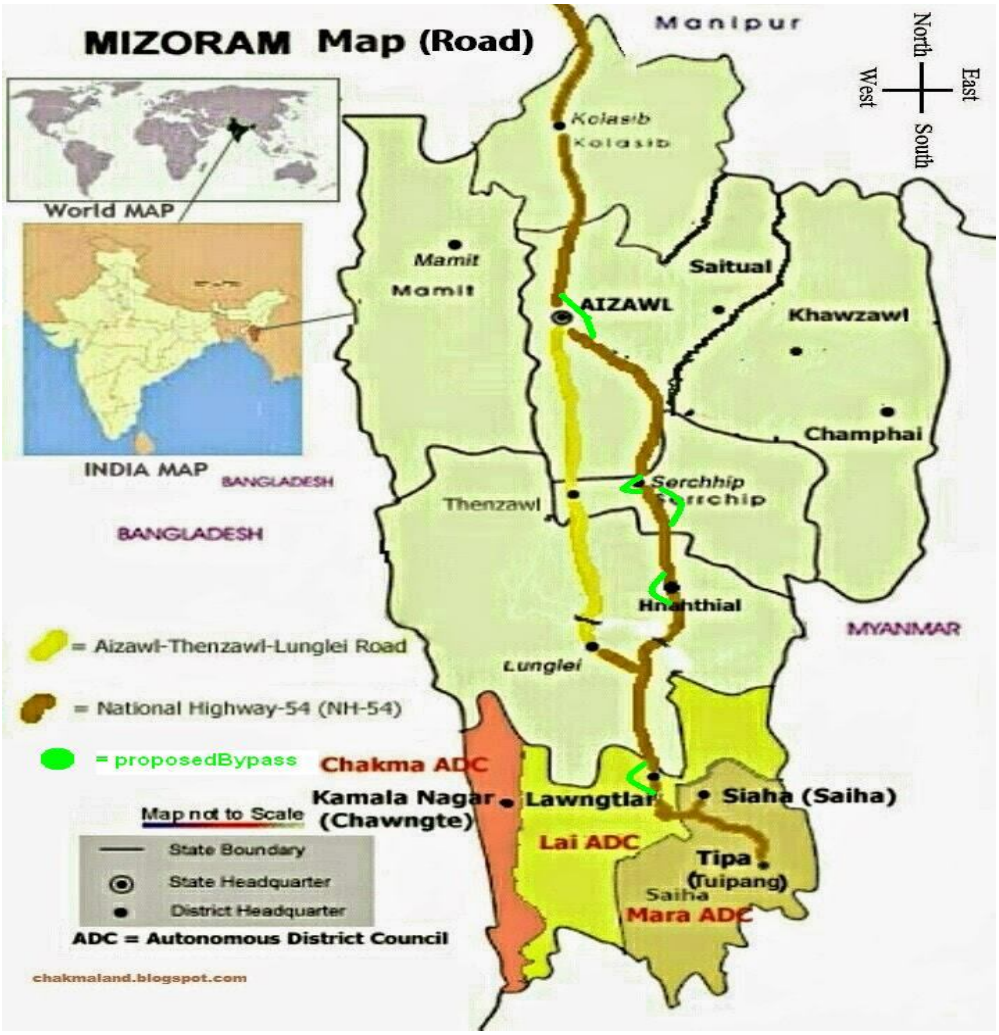
National Highways of Infrastructure Development Corporation Ltd

Consultancy Services for Preparation of Detailed Project Report for 2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojnam



FINAL DETAILED PROJECT REPORT

VOLUME – I: MAIN REPORT

PACKAGE-2

JULY-2023

CM Engineering & Solution ***in with JV***

Anandjiwala Infra Advisory in association with

Anandjiwala Technical Consultancy

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1. EXECUTIVE SUMMARY

1.1. INTRODUCTION

The Govt. of India has acknowledged the importance of better road infrastructure and launched several programs and initiatives to extend and improve India's highway network. Road development is pivotal to sustaining the country's economic growth. National Highways and Infrastructure Development Corporation Ltd (NHIDCL) premium organization under the aegis of the Ministry of Road Transport & Highways (MORTH) has undertaken the formulation of Detailed Project Reports (DPR) for **2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojna.**

Mizoram is one of the states of North-Eastern India, with Aizawl as its capital. The name is derived from Mi (people), Zo (hill), and Ram (land), and thus Mizoram implies "land of the hill people". In the Northeastern region, it is the southernmost landlocked state sharing borders with three of the seven sister states, namely Tripura, Assam, and Manipur. The state also shares a 722 Km border with the neighbouring countries of Bangladesh and Myanmar.

Like several other northeastern states of India, Mizoram was previously part of Assam until 1972, when it was carved out as a Union Territory. It became the 23rd state of India on 20 February 1987.

NH-6 is 667 Km and passes through Assam, Meghalaya, and Mizoram.NH-6 begins in Jorabat, Assam at the intersection of NH-27 and generally runs southward passing Shillong, Jowai, Badarpur, Panchgram, Kolasib, Kanpui, Aizawl, Seling, Kawlkulh, Khawzawl, Champhai and terminates near Zokhawthar at India/Myanmar border. Before the renumbering of national highways, NH-6 was variously numbered as old national highways 40, 44,154 & 54. NH-6 enters Mizoram from Bairabi. The existing NH-6 (Old NH-54) within the state of Mizoram was originally constructed as ODR Standard Road during the early part of the seventies later it was developed as an intermediate lane by the BRO. The road was upgraded to the status of a National Highway in the year 1986.No substantial improvement of the road other than normal renewal works and improvement of the blind curve have been carried out from Sairang to Aizawl section since the road was declared a National Highway.

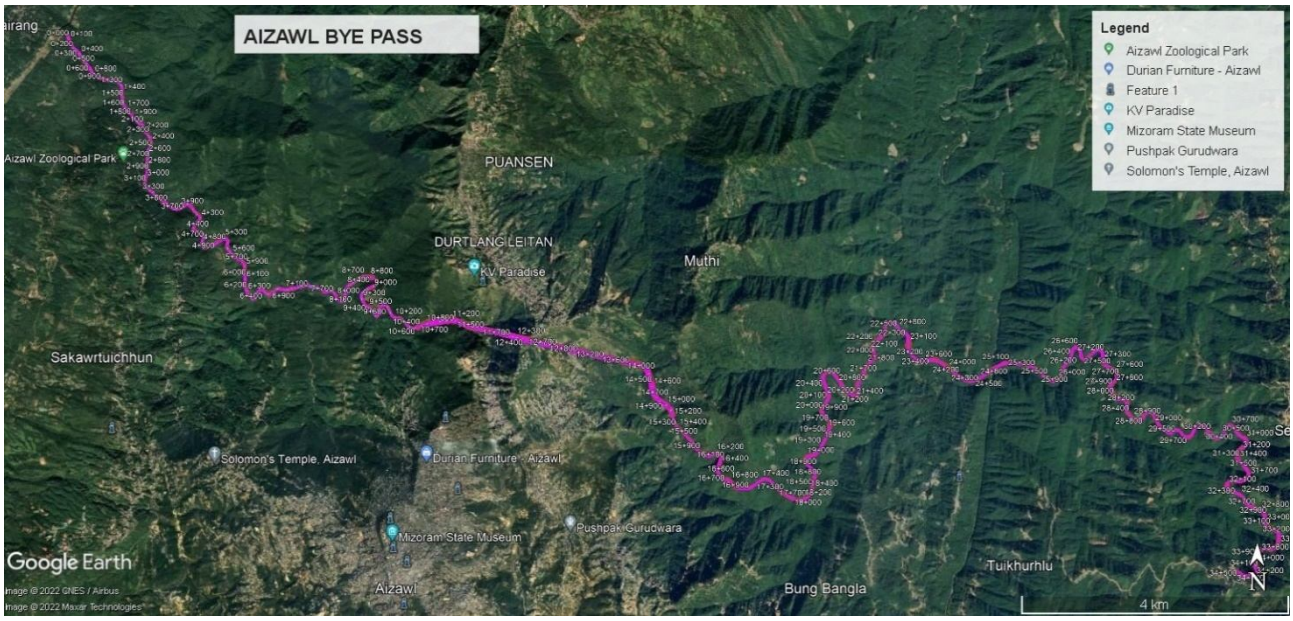
National Highways and Infrastructure Development Corporation Ltd (NHIDCL) has awarded **M/s. CM Engineering & Solution in with JV Anandjiwala Infra Advisory in association with Anandjiwala Technical Consultancy for Consultancy Services** for preparation of Detailed Project Reports (DPR) for 2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojna.

Aizawl bypass Detailed project Report is prepared in three Construction Packages as below:

Sr.No	Package No	From	To	Remarks
1	Package -1	CH: 00+000	CH:10+600	Two Lane Paved Shoulder with 3 Nos of Major Bridges
2	**Package -2**	**CH:10+600**	**CH:15+200**	**Four Lane with Twin tube Tunnel and 2 Minor Bridges**
3	Package -3	CH:15+200	CH:34+500	Two Lane Paved Shoulder with 6 Nos of Major Bridges

Instant DPR is prepared for Package -2

The instant project is for Aizawl bypasses on the Kolasib-Aizawl-Seling section of NH-6 as shown Figure



1.2. PROJECT OVERVIEW

NH-6 passes through the heart of Aizawl City and pass through its gooseneck at Bawngkawn saddle. With the ever-increasing traffic volume, the existing road network within and around Aizawl city could no longer accommodate the smooth flow of traffic. No-Entry for Heavy Motor Vehicles must be introduced during peak hour within Aizawl city which is a big setback for the development of the whole state of Mizoram. Aizawl Municipal area is 150 Sq.Km has 4.50 lakhs population and still growing.NH-6 within the city is 17.00Kms. Due to these reasons, it was felt necessary to bypass Aizawl City.

