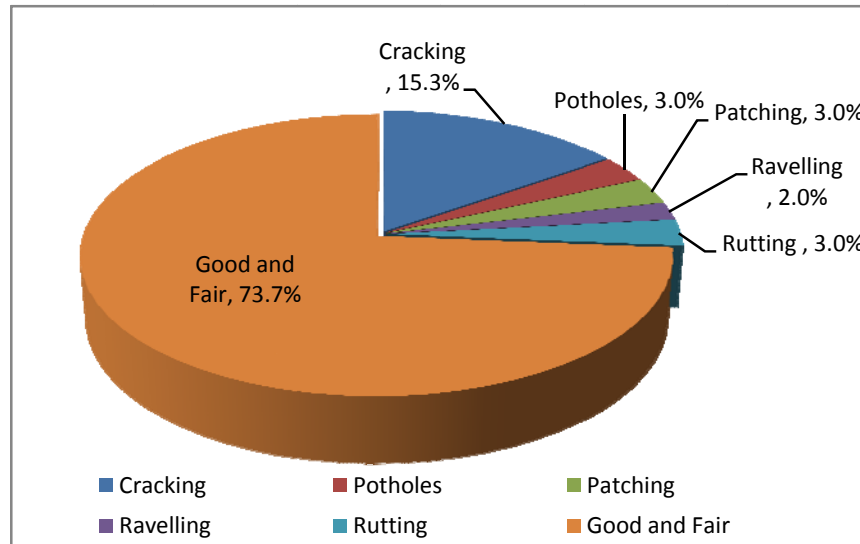
Figure 5-3 Pavement distress along Thoubal to Pallel Section

(c) Pallel Junction to Khudengthabi (km 365+900 to km 417+000)

The overall condition from Pallel to Khudengthabi for a length of 51100 m is presented in Table 5.12 and the distresses such as cracking, patching, potholes and rutting percentages are presented in below in Figure 5-5

Table 5-12 Pavement Condition rating along Pallel to Khudengthabi Section

Pavement Condition	Length (m)
Good	9200
Fair	24200
Poor	17700

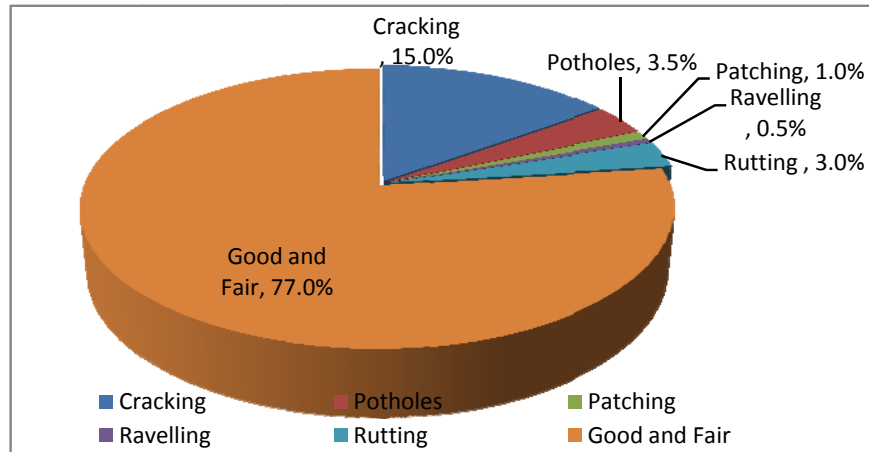
Figure 5-4 Pavement Distress along Pallel to Khudengthabi Section

(d)Khudengthabi to Moreh (Project End) (km 417+000 to km 425+411)

The overall condition from Khudengthabi to Moreh for a length of 13400 m is presented in Table 5-13 and the distresses such as cracking, patching, potholes and rutting percentages are presented in below in Figure 5-6

Table 5-13 Pavement Condition rating along Khudengthabi to Moreh Section

Pavement Condition	Length (m)
Good	800
Fair	5300
Poor	7300

Figure 5-5 Pavement Distress along Khudengthabi to Moreh Section

5.3.2.1 Summary of the Pavement Condition Survey

From Pavement Condition survey it was found that out of 100.4 km road, about 23+900 km Road length in good condition, 44+600 km length is in fair condition, 31+900 km Road length in poor condition. The details of pavement condition survey are presented in Annexure 5-2 for NH 39. Summary of the overall pavement condition with chainages are presented in below Table 5-14 to 5-16.

Table 5-14 Locations where pavement is in Good Condition

Existing Chainage		Length (m)	Remarks
From	To		
334+600	335+100	500	Good
335+200	335+700	500	Good
336+100	336+200	100	Good
336+300	336+500	200	Good
336+600	336+800	200	Good
336+900	337+000	100	Good
337+800	338+000	200	Good
338+200	338+400	200	Good
338+600	338+700	100	Good
338+800	338+900	100	Good
339+000	339+300	300	Good
339+400	339+500	100	Good
339+800	339+900	100	Good
340+000	340+200	200	Good
340+400	340+800	400	Good
340+900	341+300	400	Good
341+400	341+500	100	Good
341+600	341+700	100	Good
341+900	342+200	300	Good
342+500	342+700	200	Good

Existing Chainage		Length (m)	Remarks
From	To		
374+000	374+200	200	Good
374+400	374+600	200	Good
374+800	374+900	100	Good
375+200	375+300	100	Good
375+500	375+600	100	Good
375+800	375+900	100	Good
376+500	376+600	100	Good
376+700	376+800	100	Good
377+100	377+200	100	Good
377+700	377+800	100	Good
377+900	378+000	100	Good
378+300	378+400	100	Good
378+700	378+800	100	Good
379+200	379+300	100	Good
381+500	381+700	200	Good
381+800	382+100	300	Good
382+200	382+500	300	Good
382+600	382+700	100	Good
382+800	382+900	100	Good
383+600	383+700	100	Good

Existing Chainage		Length (m)	Remarks
From	To		
342+900	343+100	200	Good
343+400	344+000	600	Good
344+400	344+700	300	Good
345+000	345+700	700	Good
346+100	346+600	500	Good
346+700	347+300	600	Good
347+500	348+200	700	Good
348+400	348+600	200	Good
348+700	348+800	100	Good
348+900	349+200	300	Good
349+300	349+600	300	Good
349+700	350+000	300	Good
350+100	350+300	200	Good
350+400	350+600	200	Good
350+700	351+100	400	Good
351+200	351+300	100	Good
351+400	351+500	100	Good
351+700	351+800	100	Good
352+200	352+300	100	Good
352+400	352+700	300	Good
352+800	352+900	100	Good
354+900	355+100	200	Good
359+200	359+600	400	Good
359+700	359+800	100	Good
361+300	361+500	200	Good
361+600	361+800	200	Good
361+900	362+000	100	Good
362+100	362+300	200	Good
362+400	362+500	100	Good
362+600	362+700	100	Good
362+800	362+900	100	Good
363+000	363+200	200	Good
363+300	363+400	100	Good
363+500	363+800	300	Good
363+900	364+200	300	Good
364+400	364+600	200	Good
364+700	364+900	200	Good
365+300	365+400	100	Good
365+900	366+000	100	Good
366+800	366+900	100	Good
367+400	367+600	200	Good
367+800	367+900	100	Good
368+200	368+300	100	Good

Existing Chainage		Length (m)	Remarks
From	To		
384+400	384+600	200	Good
384+700	384+800	100	Good
385+100	385+200	100	Good
385+300	385+400	100	Good
385+600	385+700	100	Good
385+800	385+900	100	Good
386+100	386+200	100	Good
387+100	387+200	100	Good
387+500	387+600	100	Good
387+900	388+000	100	Good
388+600	388+700	100	Good
389+000	389+200	200	Good
389+300	389+700	400	Good
390+400	390+500	100	Good
390+700	390+800	100	Good
393+600	393+700	100	Good
393+900	394+000	100	Good
394+500	394+600	100	Good
395+000	395+200	200	Good
395+300	395+400	100	Good
395+600	395+800	200	Good
396+000	396+100	100	Good
396+200	396+500	300	Good
396+600	396+900	300	Good
397+000	397+100	100	Good
397+300	397+400	100	Good
397+500	397+700	200	Good
397+800	397+900	100	Good
398+100	398+200	100	Good
398+400	398+600	200	Good
398+700	398+800	100	Good
398+900	399+000	100	Good
399+100	399+200	100	Good
399+600	399+800	200	Good
401+100	401+200	100	Good
401+300	401+500	200	Good
401+900	402+100	200	Good
402+200	402+300	100	Good
403+000	403+100	100	Good
426+800	426+900	100	Good
427+100	427+200	100	Good
427+500	427+600	100	Good
427+800	427+900	100	Good

Existing Chainage		Length (m)	Rem- arks
From	To		
368+500	368+600	100	Good
373+100	373+200	100	Good
373+400	373+500	100	Good
373+600	373+700	100	Good

Existing Chainage		Length (m)	Rem- arks
From	To		
428+400	428+500	100	Good
428+600	428+700	100	Good
429+900	430+000	100	Good
430+100	430+200	100	Good

Table 5-15 Locations where pavement is in Fair Condition

Existing Chainage		Length (m)	Rem- arks
From	To		
330+300	330+400	100	Fair
330+700	330+800	100	Fair
331+000	331+100	100	Fair
331+100	331+200	100	Fair
331+500	331+600	100	Fair
331+800	331+900	100	Fair
334+200	334+600	400	Fair
335+100	335+200	100	Fair
335+700	336+100	400	Fair
336+200	336+300	100	Fair
336+500	336+600	100	Fair
336+800	336+900	100	Fair
337+000	337+800	800	Fair
338+000	338+200	200	Fair
338+400	338+600	200	Fair
338+700	338+800	100	Fair
338+900	339+000	100	Fair
339+300	339+400	100	Fair
339+500	339+800	300	Fair
339+900	340+000	100	Fair
340+200	340+400	200	Fair
340+800	340+900	100	Fair
341+300	341+400	100	Fair
341+500	341+600	100	Fair
341+700	341+900	200	Fair
342+200	342+500	300	Fair
342+700	342+900	200	Fair
343+100	343+400	300	Fair
344+000	344+400	400	Fair
344+700	345+000	300	Fair
345+700	346+100	400	Fair
346+600	346+700	100	Fair
347+300	347+500	200	Fair
348+200	348+400	200	Fair

Existing Chainage		Length (m)	Rem- arks
From	To		
375+400	375+500	100	Fair
375+600	375+800	200	Fair
375+900	376+500	600	Fair
376+600	376+700	100	Fair
376+800	377+100	300	Fair
377+300	377+700	400	Fair
377+800	377+900	100	Fair
378+000	378+300	300	Fair
378+400	378+700	300	Fair
378+800	379+200	400	Fair
379+800	380+000	200	Fair
380+200	380+300	100	Fair
380+700	380+800	100	Fair
381+100	381+500	400	Fair
382+100	382+200	100	Fair
382+500	382+600	100	Fair
382+700	382+800	100	Fair
382+900	383+200	300	Fair
383+300	383+600	300	Fair
383+700	384+400	700	Fair
384+600	384+700	100	Fair
384+800	384+900	100	Fair
385+000	385+100	100	Fair
385+200	385+300	100	Fair
385+400	385+600	200	Fair
385+700	385+800	100	Fair
385+900	386+100	200	Fair
386+200	387+100	900	Fair
387+200	387+500	300	Fair
387+600	387+700	100	Fair
387+800	387+900	100	Fair
388+000	388+600	600	Fair
388+700	389+000	300	Fair
389+200	389+300	100	Fair

Existing Chainage		Length (m)	Rem- arks	Existing Chainage		Length (m)	Rem- arks
From	To			From	To		
348+600	348+700	100	Fair	389+700	389+900	200	Fair
348+800	348+900	100	Fair	390+000	390+400	400	Fair
349+200	349+300	100	Fair	390+500	390+700	200	Fair
349+600	349+700	100	Fair	390+800	390+900	100	Fair
350+000	350+100	100	Fair	391+100	393+600	2500	Fair
350+300	350+400	100	Fair	393+700	393+900	200	Fair
350+600	350+700	100	Fair	394+000	394+200	200	Fair
351+100	351+200	100	Fair	394+400	394+500	100	Fair
351+300	351+400	100	Fair	394+600	395+000	400	Fair
351+500	351+700	200	Fair	395+200	395+300	100	Fair
351+800	352+200	400	Fair	395+400	395+600	200	Fair
352+300	352+400	100	Fair	395+800	396+000	200	Fair
352+700	352+800	100	Fair	396+100	396+200	100	Fair
352+900	353+600	700	Fair	396+500	396+600	100	Fair
354+500	354+800	300	Fair	396+900	397+000	100	Fair
355+400	355+500	100	Fair	397+100	397+300	200	Fair
356+200	356+300	100	Fair	397+400	397+500	100	Fair
357+000	358+300	1300	Fair	397+700	397+800	100	Fair
358+500	358+600	100	Fair	397+900	398+100	200	Fair
358+700	359+200	500	Fair	398+200	398+400	200	Fair
359+600	359+700	100	Fair	398+600	398+700	100	Fair
359+800	360+300	500	Fair	398+800	398+900	100	Fair
360+400	360+500	100	Fair	399+000	399+100	100	Fair
360+700	361+300	600	Fair	399+200	399+600	400	Fair
361+500	361+600	100	Fair	399+800	401+100	1300	Fair
361+800	361+900	100	Fair	401+200	401+300	100	Fair
362+000	362+100	100	Fair	401+500	401+900	400	Fair
362+300	362+400	100	Fair	402+100	402+200	100	Fair
362+500	362+600	100	Fair	402+300	403+000	700	Fair
362+700	362+800	100	Fair	403+100	403+500	400	Fair
362+900	363+000	100	Fair	403+600	403+700	100	Fair
363+200	363+300	100	Fair	411+200	411+300	100	Fair
363+400	363+500	100	Fair	412+900	413+000	100	Fair
363+800	363+900	100	Fair	415+100	415+200	100	Fair
364+200	364+400	200	Fair	417+200	417+400	200	Fair
364+600	364+700	100	Fair	417+900	418+000	100	Fair
364+900	365+300	400	Fair	419+600	419+700	100	Fair
365+400	365+900	500	Fair	419+900	420+000	100	Fair
366+000	366+600	600	Fair	423+000	423+300	300	Fair
366+700	366+800	100	Fair	423+500	423+600	100	Fair
366+900	367+400	500	Fair	423+800	423+900	100	Fair
367+600	367+800	200	Fair	424+000	424+400	400	Fair
367+900	368+200	300	Fair	424+600	424+700	100	Fair

Existing Chainage		Length (m)	Remarks	Existing Chainage		Length (m)	Remarks
From	To			From	To		
368+300	368+500	200	Fair	424+900	425+300	400	Fair
368+600	370+700	2100	Fair	426+100	426+800	700	Fair
370+800	371+100	300	Fair	426+900	427+100	200	Fair
372+500	372+600	100	Fair	427+200	427+500	300	Fair
372+700	372+800	100	Fair	427+600	427+800	200	Fair
373+000	373+100	100	Fair	427+900	428+100	200	Fair
373+300	373+400	100	Fair	428+200	428+400	200	Fair
373+800	374+000	200	Fair	428+500	428+600	100	Fair
374+200	374+400	200	Fair	428+700	429+900	1200	Fair
374+600	374+800	200	Fair	430+000	430+100	100	Fair
374+900	375+200	300	Fair	430+200	430+400	200	Fair

Table 5-16 Locations where pavement is in Poor Condition

Existing Chainage		Length (m)	Remarks	Existing Chainage		Length (m)	Remarks
From	To			From	To		
330+000	330+300	300	Poor	380+000	380+200	200	Poor
330+400	330+700	300	Poor	380+300	380+700	400	Poor
330+800	331+000	200	Poor	380+800	381+100	300	Poor
331+200	331+500	300	Poor	383+200	383+300	100	Poor
331+600	331+800	200	Poor	384+900	385+000	100	Poor
331+900	334+200	2300	Poor	387+700	387+800	100	Poor
353+600	354+500	900	Poor	389+900	390+000	100	Poor
354+800	354+900	100	Poor	390+900	391+100	200	Poor
355+100	355+400	300	Poor	394+200	394+400	200	Poor
355+500	356+200	700	Poor	403+500	403+600	100	Poor
356+300	357+000	700	Poor	403+700	411+200	7500	Poor
358+300	358+500	200	Poor	411+300	412+900	1600	Poor
358+600	358+700	100	Poor	413+000	415+100	2100	Poor
360+300	360+400	100	Poor	415+200	417+200	2000	Poor
360+500	360+700	200	Poor	417+400	417+900	500	Poor
366+600	366+700	100	Poor	418+000	419+600	1600	Poor
370+700	370+800	100	Poor	419+700	419+900	200	Poor
371+100	372+500	1400	Poor	420+000	423+000	3000	Poor
372+600	372+700	100	Poor	423+300	423+500	200	Poor
372+800	373+000	200	Poor	423+600	423+800	200	Poor
373+200	373+300	100	Poor	423+900	424+000	100	Poor
373+500	373+600	100	Poor	424+400	424+600	200	Poor
373+700	373+800	100	Poor	424+700	424+900	200	Poor
375+300	375+400	100	Poor	425+300	426+100	800	Poor
377+200	377+300	100	Poor	428+100	428+200	100	Poor
379+300	379+800	500	Poor				

Some of the photographs of Road Condition in NH 39 are presented below:

	
At CH 330+100 , Patching	At CH 335+700, Cracking
	
At CH 337+500 Good condition	At CH 411+500 Poor Condition
	
AT CH 420+100 Poor Condition	At CH 425+900 , Carriageway 3.5m New Pavement

5.3.3 BENKELMAN BEAM DEFLECTION SURVEY

Benkelman Beam Deflection Survey (BBD) has been carried out to assess the residual strength of the existing flexible pavement and there by assessing the requirement of structural strength overlay for rehabilitation of the same. The BBD survey was carried out in accordance with IRC-81 1997 with provisions as per Canadian Good Roads Association (CGRA) method; Deflection readings were carried out at every 50 m staggered on the project road except the Ghat section. The collected deflection data was analyses along with the corrections required in accordance with requirement of IRC-81 1997. The corrections were carried out for:

- Leg Correction
- Pavement Temperature
- Seasonal Correction
- Sub grade Moisture Correction
- PI of Subgrade

Leg correction factor:

While measuring the deflection there is every chance of deflection bowl extending up to supporting legs of the Benkelman beam. The deflection of legs is revealed by the difference in differential reading between initial, intermediate and final reading. If the differential reading between initial and final and intermediate and final differ by more than 0.025 mm then leg correction needs to be applied.

The true deflection is computed as

- $X_T = X_A + 2.91 Y$
- Where,
- X_T = True pavement deflection
- X_A = Apparent pavement deflection i.e. $2X$ (Final – Initial reading)
- Y = Vertical movement of the front legs i.e., twice the difference between the final and intermediate reading.

Correction for Temperature:

The stiffness of bituminous layers changes with temperature of the bonder and consequently the surface deflection of bituminous pavement will vary depending upon the temperature of the constituent bituminous layers. Therefore it is necessary that the measured deflection be corrected to a common standard temperature for tropical climate of India. The standard temperature is taken as 35°C. Correction for temperature variation on deflection for values other than those measured at 35°C shall be 0.01 mm for each degree of change from the standard temperature of 35°C. The correction will be positive for pavement

temperatures lower than 35°C and negative for pavement temperature higher than 35°C.

Correction for seasonal variation:

Since the pavement deflection is dependent upon change in climate/season of the year, it is always desirable to take deflection measurements during the season when the pavement is in its weakest condition. In India this condition occurs immediately after the raining season. When deflection measurements are taken during dry months, they will require correction factor, which is defined as the ratio of maximum deflection immediately after the monsoon to that of deflection in the dry months.

Correction for seasonal variation depends upon the type of the sub-grade soil; its field moisture content (at the time of deflection testing) and average rain fall in the area. For this purpose sub-grade soil has been divided into three broad categories namely sandy/gravelly clayey with low plasticity (PI <15) and clayey with high plasticity (PI >15). Similarly rainfall has been divided into two categories namely annual low rainfall (< 1300mm) and annual high rainfall (>1300mm).

Characteristic Deflection:

The statistical analysis involves calculation of mean deflection value, standard deviation and characteristic deflection. The design calculations are as under.

$$\text{Mean deflection } \bar{x} = \frac{\sum x}{n}$$

$$\text{Standard deviation } \sigma = \frac{\sum (x - \bar{x})^2}{n - 1}$$

Characteristic Deflection = Mean deflection + 2 * Standard deviation

Where,

X = Individual deflection, mm

\bar{x} = Mean deflection value mm

n = number of deflection measurements

σ = Standard deviation

Dc = Characteristic deflection

Benkelman Beam Survey carried from km 330 to 365 only that is plain area and the section from km 365 to 425 is not carried out as this hill section is recommended

for reconstruction. The deflection survey data and analysis is given in the Annexure 5.3. Brief Summary of BBD is given below:

Length of stretch with Characteristic deflection

0.5 to 0.75 mm - 18 Km

0.75 to 1.0 mm - 7 Km

Average characteristic deflection for homogeneous 1 and 2 is in the order of 0.705 and 0.753 respectively. Graphical representation for the characteristic deflection for the two homogeneous sections from km 330 to 342 and 342 to 365 is shown below.



Figure 5-6 Characteristic Deflection from Km 330 to 342

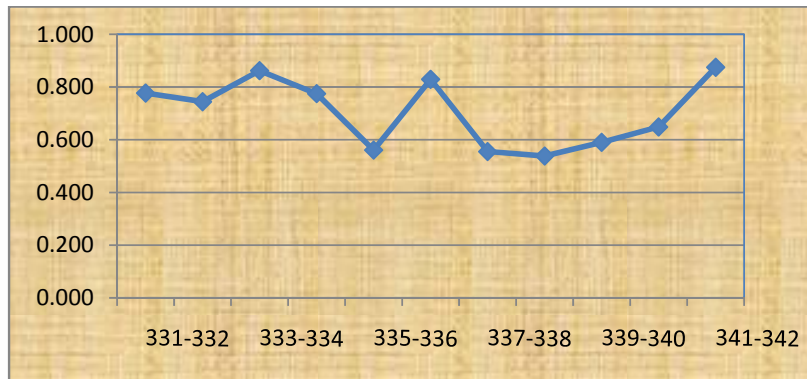
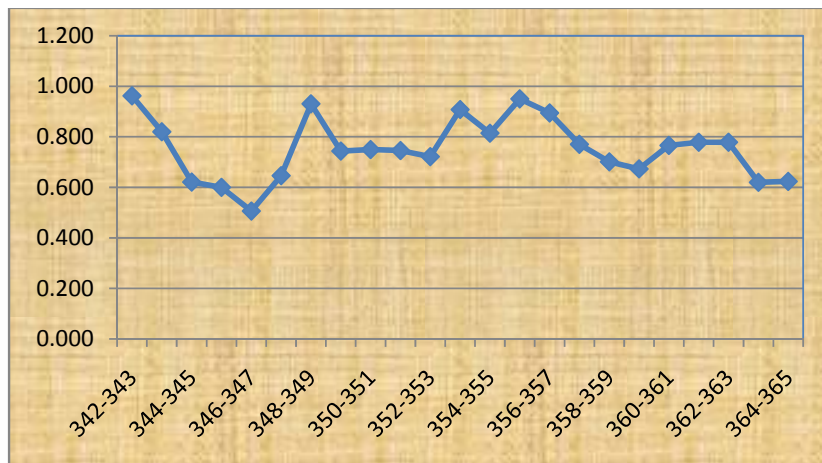


Figure 5-7 Characteristic Deflection from Km 342 to 365



Characteristic deflection values for each kilometers is set out in Annexure 5-3.

5.3.4 TEST PIT INVESTIGATIONS

5.3.4.1 Test Pits Methodology

Investigations have been carried out by digging test pits to assess the adequacy of existing pavement layers including sub-grade soil properties to establish the strengthening/ reconstruction requirement to cater for design traffic during service life.

5.3.4.2 Test Pits (1m X 1m X 1m)

Test pits were dug at 5 km interval at the pavement-shoulder interface extending through the pavement layers excluding the proposed bypass locations. Pits were made in such a way that one third of the pit (20 cm) was within the carriageway and the remaining two third (80 cm) in the shoulder, ensuring minimum damage to the original pavement and disruption to the traffic. The pits were backfilled and compacted after completion of work. The sequence of operations for large pits was as follows:

Manual excavation of 1.0 m X 1.0 m pit down to subgrade level. After reaching the subgrade level the thickness of the different pavement layers were measured and type of material examined. Subgrade soil samples were collected and the soil collected in containers for determining the field moisture content by oven-dried method.

- Field (in-situ) dry density using Sand Replacement method as per IS2720 Part 28 was carried out at the subgrade level.
- A Dynamic Cone Penetration (DCP) test as per ASTM method was carried out at subgrade level.
- One sample of 40 kg subgrade soil was collected from sub-grade for the laboratory test.

Photographs of the pavement layers were obtained at a few test pits:

	
Km:329+000 RHS DCP Work in Progress	Km:345+000 LHS Crust Details

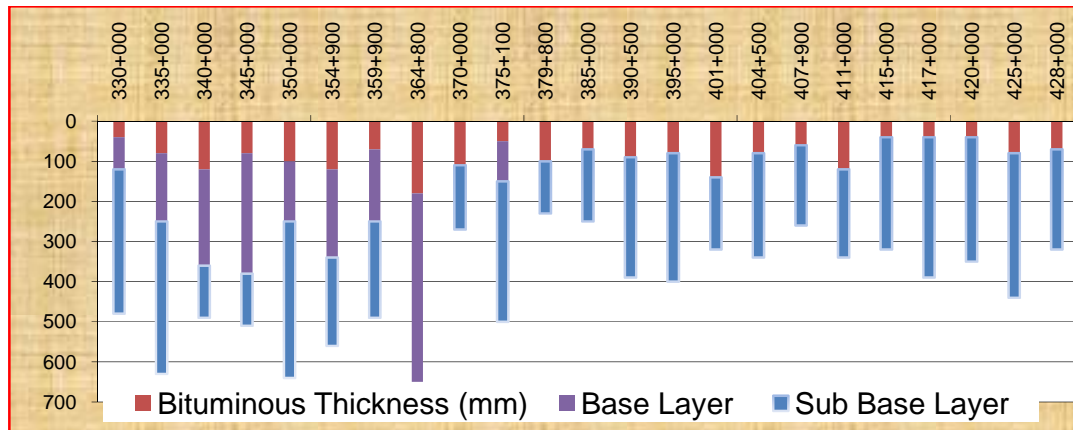
	
Km:350+000 RHS Sand Replacement in progress	Km:375+100 RHS Crust Details
	
Km:395+000 RHS Sand Replacement in progress	Km:404+500 RHS DCP Work in Progress

5.3.4.3 Pavement Composition

For each test pit, the following information was recorded

- Test pit reference (Identification number and location):
- Pavement compaction (material type and thickness)
- Subgrade type (textural classification) and condition(dry, wet)

Broad variation in pavement thickness was observed along the project road. However the pavement composition of the existing pavement is generally same composed of bituminous layers, WMM or WBM base and Sub-base. The Bituminous layer varies from 40 mm to 180 mm: Base course varies from 80 mm to 470 mm and sub-base varies from 130 mm to 390 mm. The pavement composition and thickness are presented in Figure.5.9. From the pavement composition it is clear that there is no drainage layer in plain/low laying areas.

Figure 5-8- Pavement Composition of Existing Road**5.3.4.4 In-situ –density and moisture content**

Sand Replacement method was adopted for obtaining the field density. Representative soil samples were also taken from the pit to establish moisture content. Table 5.17 shows the test result of field density and field moisture content. The field density and moisture content varies from 1.578 gm/cc to 1.867 gm/cc and 8.54% to 21.41% respectively.

Table 5-17 Field Dry Density and Moisture Content

S.No	Chainage	Side	Field Bulk density(gm/cc)	Field Moisture content (%)	Field Dry density (gm/cc)
1	329+000	RHS	1.880	14.670	1.639
2	335+000	LHS	1.932	12.890	1.711
3	340+000	RHS	2.089	11.930	1.867
4	345+000	LHS	1.847	10.250	1.675
5	350+000	RHS	1.950	13.210	1.723
6	354+900	LHS	1.944	14.330	1.700
7	359+900	RHS	2.090	15.390	1.811
8	364+800	RHS	Test not done due old BT surface encountered at subgrade level		
9	370+000	LHS	1.955	12.380	1.740
10	375+100	RHS	2.062	11.670	1.846
11	379+800	RHS	Test not done due to seepage of water		
12	385+000	LHS	1.894	12.150	1.689
13	390+500	LHS	1.977	8.540	1.822
14	395+000	RHS	2.040	17.430	1.737
15	401+000	LHS	1.911	21.100	1.578
16	404+500	RHS	1.982	21.410	1.632
17	407+900	RHS	1.962	18.240	1.659
18	411+000	RHS	1.972	19.650	1.648
19	415+000	LHS	Test not done due to seepage of water		

S.No	Chainage	Side	Field Bulk density(gm/cc)	Field Moisture content (%)	Field Dry density (gm/cc)
20	417+000	RHS	1.956	16.210	1.683
21	420+000	RHS	1.947	14.540	1.700
22	425+000	LHS	1.951	13.220	1.723
23	428+000	RHS	1.945	15.320	1.687

5.3.4.5 Field CBR using DCP

Dynamic Cone Penetration (DCP) tests were conducted at the bottom of the test pits i.e., on top of the sub-grade to assess in-situ CBR of existing sub-grade layer. The CBR value was calculated based on different layers encountered below the top of sub-grade level. The slope change in the graph (Penetration Vs Number of Blows) indicates the interface of two layers of different penetration resistance. From the graph, thickness of layer and slope (penetration mm/blow) were calculated. The following ASTM-D 6951-09 equation has been used to calculate the layer DCP-CBR value for each layer.

$$\log_{10} (\text{CBR}) = 2.465 - 1.120 * \log_{10} (\text{mm/Blow})$$

$$\text{Overall CBR} = \frac{[\sum (\text{Layer thickness (DCP-CBR)}^{1/3})]^3}{[\sum (\text{Layer thickness})]}$$

The minimum, maximum and average values of in-situ DCP-CBR values have been found to be 1.63%, 29.9% and 8.61%. The field CBR values obtained from DCP tests are given in Table 5-18.