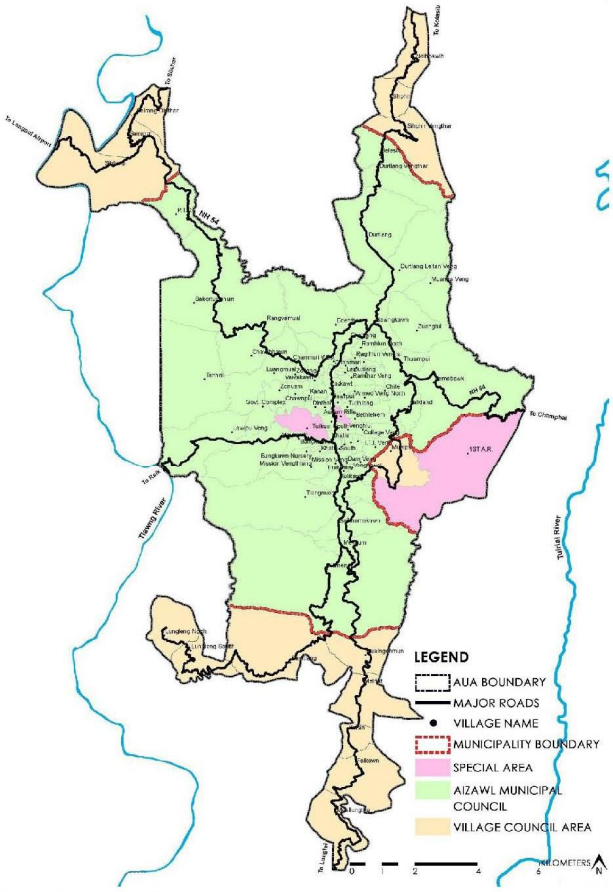


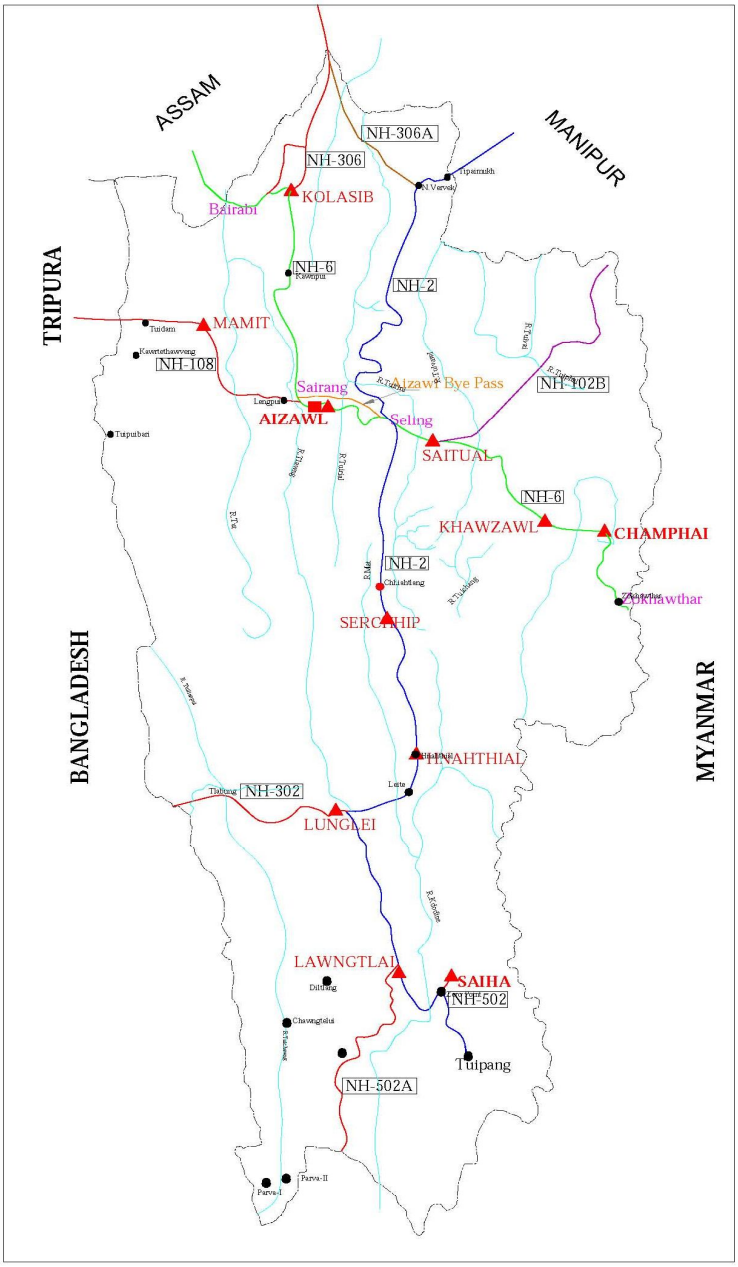
Figure 2.3: Planning area boundary

Source: Modified based on the original map form Master Plan for Aizawl: VISION 2030, Aizawl Development Authority, 2011

NH-6 from Sairang to Bung Bangla passes through heavily built-up areas which involve costly Land Acquisition and serious resettlement problems in the existing road. The existing alignment also passes through a number of sharp blind curves and landslide-prone areas at

many locations which could also pose serious problems in the future. Due to these reasons, it is necessary to re-align the existing stretch of the NH-6 between Sairang to Bung Bangla. The proposed alignment passes through mostly virgin land and will have lower cost of rehabilitation. Therefore, the re-alignment

does not pass through heavily built-up area and would involve much less LA cost as well as resettlement problem as compared to the existing alignment. The re-alignment also passes through an area with a much better topographical as well as soil conditions. Hence, apart from the reduction in length of road by Km 29.00, which would greatly benefit both Future Boarder Trade Route in terms of vehicle operating cost and travel time, the proposed re-alignment is technically far better and financially cost effective in the long run.



The proposed realignment of the existing road takes off from Sairang on NH 6 and merging with existing road Near Phaibawk Village on NH-6 to avoid the numbers of sharp curve on existing road and to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Aizawl City. It's running from North to south on the Eastern side of the hill.

1.3. KEY FEATURES OF THE PROJECT:

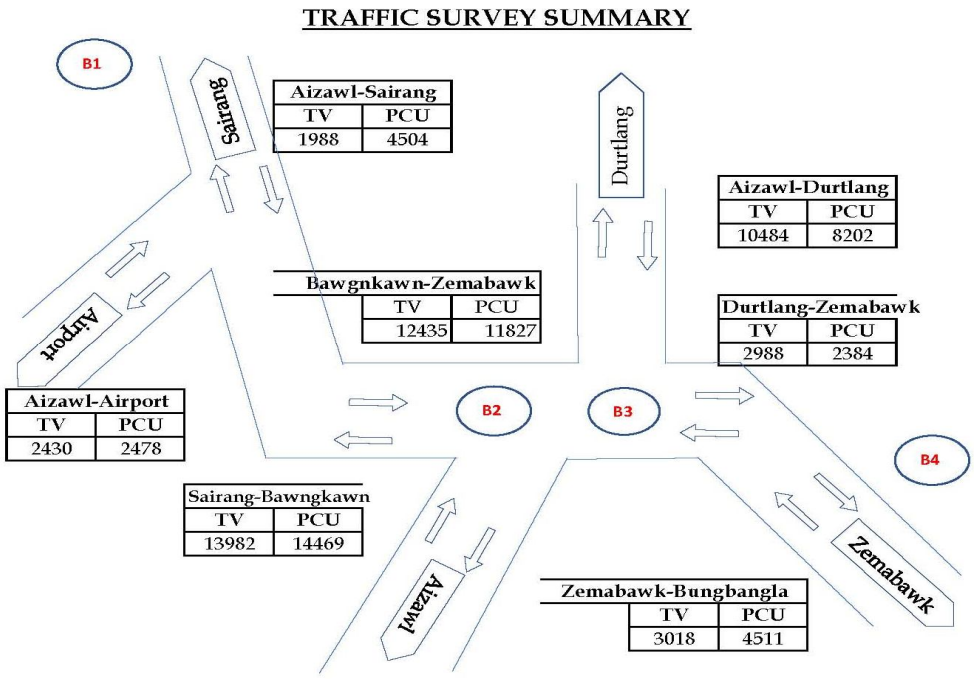
Sl. No.	Attributes	Details along the existing Stretch	Details along the Proposed Bypass Stretch
1	NH No	NH-54 (Old) / NH-06 (New)	
2	Origin-Destination	NH-6 begins in Jorabat, Assam at the intersection of NH-27 and terminates near Zokhawthar at India/Myanmar border.	

Sl. No.	Attributes	Details along the existing Stretch	Details along the Proposed Bypass Stretch
		Start: Lat: 26° 5'57.91"N & Long: 91°52'33.80"E End: Lat: 23°21'47.56"N & Long: 93°23'17.35"E	
3	Via Town	Jorabat, Byrnihat, Umroi, Shillong, Jowai, Kalain, Badarpur, Panchgram, Hailakandi Bairabi, Kolasib, Kanpui ,Aizawl, Seling, Kawlkulh, Khawzawl, Champhai and Zokhawthar	
4	Instant Project Stretch	**From Km 163+900 to Km 220+300 on NH-06 (Old NH-54)** (Sairang to Near Phaibawk Village) Start: Lat: 23°48'30.69"N & Long: 92°39'36.50"E End: Lat: 23°44'4.96"N & Long: 92°50'37.69"E	
5	Carriageway	2L (7.0 m) Over 70% of the road stretch and the remaining stretch widening of 2L is progress Under JICA Funding (Sairang to Seiling Section)	2 Lane Carriageway from CH:0+00 to CH 10+600 **4 Lane Carriageway from CH:10+600 to CH 15+200** 2 Lane Carriageway from CH:15+200 to CH 34+500
6	Service lanes and slip roads	NA	NA
7	Shoulder	Earthen varies with 1m to 1.5m	Paved shoulder 1.5 m and Earthen Shoulder 1.0 m
8	Condition of existing Pavement	Good to Fair	Green Field Alignment
9	Right of Way	Not Define (Varies from 10m to 12m)	Varies from 53.0 m to 98.0m for Package -2
9	Land use along project road	Predominant land use in the area is urban (90%) , with the rest being forest and agricultural area.	Predominant land use in the area is agricultural area.
10	Traffic on the stretch	30% of commercial goods vehicle and 70% of Passenger Vehicles	30% of commercial goods vehicle and 40% of Passenger Vehicles will be diverted to Bypass Road
11	Toll infrastructure	There are no toll Plazas in the current stretch	
12	Terrain	Steep terrain	Steep terrain
13	Structures along stretch	No bridges, mostly culvert	2 No of Minor Bridges and 1 No of Twin tube Tunnel of length 2500m and 8.0 Nos of Culverts.
13	User amenities along stretch	10 bus shelter, 1 Truck Terminal ,1 Bus Terminal and 2 rest area	4 Nos of bus shelter

Sl. No.	Attributes	Details along the existing Stretch	Details along the Proposed Bypass Stretch
14	Key utilities in the Proposed RoW	33 KV line, OFC cable and water supply pipeline along the entire stretches	
15	Forest Stretches along RoW		Muthi Community Reserve Forest CH: 14+300 to CH: 15+200
6	Rail Crossing along RoW	NA	NA
17	Other Clearance related aspects		Forest and Environmental

1.4. TRAFFIC SURVEY, ANALYSIS & FORECAST

This is to assess the capacity requirements, and pavement design, identify present and likely future traffic conditions, and have provisions for future improvements.



Sr.No.	Vehicle Type	Aizawl-Airport	Aizawl-Sairang	Sairang-Bngkawn	Bgkawn-Zbawk	Aizawl-Durtlang	Durtlang-Zembawk	Zebawk-Bubangla
1	Cars / Jeep	867	308	4039	3185	3155	737	873
2	3-Wheeler	40	50	0	0	0	1	108
3	2-Wheeler	714	365	6933	6929	6176	1868	683
4	Minibus	11	0	237	26	10	2	3
5	Full Bus	0	37	63	344	33	5	9
6	LCV	799	257	1567	1247	1002	287	678
7	Truck 2-Axle	0	602	715	610	106	86	566
8	Multi Axle Truck	0	368	428	93	2	1	97

Sr.No.	Vehicle Type	Aizawl-Airport	Aizawl-Sairang	Sairang-Bngkawn	Bgkawn-Zbawk	Aizawl-Durtlang	Durtlang-Zembawk	Zebawk-Bubangla
9	Tractor With Trailer	0	0	0	1	0	0	0
10	Cycle	0	0	0	0	0	0	0
11	Cycle Rickshaw	0	0	0	0	0	0	0
12	Hand Cart	0	0	0	0	0	0	0
13	Horse Cart	0	0	0	0	0	0	0
14	Bullock Cart	0	0	0	0	0	0	0
15	Others	0	0	0	0	0	0	0
Total Vehicle	Motorised Traffic	2430	1988	13981	12435	10484	2987	3017
	Non-Motorised Traffic	0	0	0	0	0	0	0
	Total	2430	1988	13981	12435	10484	2987	3017
Total PCUs	Motorized Traffic	2478	4504	14469	11827	8202	2384	4511
	Non-Motorised Traffic	0	0	0	0	0	0	0
	Total	2478	4504	14469	11827	8202	2384	4511
CVD	Vehicles	810	1265	3010	2321	1152	382	1354
Peak hr traffic	Vehicles	1375	1042	8025	7195	5990	1891	1716
	PCUs	1412	2270	6943	6487	4675	1416	2236
Time of peak traffic		1-2 PM	5-6 PM	12-1 PM	2-3 PM	3-4 PM	10-11 AM	2-3 PM
Peak hour traffic ratio in %		8.08%	7.49%	8.20%	8.27%	8.15%	9.04%	8.13%
Projected Traffic upto Year 2036	Vehicles	7195	5885	41363	36792	31052	8842	8922
	PCUs	7337	13334	42811	34973	24240	7060	13338
Projected Traffic upto Year 2051	Vehicles	21280	17407	113845	108849	91873	26156	26388
	PCUs	21700	39444	117826	103447	71713	20881	39441
Road user in %	2-Wheeler	29.4%	18.4%	49.6%	55.7%	58.9%	62.5%	22.6%
	Passenger Vehicles	37.8%	19.9%	31.0%	28.6%	30.5%	24.9%	32.9%
	Goods Vehicles	32.9%	61.7%	19.4%	15.7%	10.6%	12.5%	44.5%

From traffic volume counts the following observations are made,

(i) There are large numbers of 2-wheeler using the road (42.40%).

(ii) Traffic is dominated by passenger vehicles (29.40%)

(iii) The Goods vehicle traffic (28.20%).

(iv) Traffic toward Aizawl city from NH-6 and NH-108 is (4504 +2478=6982 PCU)

(v) Traffic exit Aizawl city through NH-6 is (4511+2384=6895 PCU)

Recent traffic data included in Annexure as Traffic Survey Details

1.5. SALIENT FEATURES OF THE PROJECT

Salient features based on design are as below:

Sr. No.	Description	Details
		Package – 2
1	Length of project road	4.600 Km (Green Field Alignment)
2	Proposed ROW	Varies from 24.0 m to 98.0m
3	Formation width	46.30 m for 4 Lane with Paved Shoulder including 26.30 m wide median for service building and emergence parking, utility and equipment
4	Carriageway	• 2Lane CH:10+600 to CH: 10+900 • Transition Zone from CH:10+900 to CH: 11+050 • 4 Lane Carriageway from CH:11+050 to CH 11+600 • Tunnel Twin Tube Unidirectional 2Lane carriageway from CH:11+600 to Ch:14+100 • 4 Lane Carriageway from CH:14+100 to CH 14+650 • Transition Zone from CH:14+650 to CH: 14+800 • Flaring Zone from 4Lane to 2Lane From CH:14+800 to CH:15+200
5	Type of Pavement	Flexible pavement
6	Type of shoulder	Paved shoulder 1.5 m and Earthen Shoulder 1.0 m on valley side and 1.0 m for side drain
7	Take off point	Near DurtlangLui
8	End Point	Near Muthi Lui
9	Drain	Surface Line drain 2360 Rm Catch water Drain 1410 Rm, Chute Drain 1050 Rm
10	Landslide	Nil
11	Junction	Nil
12	Bridge	2 Nos of Minor Bridge
13	Tunnel	2500 m Twin Tube Tunnel with 2 Lane Carriageway with uni-direction traffic with 4 Nos of Cross Passes as Per IRC:SP-91:2019
14	Culvert	8 Nos of Box Culvert
15	Retaining Wall	230.00 Rm
16	Breast Wall	1760.00 Rm
17	Gabion RE Wall	6700.00 Sqm
18	Gabion Wall	1300.00 Rm

Sr. No.	Description	Details
		Package – 2
19	Toe Wall	460.00 Rm
20	User amenities	4 Nos of bus shelter and layby

a) Cross Section Elements:

The design standards of relevant Indian Roads Congress for Roads and Bridges are adopted for cross-section designs of the project road. The earlier items of construction may involve the construction of the road formation, and cross-drainage works including the construction of major bridges for 4-lane standard and protection work. The later stage of the construction will cover the construction of Pavement for double lane (2x7.50 m wide) NH standard. The proposed cross-section element with dimensions is shown in the table below:

Sl.No.	Design elements	Dimensions
1	Roadway width	
	At roads and culverts*	46.30.00 m
	At bridges**	2x10.50m
2	Carriageway width	2 x 7.50 m
3	Cross slopes / Camber at straight reaches	2.5%

**Roadway width is inclusive of side drain and parapet wall/crash barrier (IRC SP: 48)*

***Roadway width is exclusive of kerbs*

b) Road Geometry:

The project corridor passes through steep to mountainous then rolling terrain. The design speed adopted is 40km / hour (IRC: 52-2019) for steep and mountainous terrain. Along the proposed alignment, there will be no hair-pin bend. However minimum design speed has been considered on technical grounds. The vertical and horizontal alignments of the proposed road can be summarized as shown in table below:

Horizontal curve details:

Sr. No	Bypass Name	Project Road length	No. of Curves with Design Speed in km/h				No. of Curves with Radius (m)		
			<30	30-40	40-50	>50	<30	30-50	>50
	Aizawl Bypass	34.500 Km	0	152	0	0	0	17	135
P2	Km 10.60 to Km 15.20	4.60 Km	0	0	0	8	0	0	8

Vertical curve details:

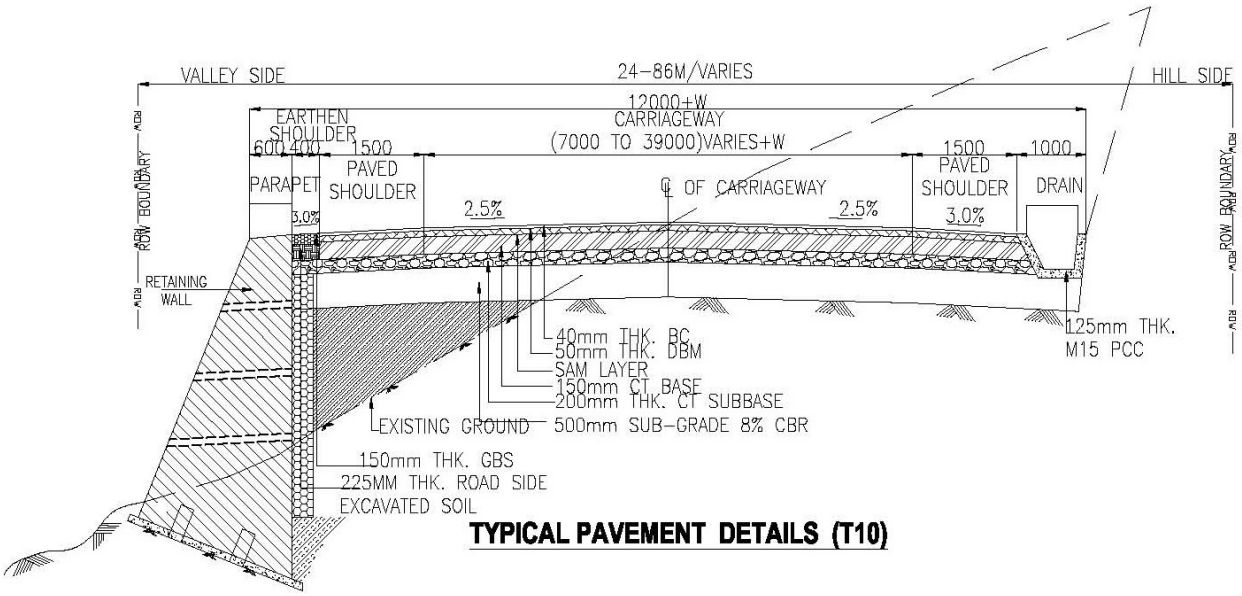
Sr. No	Bypass Name	Project Road length	Length Distribution (km) and Gradient Class				
			<4%	4%-5%	5%-6%	6%-7%	7%-8%
1	Aizawl Bypass	34.500 Km	6.820	10.140	17.550	0.000	0.000
P2	Km 10.60 to Km 15.20	4.60 Km	2.95		1.65		

c) Design of Embankment / Hill Cutting

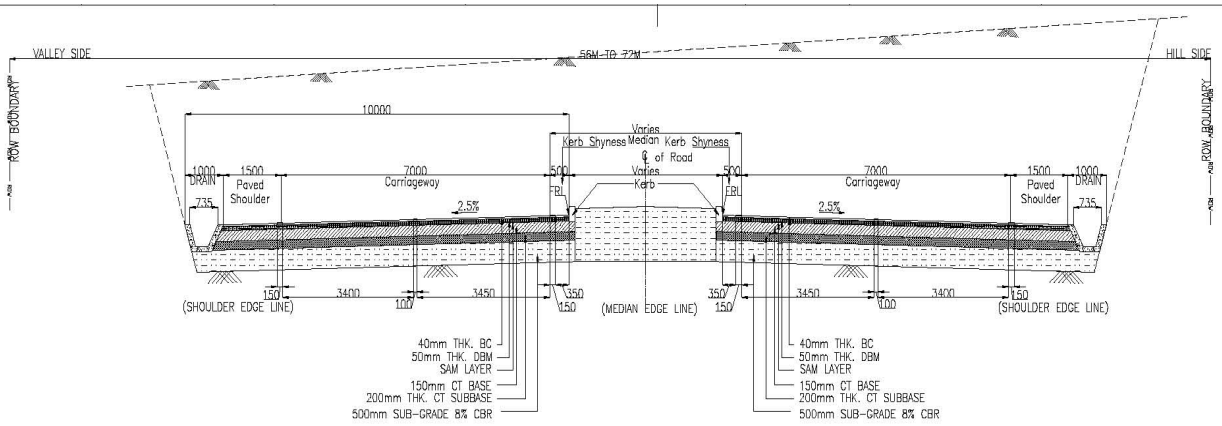
Considering the physical features, particularly the terrain, soil classification, and hill slope line, typical cross-section (Type 06 to Type 10) has been developed for hill road cutting /embankment building.

Sr.No	Description	Chainage	Typical Section
1	Flaring Zone from 2Lane to 4Lane	From CH:10+600 to CH: 10+800	Type-10 & Ref Location R/W &B/W
2	Transition Zone	From CH:10+800 to CH: 10+900	Type-10 & Ref Location R/W &B/W
3	4 Lane Carriageway	From CH:10+900 to CH 11+600	Type-6-7-8-9 & Ref Location R/W &B/W
4	Tunnel Twin Tube Unidirectional 2Lane carriageway	From CH:11+600 to Ch:14+100	Ref Tunnel section
5	4 Lane Carriageway	From CH:14+100 to CH 14+900	Type-6-7-8-9 & Ref Location R/W &B/W
6	Transition Zone	From CH:14+900 to CH: 15+000	Type-10 & Ref Location R/W &B/W
7	Flaring Zone from 4Lane to 2Lane	From CH:15+000 to CH:15+200	Type-10 & Ref Location R/W &B/W

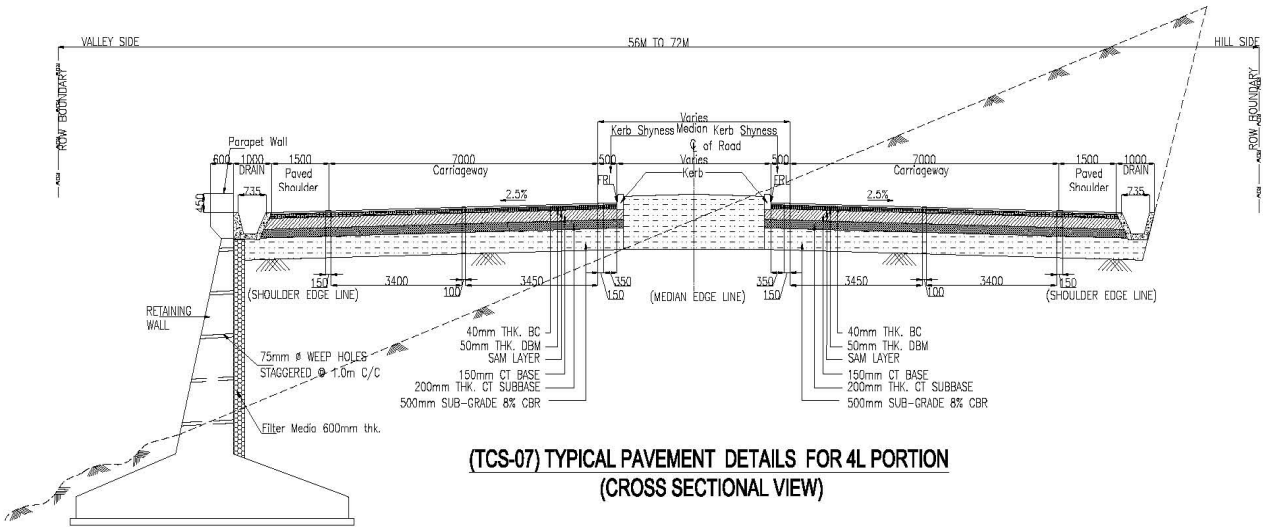
The concept Plan of the design of the embankment/hill cutting (stretch-wise) has been developed with specific mention of the formation building methodology / type to be adopted.



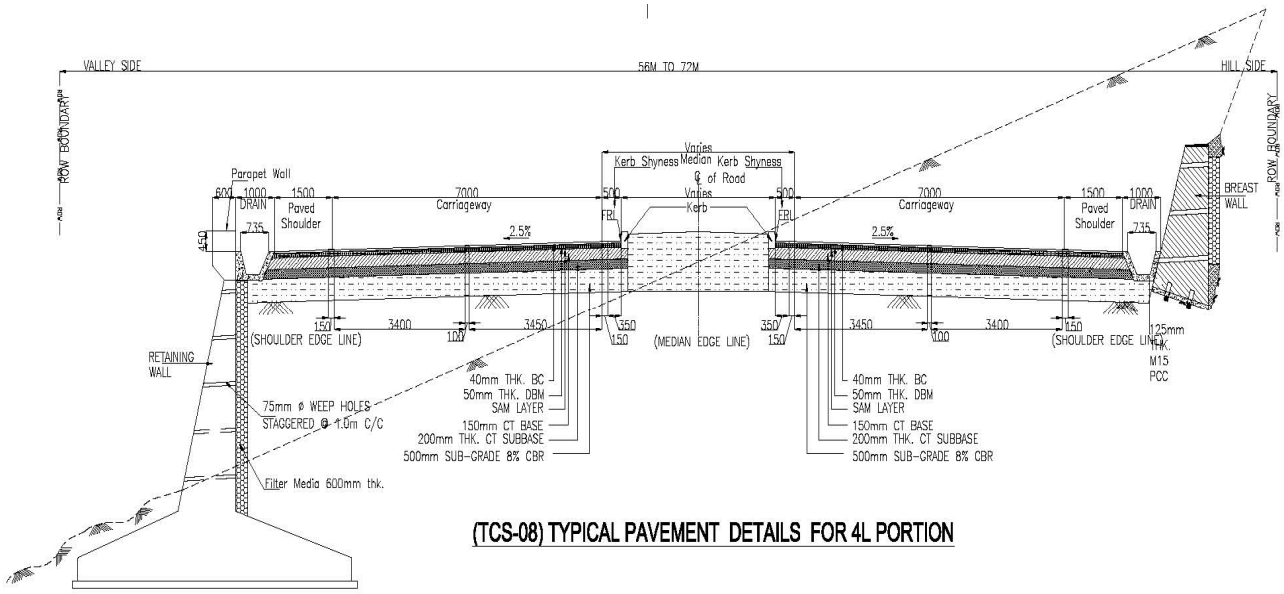
TYPICAL PAVEMENT DETAILS (T10)