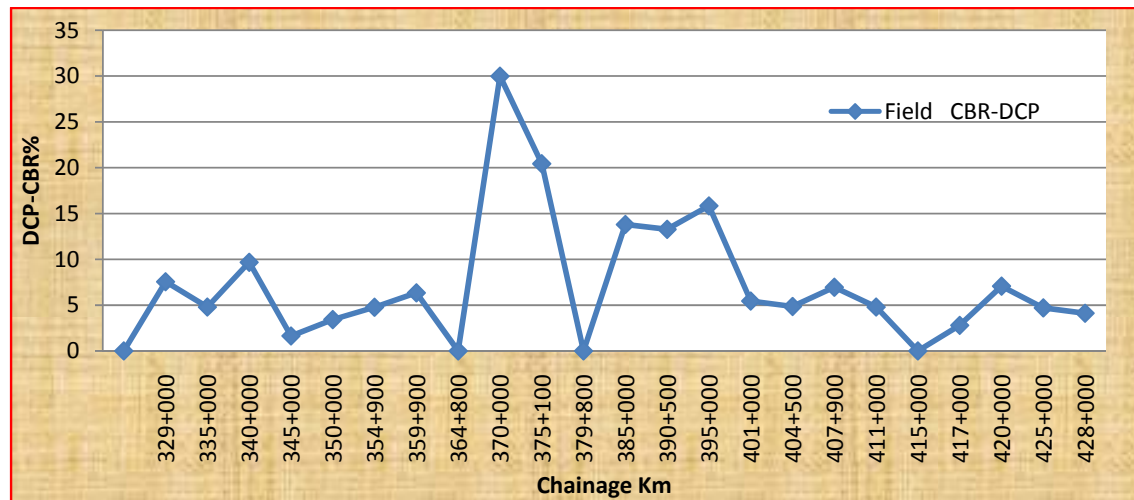
Table 5-18 Field CBR values obtained from DCP Test

S No	Chainage	Side	Field CBR (%)				
			Layer-1	Layer-2	Layer-3	Layer-4	Combined
1	329.000	RHS	8.02	7.13			7.55
2	335.000	LHS	5.91	4.11			4.79
3	340.000	RHS	15.49	9.39	7.19		9.67
4	345.000	LHS	1.63				1.63
5	350.000	RHS	3.42				3.42
6	354.900	LHS	4.68	4.85			4.77
7	359.900	RHS	6.65	5.90			6.34
8	364.800	RHS	Not Done				
9	370.000	LHS	24.90	66.39			29.99
10	375.100	RHS	18.04	19.40	21.39	22.08	20.43
11	379.800	RHS	Not Done				
12	385.000	LHS	13.31	11.82	14.80		13.80
13	390.500	LHS	13.27				13.27
14	395.000	RHS	14.88	16.70	17.44		15.83
15	401.000	LHS	5.27	5.64			5.44
16	404.500	RHS	4.68	4.98			4.85

S No	Chainage	Side	Field CBR (%)				
			Layer-1	Layer-2	Layer-3	Layer-4	Combined
17	407.900	RHS	6.78	8.40	6.23		6.95
18	411.000	LHS	4.79				4.79
19	415.000	LHS	Not Done				
20	417+000	RHS	2.79				2.79
21	420.000	RHS	8.30	5.89			7.07
22	425.000	LHS	5.23	4.38			4.70
23	428.000	RHS	3.75	4.42			4.11

Average CBR observed is 8.61 but the maximum CBR of 20 and 29 observed at locations at km 370 and km 375 respectively. Graphical representation of DCP-CBR values for test pit samples are shown in Figure-5.9.

Figure 5-9 Graphical representation of In-Situ CBR using DCP.



5.3.4.6 Characterisation of Sub grade

The following tests were conducted on each of the subgrade samples collected from test pits:

- Grain size Analysis
- Atterberge's Limits(Liquid limit and Plastic limit)
- Modified Proctor Density
- Four days soaked CBR at three energy levels

The methods of testing adopted for materials investigations are given in Table 5-19.

Table 5-19 Method of Testing

Sl. No.	Type of Tests	Unit	Test Method
1	Moisture Content Determination	%	IS 2720(Part 2)
2	Grain Size Analysis(Wet)	% by wt	IS 2720 (Part - 4)

	Sieve)		
3	Atterberg's Limits(LL,PL,PI)	% by wt	IS 2720 (Part - 5)
4	Laboratory Moisture - Density Characteristics	g/cc and %by wt	Modified AASHTO Compaction(T-180-97)
5	Laboratory CBR (4 Days soaked compaction at three energy level	%	AASHTO T-193-99
6	Free Swell Index	%	IS:2720 Part- 40
7	Field Density by Sand Replacement Method	gm/cc	IS:2720 Part-28

The Summary of laboratory test results for subgrade is given in Table 5-20. The Consultants have collected base and sub base samples at an interval of 10 km to study the gradation and plasticity characteristics of the same. The collected samples further tested for Gradation and Atterberg Limits and it is found that all the collected samples gradations are out of envelope on finer fraction. However the road condition has not shown severe distresses.

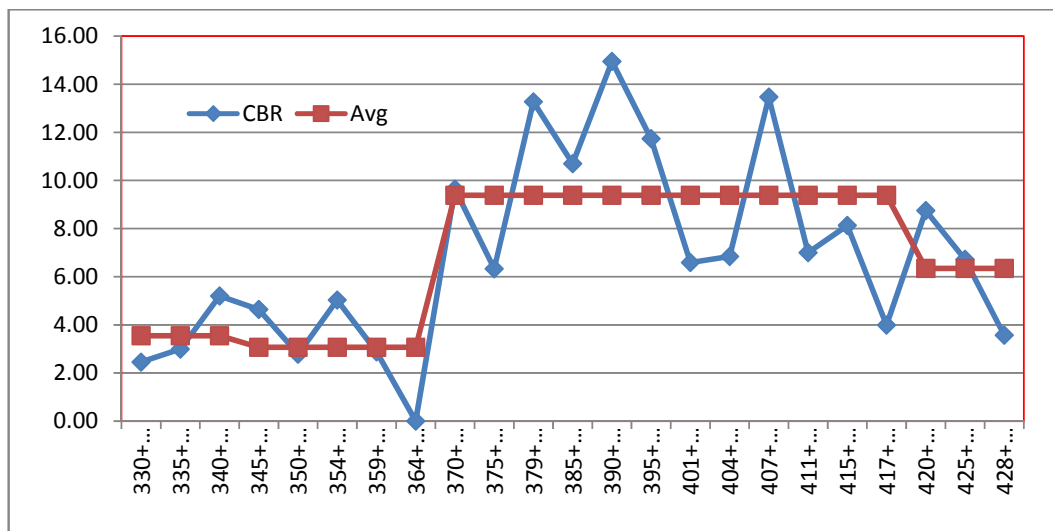
Table 5-20 Lab Test Results for Sub grade samples

S No	Location	Side	IS Classification	Sieve Analysis % by weight (IS : 2720 Part 4 - 1985)			Atterberg's Limit (IS : 2720, Part - 5-1985)			Free Swell Index % (IS : 2720 Part 40 - 1977)	Modified Proctor Test (AASHTO Modified T-180)		Un Soaked CBR (%)	4 days Soaked CBR (%) (AASHTO Method)			
				Gravel > 4.75 mm	Sand (4.75 - 0.075) mm	Silt+Clay < 0.075 mm	Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI) %		Max Dry Density gm/cc	OMC %		10 Blows	30 Blows	65 Blows	CBR at 97% of MDD
1	329+000	RHS	MH	0.51	2.51	96.98	61.76	36.99	24.77	20.00	1.710	17.60	5.95	1.49	2.23	2.98	2.45
2	335+000	LHS	MI	1.17	7.59	91.24	43.46	30.12	13.34	20.00	1.840	15.30	6.94	1.49	2.48	3.97	2.99
3	340+000	RHS	MI	4.74	22.91	72.35	40.33		NP	10.00	1.952	13.30	9.67	2.48	4.46	6.70	5.20
4	345+000	LHS	MH	4.32	12.44	83.23	53.93	34.14	19.79	20.00	1.748	15.50	7.44	2.48	3.97	5.95	4.64
5	350+000	RHS	MH	0.30	3.67	96.04	52.05	32.55	19.50	20.00	1.739	19.50	6.70	1.49	2.48	3.47	2.78
6	354+900	LHS	MI	3.03	14.82	82.15	42.08		NP	10.00	1.789	17.50	8.18	2.48	4.46	6.45	5.03
7	359+900	RHS	MI	0.96	6.82	92.22	42.26	27.74	14.52	10.00	1.792	14.10	6.45	1.49	2.48	3.72	2.88
8	364+800	Test Not Done															
9	370+000	LHS	SM	19.25	40.05	40.70	39.56		NP	10.00	1.945	15.30	15.63	4.46	8.18	12.65	9.64
10	375+100	RHS	MI	9.15	35.21	55.64	41.23		NP	20.00	1.940	13.50	11.16	2.98	5.21	8.43	6.33
11	379+800	RHS	SC	13.25	67.66	19.10	30.78	19.56	11.22	5.00	2.170	9.20	21.58	7.94	11.91	16.37	13.27
12	385+000	LHS	SM	11.49	52.10	36.40	45.10		NP	10.00	1.950	13.20	17.86	6.94	9.92	12.65	10.70

S No	Location	Side	IS Classification	Sieve Analysis % by weight (IS : 2720 Part 4 - 1985)			Atterberg's Limit (IS : 2720, Part - 5-1985)			Free Swell Index % (IS : 2720 Part 40 - 1977)	Modified Proctor Test (AASHTO Modified T-180)		Un Soaked CBR (%)	4 days Soaked CBR (%) (AASHTO Method)			
				Gravel > 4.75 mm	Sand (4.75 - 0.075) mm	Silt+Clay < 0.075 mm	Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI) %		Max Dry Density gm/cc	OMC %		10 Blows	30 Blows	65 Blows	CBR at 97% of MDD
13	390+500	LHS	SM	14.87	62.92	22.22	26.56		NP	5.00	2.116	9.40	23.07	8.43	13.39	18.4	14.95
14	395+000	RHS	SM	9.38	55.20	35.42	36.11		NP	10.00	2.030	11.50	18.60	5.95	10.42	14.88	11.74
15	401+000	LHS	MI	14.31	35.52	50.17	38.32		NP	10.00	1.872	15.50	13.39	2.48	5.46	8.93	6.59
16	404+500	RHS	ML	6.42	41.17	52.40	31.97		NP	10.00	1.980	13.70	12.40	2.98	5.95	8.93	6.84
17	407+900	RHS	SM	9.29	57.88	32.82	24.32		NP	5.00	2.110	9.70	19.35	8.18	12.40	16.37	13.47
18	411+000	LHS	MI	9.53	31.14	59.33	47.09	29.38	17.71	10.00	1.873	15.70	11.91	2.48	5.95	9.67	7.00
19	415+000	LHS	SM	10.24	44.40	45.36	47.83		NP	10.00	1.989	13.20	14.88	3.72	6.94	10.91	8.13
20	417+000	LHS	MH	2.23	11.29	86.48	56.10		NP	10.00	1.748	17.70	6.70	1.98	3.72	4.96	3.99
21	420+000	RHS	SC	17.05	35.87	47.07	47.91	31.57	16.34	30.00	1.970	13.50	14.14	2.98	7.44	11.91	8.75
22	425+000	LHS	MI	6.36	30.82	62.82	44.42	29.09	15.33	30.00	1.860	15.40	11.91	2.48	5.95	8.93	6.72
23	428+000	RHS	MH	0.63	8.44	90.93	50.70		NP	10.00	1.675	23.20	6.70	2.23	2.98	4.46	3.57

The laboratory investigations of subgrade indicate that the existing subgrade varies and generally consists of SM, SC, MH, MI and ML along the road. The percentage of gravel, sand, silt and clay are in the range from 0.30% to 19.25%, 2.25% to 67.66% and 19.1% to 96.98% respectively. The liquid limit varies from 24.32% to 61.76% and plastic limit varies from 11.22% to 24.77%. The optimum moisture content and dry density varies from 9.2% to 23.2% and 1.675 gm/cc to 2.17gm/cc respectively. The soaked CBR values of existing Sub-grade varies from 2.45% to 14.95% at 97% of MDD. The average CBR for four homogenous sections are in the order of 3.55, 3.07, 9.39 and 6.35 respectively. Graphical representation of CBR is given below.

Figure 5-10 Graphical representation of 4 days Soaked CBR.



In case of section from Km 330+000 to 346+000, the Subgrade CBR values are very low and in hilly terrain the CBR value range up to 13% @ 97% MDD. However in both cases the pavement thickness is grossly inadequate for even minimum 10 MSA. Material Investigation.

5.3.4.7 General

The material investigation for road construction has been carried out to identify the potential sources of construction material and to assess their general availability, properties and quantities. This is one of the most important factors for stable, economical and successful implementation of the road program within the stipulated time. For improvement work as well as for new carriageway/Alternative routes, the lists of material include the following.

- Grading V and VI crushed stone aggregate for sub-base-cum-drainage layer and crushed aggregates for base, surfacing & cement concrete works.
- Sand for filter material, concrete works, sub-base and filling material
- Borrow material for embankment, sub grade and shoulders

-
- Manufactured material like cement, steel, bitumen, geotextile, road appearances.

5.3.4.8 *Information on Material Sources*

The following information on material sources was sought:

- Source location, indicating places, kilometerage, availability and the status whether in operation or new source
- Access to source, indicating the direction and nature of the access road i.e. left/right of project road, approximate lead distance from the centre and type of access road.
- Ownership of land/quarries, either government or private.
- Test results, indicating the quality of materials along with their classification in details.

Probable uses indicating the likely use of materials at various stages of construction work i.e. fill materials, sub-grade, sub-base, and wearing course and cross drainage structures.

- During the processes of investigation, due consideration has been given to the locally available material for reducing the cost of construction. The samples from various identified sources have been collected for laboratory testing as per IRC/MORT&H/BIS standards.

5.3.4.9 *Material for Embankment and Sub Base*

Potential sources of earth for the construction of embankment and sub-grade (for reconstruction/new carriageway) were identified on either side of the project road. Borrow areas investigation is under progress and the details will be given in Detailed Project Report.

5.3.4.10 *STONE AGGREGATES*

The availability and quality of material as coarse and fine aggregate was explored and samples were taken from the quarry where large quantities of stone aggregates (boulders) were available. The details are given below.

Table 5-21 Details of Test Results of Stone aggregate quarries

Source	Apparent Specific Gravity	Water Absorption (%)	Combined Flakiness and Elongation Index (%)	Aggregate Impact Value (%) **	Suitability for Various Layers
Santosh Stone Crusher at km 307 on left side	2.66	1.07	30.50	12.39	1. Crusher set-up has to be adjusted to meet the Gradation requirements. 2. Suitable for all the layers
Imphal River Boulders from km 309 with a lead of 1.0 km.	2.70	0.66	0	13.35	1. Suitable for all layers

Sufficient quantity of river boulders is available in the Imphal River at Km. 309+000 RHS and lead is 1.0 km. Representative samples from the above stone crusher samples were collected for testing in the laboratory. The following tests have been conducted on the samples collected.

Aggregate Impact value As per IS:2386(Part-6)

Combined flakiness and elongation indices As per IS:2386(Part-7)

Water absorption As per IS:2386(Part-3)

MORT&H requirement of stone aggregates for their use in base / surfacing course of pavement are as follows:

- Aggregate Impact value <30%
- Combined flakiness and elongation indices <30%
- Water absorption <2%

5.3.4.11 FINE AGGREGATES

Only one source for fine aggregate has been identified which is near Yari pok village at km 342+200 on LHS and lead is about 18 km in length. The source of river sand is not suitable for cement concrete and masonry construction work due to the lab test results is out of specification limit as for IS codes. The details of quarry and properties are given in Table 5-22.

Table 5-22 Details of Natural Sand Quarries.

Source	Gradation Zone	Apparent Specific Gravity	Water Absorption	Fineness Modulus	Silt Content by weight	Bulk Density	Suitability for Works
Thoubal River	II	2.96	3.5	2.88	5.9	1.699	Not Suitable

5.3.4.12 Gradation Characteristics of Base and Sub Base Layers:

The consultants have planned for collection of base and sub base samples at 10 km intervals to study the gradation and plasticity characteristics of the same. Consultants collected 9 samples on the project corridor for Gradation and Atterberg Limits. All the collected samples gradation are out of envelope on finer fraction, however the road condition has not shown severe distresses.

The test results of the samples are presented in Annexure-5.4. DCP test results are set out in Annexure 5.5. Test results for stone aggregate are set out in Annexure 5.6. Lab test results for sub grade testing is set out in Annexure 5.7. Test results for fine aggregates are set out in Annexure 5.8.

5.4 INVENTORY AND CONDITION SURVEY OF BRIDGES AND CROSS DRAINAGE STRUCTURES

The inventory and condition survey of the CD structures along the project corridor are Carried out. Standard formats based on the guidelines as per IRC SP35, were prepared for inventory and condition survey. Instruments and tools such as GPS instrument, measuring tapes, plumb bob, small hammer, mirror, binoculars and camera were used for the survey. The location of the CD structure in this inventory is based on the chainage finalized for highway survey. Chainages of structures in this inventory is the chainage of alignment loaded in GPS instrument. The data collected was analyzed and strategy was tentatively proposed for treatment of each structure in terms of maintenance, rehabilitation or replacement during widening and improvement.

Inventory of the CD structures were in compliance with the guidelines contained in IRC SP: 35. The data were collected to the following attributes:

- Structure number
- Location and name of the stream/canal or river
- Name of the road crossing the stream/canal or river
- Year of construction of the structures
- Structure type and span arrangement
- Structure type for substructure and information on type of foundation

-
- Structure dimensions such as length, clear width, overall width, clear span, effective span, size of the vent, height from road level to existing bed level and height of parapet and railing,
 - Type of construction materials used
 - Alignment of structure viz. straight or skew
 - Type and size of the bearing
 - Type of expansion joint
 - Gradient of the bridge (both longitudinal and transverse)
 - Type of the protection provided for embankment at the approaches and the bed.

Structural condition of existing CD structures was assessed by visual inspection. Guidelines and recommendations given in IRC SP: 35, *Annex 5.6* was followed for condition survey. The following information was collected for the assessment:

Hydraulic adequacy

- Previous flood scenario of the stream /River
- Previous overtopping record of the bridges and road have been collected from local enquiry and from the concerned departments
- Collection of FSL from irrigation department in case of irrigation canals
- High flood level and year of incident
- Low water level
- Type of vent and condition
- Condition of protection works to assess the existing scour condition

Structural condition

- Condition of wearing coat, drainage spout and expansion joints
- Condition of handrail and parapet
- Condition of superstructure
- Condition of substructure
- Condition of bearing
- Condition of embankment protection work for the existing structure.

The survey data collected during the inventory and condition survey of bridges and culverts in tabulated form is given in Annexure 5.9 of this report and detailed condition survey of structures given in Appendix 5.1

5.4.1 ANALYSIS OF SURVEY DATA

The survey data has been tabulated for the convenience of extracting required information. The CD structures are identified based on the material of construction, carriage way width, total length, and type of structure, condition of structure, span arrangement and hydraulic adequacy. Identification of the structures, their condition and the selected standard cross section of approach

roads were utilized to formulate guidelines for recommendation and treatment proposal of each structure during widening and improvement.

5.4.1.1 Inventory summary

There are 15 bridges, 1 pedestrian underpass and 310 culverts in the total project stretch. From the details given below, it can be seen that there is an average of 3 culverts per km of the project corridor.

5.4.1.2 Existing bridges and culverts

Details of existing bridges, culvert and other structures situated in the project road classified based on various parameters such as functionality, type of superstructure, length, carriageway width, hydraulic adequacy and present conditions, are presented in Table 5-23 to Table 5-28.

Table 5-23 Existing bridges and culverts along the project road

Sl. No	Name of bridge/Culvert	No. of Structures
1	Major bridge	3
2	Minor Bridge	12
3	ROB	0
4	RUB	0
5	VUP	0
6	PUP	1
7	Causeway	0
8	Culverts	310

Table 5-24 List of super structure of existing structures

Sl. No	Type of superstructure	No. of Structures
1	RCC Solid slab simply supported	8
2	RCC Solid slab Continuous	0
3	T-beam RCC +Steel Composite	0
4	RCC T-beam bridge	3
5	Integral	0
6	I-Girder PSC	2
7	PSC/RCC Box	0
8	RCC Portal/Box	0
9	RCC box	0
10	Steel Truss – deck bridge	2
11	Steel composite	0
12	Brick arch	0

Table 5-25 Classification based on length of bridge

Sl. No	Length Of bridge	No. of Structures
1	Length 6 to 60m	12

Sl. No	Length Of bridge	No. of Structures
2	Length 60 and above	3

Table 5-26 Classification based on Carriage way width

Sl. No	Carriage way width	No. of Structures
1	Carriage way <7	3
2	Carriage way >7	12

Table 5-27 Classification based on Hydraulic Adequacy

Sl. No	Type of superstructure	No. of Structures
1	Overflowing/Touches the soffit of deck	0
2	Hydraulically adequate	15
3	Cause way	0

Number of structures other than bridges such as VUP/PUP/ROB etc. is 6

Table 5-28 Type of Culverts

Sl. No	Type	No. of Structures
1	Pipe Culvert	192
2	Box Culvert	1
3	Slab Culvert	117
4	Arch Culvert	0

Since most of the culverts are either pipe or slab type, widening them would not be difficult or costly.

5.4.2 INVENTORY DATA OF CULVERTS AND BRIDGES

5.4.2.1 Culverts

There are a total of 310 culverts situated on the project stretch from Lilong to Moreh. Average number of culverts per kilometer works out to be 3.0. Culverts are classified based on the type of material/structure such as RCC slab, Hybrid, pipe culvert, brick arch and RCC box culvert. (Refer Annex 5-9(a) & (b))

5.4.2.2 Bridges

There are 3-major bridge 12-Minor bridges, 1-PUP situated along the project road. The bridges are grouped based on the span arrangement, type of superstructure, width of carriage way, total width of the bridge, hydraulic adequacy, vertical clearance for the deck, free board at approaches and the type of embankment and bed protection provided. Average number of bridges along

the project road is 0.14/km. In other words, average number of CD's including bridges on entire project road is 3.14/km. (Refer *Annexure-5-9(c)*).

5.4.2.3 PUP

There is a PUP exiting at Km 341+825 on approaches of Thoubal bridge and the condition is very good. The inventory and condition of the same is given in Annexure 5.9(d).



5.4.3 CONDITION SURVEY DATA

The condition survey data reveal that structural defects are mainly due to deterioration of concrete because of aging of concrete or poor quality of construction. Spalling of cover concrete and corrosion of reinforcement in concrete structures due to exposure outside is common in most of the bridges. In bridges with articulated joints; excessive vibration is felt during heavy truck traffic flow in Lilong and Thoubal Bridges. Blockage of vents of culverts and drainage spouts, leakage of expansion joints, damages to railings and parapets, etc are common in most of the structures.

5.4.3.1 Culverts

5.4.3.1.1 *Structural condition of culverts*

The minimum vent size for such slab culverts was found to be 1.0x0.8m.

Condition survey shows that quality of concrete for the culverts along the project road which are recently constructed are good. At very few locations due to inadequate cover concrete, reinforcements have corroded.

Most of the pipe culverts in hilly area are choked due to sliding of earth, and head walls are damaged. Minimum size provided for the opening of the pipe culvert was found to be only 600mm. Culverts are functioning satisfactorily even though they are buried half way and head walls are damaged.

Culverts with R.C.C. slab type superstructure are structurally Good.

5.4.3.1.2 *Hydraulic adequacy of culverts*

Referring to the data collected from the department, all the Bridges are hydraulically adequate. Other than this visual inspection shows that most of the culverts are hydraulically functioning well. In case of pipe culverts at many locations, the vent way was blocked due to silting in plain areas, and land sliding in hilly areas. Few Pipe culverts have undergone total silting and blockage. Hydraulic adequacy of the existing culverts and additional culverts if any is to be decided after the detailed hydraulic design.

5.4.3.2 Structural condition of bridges

5.4.3.2.1 *Geometry requirement*

The majority of the bridges along the project road are of solid slab type superstructure. Other types of bridges observed are RCC T-beam, PSC I Girder Bridge, and Bailey type Super structure. For some of the bridge piers, cutwater reinforcement was seen exposed below the high flood level.

The superstructures of the slab bridges are generally in good structural condition except Bridge at Village Wangjing , where they are not as per MoRT&H standards. Overall depth provided for some of the slab bridges is less than the present design standards Actual depth needs to be checked for the loads and the required rectification measures will be recommended in DPR. R.C.C. T-beam bridges and PSC girder bridges are structurally in good condition except the bridge near Waithou Village.

There are a total of 2 PSC I girder Bridges. Condition survey shows that these bridges are in good condition. No signs of notable distress are visible either on the substructure or superstructure of these bridges.

Divided footpaths are provided in most of the bridges. Wearing coat and expansion joints are generally in fair condition. Railings are damaged either due to vehicle collision or corrosion of reinforcement. Protection works are also damaged due to excessive scour.

5.4.3.2.2 *Design loading*

The data regarding the type of loading for which the bridges were designed are required for during improvement proposal to make the bridge quality for the present day vehicular traffic. Data related to the loads for which the bridges are designed is not available.

As major stretch of the project road on the National highway, bridges are presumed as designed for IRC loading corresponding to the requirements of the traffic condition of the National highway.

5.4.3.2.3 *Hydraulic adequacy*

During normal flow condition, bridges on the project corridor are hydraulically adequate. Available data regarding the flood level during peak flood condition from local enquiry, and flood marking on permanent structures are collected by the Consultant during the investigation process.

5.4.3.2.4 *Data regarding any natural disasters viz. flood, cyclone and earthquake*

Natural calamities like flood, cyclone, earthquake etc. are causes of damage to the structure. Any major natural calamity of this nature during the service life of the structure, affects the structure in all respect. Information collected from the respective offices shows that the project area has not undergone any disastrous cyclone or earthquake.

5.4.3.2.5 *Structural condition to meet the change in IRC design standard*

Most of the bridges and culverts along the project road were constructed before the year 2000.i.e before the latest revision of relevant IRC design standards. A judicious strategy needs to be evolved for the retention, dismantling and strengthening etc. of these structures with due contingency to the economic aspect. Condition of the structure, IRC design standard requirement as well as geometric feature also plays a key role in such a decision.

5.4.4 PHOTOGRAPHS

The photographs highlighting general condition of all bridges are given with the inventory and condition survey data in annexure of this report. Photograph showing the condition of culverts are given in the subsequent pages. (Figures 5.8.1 to 5.8.12)



Fig. 5.8.1: Major Bridge at 300+150



Fig. 5.8.2: Major Bridge at 341+780



Fig. 5.8.3: Slab Culvert at 339+700



Fig. 5.8.4: Minor Bridge With Bailey type superstructure at 407+700



Fig.5.8.5:Slab culvert at 346+350



Fig.5.8.6:Slab Culvert at 354+900



Fig.5.8.7:PUP at 341+830



Fig.5.8.8:Pipe Culvert at 396+600



Fig.5.8.9:Pipe culvert at 393+040 (Partially chocked)



Fig.5.8.10:Pipe culvert at 400+400



Fig.5.8.11:Pipe culvert at 406+400
(Choked)



Fig.5.8.12:Bridge Bailey Type Super
structure at Indo Myanmar Border

Summary of Cross drainage structures details including their proposals are given below:

Table 5-29 Summary Recommendation for all Cross Drainage Structures

Sl.No	Item Description	Existing	Retained	Reconstruction	Remarks
1	Major Bridges	3	3	Nil	New two lane bridges to be constructed for 4 lane configuration for all the three Major Bridges.
2	Minor Bridges	12	10	2	7 bridges are situated in between Lilong and Pallel where four lane carriageway has been proposed, out of which 2 (Waithou and Wangjing bridges) are completely distressed and should be reconstructed for 4 lane configuration. The remaining 5 bridges can be widened to 12 m and additional 2 lane bridges should be constructed on adjacent to the existing bridge. 5 bridges are situated in between Pallel to Moreh where two lane paved shoulder configuration has been proposed. Out of 5 one bridge is situated on international boundary and one is near Lokchav village for which separate DPR has already been submitted, 2 bridges out of remaining 3 bridges are proposed to be widened to 12.9 m deck width. The last bridge at km+428+180 (Khujaikok bridge) is proposed to retain as it is.
3	PUP	1	1	Nil	The PUP is proposed to retain and widened to 4 lane configuration with service roads
4	Box /Slab Culvert	118	0	118	61 culverts are situated in between Lilong and Pallel where 4 lane is proposed and rest are (57 Nos) situated in between Pallel and Moreh. All the 118 Culverts are recommended for reconstruction.
5	Pipe Culvert	192	0	192	Culverts situated in between Lilong and Pallel and rest (192 Nos) situated in between Pallel and Moreh and all are recommended for reconstruction.
Alternative Route from Wangjing to Khudengthabi: The alternative route passes through the mountain ridge from Heirok to Khudengthabe and there is requirement of 5 cross drainage structures and there are some culverts which were in bad condition due to lack of proper maintenance hence all are recommended for reconstruction. Hence total 118 box culverts are proposed which includes new and reconstruction of existing slab culverts. Similarly total 38 pipe culverts are proposed which includes new and reconstruction of existing pipe culverts.					

5.5 TOPOGRAPHIC SURVEY

The Imphal-Moreh Project corridor has been surveyed in detail covering all items in the scope of work using the sophisticated Survey Equipments such as ORTHOPHOTO, GPS, Total Station, Auto Level and drawings to be produced as AutoCAD drawing in DWG/DXF format. The traverse and survey are conducted along the selected alignment. The survey data is processed to develop the digital terrain models of the road corridors for the final roadway design. For the alternate state highway route, satellite data processed to 1 m accuracy accuracy covering a wide corridor was obtained and used for design.

From Start of the project road corridor to Pallel the terrain is plain and hence total station, Auto levels etc are used to carry out the detailed topo survey. Even in the rolling terrain between Khudengthabi and Moreh, the same procedure has been adopted. Arial survey has been carried out in the hilly terrain from Pallel to Khudengthabi. A detailed topographic survey is carried out along the proposed alignments using GPS, Total Station and Auto Level to collect sufficient topographic information to prepare 60m wide detailed digital terrain model – maps showing existing physical features and location reference along the alignment. The surveys are undertaken by the internationally approved methods and prevailing conditions.

5.5.1 *INSTALLATION OF PRIMARY CONTROL STATIONS*

A pair of inter-visible Primary control stations had been installed at intervals not more than 5 km using Global positioning systems (GPS) and the entire survey co-ordinate system is based on the Global coordinate system such as UTM/WGS84.

DGPS observations were taken in STATIC mode and Post Processing of data is done using the Trimble Geo Office Software. Primary survey controls were established using Differential Global Positioning System (DGPS) as detailed below:

- Fixing of Horizontal control grid by using Differential Global Positioning System (DGPS) at every 5 Km radically on a pair of Primary Control Stations. The DGPS UTM WGS 84 co-ordinates converted as TM co-ordinates to used for establishing the secondary control station along the project roads.
- The primary control Points were located on the edge of the right of way (ROW) at inter-visible locations at every 5km and shall be as far as possible on either side of 5-km stone so that it can be identified easily on the field. The stations selected were ensured to be obstruction free towards sky at an angle of 15° with horizontal plane.
- The primary control station pillars were established with steel bar of 10 mm diameter, fixed in M20 RCC pillar of size 30 cm X 30 cm X 45 cm embedded in M10 concrete (50 mm all around) up to a depth of 30cm and the balance 15

cm above the ground shall be painted yellow. Pair of such pillars are located at 5 km intervals along the project road.

- The primary control stations were observed for a minimum of 1 hours and at reference stations for 30 minutes to eliminate the possible projection and time errors in the signals received from various satellites being observed at respective locations in order to ensure high accuracy in the positioning of control station within +3cm

The general methodology adopted for GPS survey is as follows:

Install a pair of points at each location such that the positions are along the alignment and near to our proposed intersections. All these points are connected by triangulation during which the observation time is 1 hours for each position. These are the primary points which are having a secondary point for each. In the next stage these primary and secondary positions are observed for more accuracy.

Care is taken to see that all the primary points are within 5 Km from at least one other primary point and all the secondary points are about 50 to 200 mts and inter visible to their respective primary points.

Proper precautions such as ensuring the availability of minimum of 4 and maximum of 12 satellites during the observations are taken care.

The output data is presented in three formats namely:

1. Lat & Long
2. UTM as per WGS 84 in Zone 45N.
3. Planner or TM

All data collection has been done using field computer/data logger. The integrity of data was checked every day on the day of survey. The horizontal and vertical alignments were also checked on the screen and any problems with the raw data will be rectified the next day. The two rover stations took common points several times a day to verify the operations of each other as the survey is in progress. For any problems discovered during the survey, corrective measures were taken immediately.

5.5.2 *INSTALLATION OF SECONDARY CONTROL STATIONS*

Secondary control station points were installed at an interval not exceeding 250m. A traversing survey was carried out using total station and auto level for transferring precise Northing, Easting and altitudes. Two rounds of angle measurements were taken on both left and right face. The angle spread between observed round will not be more than 5 sec. The secondary control stations were fixed by closed traverse and the traverse corrections were applied-based on Bowditch method.

5.5.3 DETAILED SURVEY

The topographical surveys for longitudinal and cross sections covered the following

- Longitudinal section levels along the finalized center line at 25m intervals to comply with TOR, at the locations of curve points, intersections and at the locations of change of elevations.
- Cross section elevations at 10m interval in full extent of survey for sufficient width covering sufficient number of spot levels on the ground.
- Leveling is being carried out with Auto Level with reference to the Benchmarks and Temporary Bench marks established.
- The SHELADIA team also collected details of all-important physical features along the arms of the intersections at the cross roads for a length as per IRC standard. The following details were collected by topographic survey in detail:
 - Trees with girth greater than 0.3m, electrical poles, telephone lines, OFC lines, water / oil / Gas pipe lines, manholes
 - Building lines, type of buildings (shops or houses), Right of Way boundary if available at site by presence of boundary stones.
 - Existing road edge, centerline, be recorded at an interval not exceeding 25 m
 - Location of existing features within ROW.
 - Special emphasis was made in identifying all religious places – temples, churches, mosque, locations, boundary lines and clear dimensions of compound walls and entrances.
 - Locations of roadside drain clearly identifying the type (open / closed), width of drain including the beginning and end of drain.
 - Roadside land use viz., residential, mixed residential, commercial, shops and business established areas etc.

In the Hilly terrain between Pallel and Khudengthabi, both along the existing alignment and proposed alternative alignment, a latest technology of Aerial survey has been adopted where in an aerial photograph is geometrically corrected (Orthorectified) such that the scale is uniform: the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

Orthophotographs are commonly used in the creation of a Geographic Information System (GIS). Software can display the orthophoto and allow an operator to digitize or place line work, text annotations or geographic symbols (such as hospitals, schools, and fire stations).

The Topographical Survey work was monitored full time by Consultant's Survey Engineer to maintain high precision in picking up maximum number of details in the limited time frame.

5.5.3.1 *Methodology of Error Distribution:*

In Traversing:

Linear correction of error = Closing error X Measured length for arithmetical check Perimeter

Horizontal angles: $(2n-4)$ 90° for interior angled traverse $(2n+4)$ 90° for exterior angled traverse.

Leveling:

Proportionate distribution of error to the station.

Arithmetical check.

$\sum BS - \sum FS = \sum RISE - \sum Fall = \text{Last R.L} - \text{First R.L}$. The Permissible error in leveling is 5mm / Km.

5.5.3.2 *Survey Accuracy*

Linear measurement accuracy will be 5 cms per Km. i.e 20000 accuracy. Since the bearing distance of the observed points are known by the Total Station, Co-ordinates X,Y,Z shall be calculated with computer using Auto CADD 2000.

These points whose co-ordinates are to be plotted and joined are presented in the map of the area surveyed. Survey plotting is being carried out in the office simultaneously with the fieldwork. The plotted sheets are taken to the site for verification to ensure that no detail or structure is left out. Necessary modification to the drawings if any are made and then final prints shall be taken to the desired scale.

Scale of the Survey drawings shall be 1:1000, for site verification so as to carryout proper checking. The corrections are to be incorporated in the final drawings. All Topographic features in the AutoCAD drawings are coded as per code list.

5.5.3.3 *BMs and Boundary Pillars*

After completing the horizontal alignment design the road center line shall be laid on ground and TBM pillars shall be installed.

Care shall be taken in carrying out the topographic survey for the structural components to adhere to the requirements set in IRC: SP-19-2004, IRC: 5-1998 and IRC-SP-50-1999. Temporary benchmarks will be established as pillars at the edges of ROW.

5.5.3.4 Topographic Survey Data

The data is being processed to build a digital terrain model of the road corridors and shall be presented in graphical form along the alignment design drawings. The complete data set after processing will be submitted along with the survey report.

5.5.3.5 Survey Equipment's Used

1. Electronic Digital Total Station “ Trimble” model M3 - with one-second precision, calibrated to specification was presented to the Engineer-in-charge for verification. Angle measurement, standard deviation 1”.

Laser plummet accuracy: maximum rotation diameter of laser spot $\pm 0.8\text{mm}/1.5\text{m}$. Compensator 1.5 seconds.

2. SOKKIA AUTO LEVEL C320 (No: - 10356)

Accuracy: Automatic compensation for horizontal bubble centering.

3. LEVELING STAFF

Accuracy to read 5mm least count.

4. COMPUTER for survey data processing



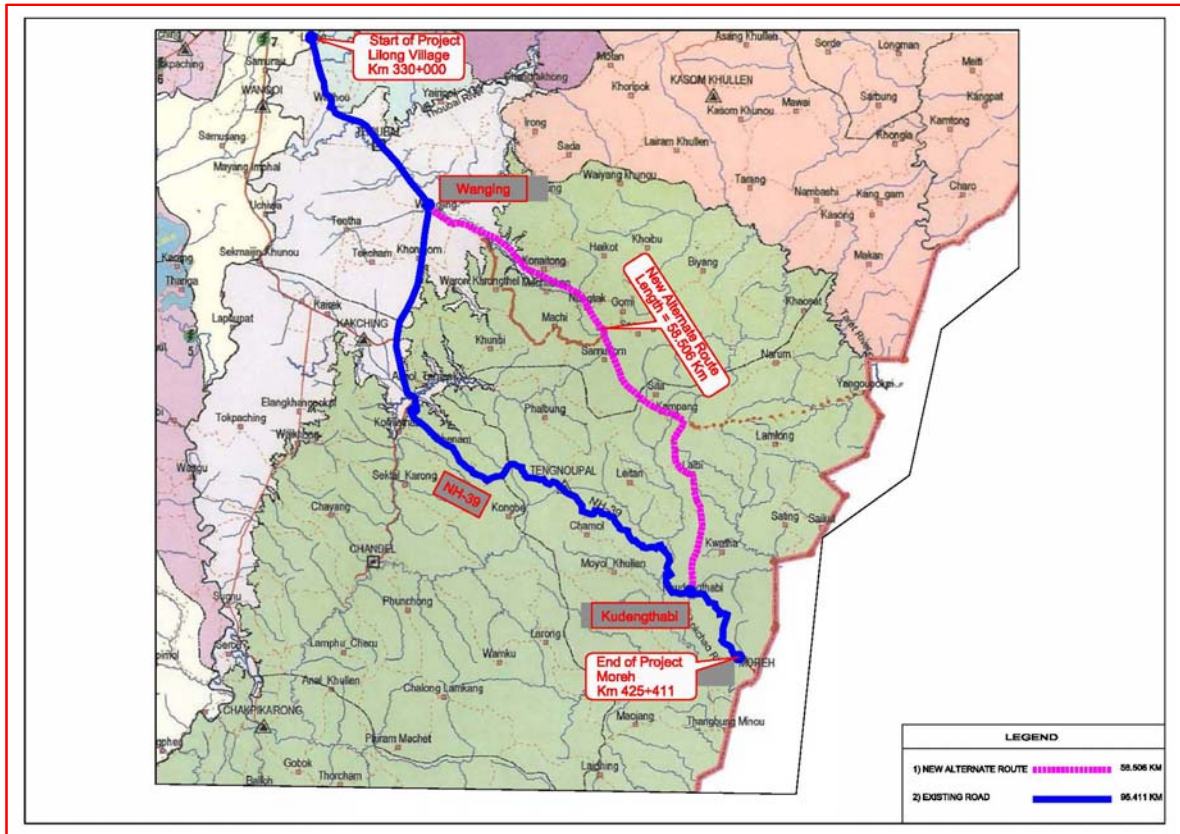
5.6 ALTERNATIVE ALIGNMENT FROM WANGJING TO KHUDENGTHABI

There is an alternative route/track existing on LHS of the project corridor in between Wangjing town and Khudengthabi village with a length of 67 kilometers.

Alternative route alignment takes from the Wangjing town on NH 39 at its Km 350+000 and merges with NH 39 at its Km 417+000 near Khudengthabi village.





First six kilometers of the section follows the all-weather road from Wangjing town to Hirock Military Camp. Further takes off from the all weather road and follows the track on rolling/hilly terrain for the remaining length of 61 kilometers.



The alignment of the alternative route is shown below:



Project Road Features are shown below:

	
<p>Heirolk Militray Camp on LHS</p>	<p>Ghat Section near Km 10+000</p>
	
<p>Village on Ridge at Km 12+000</p>	<p>All Weather Road from Almlong to Machi Village</p>
	
<p>Junction with Machi Village at Km 22+000</p>	<p>Formation Widths at Km 24+000</p>

	
<p>Culvert at Km 24+500</p>	<p>Ghat Section at Km 28+000</p>
	
<p>Land Slide at Km 29+000</p>	<p>Junction with Allweather Road at Km 29+000</p>
	
<p>Samukom Village at Km 32+000</p>	<p>Sita Village at Km 38+0000</p>

	
<p>Sita Village Junction at Km 38+200</p>	<p>Track from Km 39+000</p>
	
<p>Track at Km 44+000</p>	<p>Village Gate at Km 52+000</p>
	
<p>Track at Km 54+000 (Rain water flow on Track)</p>	<p>Difficult driving at Km 54+500</p>



B.Mohoi Village at Km 60+000



Khudengthabi Village at Km 66+500.

6 TRAFFIC FORECAST AND IMPROVEMENT PROPOSALS

6.1 APPROACH

Traffic growth on a road facility is generally estimated on the basis of historical trends and economic growth projections. Demand changes are usually because of shifts in the pattern of economic activities in the surrounding regions. Hence, future traffic estimation necessitates a preview, of the probable pattern of future growth of the economy in the project influence area (PIA).

The total traffic that is likely to patronize an improved road facility will comprise three distinct streams via) normal traffic, ii) generated (or induced) traffic and iii) diverted traffic.

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

Generated/Induced Traffic: denotes that stream of traffic which will get generated on account of the improved service (e.g. reduction in transport cost, reduced transit time, safe and comfortable travel, etc.,) or traffic generated from induced development attributes to the proposed improvements on the project road.

Diverted Traffic: denotes that stream of traffic which will get diverted from other routes / modes of transport to the project road because of the improved transport services traceable to the proposed improvements and also possible diversions away from project road sections to other network roads. Diverted traffic from rest of the network is not anticipated in the present project as there is no other road network adjacent to the project road corridor.

6.2 GROWTH RATES

The exercise of normal traffic growth rate estimation has been carried out by the Consultants using the Vehicle Registration method and elasticity approach mentioned in the IRC: 108-1996.

1. State Vehicle Registration Data;
2. Elasticity Method from IRC: 108-1996;

6.2.1 State Vehicle Registration Data

Vehicle registration data for Manipur state alone has been considered as the zone influence for other adjacent states observed is negligible. Manipur State vehicle registration data and for All India vehicle registration data were collected from the “Road Transport Year Book, Govt of India” for the years from 2004-05 to 2010-11, The estimated linear growths from the data collected is given in Table 6.1.

Table 6-1: Vehicle Registration Growth (%) for Each State

Name of State	Car/Van/Jeep/Taxi	Two Wheeler	Three Wheeler	LMV Goods	Trucks	Bus	Tractor & Trailer
Manipur	8.55	10.33	24.84	13.63	4.56	5.63	12.39
All India	10.55	9.59	8.66	16.63	5.56	10.26	7.20

Economic Indicators like Net State Domestic Product, Per Capita Income and Population for the state as well as for overall India were collected and the linear growth computed is presented below.

Table 6-2: Growth (%) of Economic Indicators

Name of State	GDP/NSDP	PCI	Population
Manipur	5.81	3.79	1.94
All India	8.48	6.88	1.50

The economic growth rate observed in the recent past in Manipur is about two-third of all of India growth rate. Some of the vehicle growth rates are higher than all India growth rates but this may be due to the very low base of those vehicle groups in Manipur. In order to see the growth trend of passenger trips and goods tonnage, the vehicle trips have been converted to passenger trips and goods tonnage and growth rate worked out as given below. The passenger trips in the state are growing at 15% below and goods tonnage at about 20% below the all India growth rates. This indicate a slightly higher elasticity of trip growth rate in Manipur, which is in line with the normal trend when the base numbers are low and higher economic growth happens compared to long term economic growth in the past.

Region	Passenger trip growth rates (%)	Goods tonnage growth rate (%)
Manipur	8.6	6.4
All India	10.1	7.9

Therefore for vehicle categories, where vehicle growth in Manipur is observed above all India vehicle growth rates, all India growth trend reduced in proportion to the passenger and goods growth rates indicated above is considered to work out the state vehicle growth trend.

6.2.2 Elasticity Method

The elasticity method relates traffic growth to changes in the related economic parameters. According to IRC-108-1996, elasticity based econometric model for highway projects could be derived in the following form:

$$\text{Log } e(P) = A_0 + A_1 \text{ Log } e(EI)$$

Where:

P = Traffic volume;

EI = Economic Indicator;

A_0 = Regression constant; T Stat;

A_1 = Regression co-efficient (Elasticity Index).

Elasticity values for car/van/jeep/taxi, bus and trucks were developed using the econometric model for Manipur, and All India vehicle registration data.

Economic parameter PCI has been used as one parameter against dependent parameter for passenger traffic growth. Whereas for goods vehicles NSDP for Manipur state has been considered as independent parameter. Elasticity values have been derived for each vehicle categories with the above approach and the details are given in Annexure 3-1. Projected elasticity values and economic growth parameter selected were multiplied to arrive growth of respective vehicle category. Recommended growth rates for all the vehicles are given in Table 6.3. Traffic growth rates given below are for unconstrained growth and as roads reach capacity, growth will reduce as congestion increase.

Table 6-3: Summary of Recommended Growth Rates for Project Road

Vehicle Type	2013-18	2018-23	2023-28	2028-33	2033-38
Car/Van/Jeep	7.2	6.4	5.8	5.0	4.0
2 Wheeler	9.0	8.0	6.5	5.6	4.0
3 Wheeler	6.5	5.8	5.2	4.5	3.6
Bus	5.0	4.3	4.0	3.4	3.4
All Trucks	5.5	5.0	4.5	4.0	3.5
LCV	6.1	5.5	5.0	4.4	3.9

6.3 FUTURE TRAFFIC POTENTIAL FOR IMPHAL –MOREH ROAD

The establishment of civilian government in Myanmar and the intensification of engagement with other countries and relaxation of trade sanctions is opening up trade opportunities with Myanmar. India is engaged in Myanmar with several projects and is actively taking steps to upgrade border trade infrastructure and other trade facilitation measures. All these are expected to significantly increase the border trade. The India-ASEAN FTA in goods has seen increasing India's trade with ASEAN has seen large increase reaching USD 80 billion last year. The FTA is expected to abolish tariff restrictions on 3200 items by end of 2013 and will facilitate large growth in trade. Myanmar with its strategic location is the only land bridge to the ASEAN nations. With the opening up of Myanmar and the large

potential in India-ASEAN trade growth, there is vast scope for generating traffic from adjacent country Myanmar for the various tradable goods. The trade potential at the Indo-Myanmar border through Moreh was estimated based on available assessments from various sources^{1,2} and volume of trade estimated through Moreh Integrated Check post within 5 years of its operationalization. It is expected that a large portion of North East India's needs will come through these border points in future. Based on the details collected from the PWD, the estimated goods vehicle traffic are given below for each type of tradable item:

1. Pulses, beans and lentils: 150 truckloads daily @ 10 tons capacity (Background of the forecast: Estimated at two-third of the North East India pulses Consumption @ 58.1gm/capita/daily currently brought from rest of India).
2. Timber and timber products (teak, hardwood & C class) - for use in 'Timber Park' at Moreh and for domestic demands: 50-60 truck loads daily (Background of the forecast: Estimated volume 200,000 cubic meters, (100,000 cum from Myanmar and 100,000 cum import from ASEAN Countries)).
3. Minerals (coal, limestone, granite, iron ore, gypsum, silica sand, dolomite, rock phosphate etc.)= 75 to 200 truck loads daily. (Background of the forecast: Estimated at the installed manufacturing capacity of the factories in North East and local market).

[India is importing about 5 million tons of rock phosphate for manufacture of fertilizer; of this about 2 million tons are imported from Kunming China. In return China imports 1.5 to 2 million tons of iron ore from India. Kunming to Kolkata via Moreh-Manipur route is less than 2000 Kms. There are huge coal mines in Myanmar, coal is cheaper and better. Other minerals command the same advantage from commercial points of view.

4. Items of general trade & commerce: 40 to 60 truck loads daily. Items: Industrial goods & FMCG products, steel bars, cement, hardwares, petroleum

¹ Kimura, F., T. Kudo and S. Umezaki (2011), 'ASEAN-India Connectivity: A Regional Framework and Key Infrastructure Projects' in Kimura, F. and S. Umezaki (eds.), *ASEAN-India Connectivity: The Comprehensive Asia Development Plan, Phase II, ERIA Research Project Report 2010-7*, Jakarta: ERIA, pp.1-56.

² *Augmenting Bilateral Trade Between India & Myanmar, Country Report*, Indian Chamber of Commerce, 2012

products, tyres, automobile parts, machinery, equipments, fabric, yarn, essential commodity products, tea, marine fish, crafts & handlooms products, minor forest products etc.

Based on the above estimates of potential traffic a minimum of 25% considered in year 2018, 50% in 2020 and 75% in 2022 (150+50+150+50= 400 and 25% of that is 100, of that is 200 and 75% of that is 300) taking a conservative approach. The bilateral trade between India and Myanmar has grown from US\$ 408 million in 2001 to US\$ 1876 million in 2012. India accounts for 15% of Myanmar's export (second largest partner) and 3% of imports and there is a large potential for increasing the share of imports from India in Myanmar's imports³. With the initiatives being taken for enhanced trade, it is anticipated that the share of India in Myanmar imports will also substantially increase and a portion of these will be through Moreh. During the 4th Joint Trade Committee, both governments agreed to double the bilateral trade to US\$ 3 billion by 2015 from the US\$ 1.5 billion trade volume in 2010-11. Assuming about one-third of the export-import through land routes and Moreh being the main gateway from Myanmar, the potential of trade through Moreh is of the order of US\$ 600 million and this in terms of truck traffic based on broad assumptions is equivalent to about 750 trucks per day. With an annual growth of 14% in trade between India and Myanmar³ and the potential for trade with other ASEAN countries also through this corridor, it is safe to assume the potential will realize in the next 10 years and the potential for truck traffic is of the order of 1000 trucks per day along this corridor including empty trucks by 2022. This is also in line with the above estimate of about 400 trucks for import alone from Myanmar (almost 600 trucks including empty trucks). For the traffic estimation a total of 800 trucks per day (import and export together) is considered by 2022 with 25% realizing by 2018, 50% by 2020 and 100% by 2022. Considering the trade growth projections in the long term, this traffic is anticipated to grow at 8% per annum for the first 10 years from 2022 and 6% per annum for the following 10 years.

The increase in trade and economic activities along the corridor will also induce passenger vehicle traffic. The passenger traffic generated along the corridor is also expected to correspondingly increase. The OD survey indicates about 173 vehicles

³ *Enhancing INDIA - Myanmar TRADE AND INVESTMENT RELATIONS: A Brief Analysis, Working Paper 23, Export-Import Bank of India, September 2013*

per day originating at Moreh. The goods traffic is projected to increase by about 15 times and this is expected to induce large increase in passenger traffic for the analysis, a 5 times increase is considered – i.e., induced passenger traffic of 865 passenger vehicles by 2022. This will also happen over the years as in the case of goods traffic and it is assumed that 25% of this additional traffic each will add in 2016, 2018, 2020 and 2022.

The road upgrading will also improve the travel speed and travel condition along the Imphal-Moreh corridor and is expected to generate a road user cost saving of over 20% and this will result in additional traffic generation along the corridor which is taken at 10% of the traffic.

6.4 TRAFFIC ESTIMATE FOR ALTERNATE ROUTE BETWEEN WANGJING AND KHUDENGTHABI

This route is a track for most of its length and is currently not motorable during rainy season and rest of the year most of its length being track is used by some four wheel drive vehicles.. Once the road is developed, it is expected to carry traffic similar to other roads with the population and activity along the road corridor. The population of the villages along the road corridor is about 18,553 as of 2011 census. The project corridor is estimated to have a population of 28,000. The trip generation per capita (passenger vehicle km) was worked out for each passenger vehicle type from the state vehicle registration data, average annual vehicle km and occupancy. Using this per capita trip generation and population, likely passenger vehicle volumes are calculated. In case of goods vehicle, both this approach and based on consumption expenditure, average value of goods, population and per capita income, goods vehicle trip generation was estimated. The estimated vehicle trip generation along this alternate route is given in Table 6.4.

Table 6-4: Estimated Traffic Potential for the Additional Alignment

Vehicle category	Estimated traffic potential along alternate route based on population and trip generation rate (2013)
Car/Jeep/Van	292
Two Wheeler	551
Three Wheeler	86
Bus	83
Trucks	118 (48 trucks based on consumption expenditure)

A comparison of trips generated from villages along NH 39 between Thoubal and Moreh with a population of 34,400 along the corridor indicate similar passenger and goods traffic levels (Passenger trips per day - 4200 along NH 39 and 4600 passenger per day estimated along Alternate route; Goods tonnage per day - 790 along NH 39 and 825 (based on population) or 340 (estimated based on consumption expenditure) along Alternate route). The passenger trip estimate

along Alternate route is little higher in comparison to NH 39 observed traffic and therefore it is assumed that atleast two-third of the traffic estimated will be realized by the first year of opening of the alternate route. In case of passenger traffic, only cars/jeeps/van or bus is found along NH 39. Considering the travel pattern along NH 39, 90 percent of the estimated passenger trips is distributed among car and bus traffic and remaining 10 percent traffic using two and three wheeler in case of alternate route. The goods traffic level on NH 39 also includes goods from border trade at Moreh which is assessed at about half of it indicating the estimate based on consumption expenditure can be considered for the alternate route. The traffic on alternate route thus estimated for opening year is also given in Table 6-5.

Table 6-5: Projected Traffic along the Additional Alignment in Opening Year

Vehicle category	Traffic estimated to realize in the opening year (2018)
Car/Jeep/Van	572
Two Wheeler	181
Three Wheeler	42
Bus	25
LCV	48
Trucks	17

In addition, there is potential for large scale quarry development along this corridor with abundant quantity of good quality aggregate availability. Based on consultation with state PWD and others involved in the construction industry, it is estimated that about 200 trucks per day will be generated by developing the quarries. This is expected to happen within 5 years of opening of the road.

The alternate route will also attract some of the Imphal-Moreh traffic as travel distance will be same but being a state highway and with only two lane without paved shoulder, it is assumed that until the Imphal – Moreh corridor becomes congested, Imphal-Moreh traffic will not use the alternate route.

6.5 TRAFFIC PROJECTIONS

Traffic projections for all the homogenous sections were computed with the growth rates given in Table 6-3 and the traffic from chapter 4 (AADT). The yearly projections summary for 30 years from year 2013 for Vehicles and PCU and for each homogenous section of Project Road is given in Table 6-6.

Table 6-6(a): Year wise AADT Projections for Project Road Sections (VEH & PCU)

	HS 1		HS 2		HS 3		HS 4	
Year	Veh's	PCU	Veh's	PCU	Veh's	PCU	Veh's	PCU
2018	35737	31812	5183	5253	2505	2928	7995	7182
2019	38307	34025	5512	5575	2863	3312	8722	7830
2020	41308	36966	6298	6759	3442	4134	9739	9061
2021	44059	39317	6705	7188	3665	4403	10385	9632
2022	47685	43143	7782	9077	4476	5676	11735	11483
2023	50873	45898	8289	9656	4773	6061	12519	12213
2024	53842	48514	8771	10227	5066	6446	13253	12917
2025	56986	51282	9283	10837	5377	6857	14032	13663
2026	60316	54209	9828	11485	5706	7293	14857	14454
2027	63847	57312	10405	12175	6059	7762	15732	15294
2028	67588	60599	11016	12910	6432	8259	16660	16186
2029	69630	62468	11393	13446	6682	8633	17205	16770
2030	71738	64402	11786	14013	6943	9026	17771	17381
2031	73913	66406	12197	14614	7219	9445	18360	18023
2032	76161	68484	12628	15250	7509	9889	18972	18696
2033	78443	70550	13043	15823	7779	10286	19573	19327
2034	80085	72129	13372	16338	8008	10648	20034	19860
2035	81767	73754	13713	16879	8246	11027	20508	20413
2036	83486	75419	14065	17440	8494	11424	20997	20987
2037	85244	77130	14427	18024	8751	11838	21499	21582
2038	87047	78894	14804	18638	9019	12273	22018	22202
2039	88890	80702	15192	19277	9297	12727	22552	22844
2040	90777	82564	15594	19947	9588	13204	23104	23514
2041	92707	84475	16010	20646	9889	13702	23672	24209
2042	94683	86439	16440	21375	10203	14224	24257	24931

Table 6-6(b): Year wise AADT Projections for Alternative Route (VEH & PCU)

	AL Section1		AL Section 2	
Year	Veh's	PCU	Veh's	PCU
2018	900	933	900	933
2019	958	989	958	989
2020	1036	1095	1036	1095
2021	1142	1278	1108	1174
2022	1202	1314	1214	1349
2023	1277	1385	1289	1421
2024	1347	1452	1360	1491
2025	1421	1522	1435	1564
2026	1500	1597	1515	1642
2027	1584	1676	1600	1724
2028	1673	1760	1690	1811
2029	1721	1807	1738	1858

	AL Section1		AL Section 2	
Year	Veh's	PCU	Veh's	PCU
2030	1770	1855	1787	1906
2031	1821	1905	1838	1956
2032	1873	1955	1890	2006
2033	1926	2007	1943	2058
2034	1965	2046	1982	2097
2035	2004	2086	2021	2137
2036	2044	2126	2061	2177
2037	2084	2167	2101	2218
2038	2125	2208	2142	2259
2039	2166	2250	2183	2301
2040	2209	2293	2226	2344
2041	2252	2336	2269	2387
2042	2296	2380	2313	2431

The vehicle wise projections for four homogenous sections on NH 39 are set out in Annexure 6.1(a) to 6.1(d) and for two homogenous sections on alternative route are set out in Annexure 6.1(e) to 6.1(f).

6.6 CAPACITY AUGMENTATION

6.6.1 HOMOGENOUS SECTIONS

The projected traffic is compared with the Design Service Volume (DSV) at Level of Service (LOS) -B (for rural roads, IRC: 64- 1990) to examine whether the facility would be able to carry the anticipated traffic or capacity augmentation would be needed. The design service volumes and capacities based on IRC 64-1990 are shown in Table 6-7(a).

Table 6-7 (a) Design Service Volume (PCU/day)

As per IRC: 64 –1990 (Guidelines for Capacity of Roads in Rural Areas)			
Terrain	Lane Configuration	Design Service Volume (LOS B)	Design Service Volume (LOS C)
Plain Terrain with Low Curvature.	2 Lane with earthen shoulder	15,000	22,500
	2 Lane with 1.5m paved shoulder	17,250	25,875
	4 Lane with 1.5m paved shoulder.	40,000	60,000
As per IRC:SP48-1998 (Hill Road Manual)			
Hilly Terrain with Low Curvature.	2 Lane with earthen shoulder	7000	10,500
	2 Lane with 1.5m paved shoulder	8,050	12,075

Based on the above design service volume for LOS B and LOS C the capacity augmentation till 2045 is established and the summary is given in Table 6-7(b).