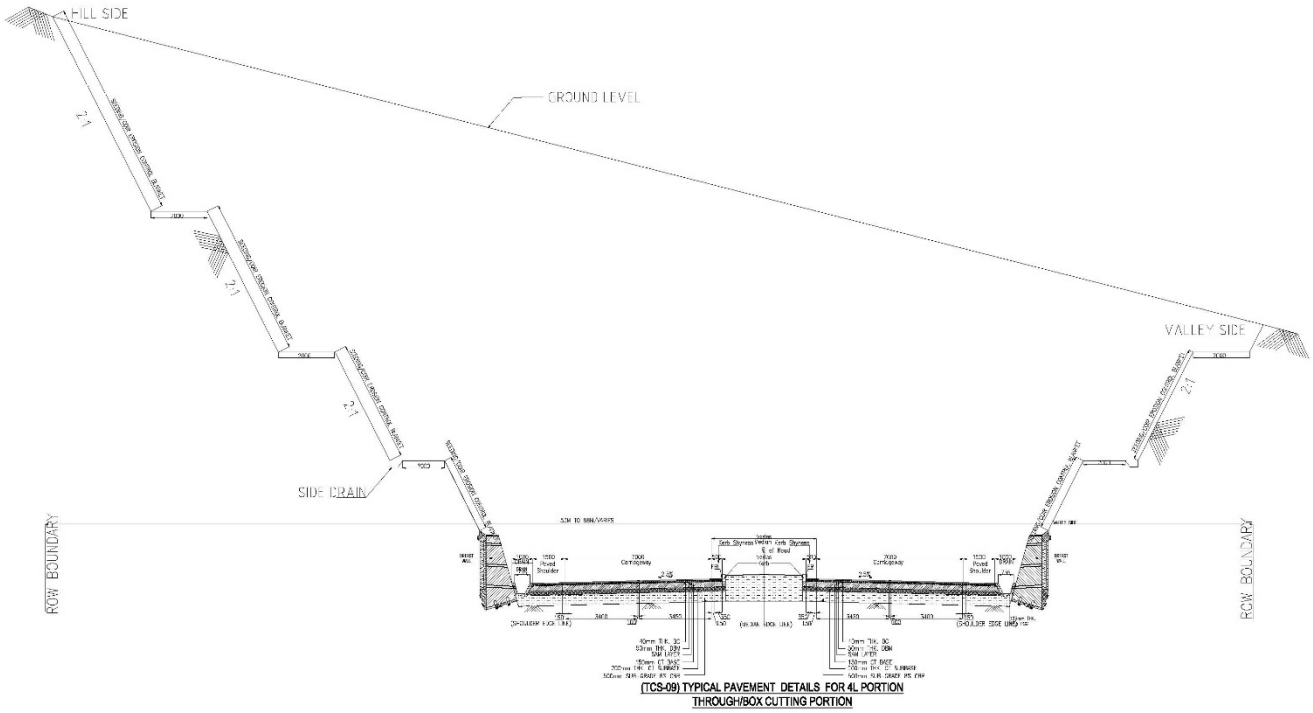
(TCS-06) TYPICAL PAVEMENT DETAILS FOR 4L PORTION



(TCS-07) TYPICAL PAVEMENT DETAILS FOR 4L PORTION
(CROSS SECTIONAL VIEW)



(TCS-08) TYPICAL PAVEMENT DETAILS FOR 4L PORTION



Through/Box Cutting Portion

d) Dumping area identified on the Proposed Road

It has been estimated that about 22.96 Lakhs cum of spoil will be generated due to widening of this road. Only 13.70% of the spoil will be reused during construction of the road rest will be disposed off 10nos. identified disposal sites which are selected based on consultation with communities.

This earth shall be disposed off as per an environmentally suitable manner.

(i) Certain guidelines for debris disposal are given below.

- The debris generated shall be disposed of within designated areas only.
- The filled-up area shall be used for designated purposes such as Playground.

(ii) Condition of dumping area selection

- Ground shape with concavity topography
- Less ground gradient than 22 degrees which assumes the average angle of spoil bank slope with necessary steps.
- No built-up area
- No national sanctuary area.

(iii) Protect dumping area as recommendations and suggestions have been made THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH, NEW DELHI on 01-11- 2018

e) Pavement Design

It is based upon CVD-3010, CBR-8%, Traffic msa -10, Design period – 15 years, VDF-1.7, Annual Growth of traffic rate 7.5%, and Design speed of 40.00 Km/hr for hilly portion. However, the proposed pavement composition is based on CBR-8% and msa -20.

Pavement composition is designed as under:

Proposed pavement for road portion

BC	:	40 mm
DBM	:	50 mm
Stress Absorbing Membrane (SAM) with crack width 6 mm to 9 mm in one layer		
Cement Treated Base (CTB)	:	150mm
Cement Treated Sub-base (CTSB)	:	200 mm
Total	:	440 mm

Proposed pavement for Tunnel Portion

- Dry Lean Cement Concrete: 150 mm
- Cement Concrete Pavement: 350 mm

f) Shoulder Design

Paved Shoulder 1.5m width on either side having the same composition of the Main carriageway and Earthen shoulder having the width of 1.0m the on valley side and a hillside 1.0m shall be used to accommodate for side drain.

g) Culverts:

The project road traverses through mountainous and steep terrains with several natural drainages such as deep gorges, depressions, etc., where perennial water and rainwater runoff are collected. Sometimes the storm runoff is accompanied by large quantities of debris from the stream side of the nullahs. Cross-drainage structures / culverts are required at these locations. From the field survey and investigations and geometric design of alignment requirement of culverts for the whole length of the project has been identified.

Sr.No	Description of Item	Unit	Package-2
A	**Box Culvert**	**No**	**8**
1	Type -1 - 2 x 2	No	5
2	Type -2 - 3 x 3	No	2
3	Type -3 - 4 x 4	No	1

h) Slope Protection works:

Adequate Protective structures are proposed for retaining of cut / fill slopes to ensure stability of the road formation at locations where required. The proposed type and length of each structure are shown in the table below:

Sl.No.	Description	Unit	Quantity
1	Vetiver grass	Sqm	20000.0
2	Seeding and Mulching	Sqm	13440.00
3	Non-woven Coir Erosion Control Blanket	Sqm	13440.00

Sl.No.	Description	Unit	Quantity
4	Turfing with Sods	Sqm	10000.00
5	Vegetables bamboo crib wall	Rm	5000.00
6	Shotcreting with welded wire mesh	Cum	525.00
7	25 mm diameter 3-meter-long steel rock bolts	Nos	585.00
8	Retaining wall for 3.0 m Height	Rm	80.00
9	Retaining wall for 4.0 m Height	Rm	00.00
10	Retaining wall for 5.0 m Height	Rm	80.00
11	Retaining wall for 6.0 m Height	Rm	70.00
12	Gabion RE Wall	Sqm	6700.00
13	Breast Wall 2.00m high	Rm	850.00
14	Breast Wall 3.00m high	Rm	910.00
15	Gabion Wall 2.00 m high	Rm	700.00
16	Gabion Wall 3.00 m high	Rm	600.00
17	Toe Wall 2.00 m high	Rm	220.00
18	Toe Wall 3.00 m high	Rm	240.00

Retaining wall Location

Sr.No.	Chainage		Length in m	Height in m	Remarks	Type
	From	To				
1	10600	10630	30	5	RHS	Plum Concrete
2	10950	11000	50	3	RHS	Plum Concrete
3	11000	11070	70	6	RHS	Plum Concrete
4	11070	11100	30	3	RHS	Plum Concrete
5	11260	11310	50	5	RHS	Plum Concrete
6	14780	14880	100	12	RHS	Gabion RE Wall
7	14910	15160	250	22	RHS	Gabion RE Wall

Breast wall Location

Sr.No.	Chainage		Length in m	Height in m	Remarks
	From	To			
1	10630	11040	410	3	RHS
2	11100	11250	150	2	RHS
3	11290	11520	230	3	RHS
4	11520	11600	80	3	RHS
5	11500	11600	100	2	LHS
6	14100	14290	190	3	RHS
7	14100	14290	190	2	LHS
8	14350	14760	410	2	RHS

i) Bridge

It is proposed to construct 2 minor bridges along the bypass as per relevant IRC standards and MoRT&H guidelines.