Table 6-7(b) Level of Service

Homogenous Section	Two lane with Earthen shoulder		Two Lane with Paved Shoulder		Four Lane with Paved Shoulder	
	LOS B	LOS C	LOS B	LOS C	LOS B	LOS C
HS 1	AA	2015	AA	2017	2022	2028
HS 2	2032	NA	2036	NA	NA	NA
HS 3 (Based on Hill roads manual)	2026	2034	2028	2038	NA	NA
HS 4	2027	2039	2030	NA	NA	NA
Alternative Route Section 1	NA	NA	NA	NA	NA	NA
Alternative Route Section 2	NA	NA	NA	NA	NA	NA

AA: Already Achieved & NA: Not Achieving Alternative Route Section 1: From Wangjing to Machi & Homogenous Section 2 from Machi to Khudengthabi

The level of service assessment indicates that HS1 is already exhausted its LOS B for two lane earthen shoulder and two lane paved shoulder configuration and four lane facility is warrants immediately. For HS 2, HS 3 and HS 4, LOS B is crossed by 2028 to 2036 with a two lane paved shoulder configuration which is within the design period of 20 years from opening year of 2018. For the two sections on alternative route, two lane with earthen shoulder will provide a LOS B all through the design period and beyond. Considering Alternate Route as a potential route for Imphal-Moreh traffic and the difficulty in developing a four lane road on hilly/mountainous terrain through which HS 3 and part of HS 4 is passing through, it is considered that the NH 39 in combination with Alternate route is providing sufficient capacity for HS 3. On NH 39, HS 1 well exceeds capacity of even 4-lane by 2028, it is recommended that HS 2 also to be developed to four lane facility to ease the pressure of development along HS 1 and extent the development all along the length up to Pallel town (foot of the hill). The summary of recommendation for all the four homogeneous sections is given below.

Table 6-7(c): Summary of Homogenous Sections.

Homogenous Section Details	Lane Configuration
HS 1: Imphal Junction to Thoubal Junction	Four-Lane paved shoulder
HS 2: Thoubal Junction to Pallel Junction	Two Lane paved shoulder
HS 3: Pallel Junction to Khudengthabi Village	Two-Lane paved shoulder
HS 4: Khudengthabi Village to Moreh Junction End	Two-Lane paved shoulder

Homogenous Section Details	Lane Configuration
Alternative Route Section 1 from Wangjing to Machi	Two Lane Configuration
Alternative Route Section 1 from Machi to Khudengthabi	Two Lane Configuration

6.6.2 CUMULATIVE MILLION STANDARD AXLES

Cumulative Million Standard axles were estimated from 2013 to 2037 for all the homogenous sections. Further lane distribution as well as directional distribution is considered as discussed below:

Directional Distribution Factor:

The value of 0.50 has been adopted as the directional distribution factor. This has been established from volume count data that split of vehicle distribution in either direction is more or less equal (51 to 49%).

Lane Distribution Factor:

For two lane single carriageway and dual two lane carriageways, the lane distribution is considered at 75% of the number of vehicles in each direction is adopted.

Vehicle Damage Factor (VDF):

The objective of analysis is to estimate the Vehicle Damage Factor (Mode wise). The Equivalency factor derived from the “fourth power rule” to achieve the Equivalent Standard Axle Load for the respective vehicle type.

Average VDF values are considered for each Homogenous section. As per IRC: 37-2001 clauses 3.3.4.4, for rolling 3.5 and for hilly 1.5 are considered.

The cumulative million standard axles (CMSA) have been computed for the recommended facility of 2/4 lane carriageway for a period of 20 years from 2018 by assuming the construction period of three years from 2015-16, 2016-17, and 2017-18. CMSA computations are given in Annexure 6-2. The computed CMSA for the all the sections are set out in table below:

Table 6-8: Summary of CMSA for Project Road Section and Alternative Route

Year	HS 1	HS 2	HS 3	HS 4	AS 1	AS 2
	4 Lane PS	2 Lane PS	2 Lane PS	2 Lane PS	2 Lane PS	2 Lane PS
2018	0.45	0.17	0.08	0.11	0.04	0.04
2019	0.92	0.36	0.17	0.23	0.09	0.09
2020	1.48	0.60	0.29	0.41	0.14	0.14
2021	2.07	0.86	0.42	0.59	0.21	0.20
2022	2.81	1.24	0.62	0.88	0.28	0.27

Year	HS 1	HS 2	HS 3	HS 4	AS 1	AS 2
2023	3.60	1.63	0.83	1.18	0.36	0.35
2024	4.42	2.05	1.06	1.50	0.43	0.43
2025	5.29	2.50	1.30	1.84	0.51	0.51
2026	6.20	2.96	1.57	2.20	0.58	0.60
2027	7.16	3.45	1.85	2.58	0.66	0.68
2028	8.17	3.98	2.15	2.97	0.75	0.77
2029	9.22	4.52	2.47	3.39	0.83	0.86
2030	10.32	5.09	2.81	3.83	0.92	0.96
2031	11.46	5.70	3.18	4.29	1.01	1.05
2032	12.64	6.33	3.57	4.78	1.09	1.15
2033	13.87	6.99	3.98	5.29	1.19	1.25
2034	15.15	7.68	4.41	5.82	1.28	1.35
2035	16.46	8.39	4.86	6.37	1.37	1.45
2036	17.83	9.14	5.33	6.95	1.47	1.55
2037	19.24	9.91	5.83	7.55	1.57	1.66

7 ENGINEERING ALTERNATIVES AND DETAILED DESIGN

7.1 Introduction

This chapter deals with the formulation of engineering improvements to the project road, keeping in mind the guidelines of IRC and MORT&H and also based on the recommendation of capacity augmentation and upgrading requirement of different sections of the project corridor.

Since one objective of design is optimization of cost to maximize benefits, the improvement measures have to be as cost-effective as possible without compromising the primary objective of providing sound engineering design with high standard of safety. As the project road passes through many built up locations, adoption of appropriate design philosophy and standards is therefore, very important to minimize the socio-economic impact. In this context, IRC standards and guidelines are found to be most suited for Indian conditions in general.

7.2 Basic Improvement Proposals

The engineering aspects of basic alternative improvement proposals mentioned at the end of Chapter 6 are discussed in the following sections and presented in brief in *Table 7.1*.

Table 7-1: Improvement Proposals

Sl.No	Improvements	Activities
1	Do Nothing	Only Routine & Periodic Maintenance and followed by PWD
2	Rehabilitation	On Existing 2-Lane Roads only; <ul style="list-style-type: none"> • Rehabilitation of existing pavement by overlay / reconstruction • New road markings • Shoulder Development by adding 2 m wide hard on valley side and 1 m paved shoulder on hill side. • Major repair of structures & appurtenances • Providing roadside drainage within ROW
3	Upgrading to Standard Two Lane with Paved Shoulders	<u>On Existing Roads less than 2-lane wide :</u> <ul style="list-style-type: none"> • Widening Intermediate Lane/ Sub-standard 2-lane Carriageway of mainline corridor to 7.0m • Strengthening of existing pavement • Building 2.0 Paved Shoulders on valley side and 1 m paved shoulder on hill side.

Sl.No	Improvements	Activities
		<ul style="list-style-type: none"> • New road markings • Realignment and Alternative construction of 2-lane configuration • Improving intersections and constructing grade-separators where necessary • Widening/upgrading of existing Structures and appurtenances • Providing roadside drainage and road lighting
4	Widening to Four Lanes with New Carriageway and Median	<p>Where traffic Demands 4-laning within next 10 years :</p> <ul style="list-style-type: none"> • Constructing new 2-lane carriageway and structures • Strengthening of existing pavement • Building 1.5 m paved shoulders & 2.0m earthen shoulders • New road markings • Providing 4.5m wide median in rural stretches and 1.5 m median in urban and constricted stretches • Alternative Realignment and bypass construction with 4-lane configuration • Improving intersections and constructing grade-separators where necessary • Widening/upgrading of existing structures and appurtenances • Providing roadside drainage and road lighting • Providing environmental mitigation/enhancement measures

7.2.1 *Do Nothing:*

This is the baseline scenario against which all higher investment proposals are compared in terms of economic benefits accrued over the analysis period. In this simplest and, as the name suggests, the least -intervention option, only maintenance carried out by the road agency routinely and according to departmental norms are considered. The work would involve:

- Routine maintenance of pavement and structures every year primarily through departmental work-force.
- Period maintenance work scheduled every 3 or 4 years out of non-plan budget of the department comprising a thin overlay of pre-mix carpet or

MSS after pothole patching etc. (In practice, however, periodic maintenance is usually carried out on a responsive basis i.e. as and when required. Scheduled intervention has been considered here for convenience).

In 'do nothing' case, the pavement is allowed to deteriorate without structural strengthening except to limit the roughness to say 8 or 9 IRI.

1. Rehabilitation:

Rehabilitation or "Rehab" is the improvement scenario applicable in case the existing road is at least 7m wide and there is no requirement of carriageway widening to meet 2-lane standard as such. The only intervention required is a strengthening overlay or reconstruction of the pavement. However, if shoulders are absent, then new hard/gravel shoulders are added not only to enhance safety but also to provide lateral support to the newly laid pavement.

In this improvement option, no geometric improvement is envisaged and all works are confined to the existing ROW with minimum disturbance to roadside activities. Bridges and structures will only be repaired and strengthen and not widened at all.

2. Widening to 2-lane standard

For the project corridor being studied, upgrading the existing road to 2-lane standard with paved and earthen shoulders, as per IRC and other codes, is the most realistic scenario that would satisfy the projected traffic for all but two section of the project corridor (refer *Chapter 6*). This improvement alternative involves implementing all the measures explained in *Table 7.1* above. All road sections with sub-7m carriageway would qualify for this level of intervention. Even the existing 7m wide road sections (constituting about 97.600 km of the total 100.400 km corridor length) would be upgraded standard 2-lane facility including widening of bridges and structures.

3. Widening to 4-lane standard

Finally, the most expensive level of upgrading discussed is the widening of the existing single carriageway road to a 2x2 dual carriageway facility. The activities involved are shown in *Table 7.1* in brief. 4-laning of an existing highway passing through built-up areas with active local life and limited ROW, is always a difficult and disruptive choice from the point of view of environmental, social and LA aspects. Therefore, decision to widen to 4 lanes by constructing a new carriageway eccentrically is to taken after serious deliberation. All said, if traffic volume in near future demands dualling, it has to be considered as necessary. Conversely, 4-laning option is applied in economic evaluation to examine the efficacy in a life-cycle situation and may only lead to rejection of the option if found unviable.

Improvement proposals for upgrading the existing two lane to four lane from 330+000 to km 366+200 (for a total length of 33.200 kms in plain terrain) and upgrading the existing 2 lane in hill section to standard two lane with paved section from km 366+200 to km 425+411 are the most likely upgrading levels that would apply to the project road, the rest of this chapter deals with the engineering solutions for these two alternatives primarily and makes preliminary recommendations where possible and necessary to assist decision making to take the study forward to the DPR stage.

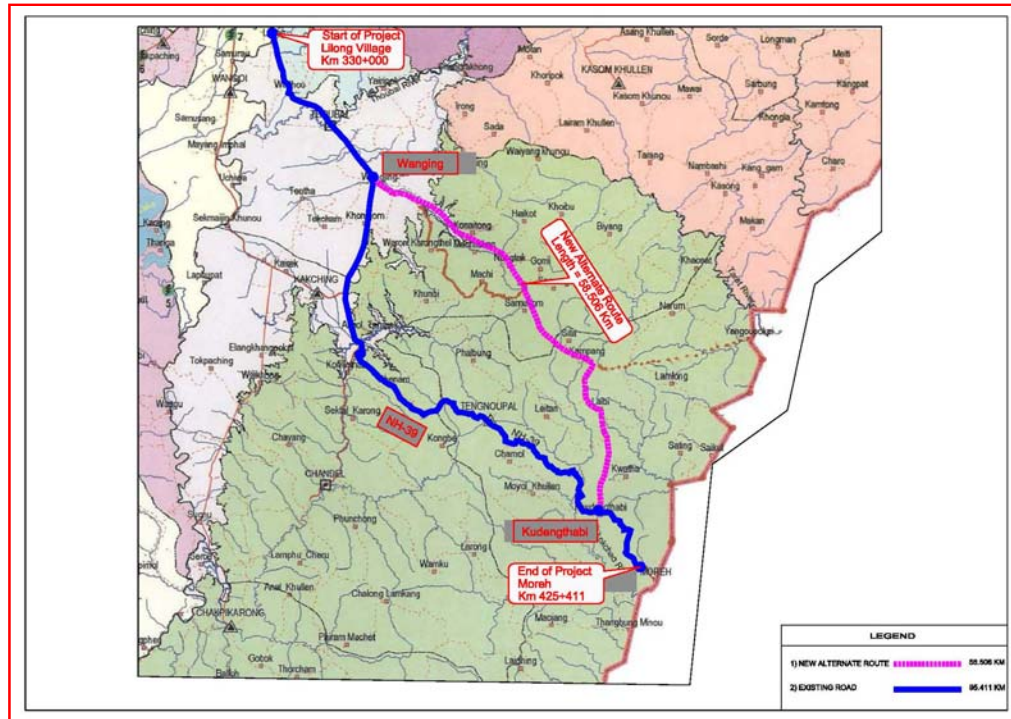
7.3 Alternative Alignment

The said alternate alignment takes off from the project corridor from Wangjing town at its km 350+000 and follows the existing Major District Road (MDR) up to Heirok town. There from the alternative alignment passes adjacent to the Heirok Military camp on a track for a length of 0.5 kilometers to join the track on hill section. Further the track passes through several villages in hilly terrain and merges with another major district road which connects Machi Junction

There is a common portion of an alternative alignment for the MDR (Tengupoal-Machi) as well as the alternative alignment from the Machi junction to Sita village junction and the width of carriageway is varies from 3.0 to 4.0 m only. Further the alternative takes left turn from the Sita village check post and passes through track on hill section and finally merges with NH 39 near Khudengthabi.

Alternative alignment passes on the mountain ridge for majority of its length the requirement of either bridges or culverts are very less. The track is not in use for motorized traffic except few motor cycles from the adjacent villages and. There was a land slide observed in between Machi village and Sita village where there was a land slide observed in between.

In this alignment there is requirement five minor bridges and culvert. The available road formation is varying from 5.5 m to 7.0 m approximately including drains. The length between Wangjing and Khudengthabi along this alternative alignment is about 58.506 kms which is same as the case of project corridor on NH 39. The development of this road helps to provide access the population along the proposed alignment for marketing the agricultural products. The major portion of this road travels on the ridge portion there by reducing the necessity of major structures. The cost benefit analysis will be studied for the alternative alignment in comparison with the existing project road corridor. Alternative alignment is shown in Figure 7-1.

Figure 7-1 Alternative Alignment

7.4 Development of Engineering Solutions

Expanding on the discussion in the previous section, the engineering solutions that emerged from the capacity augmentation requirement and the condition of the existing roads considered over a 30-year life cycle period, were:

- Rehabilitation of existing 2 - lane road and providing shoulders
- Widening of existing features as necessary to two lanes with paved and earthen shoulders
- Widening of existing features as necessary to two lane with paved and earthen shoulders and service road on built up locations
- Widening of existing features as necessary to four lane with paved shoulder
- Widening of existing features as necessary to four lanes with paved shoulder and service road on built up locations

The improvement proposals for the different road sections recommended in Chapter 6 are presented in *Table 7.2*.

Table 7-2: Recommendation for Capacity Augmentation

Sl.No	Homogenous Section Details	Recommendation on Capacity Augmentation
1	HS 1: Lilong to Thoubal (km 330 to km 342+600)	4 Lane with Paved shoulder and service road on built up location.

Sl.No	Homogenous Section Details	Recommendation on Capacity Augmentation
2	HS 2: Thoubal to Pallel (km 342+600 to km 365+900)	2 Lane with paved shoulder
3	HS 3: Pallel to Khudangthabi (365+900 to km 417)	2 Lane with Paved shoulder.
4	HS 4: Khudangthabi to Moreh (km 417 to km 425+411)	2 Lane with Paved shoulder.
5.	Alternative Alignment from Wangjing to Khudangthabi (km 0+000 to km 58+506)	Two Lane Configuration

7.5 Design Standards

Although the project road is composed of National Highway and State Highway warranty the corresponding set of design standards recommended by IRC, the nature of land use abutting the corridor has made introduction of location specific deviation essential from the point of view of safety and socio economic contribution. The design considerations and the standards adopted to formulate the typical cross sections and for preliminary design are discussed in the following sections.

The following IRC codes, inter alia, were used as reference:

- IRC: 3-1983 : Dimensions and Weights of Road Design Vehicles
- IRC: 37-2001 : Guidelines for the Design of Flexible Pavements
- IRC: 48-1988 : Hill Roads Manual
- IRC: 58-2002 : Rigid Pavements for Highways
- IRC: 64-1990 : Guidelines for Capacity of Roads in Rural Areas
- IRC: 70-1977 : Guidelines on Regulation and Control of Mixed Traffic in Urban Areas
- IRC: 73-1990& : Geometric Design Standards for Rural (Non Urban)
- IRC: 86-1983 : Geometric Design Standards for Urban Roads in plains
- IRC SP-73-2007 : 2 Lane manual for PPP project
- IRC SP-84-2010 : 4 Lane manual for PPP project
- IRC: 81:1997 : Flexible Road Pavements Using Benkelman Beam Deflection Technique
- IRC-SP 13:2004 : Guidelines for the Design of Small Bridges and Culverts

Besides, AASHTO and the TRL guidelines for pavement and geometric design were appropriately referred to.

7.5.1 GEOMETRIC DESIGN STANDARDS

The salient parameters for the geometric design of roads suggested are given in Tables 7.3 to 7.7.

Table 7-3: Design Speed

Type of Section	Ruling		Absolute Minimum
	Desirable	Minimum	
Rural	100 km/h	80 km/h	60km/h
Urban/Builtup Section	60 km/h	50 km/h	30 km/h*
Hill Roads	Ruling	Minimum	-
National and State Highways	50 km/h	40 km/h	-
Major District Roads	40 km/h	30 km/h	-

* From the point of view of safety only.

Safe stopping sight distances confirm to an object height of 0.15 m and driver's eye level of 1.05 m above road.

Table 7-4:Sight Distance Standards

Palin/Rolling Terrain				Hilly Terrain		
Design Speed (km/h)	Sight Distance (m)			Design Speed	Stopping Sight Distance	Intermediate Sight Distance
	SSD	ISD	OSD			
100	180	360	640	25	25	50
80	130	240	470	30	30	60
60	80	160	300	35	40	80
50	60	120	235	40	45	90
30	30	60	110	50	60	120

On hill roads stopping sight distance is absolute minimum from safety angle and must be ensured regarding of any other considerations. Radii for the plain terrain and hilly terrain are given in Table 7-5 and 7-6 respectively.

Table 7-5:Geometric Standards for Horizontal Alignment

Particulars	Design Speed(km/h)				
	100	80	60	50	30
Minimum radius of horizontal curve(m)*	400	255	130	90	35
Maximum super elevation 'e'	5%	5%	5%	5%	5%

* Minimum radius of the curve calculated based on maximum super elevation value of 5% and friction coefficient of 15%.

Table 7-6: Minimum Radii of Horizontal Curves

Classification	Mountainous Terrain	
	Areas not affected with Snow	
	Ruling Min (m)	Absolute Min (m)
National Highways and State Highways	80	50
Major District Roads	50	30

The super-elevation should be attained gradually over the full length of the transition curve so that the design super-elevation is available at the starting point of the circular portion. In case where transition curve cannot be provided for some reason, 2/3 of the super elevation may be attained on the straight section before start of the circular curve and the balance 1/3 on the curve.

In developing the required super-elevation, it should be ensured that the longitudinal slope of the pavement edge compared to the centre-line (i.e., the rate of change of super-elevation) is not steeper than 1 in 150 for roads in plain and rolling terrain.

Methods of attaining Super elevation in Hill Roads: The normal cambered section of the road section is changed into super elevation section in two stages. First stage is the removal of adverse camber in outer half of the pavement. In the second stage, super elevation is gradually built up over the full width of the carriageway so that required super elevation is available at the beginning of the circular curve. There are three different methods for attaining super elevation;

- (i) Revolving pavement about the Centre line;
- (ii) Revolving pavement about the inner edge and;
- (iii) Revolving pavement about the outer edge

When culverts fall on a horizontal curve, the top surface of the wearing course of culverts should have the same profile as the approaches. The super-elevation may be given to the abutments keeping the deck slab thickness uniform as per design. The level of the top of the slab of the culverts should be the same as the top level of the approaches so that undue jerk while driving on the finished road is avoided.

On Indian highways, the proportion of slow moving vehicles and heavily laden commercial vehicles in the traffic stream is substantial. Consequently, it has been observed, 70% to 80% of the vehicles travel at two-third of the design speeds. Also, speed restrictions are often imposed on curves because of line-of-sight limitations. Therefore, vehicles travelling at speeds less than the design speed, particularly the SMVs such as tractor-trailers find it difficult to negotiate superelevation higher than 5%. Slow traffic on the outer lane (s) on a curve tend to drift toward the centre of the curvature (i.e. toward the fast lane) posing hazard to themselves and all other road users. The other issue is the roll-over factor, which affects slow-moving vehicles, against travelling on the outer lane of curve. The camber break between the carriageway lane and the paved shoulder, i.e. the roll-over, has to be restricted to 8% else vehicles like tractor-trailers would overturn. Assuming that the paved shoulder camber cannot be less than 2.5%, the super-elevation shall be limited 5% so that the roll-over (2.5% + 5%) remains within 8%. However this required a flatter radius than what is proposed in the *Table 7.7*.

Table 7-7: Longitudinal Gradients in Rural Stretches (Plain/Rolling Terrain)

Particulars	Design Speed (km/h)			
	100	80	60	50
Gradient				
Ruling maximum	3.3%	3.3%	3.3%	4%
Absolute maximum	3.3%	4%	4%	4%
Min. 'K' Value (for safe stopping sight distances)				
Summit curves				
SSD	74	33	14.5	8.2
ISD	135	60	27	15
OSD	427	230	94	58
Sag curves	43	26	15	10
Grade difference not requiring vertical curve	0.5%	0.6%	0.8%	1.0%

Note: Length of curve = $K \times \text{grade difference in per cent}$

Hilly Terrain: broken back grade lines, i.e. two vertical curves in the same direction separated by a short tangent, should be avoided due to poor appearance, and preferably replaced by a single curve. Decks of small cross drainage structures (i.e culverts and minor bridges) should follow the same profile as the flanking road section, with no break in the grade lines;

The proportion of slow moving vehicles and heavily laden commercial vehicles in the traffic stream is substantial. Consequently, it has been observed, 70 to 80% of the vehicles travel at two-break in the grade line. Recommended gradients for different terrain conditions, except at hair-pin bends are given in table below:

Table 7-8: Recommended Gradients for Different Terrain Conditions

Classification of Gradient	Mountainous Terrain and steep terrain more than 200 m above MSL	Mountainous Terrain up to 3000 m height above MSL
Ruling Gradient	5% (1 in 20.0)	6% (1 in 16.7)
Limiting Gradient	6% (1 in 16.7)	7% (1 in 14.3)
Exceptional	7% (1 in 14.3)	8% (1 in 12.5)

Note: Gradients upto the ruling gradients may be used as a matter of course in design.

Table 7-9:Cross-Sectional Elements

Element Characteristics	Design Values	
	Ruling	Minimum
Widths		
Lane	3.5 m*	-
Paved shoulder	2.0 m/1.5m	1.5 m
Earthen shoulder	2.0 m	1.0 m
Slow/parking lane	2.5 m	1.5 m
Median	1.50m with RCC crash barrier. If standard wide median of 4.5m is provided, no crash barrier would be required.	
Footpath	2.5 m	1.5 m
Cross-Fall		
Carriageway	2.5%	0.5%***
Paved shoulder	2.5%	0.5%
Hard /gravel shoulder	4.0%	1.0%
Earthen shoulder	4.0%	1.0%
Footpath	3.0%	1.0%
Median top	4.0%	-
Embankment Side Slope (Vertical:horizontal)		
Fill	1(V):2(H) (min)	1(V):1.5(H)
Cut	2(V):1(H)	

* Add 0.25m on each kerb side to account for kerb shyness.

** Wide paved shoulder where necessary (ref: Para 7.4.5).

*** At junctions only, where camber may reduce to zero for level matching with cross roads

7.5.2 WIDENING OPTIONS

Capacity augmentation requirement necessitate widening of pavement throughout the section in the form of adding paved shoulder, service road, additional lanes etc. Dual carriage way is proposed where 4 lane sections is required. The dual carriageway ensures improvement of road safety by physically separating the traffic in each direction.

Options of eccentric and concentric widening to be chosen judicially as this will impact land acquisition, cost and also traffic movement during construction.

The pros and cons of each method are described below:

7.5.2.1 Eccentric Widening

In this method, the new carriageway with two or more lanes or paved shoulder is constructed along with all structures on one side of the existing carriageway without disrupting the traffic movement. The existing carriageway becomes, after strengthening and partial widening for shoulders, the second carriageway for

traffic flow in the other direction. A median usually of 1.5m is provided in the gap between the two carriageways.

The advantages of eccentric widening are:

- The traffic movement is least disturbed on the existing carriageway while the new carriageway is being constructed. The traffic shifts to the new carriageway when ready and unhindered work can be carried out on the old carriageway.
- The existing pavement can be fully utilized even after widening.
- Wider space is available for construction of pavement and structure in the new carriageway.

The major disadvantage in this method is that optimization of ROW is not possible in certain case as in general existing road is placed on the center of the ROW. Further on built up location acquisition on one side / unsymmetrical may lead to public resent and in the present climate of possessiveness of individual land holders, this is a major deterrent. Another disadvantage of eccentric widening is the additional cost of profile correction, if strengthening of existing pavement is suggested. However in case of reconstruction of existing pavement no additional cost will involve in the case of eccentric pavement.

7.5.2.2 Concentric Widening

Concentric or symmetrical widening involves widening the existing carriageway on both sides by equal extent. The final dual carriageway centerline remains coincident with the existing Centre – line.

The advantages of concentric widening are:

- Concentric widening is beneficial if the available ROW is more than the corridor of impact, since the roadway with normal embankment slopes can be accommodated without LA.
- Profile corrective cost will be minimum in case of concentric widening.

In all other cases, if LA and R&R considerations are not overriding, concentric widening should be avoided because:

- Traffic management during construction is a major issue because of reduction in roadway width.
- The existing pavement is wasted under the median in case of 4 lane.
- Widening on each side in small strips is uneconomical and construction wise unwieldy.

7.5.2.3 Conclusion on widening option

Therefore, by default, eccentric widening is considered for this study. However, concentric widening in semi-urban/urban stretches is definitely preferable to avoid unnecessary R&R and drainage problems.

In additional to all it is not advisable to shift side of widening so frequently as that will leads to serious traffic management issue and also need additional curves to be introduced to transit from one scheme to another. As in the case of addition of paved shoulders, some of the bridges may not be widened if the existing width is more than the requirement given in MORTH circulars on widening of existing structures. In this case concentric widening to be considered invariably. So wherever such constrains like bridge or built up locations exist at very closer interval concentric widening will be preferred. The widening scheme proposed for this project is given in Table 7.10 below:

Table 7-10: Proposed widening scheme

S.No	Design Chainage(m)		Length(m)	TCS Type	Type of Widening
	From	To			
1	330000	330600	600	1	Eccentric
2	330600	332300	1700	4	Concentric
3	332300	332800	500	2	Concentric
4	332800	333200	400	4	Concentric
5	333200	334000	800	2	Concentric
6	334000	334300	300	4	Concentric
7	334300	334700	400	1	Eccentric
8	334700	335060	360	3	New Construction
9	335060	335300	240	2	Concentric
10	335300	335700	400	1	Eccentric
11	335700	336100	400	3	New Construction
12	336100	336600	500	1	Eccentric
13	336600	337560	960	3	New Construction
14	337560	338400	840	2	Concentric
15	338400	339850	1450	4	Concentric
16	339850	340700	850	2	Concentric
17	340700	342240	1540	4	Concentric
18	342240	342930	690	10	Concentric (VUP)
19	342930	343600	670	9	Concentric
20	343600	345100	1500	9	Concentric
21	345100	345600	500	9	Concentric
22	345600	346000	400	9	Concentric
23	346000	348090	2090	9	Concentric
24	348090	349300	1210	11	Concentric (VUP)

25	349300	350100	800	9	Concentric
26	350100	352300	2200	9	Concentric
27	352300	353300	1000	9	Concentric
28	353300	357600	4300	9	Concentric
29	357600	358100	500	9	Concentric
30	358100	359610	1510	9	Concentric
31	359610	360530	920	11	Concentric (VUP)
32	360530	364600	4070	9	Concentric
33	364600	366200	1600	9	Concentric
34	366200	373730	7530	6	Eccentric(Hill Side)
35	373730	374020	290	8	Concentric
36	374020	418000	43980	6	Eccentric(Hill Side)
37	418000	423200	5200	6	Eccentric(Hill Side)
38	423200	425400	2200	8	Concentric

Alternate Route

39	0	6060	6060	8	Concentric
40	6060	61450	55390	6	Eccentric(Hill)

7.5.3 MEDIAN

The median is provided in a dual carriageway road to segregate horizontally opposite directional traffic. Its primary objective is to eliminate the possibility of head-on collision. The width of the median is of great significance.

IRC recommends 4.5m median on national and state highways with raised kerb. The width is considered sufficient for a vehicle losing control and mounting the median to recover and return to its own side of the highway. The raised kerb serves wheel guards (although its efficacy is suspect and may even be detrimental to safety as high speed vehicles tend to topple over after hitting the kerb). Median having width less than 4.5m must be provided with a crash barrier, either New Jersey RCC type or metal beam type because of reduction of critical recovery zone. Only where unavoidable - existing carriageway profile will be kept different elevation from new carriageway.

7.5.4 PAVED SHOULDERS

2.0 m wide paved shoulders have been adopted as an improvement option strategy for many upgrading cases. IRC recommends 1.5m wide paved shoulder on either side of carriageway of 2-lane width or more. The usefulness of a paved (or even

hard) shoulder is beyond dispute. One of the most important uses of a shoulder is to provide space for movement of slow-moving vehicles and for routine and emergency parking of vehicles.

7.5.5 SERVICE ROADS

Service roads on both sides are envisaged in congested towns / villages locations to segregate the slow moving local traffic from the high speed highway traffic. This will also cater to the need of the local pedestrians and vehicles to travel without hindering the high-speed highway traffic. In view of social aspects and density of population of Manipur, consultants feel that such built-up locations need to be provided with service road. But when considering the economy of the project, proposal of service roads are restricted at unavoidable locations. However service roads are provided on all built-up areas where raising of embankment is required due to over topping. All together service roads provided for a length of 8.5km split in 4 stretches and its details are given in *Table 7.11*.

Table 7-11: Location details of service roads proposed

SL No	Chainage (km)		Length (m)	Side	Name of Village/Town
	Start	End			
1	330+600	332+300	1700	B/S	Lilong Bazar
2	332+800	333+200	400	B/S	LilongHangamthobi
3	334+000	334+300	300	B/S	Ushopokpi
4	338+400	339+850	1450	B/S	Thoubal Town
5	340+700	342+240	1540	B/S	Thoubal Town
6	342+240	342+930	690	B/S	Thoubal Town
7	343+600	345+100	1500	B/S	Khangbok Town
8	345+600	346+000	400	B/S	Wangbal Village
9	348+090	349+300	1210	B/S	Wangjing Town
10	352+300	353+300	1000	B/S	Khongjom Town
11	357+600	358+100	500	B/S	Sora Village
12	359+610	360+530	920	B/S	KakchingLamkhai
13	364+600	366+200	1600	B/S	Pallel Town

7.5.6 TYPICAL CROSS-SECTIONS

Based on the standards and the discussions mentioned earlier typical cross-sections for application in different common situations and for assessment of preliminary costs have been developed after considerable deliberations. The types and situations attracting these cross-sections are briefly described as under:

Figures 7.2 to 7.11 show some of the typical cross-sections (refer Volume III: Drawings for details) considered as strategies in this study.

Refer Vol III: Drawings for more specific applications

Figure 7.2-TCS 1:Eccentric Widening in Rural areas – 4 lane carriageway

Figure 7.3-TCS 2 : Concentric Widening in Rural areas – 4 lane carriageway

Figure 7.4- TCS 3: New/Reconstruction in Rural areas – 4 lane carriageway.

Figure 7.5-TCS 4: Concentric Widening for 4 Lane in Urban/Built-up with Service Road

Figure 7.6-Type 5:Valley side Widening in Hill Areas- 2 lane carriageway

Figure 7.7-Type 6:Hill side Widening in Hill Areas- 2 lane carriageway.

Figure 7.8-Type 7: Both Hill & Valley side Widening in Hill Areas- 2 lane carriageway

Figure 7.9-Type8 : Concentric Widening in Urban Areas- 2 lane carriageway

Figure 7.10-Type 9: Concentric Widening in Rural Areas- 2 lane carriageway

Figure 7.11-Type 10: Typical Cross section for VUP Approach with Service Road

Figure 7.11-Type 11: Typical Cross section for Two lane VUP Approach with Service Road

Application of the different typical road cross-sections will depend on the capacity augmentation requirement, the availability of Right of Way, land use pattern etc. Use of retaining walls or geo-textile in slopes at restricted ROW locations is also recommended. Details of widening proposals and adopted typical cross section type are given in Table 7-12 below.

Table 7-12: Details of proposed cross section

SL.No	Design Chainage(m)		Length(m)	TCS Type	Type of Widening	Homogenous Section
	From	To				
1	330000	330600	600	1	Eccentric	1
2	330600	332300	1700	4	Concentric	
3	332300	332800	500	2	Concentric	
4	332800	333200	400	4	Concentric	
5	333200	334000	800	2	Concentric	
6	334000	334300	300	4	Concentric	
7	334300	334700	400	1	Eccentric	
8	334700	335060	360	3	New Construction	
9	335060	335300	240	2	Concentric	
10	335300	335700	400	1	Eccentric	
11	335700	336100	400	3	New Construction	
12	336100	336600	500	1	Eccentric	
13	336600	337560	960	3	New Construction	
14	337560	338400	840	2	Concentric	
15	338400	339850	1450	4	Concentric	
16	339850	340700	850	2	Concentric	
17	340700	342240	1540	4	Concentric	
18	342240	342930	690	10	Concentric (VUP)	
19	342930	343600	670	9	Concentric	2

SL.No	Design Chainage(m)		Length(m)	TCS Type	Type of Widening	Homogenous Section
	From	To				
20	343600	345100	1500	9	Concentric	
21	345100	345600	500	9	Concentric	
22	345600	346000	400	9	Concentric	
23	346000	348090	2090	9	Concentric	
24	348090	349300	1210	11	Concentric (VUP)	
25	349300	350100	800	9	Eccentric	
26	350100	352300	2200	9	Concentric	
27	352300	353300	1000	9	Concentric	
28	353300	357600	4300	9	Concentric	
29	357600	358100	500	9	Concentric	
30	358100	359610	1510	9	Concentric	
31	359610	360530	920	11	Concentric (VUP)	
32	360530	364600	4070	9	Concentric	
33	364600	366200	1600	9	Concentric	
34	366200	373730	7530	6	Eccentric(Hill Side)	3
35	373730	374020	290	8	Concentric	
36	374020	418000	43980	6	Eccentric(Hill Side)	4
37	418000	423200	5200	6	Eccentric(Hill Side)	
38	423200	425411	2211	8	Concentric	
39	000	6060	6060	8	Concentric	Alternative Route
40	6060	61450	55390	6	New Construction	Alternative Route

7.6 Earthwork Design

7.6.1 EMBANKMENT HEIGHT

From the inventory analysis, it is observed that the project road has embankment height varying from zero to 1.0 m only and HFL during monsoon season will be above natural ground level in many places. Raising of the embankment is proposed for total section in Plain Area in between Imphal and Pallel. Section wise length for requirement of rising of embankment on account of in adequate height is given in Table 7.13.

Table 7-13: Requirement of raising of embankment

Sl.No	Chainage (km)	Section	Length of Raising (km)	Average Raising(m)
1	330+000 to 334+300	Lilong to Thoubal	4300	1
2	343+300 to 344+300	Thoubal to Pallel	1000	1

Sl.No	Chainage (km)	Section	Length of Raising (km)	Average Raising(m)
3	345+500 to 347+500	Thoubal to Pallel	2000	1
4	349+000 to 351+000	Thoubal to Pallel	2000	1
5	353+000 to 365+000	Thoubal to Pallel	12000	1

7.6.2 EMBANKMENT STABILITY

The soils locally available for embankment construction are dominantly clayey silts and silty sands of low plasticity. For preliminary design purposes, embankment slopes (V:H) of 1:2 have been adopted. Even when well compacted, the slope face may be subject to erosion, and protection will be carried out. This may include:

- Planting of the slope face with grass.
- on high embankments, for example on bridge approaches, channelizing surface water flow through kerbing and lined chutes at regular intervals.



Figure 7-4: TCS 3- New/Reconstruction in Rural areas – FOUR LANE CARRAIGEWAY

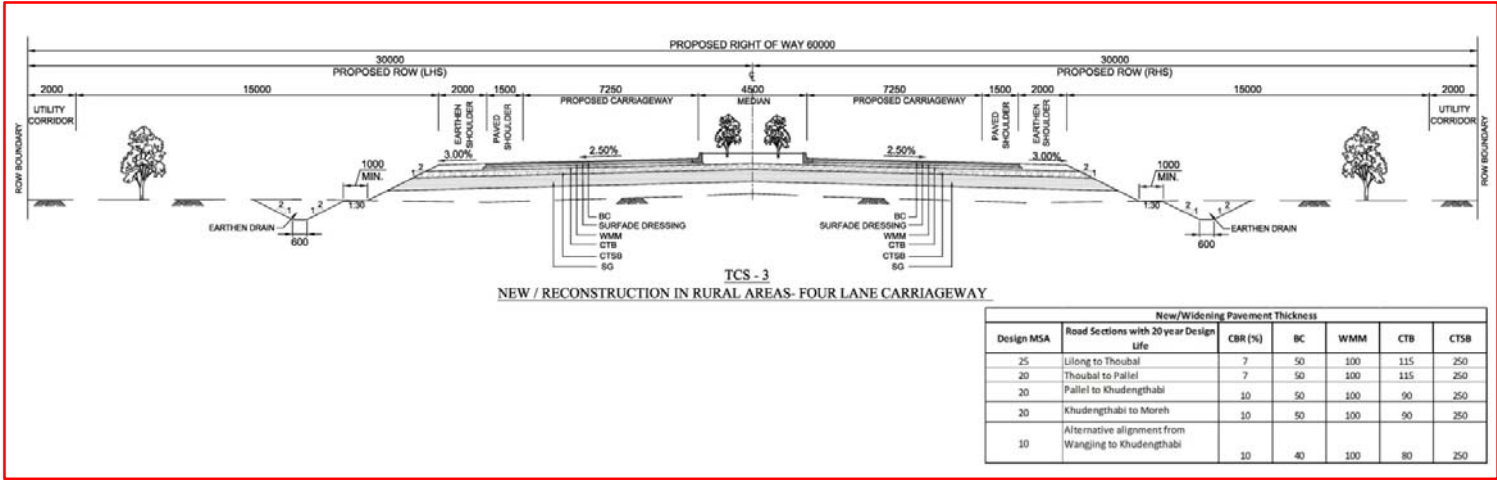


Figure 7-5: TCS 4 - Concentric Widening for Four lane in Urban/Built-up with Service Road

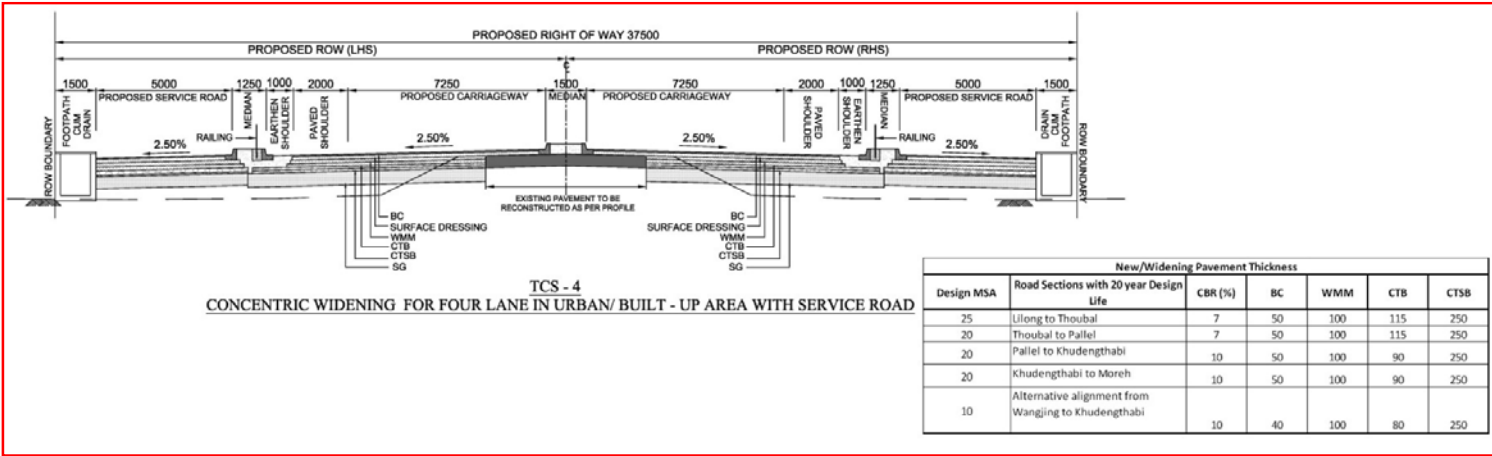


Figure 7-6: TCS 5- Valley side Widening in Hill Areas- TWO LANE CARRAIGEWAY

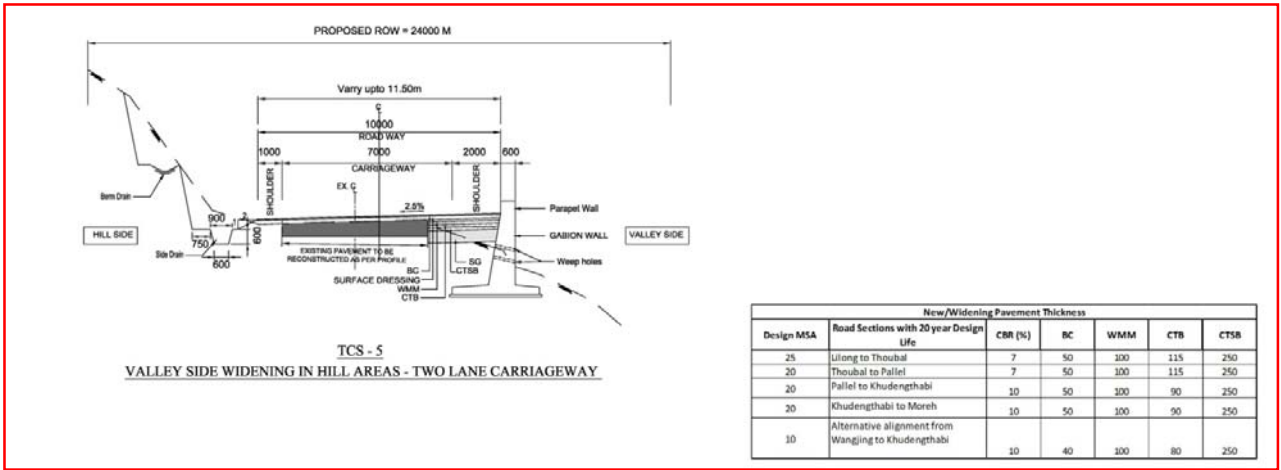


Figure 7-7: TCS 6- Hill side Widening in Hill Areas- TWO LANE CARRAIGEWAY

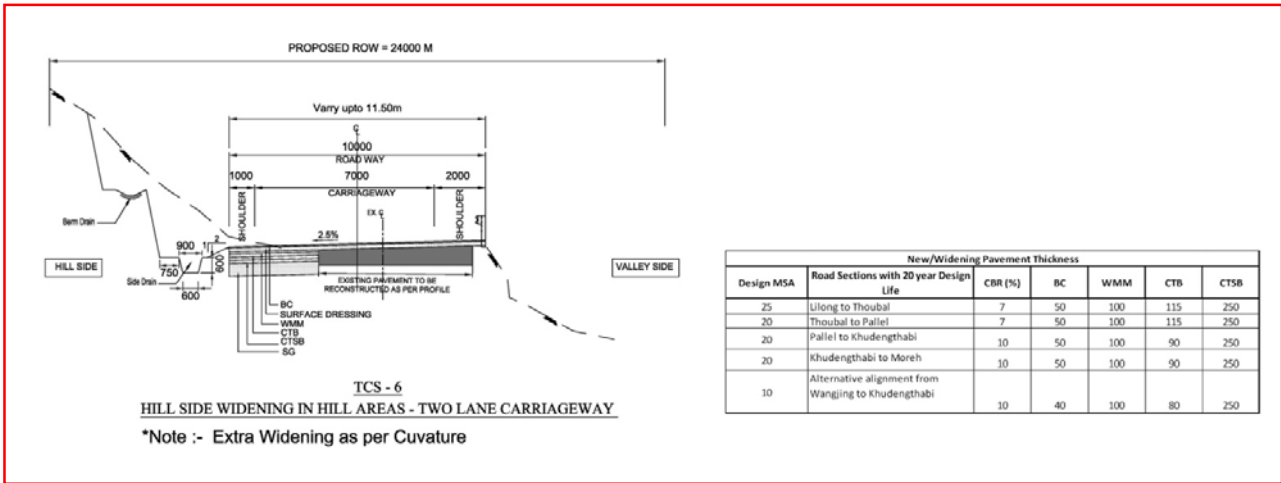


Figure 7-8: TCS-7-Both Hill & Valley side Widening in Hill Areas- TWO LANE CARRAIGEWAY

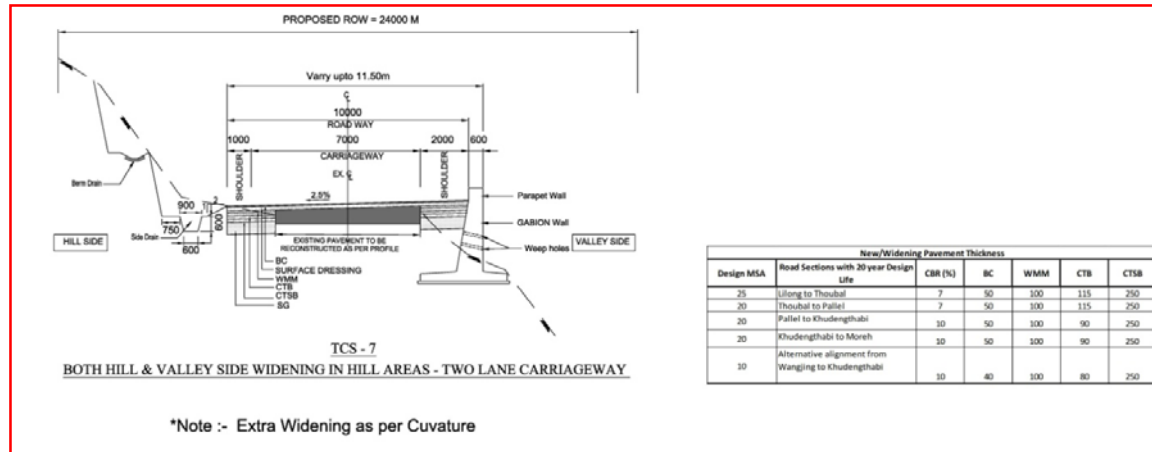


Figure 7-9: TCS-8-Concentric Widening in Urban Areas- TWO LANE CARRAIGEWAY

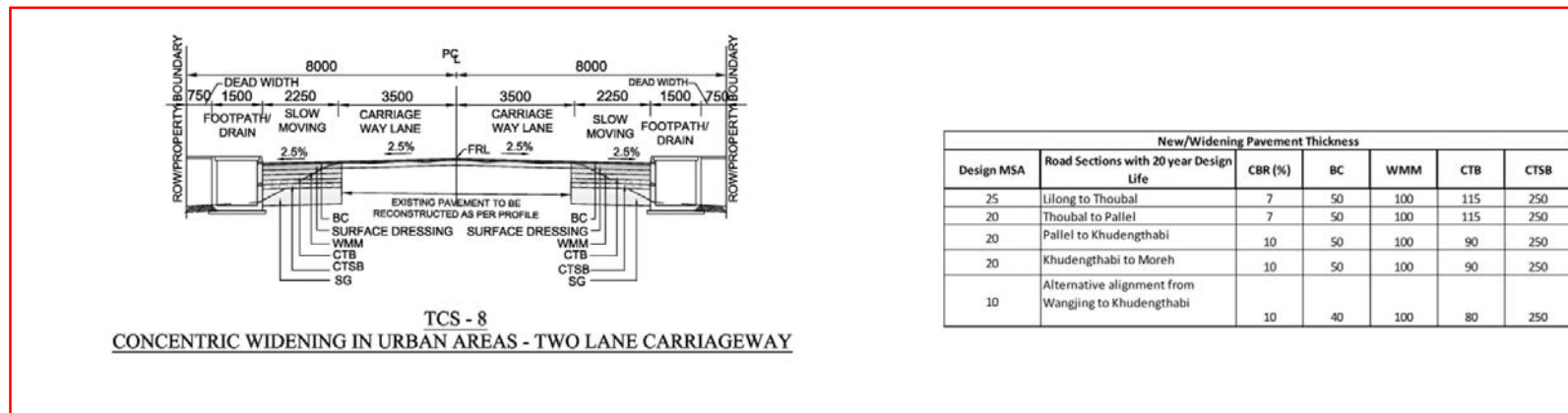


Figure 7-10: TCS-9- Concentric Widening in Rural Areas- TWO LANE CARRAIGEWAY

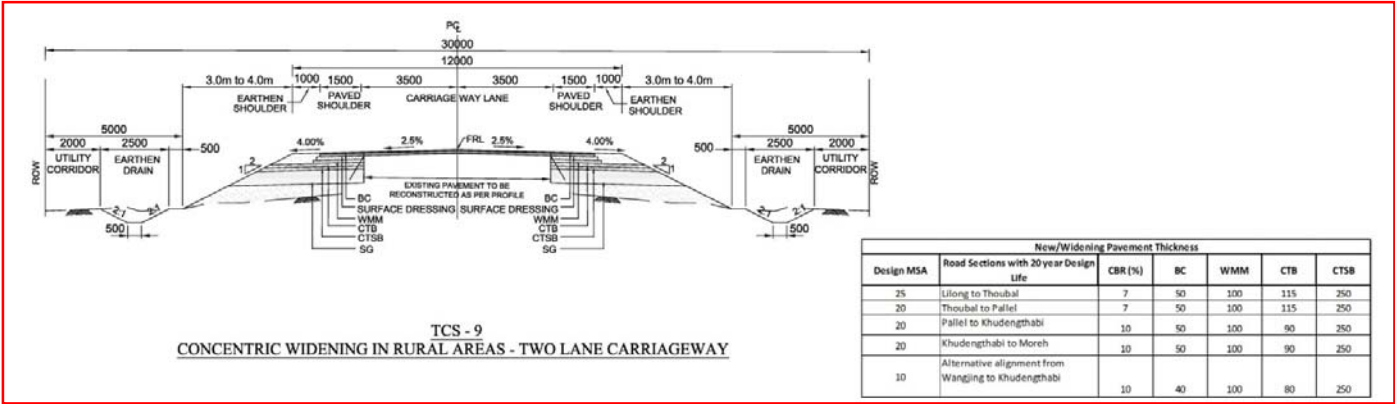


Figure 7-11: TCS-10-Typical Cross section for VUP Approach with Service Road

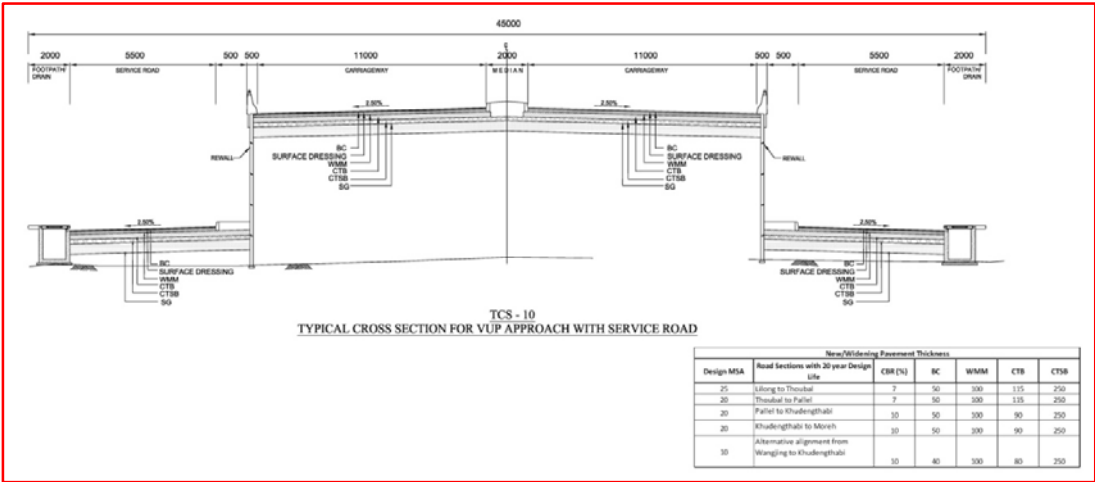
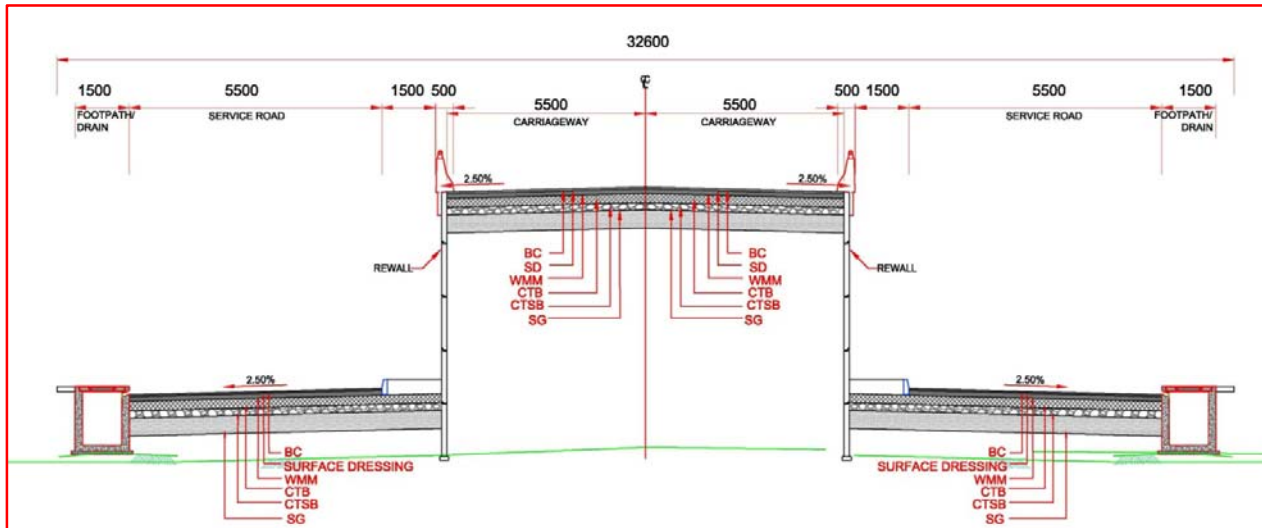


Figure 7-12: TCS-11-Typical Cross section for Two lane VUP approach with Service Road



7.7 Pavement Design

The general design procedure is based on the prevalent practices in the country. The design of pavement structure has been carried out as per IRC Guide lines and TOR. The detailed design of new pavement and overlays on existing pavement shall be based primarily on IRC-37:2012 and IRC-81: 1997 for flexible pavement and IRC-58: 2011 for rigid pavement.

7.7.1 DESIGN LIFE

The design life of pavement has been considered in accordance with IRC-37:2012 guide. The year of opening for the traffic has been considered as 2017. As per TOR, design life for the flexible pavement is considered 10 years and in case of rigid pavement it is 30 years. The design loading in case of flexible pavement is computed for both 15 years and 20 years.

7.7.2 DESIGN TRAFFIC

Traffic assigned to each homogeneous section as well as for the proposed bypasses considered from Chapter 6 (Ref ; Table 6.4 (a) and Table 6.4(b)).

7.7.3 VEHICLE DAMAGE FACTOR

The objective of analysis is to estimate the Vehicle Damage Factor (Mode wise). The Equivalency factor derived from the “fourth power rule” to achieve the Equivalent Standard Axle Load for the respective vehicle type.

7.7.3.1 Methodology

Average VDF values are considered for each Homogenous section. As per IRC: 37-2001 clauses 3.3.4.4, for rolling 3.5 and for hilly 1.5 are considered.

The cumulative million standard axles (CMSA) have been computed for the recommended facility of 2/4 lane carriageway for a period of 20 years from 2017 by assuming the construction period of three years from 2013-14, 2014-15, and 2015-16. CMSA computations are given in Annexure 6.3. The computed CMSA for the all the sections are set out in table below:

7.7.4 DESIGN TRAFFIC LOADING

Table 6.6 of Chapter 6 show the cumulative standard axles occurring on four homogeneous section year-by-year till 2036. These values contribute the traffic loading for use in the design. The summary of CMSA for 10, 15 and 20 years is given below.

Table 7-14: Summary of CMSA for Homogenous Sections

Homogenous Section	10 Year (2026)	15 Years (2031)	20 Years (2036)
Lilong to Thoubal Junction(4 Lane)	7.16(10)	12.64(15)	19.24(20)
Thoubal Junction to Pallel (4 Lane)	3.45(5)	6.33 (10)	9.91(15)
Pallel to Khudengthabi(2 Lane)	1.85(5)	3.57 (5)	5.83 (10)
Khudengthabi to Moreh(2 Lane)	2.58(5)	4.78(5)	7.55(10)
Proposed Alternative			
Wangjing to Machi	0.66(5)	1.09(5)	1.57(5)
Machi to Khudengtahbi	0.68 (5)	1.15 (5)	1.66 (5)

7.7.5 DESIGN CBR

Design CBR will be based on the results of borrow area sample testing as the borrow area sampling is not carried out a minimum CBR of 7% and 10% for Lilong to Pallel (HS 1& HS 2) and from Pallel to Moreh recommended respectively. A minimum 10% CBR has been recommended for the alternative alignment.

Minimum design traffic of 25 CMSA and 20 CMSA for Lilong to Pallel (HS 1& HS 2) and from Pallel to Moreh recommended respectively. For the alternative alignment minimum design traffic of 10 CMSA has been recommended. Based on the pavement condition and keeping the embankment heights and overtopping situation the total project road section from km 330+000 to km 425+411 has recommended for reconstruction. In continuation to the discussion held in Imphal in the month of Jan 2015, the consultants are recommending for Cement Treated Base with Crushed Aggregate and Cement Treated Sub base with Natural GSB. In order to have retardation of any cracks Single Coat Surface Dressing with nominal size of 9 mm aggregate has been considered in between Wearing Course and WMM Crack relief layer.

Table 7-15: New/Widening Pavement Thickness

Design MSA	Road Sections with 20 year Design Life	CBR (%)	BC	WMM	CTB	CTSB
25	Lilong to Thoubal	7	50	100	115	250
20	Thoubal to Pallel	7	50	100	115	250
20	Pallel to Khudengthabi	10	50	100	90	250
20	Khudengthabi to Moreh	10	50	100	90	250
10	Alternative alignment from Wangjing to Khudengthabi	10	40	100	80	250

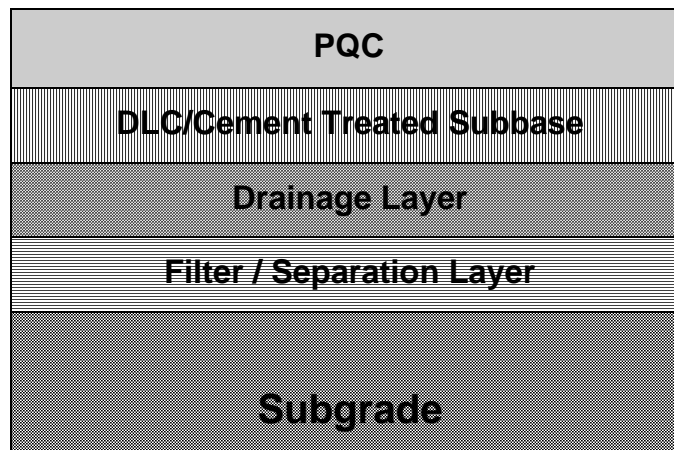
7.7.6 REHABILITATION OF EXISTING PAVEMENT

Total project road section is recommended for reconstruction due the following reasons:

1. Poor Pavement Visual condition
2. Less Embankment height
3. Overtopping
4. Subgrade failure at certain places in plain terrain
5. Subbase layer and bituminous layers only observed in hill y terrain

7.7.7 RIGID PAVEMENT DESIGN:

Rigid Pavement thickness is proposed with the following composition and the design period will be for 30 years.



Separation layer between sub base pavement: Foundation layer should be provided below concrete slabs should be smooth to reduce the inter layer friction. A separation membrane of minimum thickness of 125 micron polythene is recommended to reduce the friction between concrete slabs and dry lean concrete sub-base (DLC).