Sr. No.	Location (Km)	River Name	Proposed bridge on Aizawl Bypass					
			Type	Span Arrangement	Carriageway	Total width	Super structure	Foundation
1	11+530	Durtlang Lui	RCC Box Cell	1X 8	2x10.15	96.428 (SK)	Box	Open
2	14+325	Muthi Lui	RCC Box Cell	1 X 10	2x10.15	46.90	Box	Open

j) Tunnel

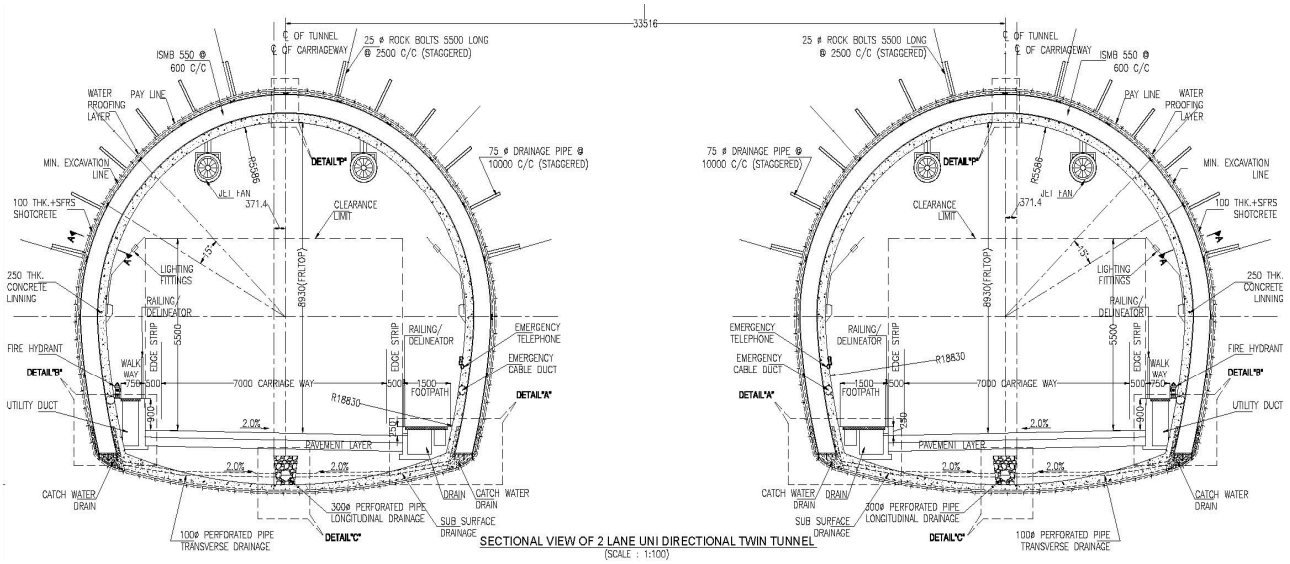
It is proposed to construct one twin tube 2 Lane Tunnel as per specification configuration of IRC: SP-91-2019 and relevant IRC standards and MoRT&H guidelines.

➢ **Functional/Safety Requirements Based on Length of Tunnels**

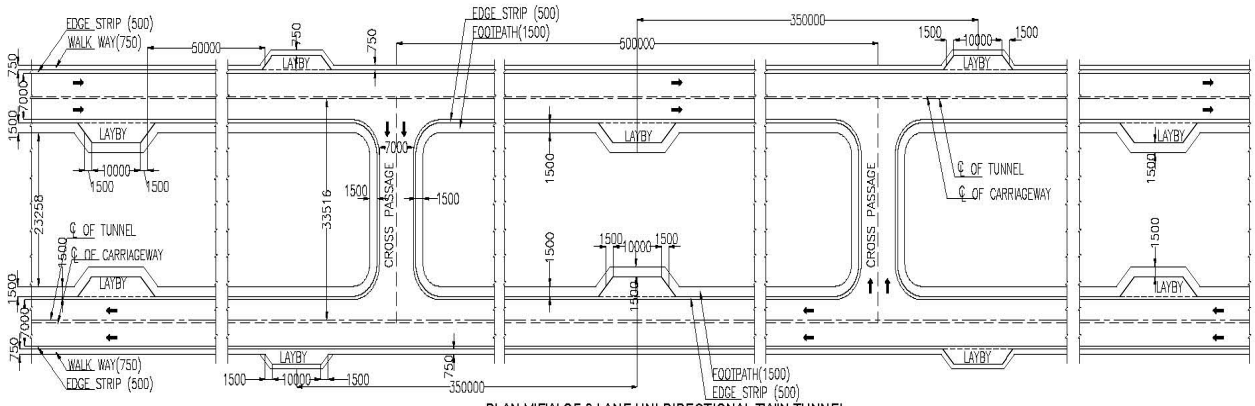
Classification of Tunnel	Double Tube Uni-Directional				
	CP	Vent	Light	Comm	Fire Safety
Long tunnel >1500 m	Yes	Yes	Yes	Yes	Yes

- Fire safety - Fire extinguisher at spacing of 100 m
- Communication - Telephone at spacing about 100 m
- Lighting - Tunnels Lighting as IRC:SP-91-2019
- Cross Passages - Cross passages provided at 500 m spacing

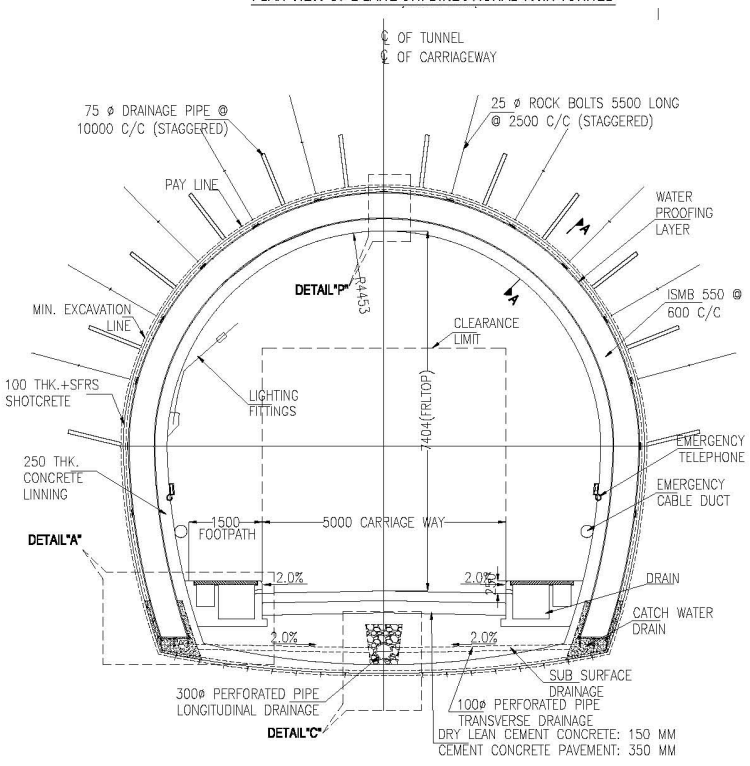
Sl.No	Chainage	Length	Carriageway	Remarks
1	CH: 11600 to CH: 14100	2500.00m	7.0 m (Walkway &utility 750+Edge strip 500+Carriageway 7000+Edge Strip 500+ Footpath cum drain & utility 1500) mm	Twin Tube Tunnel, having Inlet Portal 100.0 m and Outlet Portal 100.0 m Rigid Pavement composition within the Tunnel portion DLC – &utility 150 mm PQC – 350 mm
2	Cross Passage	4x22.7m	(Footpath cum drain & utility 1500+Edge strip 500+Carriageway 5000+Edge Strip 500+ Footpath cum drain & utility 1500) mm	Rigid Pavement composition within the Tunnel portion DLC – &utility 150 mm PQC – 350 mm



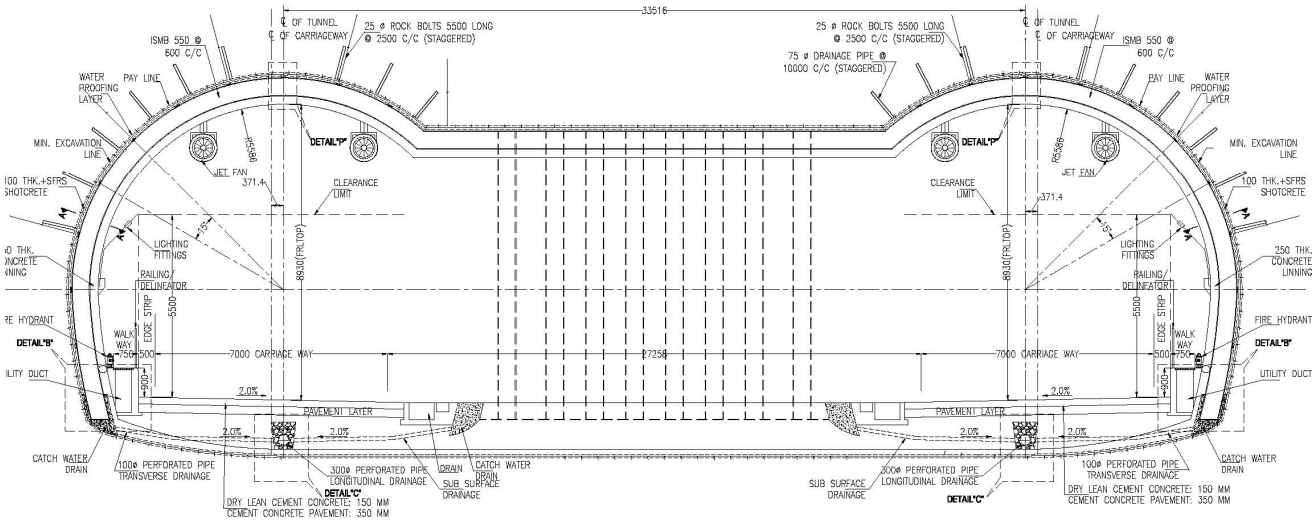
SECTIONAL VIEW OF 2 LANE UNI DIRECTIONAL TWIN TUNNEL
(SCALE : 1:100)



PLAN VIEW OF 2 LANE UNI DIRECTIONAL TWIN TUNNEL



SECTION OF CROSS PASSAGES TUNNEL
(SCALE : 1:100)



SECTIONAL VIEW OF 2 LANE UNI DIRECTIONAL TWIN TUNNEL CROSS PASSAGES
(SCALE : 1:100)

- **Tunnel Ventilation and Fire Fighting System:**

The ventilation system chosen is longitudinal ventilation with Jet Fans . 2x13 Nos Jet in tube.(1487 N Thrust). Fresh air demand can be provided to the tunnel without exceeding the maximum airspeed in tunnel (10 m/s according to RVS 09.02.31).

- Fire thermal power of 50 MW.
- The defining parameter here is the fire power, that depends on inflammable goods, fuels, vehicle fire etc. that will be transported through the tunnels.
- 70% light vehicles (35% petrol, 35% diesel), and 30 % heavy vehicles (trucks, busses,)
- Twin tube unidirectional tunnels having 2 lane for each direction.