The summary of rigid pavement thickness for all the homogeneous section with 150 mm DLC are given below:

Table 7-16 :Summary of Rigid Pavement Thickness

Homogeneous Section	PQC (mm)
HS 1: Lilong to Thoubal Junction	230
HS 5: Thoubal to Pallel	220
HS 6: Pallel to Khudengthabi	220
HS 7: Khudengthabi to Moreh	220
Both Directions Combined.	220

Bituminous Wearing Course (Blacktopping)

Two most common complaints heard India from road users against rigid pavement are:

- Overheating of pneumatic tyres
- Excessive noise emitted from wheels

Since these are issues related to rubber-concrete friction at high speed, a simple solution could be to provide a bituminous surface over the PQC i.e. blacktopping the concrete pavement. For this purpose, 25mm SDBC/BC over a 12mm layer of Mastic Asphalt (as laid on concrete structure decks) can be suggested. Presumably, this will increase the initial cost of rigid pavement slightly and also affect adversely the life cycle cost advantage of rigid pavement over flexible pavement to some extent. Even then, the benefits of low or no long-term maintenance of concrete will still outweigh that of bituminous pavement and, yet remove all objects to the use of the former in highways.

In the feasibility study stage of the project, this solution has been adopted.

7.8 Proposed Maintenance

Routine and periodic maintenance as per IRC guidelines are assed. Periodic maintenance with overlay comprising 40 mm BC has been proposed after every improvement work (intervention) scheduled every 5 years till the next major intervention. Structural overlay due on the terminal design year (generally the 10th year) has been proposed on all improved pavements. The average structural overlay thickness of DBM-60mm and BC-40mm has been considered for HDM analysis. Table 7-17 gives the maintenance requirement for the pavement for 30years.

Table 7-17 :Annual Periodic maintenance

S.No.	Year	Flexible Pavement			Rigid Pavement with 25 mm BC Blacktopping		
		Initial Construction Cost	Routine Maintenance *	Periodic Maintenance	Initial Construction Cost	Routine Maintenance **	Periodic Maintenance
1	2015	30% of Total Cost			30% of Total Cost		
2	2016	40% of Total Cost			40% of Total Cost		
3	2017	30% of Total Cost			30% of Total Cost		
4	2018		Yes				
5	2019		Yes				
6	2020		Yes				
7	2021		Yes	40mm BC of Functional Overlay		1% of Total Area damaged Panels to be replaced	
8	2022		Yes				
9	2023		Yes				
10	2024		Yes				
11	2025		Yes				
12	2026		Yes	40mm BC+60mm DBM Structural Overlay		1% of Total Area damaged Panels to be replaced	25mm of BC Functional Overlay
13	2027		Yes				
14	2028		Yes				
15	2029		Yes				
16	2030		Yes				

S.No.	Year	Flexible Pavement			Rigid Pavement with 25 mm BC Blacktopping		
		Initial Construction Cost	Routine Maintenance *	Periodic Maintenance	Initial Construction Cost	Routine Maintenance **	Periodic Maintenance
17	2031		Yes	40mm BC of Functional Overlay		1% of Total Area damaged Panels to be replaced	
18	2032		Yes				
19	2033		Yes				
20	2034		Yes				
21	2035		Yes				
22	2036		Yes	40mm BC+60mm DBM Structural Overlay		1% of Total Area damaged Panels to be replaced	25mm of BC Functional Overlay
23	2037		Yes				
24	2038		Yes				
25	2039		Yes				
26	2040		Yes				
27	2041		Yes	40mm BC of Functional Overlay		1% of Total Area damaged Panels to be replaced	
28	2042		Yes				
29	2043		Yes				
30	2044		Yes				
31	2045		Yes				
32	2046		Yes	40mm BC+60mm DBM Structural Overlay		1% of Total Area damaged Panels to be replaced	25mm of BC Functional Overlay

S.No.	Year	Flexible Pavement			Rigid Pavement with 25 mm BC Blacktopping		
		Initial Construction Cost	Routine Maintenance *	Periodic Maintenance	Initial Construction Cost	Routine Maintenance **	Periodic Maintenance
33	2047		Yes				
34	2048		Yes				

*significant routine maintenance involving crack repair, pot patching, edge repair etc.

** negligible routine maintenance involving only joint cleaning and surface brushing.

7.5.2 Other Typical Designs

In addition to the main elements of the roads, typical designs of other essential standard features were considered for the purpose of quantification and costing.

7.9.1 JUNCTION IMPROVEMENT

The upgrading of the project roads would involve improvement of junctions, with other roads, in order to carry through the standard features of the project roads. As a policy, improvement of the cross roads over a suitable length from the junction has been proposed. The existing junctions requiring improvement have been classified into two categories, major and minor.

7.11.1.1 Major Junction

Intersection of the project road with another highway or a major district road is treated as a major junction. (refer Volume III: Drawings) show the typical improved layout of major 4-legged and “T” junction respectively. The lists of major junctions and underpasses along with the summary of improvements are given in *Table 7.18*.

Table 7-18:Details of major junctions

SL. NO	Existing Chainage (km)	Road Leads To	Juncti on Type	Proposed Improvements
1	342+600	Yaripok on LHS and MayangImphal on RHS	+	VUP
2	360+000	Kakching	T	VUP

7.11.1.1 Minor Junction

Intersection of the project road with a minor road such as ODR or village road has been termed as a minor junction. The minor road approaches, however, are proposed to be widened to facilitate easy movement of turning traffic.

7.9.2 ROAD FURNITURE AND MARKINGS

The road furniture proposed to be provided include routine and special road signs; hectometer, kilometer and 200 m stones, guard posts on high embankment stretches (3m and above) e.g. bridge approaches and also at sharp curves. The existing furniture, which are in a reasonably good state of repair, are proposed to be recycled to the extent possible. Road markings would be generally standard centerline and yellow edge markings using thermoplastic paints. Lane markings, kerb/object markings, etc. as required under different options and stretches have been considered. Street illumination for urban road sections has been considered and included in design as appropriate.

7.9.3 SAFETY FEATURES

The typical provisions that have been considered in design to prevent or minimize accidents are:

- Reflective studs (cats' eyes) on road markings.
- Double Beam Crash barriers in high embankment greater than 3 m and on approaches of bridges and also on valley side.
- Pedestrian crossings with road markings and reflective studs.
- Pedestrian guardrails (in Palin built-up area)

7.9.4 *TRUCK TERMINAL, TRUCK LAY BAYS AND REST AREA*

Based on the inventory data collected it is observed that way side amenities like truck lay bays and rest area is not available along the project. Since the project road improvement envisages induced truck traffic into the project, adequate number of truck lay bays to be provided. The exact location of the truck lay bays shall be finalized during the DPR stage. Appropriately designed rest areas are not available on the project alignment. However some facilities are available in Thoubal and Pallel towns. Rest area facilities are proposed on the following locations

- 1) Near Thoubal
- 2) Near Pallel

No major industrial corridor which requires a truck terminal kind of facility is existing on the project road. However during the DPR stage requirement of truck terminal shall be further assessed and if required it shall be proposed.

7.9.5 *BUS BAYS / WAY SIDE BUS STOPS*

Considering the overall safety of traffic and minimum hindrance to through traffic, bus bays with pick-up bus stops have been proposed at following major town and villages along the project road .

Bus stop locations will be finalized such that,

- It shall not be located at horizontal curves.
- It shall not be located on top of summit vertical curves.
- it shall be located away from intersection as specified in IRC: 80-1981
- It shall be located preferably at straight road at flat gradient with good visibility.
- The location should not be prone to land slide for the safety of passengers.

The shelter shed for passenger shall be structurally safe and aesthetically pleasing in appearance, while also being functional so as to protect the waiting passenger adequately from the sun, wind, and rain. Bus-lay bays shall also be designed with proper drainage (Cross and Longitudinal) along with proper signage and markings. There are 12 bus shelters are observed along the project corridor, however the following villages are recommended for providing bus shelters.

Table 7-19:Details Village Required for Bus Shelters

Existing Alignment	Alternative Alignment
Lilong Bazar Village	Heirolk town
LilongHangamathobi Village	Litan village
Thoubal Village	Karongthel/Khulsaibung village
Khangabok Village	Chanchi village
WangjingjiomVilage	Shamlong village
Sona Village	Lamlong village
KackchingLamkhai Village	Machi village
Pallel Town	Samukom village
Bangjing Village	Sita village
Tengoupal Village	Kampangkhulen village
Chahmol Village	Wapur village
Chikim Village	Leibi village
Moreh Village	B.Molhoi village

7.9.6 TOLL PLAZA

Based on the finding of chapter 6, toll plaza are proposed at the following location. However during the DPR stage, the requirement toll plaza will be reviewed in consultation with the PIU based on the tolling policy of the execution agency. The exact location of the Toll plaza will be identified based on the availability of land and the suitability during the DPR stage.

- 1) In between Lilong and Thoubal
- 2) In between Palleland Moreh

7.9.7 RETAINING WALL

Upgrading options involving widening of the roadway in hilly terrain on valley side up to 9 m heights. The same criteria recommended for alternative route from Wangjing to Khudengthabi for a length of about 58.506 kilometers.

7.9.8 ROADSIDE DRAIN AND FOOTPATH

In rural sections of the road, unlined toe drains are invariably proposed unless, the embankment height exceeds 1 m. The toe drain literally starts from the embankment toe with a generally acceptable slope of 1:1. The depth of this drain would have to be sufficient to allow at least the drainage layer in the pavement to be exposed to daylight. As a rule, the minimum depth should be 60 cm.

In urban and semi-urban areas, to facilitate proper drainage of surface run-off, roadside drains have been proposed. The three common types of drains envisaged are:

- i) Lined rectangle open drain in semi-urban area
- ii) Lined trapezoidal type open drain in semi-urban areas
- iii) PCC box-type covered drain with footpath in urban areas

-
- iv) RCC pipe drain under footpath/shoulder in urban areas
 - v) Chute drains in high embankment would also be required.

7.9.9 PAVER BLOCKS IN URBAN AREA

7.9.9.1 In Service Roads

The service roads in urban areas where the right of way is a constraint to have exclusive utility corridor (refer typical cross-sections), are proposed to be constructed with vibro-pressed interlocking concrete paver blocks. Laid on a sand-bed of 50 mm over granular base and sub-base courses, these paver blocks function very well in urban situations because these:

- a) are not affected by poor drainage conditions
- b) can be easily removed and re-laid in connection with maintenance of utility services housed below.
- c) present a clear distinction between the main carriageway and the slow-lane.

7.9.9.2 In footpath

Paver blocks have also been proposed in footpath albeit of lower thickness 50 mm. Paver block construction would generally conform to IRC 63-2004.

7.9.9.3 Median Opening

In dual carriageway roads, median opening at important junctions, and at regular interval of 2 km in straight stretches have to be provided.

7.10 HYDROLOGY AND DRAINAGE DESIGN

7.10.1 HYDROLOGY AND HYDRAULIC STUDY OF CROSS DRAINAGE WORKS

The main objective of the hydrological and hydraulic study is to determine the required size of drainage structures to allow the estimated design flow of the streams to cross the road safely, and to check whether waterways of existing structures are sufficient to pass the flow without risk so that appropriate decisions could be taken concerning their rehabilitation.

The hydrological and hydraulic study for the project has been based on:

- Topographic survey data of cross drainage structures
- Generated topographical data and maps of streams for upstream and downstream, rainfall intensity, duration and its distribution.
- Rainfall pattern of the project site

7.10.1.1 Project Description

The project alignment is passing through 12 minor streams and 3 major streams. After extensive study of catchments, it has been found that most of the streams are

originated at different ranges of hills and the toes of hills are thickly populated along both sides of banks of the streams. Maximum discharge of streams are vanished through irrigation canals for the domestic and agricultural requirements of local body.

The existing project road is hydraulically adequate and no overtopping of road was observed.

7.10.1.2 Data Collection and Data Analysis

Requirements for Hydrology and Drainage design

The hydrological study aims at estimating the peak discharge of the flood generated by the run-off of rainfall within the catchment area. The hydrological study requires:

- Knowledge of the characteristics of peak rainfall in the regions:
- Knowledge of the characteristics of the catchment areas:
- Topographic data about the stream, upstream and downstream:
- Survey of India topo maps to a scale of 1: 50,000 for identification of catchment area and its characteristics.
- Site study of the characteristics of the catchment areas, HFL from local enquiry.

Data Collection

Topographic surveys have been done at all the major and minor stream crossings with a view to obtain the cross section of the rivers at the proposed road crossing. As per IRC: SP: 13-2004 Clause 3.3, Table-1, approximate distances, upstream and downstream of the selection site of crossing at which cross sections should be taken are as under.

Catchment Area	Distance (u/s and d/s of the crossing) at which cross sections should be taken)
Upto 3.0 sq. km	100m
From 3.0 to 15 sq. km	300m
Over 15 sq. km	500m

For major bridges and spans more than 30m and for the catchment area more than 15 square km the topographic surveys of about one and a half km or the width between the banks (whichever is more as per IRC 05-1998, clause 102.1.2.3) are

yet to be carried out. But it is unable to perform the topographic surveys for the hilly regions of the stream and built up area. therefore the cross sectional area of such locations are taken as: cross sectional area of chord or cross sectional area of trapezoidal with an assumption of appropriate side slope, where top width equal to the proposed width of linear waterway and depth equal to depth of water as per inventory.

The characteristics of the catchment areas have been ascertained from Survey of India topo sheets, to a scale of 1:250000/1:50000 from which, catchment area at the proposed bridge site, length of the stream and fall in elevation from originating point to the point of crossing, could be determined.

HFL data

The High Flood Levels (HFL) have been obtained from existing flood marks or ascertained from enquiry with local people.

7.10.1.3 Methodology of Discharge Calculations

Discharges for the major and minor bridges are worked out as per methodology described under various applicable standards of IRC, e.g. IRC: 5 -2000, pocket book of bridge engineers and SP-13-2004. The computed values are adopted through site validation and local inquiry with judgment.

The following methods have been used to estimate the peak discharge and waterway for bridge sites on major and minor streams.

- Area Velocity Method/Slope Area Method
- Catchment Area Method
- Rational formula
- Dicken's formula
- Synthetic Unit Hydrograph (as per CWC Manual-subzone 2b)

Paths of streams having nominal discharges of minor bridges at some locations could not identify on topo sheets. So, the calculation of discharges for those particular bridges has to be done as per Area Velocity method only.

For catchment areas not exceeding 50 sq. km, Rational method is an universally accepted empirical formulae relating rainfall to run-off as per clause 10.4 IRC SP 42-1994. If the catchment area is more than 50 sq. km the calculation of discharge has to be done as per Synthetic Unit Hydrograph method.

7.10.1.3.1 Area Velocity Method/Manning's Formula

This method has been utilised to calculate the discharge from the stream cross-section and stream slope/bed slope at the proposed bridge sites, for both major and minor bridges. After plotting the cross section of the river, and marking the

observed HFL, the cross sectional area (A) and wetted perimeter (P) have been computed. The bed slope of the river has been estimated along its length.

The velocity and Discharge have been calculated using the Manning's formula:

$$V = 1/n R^{2/3} S^{1/2}$$

$$Q = A \times V$$

Where,

$$V = \text{Velocity in m/sec}$$

$$R = \text{Hydraulic mean depth in m}$$

$$S = \text{Flood slope/bed slope}$$

$$n = \text{Co-efficient of rugosity}$$

$$Q = \text{Peak Discharge}$$

$$A = \text{Area of cross section}$$

The value of 'n' has been adopted as per soil criteria and river bed characteristics, observed at site and are based on Table 5.1 of IRC SP-13: 2004 which has been tabulated below.

Surface	P e r f e c t	G o o d		
Natural Streams				
1. Clean, straight bank, full stage, no rifts or deep pools	0 . 0 2 5	0 . 0 2 7 5		
2. Same as (1), but some weeds and stones	0 . 0 3 0	0 . 0 3 3		

3. Winding, some pools and shoals, clean	0 . 0 3 5	0 . 0 4 0		
4. Same as (3), lower stages, more ineffective slope and sections	0 . 0 4 0	0 . 0 4 5		
5. Same as (3) some weeds and stones	0 . 0 3 3	0 . 0 3 5		
6. Same as (4), stony sections	0 . 0 4 5	0 . 0 5 0		
7. Sluggish river reaches, rather weedy or with very deep pools	0 . 0 5 0	0 . 0 6 0		
8. Very weedy reaches	0 . 0 7 5	0 . 1 0 0		

7.10.1.3.2 Catchment Area Method

a). Rational Formula

Pocket Book for bridge engineers, published by IRC or methodology available in IRC: SP-13:2004 has been adopted for computation of discharge by this method. In this method discharge is assumed to be proportional to the upstream catchments at the crossing and critical intensity of rainfall.

$$Q = 0.028 P f A I_c$$

Where:

Q = Maximum runoff in cumecs

A = Catchment area in hectares

I_c = Critical intensity of rainfall in cm/ hr.

P = Coefficient of run-off for the given catchment characteristics.

f = Spread factor for converting point rainfall into aerial mean rainfall.

$$I_c = I_o * [2 / (T_c + 1)]$$

I_o = Intensity of one hour rainfall that occurs from the severest storm in the region. The intensity is chosen from Appendix – A of SP-13-2004.

T_c = Time of concentration in hour.

Table 4.1 Maximum Value of P in the Formula $Q = 0.028 P A I_c$

Steep, bare rock and also city pavements	0.90
Rock, steep but wooded	0.80
Plateaus, lightly covered	0.70
Clayey soils, stiff and bare	0.60
-do- lightly covered	0.50
Loam, lightly cultivated or covered	0.40
-do- largely cultivated	0.30
Sandy soil, light growth	0.20
-do- covered, heavy brush	0.10

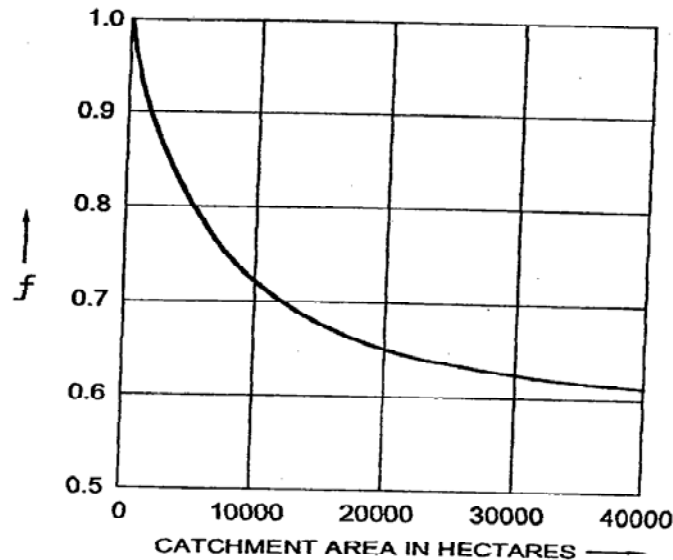


Fig. 4.2 'f' curve

Time of Concentration

Time of concentration (T_c) has been determined from the following Empirical Formula:

$$T_c = \left[\frac{0.87 \cdot L^3}{H} \right]^{0.385}$$

Where, L is the distance of basin critical point to the outfall point/crossing in km and H is the elevation difference in meter in length L .

Point rainfall values are adjusted for aerial mean value using recommended spread factor as per IRC: SP-13, vide fig. 4.2, showing 'f' curve.

Maximum rainfall

The alignment falls under flood estimation report of central water commission subzone (2c) which is under preparation by CWC. So, the calculation for discharge by SUH has been done by using CWC subzone (2b) since it lies between latitude of $24^\circ 43'N$ and longitude of $94^\circ 17'E$ and topography is also almost same.

The maximum 24 hour rainfall has been taken as 320 mm for 100 years return period as per flood estimation report of Central Water Commission, Subzone (2b)

b). Dicken's Formula

It has been used to estimate flood discharges from a single parameter, catchment area. Flood discharges calculated from these formulae cannot be assigned with any Return Period.

$$\text{Discharge, } Q = C A^{0.75}$$

Where, A = Catchment area in Sq. km.

C is Run-off coefficient, which depends on the annual rainfall. The max annual rainfall collected from various rain gauge stations within the project site is 1650mm. So, the value of C adopted is 17.

7.10.1.3.3 Synthetic Unit Hydrograph (as per CWC Manual-subzone 2b)

According to CWC Manual of sub zone (2b) the Synthetic Unit Hydrograph was computed by using the equations given below:

Basin Lag,

$$t_p = 2.87(q_p)^{-0.839}$$

Peak of the Unit Hydrograph,

$$Q_p = 0.905(A)^{-0.753}$$

Peak of the Unit Hydrograph per Unit area in cumecs per sq.km,

$$q_p = Q_p / A$$

Width of Unit Hydrograph measured at 50% max. Peak discharge

$$Q_p, W_{50} = 2.304(q_p)^{-1.035}$$

Width of Unit Hydrograph measured at 75% max. Peak discharge

$$Q_p, W_{75} = 1.339(q_p)^{-0.978}$$

Width of Unit Hydrograph measured at 50% of Q_p between the rising limb and Q_p , ordinate in hours,

$$W_{R50} = 0.814(q_p)^{-1.018}$$

Width of Unit Hydrograph measured at 50% of Q_p between the rising limb and Q_p , ordinate in hours,

$$W_{R75} = 0.494(q_p)^{-0.966}$$

Base width,

$$T_B = 2.447 * (t_p)^{1.157}$$

Time from start of rise to the peak of Unit Hydrograph,

$$T_m = t_p + t_r / 2$$

Max. Peak discharge,

$$Q_p = q_p \times A$$

7.10.1.4 Design Discharge

The design discharge has to be considered according to IRC: 5-1998 in which the design discharge shall be adopted by considering the maximum discharge of all methods.

But, according to site investigation all structures are hydraulically adequate and maximum discharge of streams are vanished through irrigation canals for the domestic and agricultural requirements of local body. So, there has been a reduction of 30% to 40% in maximum total discharge taken as per site condition while fixing the design discharge and design HFL.

7.10.1.5 Design HFL

If the design discharge is obtained by area velocity method as governing case, then the design HFL has been taken as the observed HFL only. If not the design HFL has

been obtained by back calculation, i.e., keeping the design discharge as constant, passing it through bridge site cross section and modify the HFL accordingly.

7.10.1.6 Linear Waterway

Linear water way is obtained by dividing the design discharge by velocity through vent, depth of flow and factor of safety which depends on shape of cross section of stream.

7.10.1.7 Afflux Calculation

If any of the bridges in the alignment have less clear waterway as compared to natural stream width. This causes afflux at bridge sites during flood. Afflux for the bridges has been calculated using Moles worth formula as described in IRC: 89-1997 and pocket book for bridge engineers. Value of afflux, h in meter, is given by the following expression:

$$\left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Where, V = Average velocity of river prior to obstruction in m/sec

Au = Unobstructed sectional area of the channel in m²

Ae = Sectional area of river at obstruction in m²

7.10.1.8 Results

Design discharge	= Q in 'cumecs'
Velocity	= V _f in m/sec
Effective Linear water way	= L _{eff} in 'm'
Depth of flow (from the lowest bed level)	= Actual depth of flow
Afflux	= Afflux provided
Free Board	= depends on the discharge(table 1)
Depth of Soffit	= (HFL + Afflux + Free Board)

Table: 1(Free Board)

Discharge (Cumecs)	Free Board(mm)

Up to 0.30	150
0.30 - 3.00	450
3.00 - 30.00	600
30.00- 300.00	900
300.00- 3000.00	1200
>3000.00	1500

7.10.1.9 Scour depth

The scour depth is calculated according to the IRC SP: 13-2004. From the soil samples, recovered from the bore holes during soil investigation, grain size analysis are carried out and silt factors are calculated up to the depth of anticipated scour level in accordance with IRC-5.

The mean scour depth is calculated using the formula:

$$d_{sm} = 1.34(D_b^2 / K_{sf})^{1/3}$$

Where,

K_{sf} = silt factor

D_b = (Q_b / L_e) Design discharge in cumecs per meter width.

d_{sm} = mean scour depth of scour level below HFL.

L_e = effective linear water way.

Q_d = Design discharge according to IRC 5 :1998

All the calculated hydrology and hydraulic data, scour calculations and recommendations for bridge structures have been summarized in Appendix – 1.1.

7.10.2 DRAINAGE DESIGN

A good drainage system is vital for the safety and longer life of any structure. This is more relevant in the case of highways. Proper drainage of road surface, pavement and the foundation layers is basic requirement for maintaining the structural soundness and functional efficiency of a road. Pavement structure including subgrade must be protected from any ingress of water. For this purpose, the following conditions have to be ensured.

- Saving the pavement structure from stagnation of water.
- Efficient dispersal and disposal of water.
- Quick disposal of sub-surface water away from the pavement.
- Interception of the surface runoff.
- Keeping the water flow duration on the pavement to a minimum.

Longitudinal gradient of minimum 0.3% is followed for better internal drainage of pavement layers. Camber of 2.5% is considered for flexible pavements as per IRC: SP: 84-2009 and IRC: SP: 42-1994 for quick surface runoff disposal from the pavement. Hence, it is considered enough to drain out the water from the pavement surface even with steepest longitudinal gradient of 5%, being ratio of longitudinal gradient to cross slope is 2.0.

Drainage design needs to be carried out for the following types of drainage situation:

- a) Drainage at Urban/Built-up locations.
- b) Drainage at Rural areas.
- c) Drainage at High Embankments.
- d) Median Drainage at Super Elevated Sections.
- e) Drainage in Hill Sections

7.10.2.1 Drainage AT URBAN/Built-up Section

Concrete or lined closed drains or pipe drains shall be used in Urban/Built-up Sections.

Minimum Section of Drain

As per IRC standards, It should be possible to clean the drains periodically using a spade. Accordingly, the minimum width of drain shall not be less than 250mm. In case of pipes drains, the minimum diameter is 600mm.

Minimum and Maximum Velocities:

The velocity values in excess of maximum permissible velocity will cause erosion in the drain which increases the maintenance cost and also weakens the road structurally. A minimum self cleansing velocity is also required to disperse floating debris conveniently. Clause 4.9.3.a of IRC: SP: 50- 1999 suggests minimum velocity for concrete drain is 0.75 m/sec and maximum velocity is 6.0 m/sec.

7.10.2.2 Drainage at Rural areas

Trapezoidal unlined open drains with minimum bed width of 0.5m and side slope 1:2 s shall be used in rural sections. Minimum velocity for open drain is 0.45 m/sec and maximum velocity is 1.2 m/sec shall be maintained as per codal provisions.

7.10.2.3 Drainage at High Embankments

In high embankment and bridge approaches if water is allowed to leave the carriageway at undefined spots, it may cause serious damage to embankment and pavement crust. This problem of erosion of slopes and shoulders is more pronounced in more than 3 m high embankments.

In such location where embankment height more 3m, rain water is collected in small manageable quantities through longitudinal kerb channel at the edges of roadway and brought down through chutes without damage. Drainage arrangement in such location is provided as per section 7 of IRC SP: 42.

7.10.2.4 Median Drains in Super Elevated Stretches

Clause 3.2.4 of IRC: SP: 50-2013 is reproduced here that “The provision of median openings (cuts) at super elevation and curves in divided carriageway shall be for and upto two lanes as shown in Figure 3.2.4(a) and 3.2.4(b) of the same code”. The same clause also says that “in locations where carriageway slopes towards median, as may be the case where road is in curve, necessary openings shall be provided in the median for smooth passage of water from one lane to other and to towards side drain”.

As per Fig. 3.2.C. of IRC: SP: 50-1999 or IRC: SP: 50-2013, if the finished road level of inner carriageway near median is less than or equal to that of the outer carriageway, the runoff shall be collected through the median cuts provided at the regular interval. If the finished road level of inner carriageway is more than that of the outer carriageway, the runoff shall be collected through the longitudinal median drains and the same shall be drained off into the nearby cross drain or can be taken out by providing cross culverts below the pavement.

7.10.2.5 Drainage in hill sections

Inadequate cross drainage on a hill road causes softening of the sub-grade and renders it too weak to take the load of moving traffic. Roadside drains are therefore

necessary on a hill road. According to clause 8.4.1 of IRC: SP: 48-1998, they should be taken below the sub-grade of the road or in a kutchra road these are invariably taken about 300mm below the road surface.

Roadside drains should generally be of uniform section throughout irrespective of the location of road on the hill slope. They are generally constructed to parabolic, trapezoidal, triangular, V-shape, kerb and channel or U-shaped cross sections.

Minimum size of drain 60 cm x 60 cm and should have a gradient of 1:20 to 1:25 to develop self cleansing velocity to disperse floating debris conveniently. In continuous long stretches of road with steep grades, the road side drains should be stepped to break the velocity. A 0.60m high toe wall along the hill side will be required to prevent erosion of hill-slope-as an integral part of side drain.

7.10.2.6 Catch water drain in Hill section

Catch water drain, also known as intercepting drains, is provided on hill slope above cutting to collect and remove surface water runoff from upper reaches. As per Clause 6.5 of IRC: SP: 84-2009, these drains shall be trapezoidal shape and stone lined and cement pointed. The drains are designed for carrying the intercepted water to the nearest culvert or natural drainage channel. It is to be ensured that the catch water drains are provided in stable hill slopes outside the periphery of slide/unstable areas.

7.10.2.7 Culverts

To discharge runoff from hill side drain to valley side, 8 to 10 culverts or scuppers shall be provided. 3 culverts shall be provided in plain terrain. Almost from km. 352 to end of project stretch is rolling terrain. But some of locations in rolling terrain are falls on ridge alignment. So, an approximate number of culverts 5 per km have been provided based on site investigations. The list of proposed and existing culverts has been provided in Appendix -1.1.

7.10.3 DESIGN STANDARDS

The design of drainage structures is carried out in accordance with the following codes:

IRC: SP: 13 - 2004, "Guidelines for the design of small bridges and Culverts".

IRC: 5 - 1998 "Standard specifications and code of practice for Road bridges".

IRC: SP: 84 - 2009, "Manual of Specifications & Standards for Four laning of Highways through Public Private Partnership".

IRC: SP: 42 - 1994, "Guidelines on Road Drainage".

IRC: SP: 50 - 1999/IRC: SP: 50 - 2013, "Guidelines on Urban Drainage".

IRC: SP: 48- 1998, "Hill Road Manual".

7.11 BRIDGES AND CULVERTS

7.11.1 STRUCTURE DESCRIPTION

7.11.1.1 Minor bridges:

Minor bridges along the project road are of RCC solid slab type and RCC I girder superstructure with simply supported spans. There are two minor bridges with steel truss girder bridges with wooden deck superstructure observed. Most of the solid slab bridges are with tar paper bearings. Expansion joints are not visible and few of them are without approach slabs.

The existing minor bridges with solid slab substructure are with plain cement concrete or masonry piers are with open foundations. 7 minor bridges are situated in plain terrain and 5 minor bridges are in hilly terrain.

Table 7-27: Details of Minor bridges

Sl. No.	Chainage	River/Bridge name	Superstructure Type	Span arrangement	Remarks
1	334+330	Ushoipokpi	RCC Solid slab	5.6+6.0+5.6	
2	336+100	Waithou	RCC girder	3x13.2	Poor condition
3	344+150	Arong Bridge	RCC T girder	3x11.0	
4	347+600	Khangabhok	RCC Solid slab	2x7.0	
5	348+150	Wangjing	RCC Solid slab	8.8+8+8.8	Poor condition
6	349+900	Uningkhom	RCC Solid slab	2x5.8	
7	352+800	Khongjom	RCC Solid slab	2x5.8	
8	407+450	Lokchao	RCC abutment with bailey super structure	1x30.5	
9	409+000		RCC Solid slab	1x10.0	
10	412+230		RCC Solid slab	1x10.0	
11	428+180	Khujairok	RCC T girder	1x16.0	
12	430+400	Border	RCC abutment with bailey super structure	1x44.1	This bridge is on international border

7.11.1.2 Major bridges:

Out of 3-major bridges, two are with PSC I girder simply supported type superstructure and one is RCC solid slab with Pier and abutment support. Following *Table 7.21* give the basic superstructure system and span arrangement of the Major bridges. All the major bridges are in plain terrain only. At one location i.e

at Pallel town new bridge is under construction with the span of 3 x 24.0m with RCC I girders on realignment of the existing road.

Table 7-28:Details of Major bridges

Sl. No.	Chainage	River/Bridge name	Superstructure Type	Span arrangement	Remarks
1	330+150	Lilong	PSC I girder	1x48.5+1x48.5	
2	341+780	Thoubal	PSC I girder	2x34.5	
3	365+550	Pallel Bridge	RCC Solid slab	6x10.0	New Bridge of 3x24.0m Span is under construction in realignment of the existing road

Major bridges with PSC I girder type superstructures are with MS ROCKER CUM ROLLER bearings. Expansion joints at abutments and piers are of strip seal type. All the bridges are observed with well foundation and piers are of plate type.

7.11.1.3 VUP/PUP/CUP

There is one Pedestrian Under Pass (PUP) situated on the project road which is in the approach of Thoubal bridge and it is in fair condition.

7.11.1.4 Culverts

Culverts are of box/slab, pipe and brick arch type. Number of culverts in plain terrain is less when compared with the hilly terrain.

7.11.2 GENERAL GUIDELINES FOR WIDENING AND IMPROVEMENT OF STRUCTURES

7.11.2.1 Bridges and culverts

- All structures along the project road were inspected for hydraulic adequacy, structural condition and loading for which those are designed. Structures are recommended for reconstruction if not satisfying the standards, else proposed for widening.
- Additional culverts will be proposed on existing road to ease the natural flow of water without causing damage to the embankment if required based on hydraulic calculations.
- Pipe culverts with diameter of the pipe below 900mm or not hydraulically functioning are recommended for replacement with new pipes of diameter 1.2m or box culverts with equivalent vent size depending up on the height of embankment.

-
- Culverts are recommended for reconstruction where the embankment needs to be raised and the culverts are not structurally sound enough to carry the load of extra fill.

7.11.3 DESIGN STANDARDS

Following IRC/IS Codes are referred,

- IRC: 5-1998 : Standard Specifications and Code of Practice for Road Bridges, Section-I: General features of Design.
- IRC: 6-2010 : Standard Specifications and Code of Practice for Road Bridges, Section-II: Loads and Stresses.
- IRC: 22-2008 : Standard Specifications and Code of Practice for Road Bridges, Section-VI: Composite Construction.
- IRC: 78-2000 : Standard Specifications and Code of Practice for Road Bridges, Section-VII: Foundation & Substructure
- IRC: 83-2011 : Standard Specifications and Code of Practice for Road Bridges, Section-IX: Bearings - Part II: Elastomeric Bearings.
- IRC: 83-2002 : Standard Specifications and Code of Practice for Road Bridges, Section-IX: Bearings - Part III: POT, POT-cum-PTPE & Metallic guide Bearings.
- IRC: 112-2011: Code of Practice for Concrete Road Bridges
- IRC: SP 13-2004: Guidelines for Design of Minor Bridges & Culverts
- IRC: SP: 35 : Guidelines for Inspection and Maintenance of Bridges
- IRC: SP 37 : Guidelines for Evaluation of Load carrying capacity of Bridges
- IRC: SP40 : Guidelines for Techniques for Strengthening and Rehabilitation of Bridges
- IRC: SP 48-1998: Hill Road Manual
- IRC: SP84-2009 : Manual of Specifications and Standards for Four Laning of Highways through Public Private Partnership

7.11.4 CODAL RECOMMENDATIONS FOR IMPROVEMENT OF EXISTING BRIDGES

According to the directive of MoRT&H, the overall width of bridges irrespective of length and location (rural, urban, plain) shall be compatible with the road adjacent to it. As such after improvement, all bridges should have width equal to carriage way width of intermediate approaches plus paved shoulders even if it not exists at present.

On two-lane highways, the overall width of the bridge deck (outer edge to outer edge) shall be equal to the roadway width of the approach roads.

Based on the inventory and condition survey of existing structures along the project road, MoRT&H& IRC circulars/codal provisions the following improvement proposals are suggested.

The deck width configuration for 2- lane bridges in 2- lane sections is modified vide MoRT&H circular No: RW/NH/33044/2/88-S&R (B) dated 24.03.2009 and those in 4 lane sections are as per IRC: SP: 84-2009. The width requirements are as follows.

- New bridges in 2lane improvement in rural section without footpath should 12.9m (0.45+0.75+10.5+0.75+0.45) or 12.0m (0.5+0.75+9.5+0.75+0.5) depend upon the carriageway.
- New bridges in 2lane improvement in urban section with footpath should be 14.8m (0.2+1.5+0.45+0.25+10.0+0.25+0.45+1.5+0.2).
- New 2lane Bridge with footpath in 4-lane road should be 12.0m (0.5+1.5+0.5+0.25+8.5+0.25+0.5).

These standards call for the paved width to be carried through the bridges.

Minimum clear carriageway width for a two lane bridge shall be 7.5m as per Clause: 112 of IRC: 5-1998. Dismantling and reconstruction of existing structures will be avoided as far as possible except where it is essential because of the poor structural conditions orhydraulic inadequacy. Based on this,Bridges in waitou 336+100 and Bridge in wanging 348+150are structurally distressed are recommended for reconstruction.

It will be ideal from safety point of view for all minor bridges to have width as per MoRT&H circular No: RW/NH/33044/2/88-S&R(B) dated 24.03.2009. However, keeping in view of Section 3.0 of MoRT&H circular, bridges that are in fair condition are retained with repair and rehabilitation with proper safety. Highway approaches of these bridges shall be designed for proper traffic guidance with the help of crash barriers hazard markers etc. Transition from highway to bridge section shall be for a length having a merging slope of 1 in 20on either side.

The width of new bridge on 2- Lane National Highway with and without footpaths is per Ministry Circular No: RW/NH/33044/2/88-S&R (B) dated 24.03.2009. Width of bridge on 4- Lane according to manual is as follows:

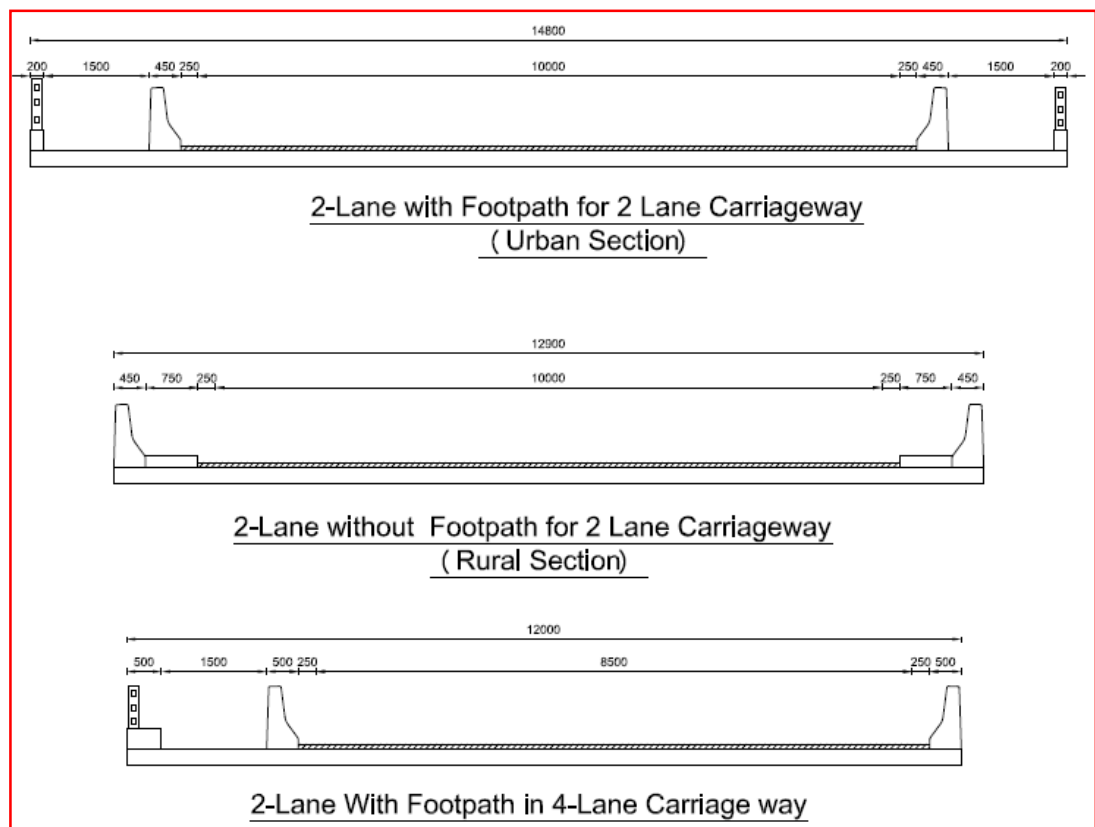
Table 7-29: Bridge Cross Sectional Details.

Bridge Cross section Features	2- Lane with FP for 2 Lane CW (Urban)	2 Lane without FP for 2 Lane CW (Rural)	2 Lane structure with FP on 4 Lane CW*
CW	10.00m	10.00m / 9.00m	8.50m
Shyness	0.25m on both sides	0.25m on both sides	0.25m on both sides
Safety Kerb	Not provided	0.75m on both sides	Not provided

Bridge Cross section Features	2- Lane with FP for 2 Lane CW (Urban)	2 Lane without FP for 2 Lane CW (Rural)	2 Lane structure with FP on 4 Lane CW*
Crash Barrier	0.45m on both sides	0.45m / 0.50m on both sides	0.50m on both sides
Footpath	1.50m on both sides	Not provided	1.50m on outer edge
Kerb + Railing	0.20m on both sides	Not provided	0.50m on outer edge
Total Deck Width	14.80m	12.90m / 12.00m	12.00m*

For 4-lane section, clear gap between the structures will be guided by approach section of highway. Deck cross sections are given in Fig 7.13

Fig: 7.13 Bridge cross sectional Features



7.11.5 IMPROVEMENT PROPOSALS

7.11.5.1 General

It shall be an objective to retain maximum number of structures in the project road with rectification or strengthening, if found complying with standards or it can be brought to required strength after rehabilitation. Treatments for existing cross drainage structures are proposed for the following reasons.

Geometrical reason	:	To match existing cross section to selected standard cross section and dimensional requirements as per MoRT&H standards.
Functional adequacy:		Reviews the availability of required carriageway width, space for provision of crash barrier, foot path and railing etc.
Structural reasons	:	Depending upon the condition of the existing structure
Hydraulic reasons	:	Depending upon the hydraulic inadequacy of existing structures.
Loading standards	:	Review the loading standards and to ensure the structure will function for the present day loading standards.

Bridges which will not face any of structural and foundation problems during widening and improvement will be widened to a cross section to meet the highway section. Bridges with well foundation cannot be widened but will be retained if they are in fair condition. Components like bearings, expansion joints, railings, crash barriers, wearing surface, stone pitching in slopes of quadrants and wing walls, etc., which are intact shall be replaced/repared. Damaged secondary structural components of the bridges shall be suitably repaired. All major bridges along the project road which are having minimum carriageway width of 7.5 m are proposed to be retained with minor repair. However in the highway improvement proposal, the project road from Imphal to parallel is most likely to be of 4-lane dual carriage way with paved shoulders. The bridges in this section need to be dealt case by case depending up on the feasibility of widening of the bridge or construction of new bridge parallel to the existing.

Based on the above, the improvement proposals in 2-lane sections are as follows:

- (i) Bridges which are hydraulically deficient are proposed for reconstruction. At DPR stage flood frequency need to be evaluated for bridges which are recommended for reconstruction to evaluate the proposal made based on HFL data collected.
 - (ii) Major bridges with well foundation or open foundation which are in fair condition and having a minimum carriageway width of 7.5m are proposed to be retained with repair and rehabilitation.
 - (iii) Minor bridges with well foundation which are in fair condition having carriageway width above 7.5m are proposed to be retained with repair and rehabilitation.
 - (iv) Minor bridges with open foundation which are in fair condition are proposed to be retained with repair and rehabilitation provided the structure meets the width requirement as per the standard.
-

- (v) Minor bridges with masonry piers and abutments are retained if the condition of the bridge is good.
- (vi) Bridges with superstructure in poor condition and substructure and foundation in good condition are proposed for deck replacement.
- (vii) Bridges with substructure or foundation in poor condition are proposed for reconstruction.

Existing 2- lane bridges falling in proposed 4- lane sections, criteria from (i) to (vii) will be followed along with new 2- Lane Bridge as per the proposed cross section compatible with the highway section.

7.11.5.2 Standards Adopted for Existing Bridges

Condition survey and local enquiry shows majority of bridges in the project road are old bridges except a few which are recently constructed.

Bridges which are in fair condition and retained are proposed with the necessary repair and rehabilitation measures based on the guidelines and recommendations contained in IRC: SP: 35.

Bridges which are retained and are in satisfactory structural condition as per visual condition survey, supplementary tests are recommended as per IRC: SP: 35 & IRC: SP: 40. Relevant tests will be carried out to qualify the nature of damage and determine the extent of rectification need to be done during repair.

It is a general practice to make use of the loadings for which the structures is designed given in as-built drawings to evaluate the load carrying capacity of existing bridges. In the absence of this information, evaluation of load carrying capacity or rating of the bridge will be carried out by analytical and correlation method as per IRC: SP: 37. When it is not possible to determine the load carrying capacity of the bridges using analytical or correlation method the same will be carried out by load testing after the approval by client as the same is not envisaged in the scope of work.

The residual life of bridges which are proposed to retain, with and without the strengthening and rehabilitation will be calculated as per acceptable standard practice.

7.11.5.3 Standards for Box/Slab, and Pipe Culverts

The culvert along the project road is either box/slab and pipe culverts.

Box culverts both without and with cushion are proposed depending upon the location, size, finished road level (FRL) and invert level.

Brick arch culverts along the project stretch are recommended for replacement.

Existing pipe culverts having diameter less than 0.9m diameter are recommended for replacement with Pipe culverts of 1.2m dia. or box culvert with 1.5 x 1.5 or equivalent size depending up on the height of embankment.

The existing pipe culverts having diameter less than 900mm or in distressed condition shall be replaced with 1200mm dia. NP4 pipes. The blocked pipe culverts will be proposed for reconstruction.

The diameter of the new pipe culverts shall be minimum 1200mm. The minimum cushion over the existing pipe culvert shall be 600mm and for the new culvert shall be 1000mm.

The culverts which are structurally in fair condition are proposed to be retained and proposed for widening to the full width of road approach.

To improve the cross drainage facility across the road embankment number of CDs is recommended to be increased to 3/km.

7.11.5.4 Widening of the existing solid slab superstructure and abutment / pier substructure with open foundation

Following the guidelines above, the bridges which are retained are proposed for widening by monolithic construction matching with the existing cross section of superstructure. Abutment and pier with open foundations are widened to the required width.

The widening of the existing solid slab superstructure will be done by chipping the edge 600mm to expose the reinforcement inside. Reinforcement for the proposed new construction shall be lapped or welded to the reinforcement in existing slab. Diameter and spacing followed for the new construction needs to be same as that of the reinforcement in existing one.

Similarly the abutment and pier along with open/raft foundation shall be widened by providing keying in the existing structure and constructing the widened portion to the required width, so that the structure will be monolithic with the existing structure.

The abutment and piers caps need to be widened for additional width to accommodate the transverse seismic stoppers to prevent the dislocation of superstructure.

7.11.5.5 Widening of Box/Slab Culverts

The overall width of culvert would be equal to the formation width of the road at culvert location. Width of new culverts and that of the existing culverts to be widened are to be decided based on the highway cross section. Accordingly total width of the culverts between parapets in urban/ rural area is as follows.

2- Lane highway without service road (Rural) :	13m*
2- Lane highway without service road (Urban) :	15.5m*
4- Lane highway without service road (Rural) :	27.0m
4- Lane highway with service road (Urban) :	38.5m

**The length of culvert depends on fill on the culvert and curvature*

All the culverts are proposed to be widened to this width. At locations where culverts are very near to bridges, the widening is to be done to match the bridge centerline so that sharp horizontal curve at bridge approaches could be avoided. Floor protection viz. flexible and rigid aprons shall be provided as a measure of control of erosion. In protection to embankment shall be slopping wing walls or stone revetment with return walls. In hill roads Guide walls, Chute and catch pits to be provided to dissipate the energy and to prevent the erosion.

7.11.5.6 Widening of Pipe culverts:

Referring to the above standard, pipe culverts are proposed for widening or reconstruction. Suitable CD structures viz. RCC box culverts are proposed based on hydrological requirements. For the proposed new construction, geometrical sections given in MoRT&H and IRC SP: 13-2004 shall be followed.

7.11.5.7 Protection works at high embankment location:

Existing project road is not with any embankment protection work except at certain locations near to cause ways. At flood zones the embankment is raised. Suitable protective measures are proposed to accommodate the slope of the embankment with in ROW if the ROW is in sufficient. Accordingly, retaining wall is proposed wherever required and also for the widened portion of the bridges. Treatment proposal for bridges. The treatment proposals are defined in the subsequent paragraphs.

7.11.5.8 Minor repairs:

All rectifications for secondary structural members, maintenance and repair for proper functioning of the bridges hydraulically without disturbing the main load carrying structural member will fall under this. Minor repairs proposed for structures include cleaning of vents, removal of vegetation and repair of pointing, plastering and coping.

7.11.5.9 Major repairs

Major repairs include repair of protection work, masonry work in substructure, and parapets, restoration of concrete cover, removal and replacement of corroded steel, repair of railing and expansion joint, replacement of wearing coat, and replacement of bearings. It is also proposed to include profile correction at deck

level and replacement of existing railing with crash barrier as required by IRC 5:1998.

7.11.5.10 Strengthening and rehabilitation

Replacement of distressed superstructure is proposed if the condition of the substructure is not in good condition. Strengthening of the existing structure shall be done wherever the load carrying capacity of the structure is found inadequate.

7.11.5.11 Repair scheme of structures along the project roads

The repair strategy for the existing culverts would be as per guidelines laid in IRC: SP-37 and IRC: SP-40. Minor repair works like guniting, replacement of highly corroded reinforcement, repair of substructure etc. have been suggested as follows.

7.11.5.12 Guniting

At places where a large area of soffit of deck slab is distressed and shows spalling of concrete and corroded exposed reinforcement, guniting is recommended. Before guniting the corroded reinforcement should be cleaned by sand blasting and if it is found that during the cleaning operation the diameter of the reinforcement bar has gone down substantially, then this has to be replaced by new reinforcement.

7.11.5.13 Anchoring of Reinforcement Bar

At certain locations it is required to replace the reinforcement bar and for that purpose, epoxy-based compound of anchor grout is recommended.

7.11.5.14 Repair of Corroded/Exposed Reinforcement

Wire brushing/grit blasting should be used to clean corroded reinforcement, suitable protective coating should be applied at the corroded reinforcement.

7.11.5.15 Repair of Existing Parapet

Where existing parapets are found damaged, these are to be replaced or repaired.

7.11.5.16 Repair of Masonry Substructure

Vegetation should be removed properly from surface of substructure. Re-pointing should be done with mortar.

7.12 Recommendation for bridges along the project road

As a safety consideration, width of the bridges was proposed to match with the width of the road at approaches. That is 14.8m in urban and 12.9 / 12.0m in rural for the 2lane and 27.5m (12+3.5+12) for 4lane road improvement.

7.12.2 MAJOR BRIDGE

7.12.2.1 Major bridges on existing road

The important major bridges that would be covered in this study are being addressed as described below.

(1)Lilong Bridge at chainage 330+150 is PSC I-girder type superstructure with well foundations. Condition survey shows that this bridge is of structurally sound and hydraulically functioning good. The bridge is also met the carriageway requirement of 2lane improvement even though the total width of the bridge is less than that required. Considering these parameters, this bridge is proposed to be retained with minor repair and rehabilitation.

(2)Thoubal bridge. at chainage 341+780,is PSC I-girder type superstructure with well foundations. Condition survey shows that this bridge is of structurally sound and hydraulically functioning good. The bridge is also met the carriageway requirement of 2lane improvement even though the total width of the bridge is less than that required. Considering these parameters, this bridge is proposed to be retained with minor repair and rehabilitation

(3)Palle Bridge at chainage 365+500 a new 2 lane bridge is under construction of the realignment of the existing road during inventory it is observed that super structure is casting.

7.12.3 MINOR BRIDGES

7.12.3.1 Bridges on existing road

Minor bridges at chainage 334+330,347+600, 348+150,349+900,352+800 are the RCC solid slab type,, 336+100, 344+240 are RCC T girder bridges. These bridges fall in 4 lane improvement stretch of the project corridor. Condition survey shows that these bridges are of structurally sound and hydraulically functioning well except the bridges at 336+100 and 348+150are structurally distressed hence these can be reconstructed. Remaining bridges are structurally sound, hence these can be widened to 12.0m and a new 2 lane bridge is proposed parallel to the existing bridge.

Minor bridges at chainage 409+000 and 412+230 are solid slab bridges which fall in 2 lane improvement with paved shoulder. These bridges are structurally sound so they are widened to 12.9m concentrically. (Refer Annex 7.1)

Bridge at chainage 407+450 is stone abutment with foundation on rock with bailey super structure; Separate DPR had been submitted to the bridge. Hence not in the scope of the present study.

Bridge at 428+150 is RCC girder bridge is structurally sound and comes in 2 lane improvement of the project and as it is meeting the 2 lane carriage way width, hence it is retained. Bridge at chainage 430+400 is across menar river with RCC abutment

with bailey type super structure is on the international border hence not in the scope of the project.

7.12.3.2 VUP/PUP/

There is one PUP in the approach of Thoubal Bridge, which is structurally sound and is proposed to be widened to meet the requirement for the improvement to 4 lanes. Two new VUPs are proposed along the project road, chainages and the span arrangements are given below.

Table 7-30 (a): Details of New VUP on Existing Road

Sl. No	Design Chainage	Proposed span (m)	Type of structure	Road Crossing	Structure Type
1	342+535	1x20.0 x 5.5	RCC	4 lane	VUP
2	360+132	1x20.0 x 5.5	RCC	2 lane	VUP

7.12.3.3 Viaduct

Due to steeper slope, it is difficult for the vehicle to mount the road. Hence viaduct has been provided at Km-397.960 on Nh-39 for easier mounting of vehicle.

Table 7-30 (b): Details of New Viaduct Existing Road

Sl. No	Design Chainage	Proposed span (m)	Type of structure	Road Crossing	Structure Type
1	397+960	9x33.0	PSC	2 lane	Viaduct

7.12.4 CULVERTS

Referring to the standards highlighted in the previous sections, improvement proposal for culverts are prepared. Annexure 7.2 gives the improvement proposal for pipe culverts of the project road in main alignment. Improvement proposal for Box/Slab and culvert of main alignment is given in Annexure 7.3. Improvement and new proposals of Box/Slab/Pipe Culverts in alternate alignment are given in Annexure 7.4(a), (b). Summary of improvement proposal for pipe and box culverts along the project road for main alignment and alternate route are given in Table 7.31 and table 7.32.

Table 7-31(a): Summary of Pipe Culvert improvement proposal

Item Description	Numbers
No of Pipe Culverts	192
Retained	0
Reconstruction	192

Table 7-31(b): Summary of SLAB/BOX/ARCH culvert improvement proposal

Item Description	Numbers
No of Culverts	118
Retained	0
Reconstruction	118

Table 7-32(a): Summary of Pipe Culvert proposal in alternate alignment

Item Description	Numbers
Retained	0
Reconstruction & New Construction	140

Table 7-32 (b): Summary of SLAB/BOX/ARCH Culvert improvement proposal in alternate alignment

Item Description	Numbers
Retained	0
Reconstruction and New construction	40

7.13 GEOTECHNICAL INVESTIGATIONS AND SUB-SOIL EXPLORATIONS

7.13.1 GENERAL GEOLOGY

The project road corridor follows primarily North to South East direction with starting chainage at Km 330+000 i.e 10 km from the Imphal to Km 430+400 near Moreh on NH-39 passes through the towns Lilong, Thoubal, Pallel, Thengunopal and Khudungthambe in the state of Manipur.

The state is surrounded by northern mountains and the south-east alluvial plains. The project road passes primarily through the North to south east alluvial plains up to Pallel and thereafter hilly terrain continues up to Moreh town and further through the rolling terrain up to end of the project corridor.

Manipur is mainly with alluvial soils which had originally developed by the sediments brought by the surrounding hills rivers. Physiographically, Manipur may be characterized in two distinct physical regions – an outlying area of rugged hills and narrow valleys, and the inner area of flat plain, with all associated land forms. The soil cover can be divided into two broad types, viz. the red ferruginous soil in the hill area and the alluvium in the valley. The valley soil generally contains clay, loam, underlain by the rocky stratum. On the plains, especially flood plains and deltas, the clayey stratum is quite thick. The top soil on the steep slopes is very thin. Soil on the steep hill slopes is subject to high erosion, resulting in gullies and barren rock slopes.

Physiographically Manipur is classified into two distinctive Regions, on the basis of distribution of soils and landforms.

- Alluvial Zone: comprising of Imphal East, Thoubal Districts, The central area of flat plain with the entire allied land forms.
- Hill region: covering the district of Chandel, A remote area which consist of rugged hills and slender valleys

Along the project corridor, the landforms are primarily alluvium soils i.e. clayey stratum with available surface and groundwater resources. Main source of water in Manipur is rain fall with annual average receipt of which is around 1468mm. However, the rain distribution varies from 933 mm in Imphal to 2593 mm in Tamenglong.

7.13.2 PROGRAM FOR GEOTECHNICAL INVESTIGATIONS AND SUB-SOIL EXPLORATION

Evaluation and knowledge of sub soil stratification and engineering characteristics of the soil / rock strata encountered during the exploration works is of significance in order to design safe and economical foundations of the structures and the embankments. Safe bearing capacity and pile / well foundation load carrying capacity of subsoil strata primarily depends on the type of sub-soil / rock sub-strata and their engineering characteristics, ground water table and subsoil stratification in general. The sub soil investigations will be carried out to disseminate and characterize sub soil stratifications and engineering properties of different soil and rock strata encountered along the project site at the

designate and proposed Bridges, Viaducts and Underpasses etc. along the high embankment and any other location necessary for proper design of the works and conduct all relevant laboratory tests on soil and rock samples shall be verified.

Consultant are in process of devising a comprehensive Geotechnical and Subsoil exploration program, based on data collected from structural and hydrological condition surveys of the existing bridges / structures whereby the existing structures require modification or reconstruction from the detailed engineering design considerations. The investigation program also caters to encompass for the proposed all the new structures / bridges / Viaducts / Underpasses etc. along with the high embankments and any other location for proper design of the works and conduct relevant Field and laboratory tests on soil and rock samples retrieved during the investigations. Plans showing location of deep borehole thus for all such structure locations in accordance to IRC 78: 2000 and as per Clause 4.11.4.4 of the TOR shall be prepared prior to investigations. A detailed methodology of undertaking the Geotechnical and Subsoil Investigation program to be adopted shall be prepared and included in subsequent reports.

7.13.3 GUIDELINES FOR GEOTECHNICAL INVESTIGATION

Guidelines on the number of bore holes for Major and minor bridges are given below based on the following criteria from the TOR and stipulations from IRC 78: 2000.

Table 7-33: Details of Required Boreholes

Sl. No	Length of Structure (m)	Type of Bridge / Pavement Conditions	No. of Boreholes
1	0 – 30	Minor Bridge	1
2	30 – 60	Minor Bridge	2
3	>60	Major Bridge	One borehole at each and every support
4	Embankment / Retaining Structure of height more than 6m	Approaches to the Structures	1 on Each side

Apart from the above, additional boreholes may be required to be undertaken at locations of bridges / structures if significant variation in subsurface variability is such that explorations at the suggested spacing are found insufficient to adequately define the subsoil characteristics, else otherwise noted from those compared to the preliminary bore logs, available if any in consultation with the PWD officials. Additional Boreholes / Trial Pits, where deemed necessary.

Preliminary assessment on the number of boreholes planned for different structures are prepared and attached as in Annexure for the assessment considerations. A detailed BH plans are prepared for each structures planned for

the Geotechnical Investigations works based on final highway alignment, structural and hydrological considerations and submitted to the PWD for approval and a methodology on Geotechnical Investigation including termination criteria of depth of Boreholes for different structures.

Based on preliminary Geotechnical Investigation results available from some of the field logs along the project road, the subsoil is primarily layers of alluvial deposits (silty clay / clayey silt / silty sand) of varying consistency. Preliminary analysis of results suggest that Pile / Well foundation shall be foundation for the bridges of major spans (>10m) where as for the box type / smaller spans (<10m) shallow foundation is feasible with occasional requirements of ground improvement by way of excavate and replace with suitable compacted soil fill.

7.14 Shifting of Utilities

Utilities like telephone cable, electrical lines along with water supply lines may be required to shift during widening. A proper scheme of relocating these shall be worked out once the widening schemes are approved. Details of the utilities along the project road are given in the inventory. Strip plan showing existing utilities and relocation plan for the affected utilities due to the widening shall be submitted separately.

8 COST ESTIMATE

8.1 General

The project cost estimates have been prepared based on various items of works required for the rehabilitation and up-gradation work. The item rates for road works have been taken from Manipur PWD (NH Division), schedule of rates (SOR) 2013.