The longitudinal (Jet) fans need to comply with fire rating (250°C - 2 hrs/400 °C - 2 hrs) in accordance with design of the tunnel

The concentration of CO inside the tunnel should not exceed 70 ppm for normal flowing traffic. This concentration may be permitted up to 100 ppm during traffic congestion. If the CO concentration reaches 200 ppm, tunnel operations should be immediately suspended.

It is recommended to permit a maximum average in-tunnel concentration of 1.0 ppm NO_2 along the length of the tunnel at any one time. For a short-time working exposure a limit of 5 ppm is recommended.

- **Automatic Tunnel Fire Detection and Warning Systems**

The key objective of the automatic tunnel fire detection and warning systems is to provide prompt, accurate, and reliable fire detection while preventing nuisance alarms. Prompt and accurate fire detection will result in timely activation of tunnel ventilation system in the predetermined mode of operation to maintain tenable environment for evacuees. The successful management of tunnel fires requires that fires are detected quickly and accurately while they are still at a controllable size (in the order of 1 - 5 MW [3-17 MBtu/hr]).

- **Fire Fighting Systems**

Fire Suppression Systems with the goal to reduce the fire HRR by sufficient application of water, e.g., Deluge system with adequate water storage inside/ outside tunnel.

The standpipe system for firefighting shall be a Class – I" automatic Wet" type system. It contain water at all times that is attached to a water supply capable of supplying the system demand at all times and that requires no action other than opening loose valve to provide water at loose connections. 150 mm main waterline shall be laid on one side of the walkway of tunnel wherein standpipe system shall be installed at an interval of 80 m. The required flow rate for the standpipe system shall be 1920 l/minute. It shall be connected to a reliable water supply storage tank which is capable of supplying the system demand for a minimum of 1 hour.

- **Passive fire protection systems**

Tunnel lining and interiors may be coated with fireproof coatings to keep the strength of structural elements and concrete lining within safe temperature ranges.

- **Tunnel lighting system**

The lighting requirements of a tunnel are totally different by day and by night. At night the problem is relatively simple and consists in providing luminance level on lit routes inside the tunnel at least equal to those outside the tunnel. The design of lighting during daytime is particularly critical because of human visual system. The driver outside the tunnel cannot simultaneously perceive details on the road under lighting levels existing in a highly illuminated exterior and a relatively dark interior. When the visual system can adapt to rapid reduction in ambient illumination such as that produced when passing from daylight into the darkness of a tunnel these adjustments are not instantaneous. The adaptation process takes a certain time, depending on the amplitude of the reduction, the greater the difference, the lighting level outside and that inside the tunnel.

It is practical to distinguish different zones in the tunnel in order to determine the longitudinal lighting level at daytime lighting i.e. the access zone, the threshold zone, the transition zone, the interior zone and the exit zone.

Safety in the event of a fire is of paramount importance in a tunnel. The catastrophe consequence of the tunnel fires not only resulted in loss of life, property but also concerns of the lack of fire life safety protection in the road tunnels. Minimum fire protection requirements are based on tunnel length. Where tunnel length is 240 m and where the maximum distance from any point within the tunnel to an area of safety exceeds 120m, all safety measures are taken.

Road tunnels require a dependable power supply and a flexible power distribution system that will provide maximum reliability and power continuity for tunnel ventilation, lighting and water pumping etc. Minimum illumination level is to be maintained without interruption. During the daytime, when vehicle do not have their headlights on, a sudden loss of all tunnel illumination can cause driver confusion and result in an accident.

In order to provide reliability and continuity, diversity is needed in the power distribution system so that an alternate power source is available upon failure of the normal power source. The tunnel lighting can be provided from alternate source of emergency i.e. solar power voltalic calls.

For the two-service system, two services from separate and independent sources of the power are needed. The primary power source i.e. sub-station is existing near site. The power line can be drawn from sub-station to provide the necessary power required for the tunnels.

The secondary source is anticipated to come from Alternate source of energy i.e. solar power voltalic cell.

The electric power shall be required of the order of 2.6 MW. The limitations of solar power system are the following:

- During continuous rainfall days or in cloudy weather conditions, the array cannot be charged. Under such situation main power supply from sub-station shall be restored.
- Shadow free area is necessary for installation of array.

➢ **Tunnel Drainage**

Drainage is needed inside the tunnels to remove water and other liquids introduced during firefighting, washing of tunnel interiors, flushing of pavements and water dripping from vehicle during rainy season. Water will drain from the roadway into drainage inlets along each side of the tunnel. Inlets will be connected to longitudinal drain provided in concrete below the walkway leading to the portal of the tunnel. Near the portal, covered trench culvert shall be constructed to pass the discharge. Closed spaced drain inlets are preferred as they help to prevent propagation of fire by burning fuel in case of serious accident.

➢ **Emergency Communication:**

Emergency telephones should be provided in the tunnels and connected to the emergency power supply. When such a telephone is used, the location of the caller should be identified both at the control centre and personnel by a warning light visible to rescuing personnel. Telephones shall be provided at suitable places such as near the portals and at emergency exists. Communication system should give the traveling public the possibility of summoning help and receiving instructions and should ensure co-ordinate rescue. Systems should raise the alarm quickly and reliably when unusual operating conditions or emergency situations arise.

(i) Supplying, installation, testing and commissioning of basic security system comprising of PTZ / fixed camera, cabling, digital recording , HD display system in the tunnel to include control room at the gate and intercom connection to each dwelling unit, and basic IP based CCTV system to be installed at the entry and exit points, parking areas, entry point of each dwelling unit and other common areas as required including CCTV control room, required under ground cabling, digital recording system and monitor/ monitors with minimum display of 5” x 8” per camera in the control room

(ii) Supplying, installation, testing and commissioning of LAN system comprising of core switches & L2 switches with 10 G, 10 giga SFP modules, WIFI access points, WIFI controller, network management software, racks, CAT 6A cable, patch panels, OFC etc.

(iii) Supplying, installation, testing and commissioning of IP based EPABX system comprising of core switches & L2 switches with 10 G, 10 giga SFP modules, industry standard appliance server, cloud-based, enterprise-grade UC solution, MID/ENTRY level IP/SIP phone with, dual 1 gig ports, racks, CAT 6A cable, patch panels, OFC etc.

(iv) Supplying, installation, testing and commissioning of driver face and automatic number plate recording system / recognition system including high resolution camera and software set for the driver face capture and automatic number plate recording.

(v) Baggage scanner big: computer based multi energy X-Ray baggage inspection system capable of passing through bags/parcels of dimension 940mm (W) x 640mm (H) with Belt Height- 750mm-850mm with 22’724” LCD Monitor, Input/ Output rollers with frames etc. as required.

(vi) Electromechanical boom barrier with all accessories upto 6 meter length.

(vii) SCADA systems & network devices and instruments for 3D monitoring

- **Service building and utility Building for Tunnel operation & Maintenance**

During operation and Maintenance period of Tunnel several utilities required to installation and continuous supervision of security official and Tunnel maintenance engineer and supervision staff need to stay 24x7 Hour. Therefore, either end of Tunnel 4 story building having floor area 2x37.2m x 15m is proposed with all necessary amenities as per CPWD Manual

- **Water proofing**

Water proofing (Umbrella System water proofing for tunnel geotextile/ drainage layer nailed at intervals onto tunnel wall using PVC-disk, 2pcs/sq.ya. membrane 3.0 mm welded to PVC disk. Joints are welded by hot wedge machine or hot air. water barrier welded to the membrane as required including cost of all materials, machinery, labour, ventilation, lighting, drainage etc., complete.)

- **Energy Supply 2 Nos of 2.6 MW Substation**

Supplying, installation, testing and commissioning of 33 kV substation comprising 33 kV HT panel, transformers 33kV/11 kV, 11 kV HT panel, inter connections, 11 kV HT underground cabling to the distribution substations on ring main system, substation earthing, substation safety equipment including civil work component.

Power Distribution

Supplying, installation, testing and commissioning of 33 kV/0.433 kV or 11 kV/0.433 kV substation equipment comprising HT panel, dry lypc/Oil type transformers, HT cable, bus trunking from transformer to LT panel, LT panels, automatic power factor correction panel, active harmonic fdters, TVSS (transient voltage suppression system), SPD (surge protection system), essential panel, earthing, required inter-connections, substation safety equipment including LT cabling from substation to the buildings fed by the substation including civil work component.

Emergency Power Supply

Supplying, installation, testing and commissioning of DG sets, AMF panel, bus ducting/ cables from DG sets to essential panel, DG set enclosure room sound insulation/ ventilation/smoke exhaust as required, earthing of DG set system, control cabling, fuel tank/piping, DG set exhaust piping/ exhaust chimney as per CPCB norms, civil works connected with DG sets including foundation as required.

Providing and supply of 11 kV Line from Luangmual Sub-station to Aizawl Bypass inlet substation (7Km length) and Zuangtui Sub-station to Aizawl Bypass Tunnel outlet substation (2Km length) including civil works foundation as required

k) Drainage Design

A cardinal rule while planning drainage is the least interference with natural drainage. Minimum interference with natural drainage means stable earth face / surface with some kind of vegetative cover preventing erosion and allowing free drainage. While aligned towards the road surface the water may be diverted and guided to flow in a definite path and the flow on the valley side controlled so that stability may not be affected. It helps in protecting the road bed and pavement. A network of drains helps in confining and controlling flow of water run and check adverse effects on road structure. In the case of hill

the road acts as an interceptor and its longitudinal cut on hill slope obstructs the natural drainage and the road ledge and therefore acts as a collection area of all water from hill side. As such adequate drains in the form of catch water drains collecting flow from hill side to bring it to side drain leading to cross drains and further discharge in into natural drainage channels through valley side drains / chutes, are essential for stability of road.