8.2 Estimation of Quantities and Cost

The quantities of all major items of work proposed for the Project Road – namely, the carriageway, shoulder, and median - have been estimated on the basis of the typical cross section, detailed plans and preliminary designs furnished in this Report.

The total earthwork in cut-and-fill has been determined from computerised MX software.

The rates for different categories have been ascertained from the Manipur Schedule of Rates for National Highways- Works 2013.

Site Clearance: The area considered for Site Clearance is the area within the proposed Right of Way minus the existing carriageway area and dismantling of crust of existing carriageway.

Earth Works: This item provides for roadway excavation, earthwork in embankment, subgrade and shoulders, medians, islands including disposal of surplus earth and unsuitable material. The earthwork quantities are based on our site surveys. The new construction will be having an embankment height of approximately 0.5 m throughout the project road.

Sub-base, Base, Surface Courses: This item provides for the items of Cement Treated Sub Base (CTSB), Cement Treated Base (CTB) and WMM for the main and service road.

Bituminous Works: For flexible pavement, the subhead for bituminous works provides for all items of bituminous courses and surfacing. Pavement options for rigid and flexible with Cement Treated have been considered for the project road. Quantities for the pavement component are based on the pavement designs proposed in Chapter 7.

Culverts: The estimation of quantities for culverts was based on site inventory and condition survey. The detailed recommendations are given in Chapter 5.

Bridges and structures: The cost for bridges has been worked as per Preliminary Drawings and also based on Rate per square meter basis.

Junctions Improvement: This item includes quantities of kerbs, railings, median etc. at the location of junctions. Other items of roadworks have been included under the

respective items of works. The cost for junctions includes the cost for at grade junctions, which need improvement along the highway.

Traffic Signs and Markings: Proper traffic signs were selected at required locations along the project corridor and special signs at tollgates were designed. It is reviewed considering the traffic and pedestrian safety and the number of traffic signs shall be minimum and modified if required. Centre line and edge markings required from safety point of view were considered in the quantity estimate. RCC Guard posts, double sided metal beam barrier and pedestrian steel guards taken at relevant locations.

Drainage and Protection works: Provision under this sub-head has been made for surface, subsurface and roadside drains, drainage chutes in cement concrete and stone pitching at outfalls/escapes for drainage. This item covers for unlined, open lined and covered drains.

Toll Plaza: Toll Plaza location is designed for rigid pavement. The cost for the toll plaza includes cost of construction of tollbooths, electrical works, high mast lighting, and toll administrative building with all other features as desired for National Highway Standard.

Miscellaneous Items: A lump sum amount for project house, furniture and equipment required for project maintenance, parking, footpath, electrifications, and roadside amenities. In addition to these, traffic control and diversion, bus-bays and cross utility ducts have also been provided.

Traffic Management and Miscellaneous: Provision for Traffic Management and Miscellaneous items has been taken in the estimate. The following items are also considered in the Estimate:

Land Acquisition, Resettlement and Rehabilitation and Social Costs: Based on alignment design, land and structure acquisition cost including rehabilitation and resettlement costs are being assessed by the social team and will be presented in the separate volume on Social Impact Assessment Report.

Relocation of Utilities: Relocation of Utilities like Electric lines, Telephone lines, OFC etc within the proposed ROW have been estimated for costing purpose. The concerned Administrative Departments have been requested to give the detailed cost estimates duly approved / sanctioned by the competent authority. This will be included in the final submission.

Environmental Improvement Works: The cost of environmental improvements works including the cost of tree cutting and elephant under passes is included in the civil works and tree planting and monitoring cost is given separately under EMP cost in the project cost estimate.

Contingencies and Price Escalation Charges: The project cost estimate is based on 2013 rates and to update the cost to 2015 level, a 10% price escalation is considered. To the base project cost thus estimated, physical contingency at 2.8%, Agency & Supervision Charges at 3%, Quality & Road Safety Charges at 0.25%, Maintenance Charges during construction 3.5% and price contingency at 5% per annum assuming a 3 year construction period is added.

8.3 Unit Rates& Price Escalation Charges:

Unit rates are applied to the quantities to get the direct cost of construction. The rates and inputs for analysis of unit rates have been based on the Manipur Schedule of Rates for National Highways works(PWD)2013.10% Escalation charges are considered on SOR rates. This is been considered due to recent increase in POL and Materials. The Unit rate considered in Bill of Quantities is as follows:

S. No	Item Description	Unit	Rate
1	Bituminous Course (BC)	Cum	14,994
2	Dense Bituminous Macadam (DBM)	Cum	13,966
3	Wet Mix Macadam (WMM)	Cum	2862
4	Granular Sub Base (GSB)	Cum	489
5	Cement Treated Sub Base (with 2% Cement Content)	Cum	855
6	Cement Treated Base (with 4% Cement Content)	Cum	3412
7	Sub Grade (SG)	Cum	255
	Foundation		
6	M15 PCC	Cum	7,025
7	M20 PCC	Cum	7,682
8	M25 RCC	Cum	8,359
9	M30 RCC	Cum	8,730
10	M35 RCC	Cum	9,458
	Sub Structure		
11	M30 RCC	Cum	8,874
12	M35 RCC	Cum	9,615
13	M40 RCC	Cum	9,917
	Super Structure		
14	M30 RCC	Cum	10,917
15	M40 RCC	Cum	12,023
16	M45 PSC	Cum	16,607
17	HYSD Foundation	MT	98,851
18	HYSD Sub Structure	MT	98,851
19	HYSD Super Structure	MT	99,284
20	HT Steel	MT	182,422
21	Crash Barrier M 40	Rmt	7,396
22	Pile M 35	Rmt	17,827
23	Pile M 40	Rmt	18,718
24	Pile M 45	Rmt	19,654
25	Pile Cap M 35	Cum	10,008
26	Pile Cap M 40	Cum	10,305
27	Pile Cap M 45	Cum	10,821

8.4 Preliminary Project Cost

The cost estimates have been prepared item-wise as per details given below:

Table 8.1 (a) PROJECT COST FOR IMPHAL – MOREH SECTION				
Existing Route_NH 39				
Bill. No.	Description	Km 330+000 to Km 342+930	Km 342+930 to Km 425+411	Km 330+000 to Km 425+411
		4Lane Portion	2Lane Portion	Total Project Cost
1	SITE CLEARANCE AND DISMANTLING	20,766,662	35,596,587	56,363,249
2	EARTHWORK	118,695,745	1,706,538,639	1,825,234,384
3	GRANULAR SUB-BASE AND BASE COURSE	242,323,401	1,050,995,838	1,293,319,239
4	BITUMINOUS COURSE	305,753,888	865,304,877	1,171,058,765
5	CULVERTS	104,822,099	400,784,904	505,607,003
6	BRIDGES (Underpasses, Vaiduct, Minor & Major Bridges)	438,623,086	214,184,009	652,807,095
7	JUNCTIONS, TOLL PLAZA	168,379,055	57,664,265	226,043,320
8	DRAINAGE AND PROTECTIVE WORKS	415,672,608	532,391,608	948,064,216
9	TRAFFIC SIGN, MARKING & OTHER APPURENANCES	47,675,228	74,349,944	122,025,172
10	MISCELLANEOUS	15,094,727	216,351,560	231,446,287
11	MAINTENANCE , REPAIRS & REHABILITATION	21,931,154	10,709,200	32,640,355
12	ELECTRICAL ITEMS	38,625,000	22,700,000	61,325,000
	Total(Civil Cost)2015-2016=	1,938,362,653	5,187,571,431	7,125,934,084
	Cost per KM (INR Crores/Km) =	14.99	6.29	7.47
	Labour Welfare Cess at 1%	19,383,627	51,875,714	71,259,341
	Add physical contingency at 2.8%	54,274,154	145,252,000	199,526,154
	Agency Charges at 3%	58,150,880	155,627,143	213,778,023
	Quality Control at 0.25%	4,845,907	12,968,929	17,814,835
	Road Safety at 0.25%	4,845,907	12,968,929	17,814,835

	Supervision at 3%	58,150,880	155,627,143	213,778,023
	Price escalation @ 5% per annum (3 year construction with 30:40:30 disbursements at a total of 10%)	193,836,265	518,757,143	712,593,408
	Utility shifting (Provisional sum)			
	EMP and Environmental Monitoring			
	Land Acquisition and Resettlement			
	Total Project Cost (2013)	2,331,850,272	6,240,648,432	8,572,498,703
	Total Project Cost (2013) in Rs. Crores	233.19	624.06	857.25
	Length (Km)	12.93	82.48	95.411
	Cost per KM (INR Crores/Km)	18.03	7.57	8.98
	Total Project Cost in USD @ INR 58/USD	40,204,315	107,597,387	147,801,702
	Cost per KM (USD Million/km)	3.11	1.30	1.55

Table 8.1 (b) PROJECT COST FOR IMPHAL – MOREH SECTION

ALTERNATIVE ROUTE		
	Km 0+000 to Km 58+506	
Sl. No.	Description	Project Cost
1	SITE CLEARANCE AND DISMANTLING	35,744,749
2	EARTHWORK	1,616,734,559
3	GRANULAR SUB-BASE AND BASE COURSE	516,916,030
4	BITUMINOUS COURSE	571,335,245
5	CULVERTS	216,067,090
6	BRIDGES (Underpasses, Vaiduct, Minor & Major Bridges)	223,600,522
7	JUNCTIONS, TOLL PLAZA	98,936,545
8	DRAINAGE AND PROTECTIVE WORKS	943,655,103
9	TRAFFIC SIGN, MARKING & OTHER APPURENANCES	82,382,350
10	MISCELLANEOUS	195,895,584
11	MAINTENANCE , REPAIRS & REHABILITATION	-
12	ELECTRICAL ITEMS	33,090,000
	Total(Civil Cost)2015-2016=	4,534,357,776
	Cost per KM (INR Crores/Km) =	7.64
	Labour Welfare Cess at 1%	45,343,578
	Add physical contingency at 2.8%	126,962,018
	Agency Charges at 3%	136,030,733
	Quality Control at 0.25%	11,335,894
	Road Safety at 0.25%	11,335,894
	Supervision at 3%	136,030,733

	Price escalation @ 5% per annum (3 year construction with 30:40:30 disbursements at a total of 10%)	453,435,778
	Utility shifting (Provisional sum)	
	EMP and Environmental Monitoring	
	Land Acquisition and Resettlement	
	Total Project Cost (2013)	5,454,832,405
	Total Project Cost (2013) in Rs. Crores	545.48
	Length (Km)	59.359
	Cost per KM (INR Crores/Km)	9.19
	Total Project Cost in USD @ INR 58/USD	94,048,835
	Cost per KM (USD Million/km)	1.58

9 ECONOMIC ANALYSIS

9.1 INTRODUCTION

The proposed project involves capacity augmentation and rehabilitation of the NH 39 and an additional route from Wangjing to Khudengthabi. Project road corridor start from km 330+000 and end at km 425+411 and the alternative route start from Wangjing at Km 350 on NH 39 and finally merges with the project corridor near Khudengthabi (Km 417 on NH 39).

An economic evaluation of the proposed project components was undertaken. The evaluation methodology is determined by the magnitude of the impact of the project road improvements have on the transport conditions as compared with the present situation. In case of NH 39, the project road improvement consists of the improvement of an existing road, which is already travelled by motorized traffic but has capacity constraints and deteriorated road condition. The proposed project will augment traffic capacity, improve the geometry, remove major bottlenecks such as congested urban sections near Thoubal town. The main impact of the improvement is a reduction in transport costs. The HDM-4 model is used for estimating the costs and benefits associated with both without and with the project scenarios in order to establish the economic viability of the proposed project. In case of alternate route, it is mostly a track and not motorable during rains making it motorable at all for over 4 months and for the rest of the time only four wheel drive utility vehicles can travel along the route.

In terms of transport economics, the improvement of road corridors will result in savings to road users and the society as a whole in the form of reduced vehicle operating and time costs for passengers and freight traffic. The additional route will largely benefit the population along the corridor with transportation costs for which they currently use longer routes. These reduced costs, calculated over the project life, are compared with construction costs for each road improvement option (including the cost of environmental and social impact mitigation measures). The results are expressed in Economic Internal Rates of Return (EIRRs) and ratios between Net Present Value (NPV) and capital costs of the proposed road improvement.

Opportunity Cost of Capital: To be acceptable for implementation, the proposed investments have to result in an EIRR of at least equal to the opportunity cost of capital, which is set at 12 percent. The NPV is calculated using opportunity cost of capital as the discount rate.

Shadow Pricing and Use of Conversion Factors: All costs and benefits are valued in monetary terms and expressed in economic prices to avoid distortions in the input prices of labor, materials, equipment and foreign exchange due to market

imperfections. In calculating the road agency economic costs (construction and maintenance), economic costs of construction were derived from the financial construction cost by applying a conversion factor of 0.85. As explained in the next section on HDM input data, the economic cost of vehicle operating and time costs (VOCs) have been calculated separately for each individual component. Therefore, a CF has not been used for these costs.

9.2 ECONOMIC ANALYSIS PARAMETERS

The Highway Design and Management Model (HDM) is essentially an analytical tool for engineering and economic assessment of road investment and maintenance strategies and viability of road investments in terms of savings in vehicle operating, time and road maintenance costs. HDM is based on physical and economic relationships derived from extensive research in road deterioration, mainly resulting from traffic volumes and characteristics (such as axle loadings), environment and the effects of maintenance activities. The model requires input data on traffic, road geometry, condition, and pavement structure and material characteristics of the existing road as well as maintenance and road improvement costs and vehicle operating cost parameters for representative vehicles.

9.2.1 TRAFFIC

The base year traffic assessment and forecast are presented Chapter 4. The analysis identified 4 homogenous traffic sections on the NH 39 corridor and the additional route is considered as one homogenous section.. The economic analysis has been carried out considering the homogenous traffic sections with data input given by homogenous sections and then the output combined for each corridor. The base year traffic parameters on NH 39 is given in Table 9.1.

Table 9.1: Base Year Traffic Volume along NH 39Corridor

Homogeneous Sections	AADT (Motorised)	Percent of Passenger Vehicles	Percent of Goods Vehicles	Percent of Non-Motorized Vehicles)
HS 1	22013	94.17	3.99	1.86
HS 2	2689	82.93	8.61	8.57
HS 3	1326	87.49	12.51	0.00
HS 4	4682	93.97	4.16	1.87

The base year traffic obtained from the traffic surveys constitutes the normal traffic. In addition to this two other types of traffic, diverted and generated/induced traffic also may be considered. The study of road network indicates that lot of potential to generate traffic by means of improving the international trade between Myanmar and India and the details of potential traffic

are discussed in Chapter 6. Traffic estimates for alternate route and traffic growth projections are also given in Chapter 6 which has been used in the analysis.

9.2.2 ROAD CHARACTERISTICS

The inventory and condition survey data, material and pavement investigations data and their analysis presented in Chapter 5 provide the required HDM input data for the existing road characteristics.

9.2.3 VEHICLE CHARACTERISTICS

The HDM model takes as input the vehicle technical and operational characteristics, vehicle prices, tire prices, fuel price, maintenance and vehicle operation staff costs. The technical and vehicle operating characteristics are adopted from other similar studies with minor adjustment based on consultant's judgment/experience in similar projects. The vehicle price, tire price and maintenance and vehicle operating staff cost were collected from North Eastern Part of India is adopted for the study. Economic fuel prices have been derived excluding all taxes and duties.

9.2.4 VALUE OF TIME FOR PASSENGER AND FREIGHT

For passenger-carrying vehicles, values of passenger working and non-working time were calculated based on per capita income in the state. The per capita income per employed person is worked out and average hourly income is derived assuming 2080 hours of work per year. The value of time in private passenger vehicles is equated to the income level of owners of these vehicles, which is substantially higher than for the population in average. The hourly cost for passengers in public transport vehicles in rural areas may be at the lowest be equated with opportunity cost of labor, or minimum wage levels. The work time for bus, two wheeler and car passengers are valued at 0.5, 1.0 and 2.0 times the average hourly income thus estimated considering the likely income range of bus, two wheeler and car passengers. The value of non-work time is taken as one-fourth of value of work time. The values for the state GDP per capita was obtained from the Economic Survey of India 2012-13. A summary of the calculated values of time for each passenger-carrying vehicle is presented in Table 9.2 below.

Table 9.2 Adopted Values of Passenger Working and Non-Working Time

State	Estimated NSDP per capita at current prices, 2013 (INR)	Bus (INR per hour)		Car (INR per hour)		Two- & Three-Wheelers (INR per hour)	
		Working	Non-Working	Working	Non-Working	Working	Non-Working
Manipur	37705	17.0	4.3	68.0	17.0	34.0	8.5

For goods-carrying vehicles, a value of time for cargo was calculated as well using the method suggested in the HDM manual—taking the value of cargo and the

opportunity cost. Value of time for freight is calculated as time value of goods in transit, i.e. the value of the goods carried times the commercial interest rate paid by the owners as an inventory cost. Considering the predominance of regional trade and main goods carried, a cargo value of INR 60,000 per ton is assumed and the opportunity cost of cargo delay or value of time for cargo is estimated at INR 1.65 per ton per hour, considering 75% of cargo to be benefited and an interest rate of 12%.

9.2.5 SALVAGE VALUE

A straight-line depreciation method is used to calculate the salvage value of project elements at the end of the analysis period. Among the project elements, bituminous components are assumed to have a life of 20 years with periodic renewal as needed and will have no salvage value. The pavement structure below bituminous layer in the widening portion and new construction is assumed to have a 40 year life for salvage value calculation. Bridges and cross drainage structures can have a life of more than 50 years. Assuming a 50-year life for all structures, the salvage value was calculated on a straight-line depreciation method. The salvage value thus estimated is 29 % for NH 39 and 33% for alternated route at the end of the analysis period.

9.2.6 OTHER INPUT PARAMETERS

Other parameters used such as the analysis period, discount rate, salvage value, construction period and the year of opening of the road for traffic after construction are presented in the Table 9.3 below.

Table 9.3 Other Input Parameters Used for the HDM4 Analysis

Other Input Parameters	Value
Analysis period (Years) from Opening Year	20
Discount rate (%)	12
Construction period (Years)	3
Construction start year	2015
Opening year for traffic	2018

9.3 CONSTRUCTION AND MAINTENANCE

The construction and maintenance alternatives for the HDM analysis have been defined based on the improvement options identified in Chapter 7. Based on the traffic and capacity assessment, four lane cross section is adopted for homogenous traffic sections 1 and 2, and two lane configuration with paved shoulders for all other homogeneous sections including additional route. For each alternative defined, a set of maintenance and improvement standards needs to be assigned. The maintenance and improvement standards define the work items to be carried out on the project road over the analysis period.

The construction cost estimate for project option is given in Chapter 8. The maintenance unit costs adopted are based on the unit cost estimates for the project. The routine maintenance cost is adopted based on values used in other similar projects. The routine maintenance cost is assumed at INR 90,000 per km for existing

two lane roads, INR 120,000 per km for upgraded two lane roads and INR 180,000 per km for four lane roads. Civil Works Costs and Routine and Periodic maintenance costs considered are given below. In addition to the civil work cost, project cost considered for economic analysis include physical contingencies at 2.8%, construction management costs at 3% and a lumpsum provision of INR 45 crores for NH 39 and INR 30 crores for Alternate Route for utility shifting, environmental and social costs.

Table 9-4 Summary Maintenance Costs

Sl.No.	Maintenance Item	Costs (INR)
1	Routine Maintenance every year	
	(a) 2L without project per km	90,000
	(b) 2L with project per km	1,20,000
	(c) 4L with project per km	1,80,000
	(d) Patching per sq m	875
	(f) Edge Repair	1170
2	Periodic Maintenance	
	(a) Thin Overlay per Sq m (25 SDBC-without project)	260
	(b) Thin Overlay per Sq m (40 BC-with project)	575
	(c) Structural Overlay per Sq m (40BC & 60 DBM)	800

9.4 ECONOMIC ANALYSIS

An economic analysis has been carried out for the project road sections. On the benefit side, vehicle operating cost savings and travel time savings are quantified and included in case of NH 39. Other benefits include accident cost savings and environmental benefits. The improvement in geometry, directional separation in the four lane section, widening in the hill section, road signs and markings, improved layout in town sections are likely to reduce accidents. At the same time, the increase in speed resulting from improvement may increase the severity of accidents. The main environmental benefit will be from capacity augmentation and the reduced congestion and vehicle emissions. Overall the impact will be positive but reduced accident benefits and vehicle emissions were not quantified and included in the analysis. In case of villages along the Alternative Route, it provides a shorter direct route along the main travel corridor and based on the road network access in the area it is assessed that upto 10% reduction in travel distance can be realized and a 5% reduction in distance is considered in the analysis.

The results of economic analysis using HDM-4 model for the project road are summarized in Table 9.5. The results indicate that the project development option have a rate of return well above the opportunity cost of 12%.

Table 9.5 Results of Economic Analysis

Description of Option	EIRR (%)	NPV (INR Million)
Imphal – Moreh Section	17.0	3161.58
Additional Alternative Route	13.0	232.45

Note: EIRR – Economic Internal Rate of Return; NPV – Net Present Value

Sensitivity analyses were also carried out to investigate the robustness of the economic viability of the project to cost over-runs and benefit reductions. The cases analyzed are:

- Case I Base Cost and Base Benefits
- Case II Increase Capital Costs by 15 % and Base Benefits
- Case III Base Cost and Decrease Benefits by 15 %
- Case IV Increase Capital Costs by 15 % & Decrease Benefits by 15 %

The results of the sensitivity analyses for the road corridors are given in Table 9.6. As shown, either with an increase in capital costs by 15 percent or a reduction in benefits by 15%, both project corridors still has an EIRR of above 12 percent except in one case but with a combination of both an increase in cost and decrease in benefits of the magnitude of 15% will result in EIRR falling below 12%. Considering the larger trade related economic impact for the north eastern region in case of Imphal-Moreh section and the project area economic development with new access in case of Alternate Route which are not captured in the economic analysis, the acceptable EIRR threshold could be lowered to 10% and even in the worst case scenario, EIRR is above 10% and therefore the project is considered economically viable. Based on the economic analysis of the project options, as well as on the engineering and traffic assessment, the proposed project is recommended for implementation.

Table 9.6. Sensitivity Analysis Results

	Imphal – Moreh Section		Additional Alternative Route	
Sensitivity	EIRR	NPV	EIRR	NPV
Case I	17.0	3161.58	13.0	232.45
Case II	17.0	3959.76	13.0	449.43
Case III	17.0	2926.78	13.0	332.19
Case IV	14.0	1246.76	10.0	(739.97)

Cash Flow Stream for the two projects for base case is given below in Table 9.7(a) and Table 9.7(b) respectively.

Table 9.7(a). Cash Flow Stream for ImphalMoreh Section

Year	Increase in Road Agency Costs		Decrease in Road User Costs		Net Benefits
	Capital Costs	Maintenance	Vehicle Operating Costs	Time Costs	
2016	2186.0	0	0	0	(2,185.99)
2017	2914.6	0	0	0	(2,914.65)
2018	2186.0	0	0	0	(2,185.99)
2019	0	4.6	384.4	240.4	620.20
2020	0	4.6	425.7	265.2	686.30
2021	0	4.6	475.6	294.3	765.30
2022	0	4.6	546.3	334.8	876.50
2023	0	4.6	712	402.8	1,110.20
2024	0	308.1	844.1	473.9	1,009.90
2025	0	4.6	986.3	545	1,526.70
2026	0	-2.7	1177.2	644.7	1,824.60
2027	0	-79.1	1455.2	785.3	2,319.60
2028	0	-66.2	1544.2	855.8	2,466.20
2029	0	-14.5	1768.6	1002.9	2,786.00
2030	0	285.7	2102	1172.2	2,988.50
2031	0	-18.4	2392.1	1288.8	3,699.30
2032	0	-17.4	2570.2	1361.6	3,949.20
2033	0	-18.1	2531.4	1337	3,886.50
2034	0	-22.1	2559.2	1345.1	3,926.40
2035	0	-94.3	2591.2	1355.1	4,040.60
2036	0	277.8	2526.8	1379.7	3,628.70
2037	-1093.0	-24.2	2643.1	1383.8	5,144.09
				EIRR (%)	17%
* All Costs in Million Rupees				NPV @ 12%	3161.58

Table 9.7(b). Cash Flow Stream for Additional Alternative Route

Year	Increase in Road Agency Costs		Decrease in Road User Costs		Net Benefits
	Capital Costs	Maintenance	Vehicle Operating Costs	Time Costs	
2016	1390.98	0	0	0	-1391.0
2017	1854.64	0	0	0	-1854.6
2018	1390.98	0	0	0	-1391.0
2019	0	3.9	354.64	139.872	490.612
2020	0	3.9	379.936	149.792	525.828
2021	0	3.9	406.968	160.58	563.648
2022	0	3.9	435.984	172.112	604.196
2023	0	3.9	467.108	184.388	647.596
2024	0	3.9	500.464	197.656	694.22
2025	0	129.5	532.208	210.304	613.012
2026	0	3.9	566.556	223.696	786.352
2027	0	3.9	602.64	237.956	836.696
2028	0	3.9	641.08	253.208	890.388
2029	0	3.9	681.876	269.328	947.304
2030	0	3.9	725.4	286.564	1008.06
2031	0	3.9	760.74	300.824	1057.66
2032	0	129.5	797.692	315.704	983.896
2033	0	3.9	838.736	331.328	1166.16
2034	0	3.9	880.028	347.82	1223.95
2035	0	3.9	923.18	365.056	1284.34
2036	0	3.9	968.44	383.16	1347.7
2037	-695.5	3.9	1015.81	402.132	2109.53
				EIRR (%)	13%
* All Costs in Million Rupees				NPV @ 12%	232.45

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Chapter 10.0 CONTRACT PACKAGING

10.1 General

In packaging contracts, there must be weighing between economy and work efficiency. Based on local geo political system, accessibility to site and weather conditions plays vital role in deciding the most optimal contract packaging. Knowing the project area and uncertainties, it is the opinion of the Consultants that the packages shall be of smaller length and longer duration to avoid slippages and pitfalls. Contract packaging has to be based on fore thought, requires interaction between project development team and MoRTH / PWD who are responsible for managing the project to account possible packaging effects. Project size, equipment requirements, physical features and responsibilities including risk imposed on the contractor are all critical factors impacting bid prices and competition. The Consultants based on the understanding of the project sites, the contract packaging has been prepared for consideration of MoRTH/PWD.

10.2 Contract Packaging

The following key factors in Construction Contract Packaging are considered in making the recommendation on Contract Packaging,

- Logical sections for construction, worksite access and earthwork balance
- Administrative jurisdiction and administrative efficiency
- Size of contract to attract medium and large size contractors with the required equipment and capability
- Time to completion
- Environmental requirements and constraints to specific segments

The proposed Construction Contract Packaging Summary is given below.

Package 1

Segment 1:

Lilong to Thoubal (From Km 330 to Km 342+600), including Roadwork / protective works, road furniture and drainage and all major structures like Bridges. There are 2 minor bridges and 2 major bridges situated in this segment.

Segment 2:

Thoubal to Pallel (From 342+600 to Km 365+900)including Roadwork / protective works, road furniture and drainage and all major structures like Bridges. There are 6 bridges existing out of which 1 is a major bridge. There is a new bridge under construction near Pallel town on Sekmai River, which will be ready by end of this year.

Package 2

Segment 3:

Pallel to Khudengthabi (From Km 365+900 to Km 417)including Roadwork / protective works, road furniture and drainage and all major structures like Bridges. There are 3 minor bridges existing in this segment.

Segment 4:

Khudengthabi - Moreh (From Km 417 to Km 425+411)There are 2 minor bridges existing in this segment out of which one bridge is located on the border at Km 430+400 which is a Bailey steel bridge and only half length maintained by India.

Package 3

Alternative alignment Take off from Wangjing town on the project corridor(km 350)and finally merges with the project corridor near Khudengthabi village(km 417)

The proposed Contract Packages, along with final design length of sections included in the project, are presented in Table 10.1(a) to Table 10.1(c). The final road alignment, highlighted in red, is shown in Figure 10.1. The mode of contract is indicated as EPC model. The technical specification prepared based on "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fifth Revision April 2013, Latest Revision) have been updated based on the recent update.

Fig 10.1 Final Alignment of AH 01 and and Alternate alignment

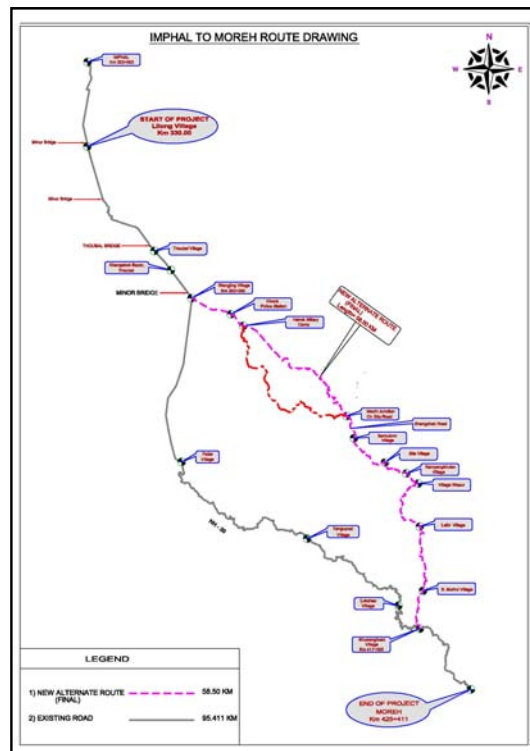


Table 10.1(a) Contract Package 1

Package No.	Section	Sub-section Length (Km)	Package Length (KM)	Estimated Civil Works Cost (INR Crores)	Proposed Duration (Months)
1	Km 330 to Km 342+930	Km 330+000 to Km 342+930	12.93	193.84	48

Table 10.1(b). Contract Package 2

Road Agency/ Package No.	Section	Sub-section Length (Km)	Package Length (KM)	Estimated Civil Works Cost (INR Crores)	Proposed Duration (Months)
2	Km 342+930 to Km 425+411	Km 342+930 to Km 425+411	82.48	518.76	48

Table 10.1(c) Contract Package 3

Package No.	Section	Sub-section Length (Km)	Package Length (KM)	Estimated Civil Works Cost (INR Crores)	Proposed Duration (Months)
3	Wangjing (km 350) to Khudengthabi (km 417)	Km 350 of NH-39 to Km 417 of NH-39, along the new alignment passing through Villages Hirok, Machi and Sita.	58.5	453.43	48