In view of the above, the drainage system should consist of the following:

- Pavement drainage
- Roadside drains
- Chutes drain.
- Catch water drains.
- Cross Drainage
- Rain cut drain.
- Pavement Drainage

For quick dispersal of precipitation on road surface, it would be necessary that water travel the least distance. However, steep cross slope is objectionable from traffic comfort consideration. Thus, a judicious balance has to be kept between two conflicting requirements. A unidirectional camber of 2.5% away from the center of carriageway has been considered.

In the case of re-entrants, it is necessarily to have cross drainage points, cross-fall is given towards the valley side. The surface run-off, which is mostly due to local rainfall on the roadway, is allowed to flow down quickly to the adjacent natural ground where appropriate cross fall is available.

Adequate care has to be taken in geometric to ensure channelized drainage to avoid damage to road shoulders. 3.0 % slopes have been considered for drainage for the shoulders.

- **Chutes**

Surface run off on a hill slope flows down in the form of natural gulleys / chutes. The water entrapped in the catch water drains is also brought down by connecting them with existing natural gulleys. It is therefore desired to provide lined chutes to lead the discharge to the catch pit of culvert or to a natural drainage channel. The chutes of the culverts form a part of the culvert structure and are given in the respective drawings of culverts.

Sr.No	Description of Item	Unit	Package-2
1	Concrete lined side drain	Rm	2360
2	Catch Water Drain	Rm	1410
3	Chute Drain	Rm	1050

l) Road Signs, Marking, and Furniture

The provisions of following road fixtures have been considered in this project:

(a) Mandatory / Regulatory Signs,

(b) Cautionary /Warning Signs and

(c) Information Signs.

(d) Route Marker Signs are provided.

(e) KM Stones are included as per type design.

m) Street Furniture

Traffic Safety Posts and Parapet Walls are included. Traffic Signs Marking & other Road Appurtenances

n) Roadside Amenities

Continuous long-distance travel on highways at speed is liable to cause fatigue as also mental tension to the road users. Moreover, the monotony of driving over long sections in rural areas with no likelihood of any cross traffic brings a sense of complacency in many drivers and such distractions could result in serious accidents.

Sr.No	Description of Item	Unit	Package-2
1	Bus Shelter & Layby	Nos	4

o) Service building and utility Building for Tunnel operation & Maintenance

During operation and Maintenance period of Tunnel several utilities required to installation and continuous supervision of security official and Tunnel maintenance engineer and supervision staff need to stay 24x7 Hour. Therefore either end of Tunnel 3 story building having floor area 2x37.2m x 15m is proposed with all necessary amenities as per CPWD Manual

1.6. HYDROLOGICAL & DRAINAGE STUDY

The proposed road alignment is in hilly terrain wherein the water drains to Tlawng River before Tunnel (T1) and after Tunnel (T1) water drain to Tuirial River. Dur Lui, Chhimluang Lui, Bengbawng Lui, Rangvamual Lui, and Leitan Lui are tributaries of the Tlawng River, and Chite Lui and Muthi Lui are tributaries of the Tuirial River. The shape and size of the catchment with respect to Major River and its tributaries are defined on the ground. The hydrological investigations shall be carried out to collect the data in respect of catchment characteristics, rainfall, stream channel characteristics, design discharge; waterway, etc. for all bridges and cross drainage works. The topography of the hill generates numerous water courses. Uncontrolled water is the primary cause of problems and even failures of complete sections of roadway structures. The proposed road is new construction; the requirement for drains has been identified.

1.7. GEOLOGY OF AREA

The soils in the project area are primarily silty sands with gravel and rock fragments. The geology of the Aizawl region is quite similar to the other parts of Mizoram although it has some variations in local extent. To begin with, the broader, expect of the litho-stratigraphic occurrences of different Bhubhan Units. The distribution of the rock units into the three Bhuban members and Bokabil Formation of Surma Group and rocks of Barial Groups are according to the stratigraphic nomenclature and respective litho-association. The higher ridge of the Aizawl anticline comprises rock of the Middle unit with the outer western and eastern flanks having both Upper Bhubhan rocks. Their boundary is gradual and has not been established properly. This is because the units are not comprised of lithology rather have litho-association of different rock types. Sandstone, siltstone, shale, and their admixture in various proportions are present. Road traverse along Aizawl-Durtlang towards the north, Aizawl-Hlimen towards the south, Aizawl Tuirial towards the east, and Aizawl-Sairang along with Aizawl-Mizoram University(MZU) section towards west. Massive and bedded

sandstones are found mostly in the Hlimen area and in some parts of the Durtlang section. Siltstone and shales units are present over and under these thick sandstone beds and cause instability in many parts of this North-South section. Based on the field observations and microscopic study, rock of this area can be classified into the following (i) shale (ii) siltstone (iii) sandstone. The rocks are highly jointed with diversity in their orientations. Shale and Siltstone are dark gray to grey in colour and are usually splintery. This group of rocks occupies the core of anticlines, flanked on either side by the rocks of the upper Bhuban Formation. In some horizons, this unit exhibits thinly bedded, flesh-red colour.

1.8. SEISMICITY OF AREA

The Northeast states are located between the northern collision and eastern seduction margins of the Indian plate. Mizoram is in Zone V according to the seismic zoning map. The state of Mizoram is spread on the Himalayan Mountain range with two main Thrust faults; the Mat fault and the Tuipui fault crossing the state. The area has been affected by several faults of varying magnitude which are mostly transverse / oblique in disposition. Major faults are Chite Fault and Chakai Lui. The general trend of oblique faults is roughly NNW-SSE. Due to the continuous thrusting of Indo-Australian plate against Eurasian plate, Mizoram has been a moderately active seismic region in the historical times.

1.9. LAND ACQUISITION PLANS AND FOREST CLEARANCE

a) Land Acquisition

Sl.No.	Land Area Details		From	To	Area in Ha
1	Open Area portion	Road portion including part of portal portion	10600	14300	10.515
2		Tunnel portion including part of portal portion (CH:10650 to CH:14050)			***14.400****
3	Muthi Community Reserve Forest		14300	15200	5.922
				Total	**16.437**

***** Area above the Tunnel portion including part of portal portion (CH:11650 to CH:14050) not considered for Land Acquisition.***

The total alignment is sprayed with non-habitation all along. There are mainly agricultural fields, Teak wood Garden and Orange Garden both sides along the project road. Hence, compensation will be provided for the above properties. For this matter, required fund shall be required for compensation or relief & rehabilitation.

b) Forest Clearance

The road passes through forest area due to which, State Forest authorities should need to be conduct a detail survey

Sl.No.	Land Area Details	From	To	Area in He
1	Muthi Community Reserve Forest	14300	15200	5.922
			Total	**5.922**

However, our survey team has conducted a detailed survey of the alignment and the following is the findings of that survey:

1) That the proposed road alignment does not form part of National Park, wildlife sanctuary, biosphere reserve, tiger reserve, elephant corridor, etc.
2) No rare / endangered / unique species of flora and fauna are found in the area.
3) No protected archeological / heritage site / defense establishment or any other important monument is located in the area.
4) The requirement of forest land as proposed by the user agency is unavoidable and the barest minimum for the project. No alternative for the project exists.
5) No work in violation of the Forest Act has been carried out.

After due verification and assessment, the Estimate for Net Present Value and Compensatory Afforestation shall be frame by the concerned Environment and Forest Department.

1.10. ENVIRONMENTAL AND SOCIAL ASPECTS:

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

Based on the environmental assessment and surveys conducted for the project, associated Potential adverse environmental impacts can be mitigated to an acceptable level by adequate Implementation of the measures as stated in the EIA Report. An adequate provision has been made in the cost estimate to cover the environmental mitigation and monitoring requirements and their associated costs as suggested in the environmental budget. Environmental clearance is not required as the length of the road is only

A Resettlement Action Plan will be prepared for the project stretch for the Project affected Persons based on baseline socio-economic survey and census survey data. This resettlement plan (RP) will be prepared in accordance with, the National Policy on Resettlement and Rehabilitation (NPRR), and the State Government's framework of resettlement policies, and other social safeguard policies to protect the rights of the affected persons and communities.

1.11. MATERIALS, LABOURS, AND CONSTRUCTION EQUIPMENTS:

a) Materials:

The rock deposits are available along or the vicinity of the project road alignment. Besides, cobbles, pebbles and sand deposits are available in the rivers or streams crossing the main alignment. Construction materials for GSB, Cross drainage & Masonry R / Wall etc. works, will be available at local quarry within the project corridor and WMM, DBM & BC material from Tlawng and Tuirial River and its tributaries within the project corridor. Water Absorption and AIV of these quarries are within the limit of the Ministry's Specifications. Bitumen, steel and cement will have to be taken from Aizawl.

b) Labour:

Local labourers skilled & unskilled are available in plenty. However, where required, imported labourers will also be engaged for road construction works. Since the area is malaria infested, medical assistance with qualified practitioners will be required during the execution of the project. Comparatively higher wages (from the National average) and incentives must be paid to labourers for the work. It is envisaged that equipment / machine-intensive method would be adopted for proposed construction works.

c) Equipment:

Heavy Machineries like Bull dozers, Excavators, Loaders, Air compressors, Vibratory / Static Road Rollers, Wet-mix plants, Electric generator sets, Motor Graders, Tractor–Rotavators, Hot / batch-mix plants, Paver-finishers, etc. as required for the execution of the work will be arranged by the contractor executing the project.

1.12. UNIT RATES AND COST ESTIMATES:

The cost estimate for the proposed construction work has been based on the quantities worked out from the design drawings.

a) Unit Rate:

The unit rates for arriving at the cost of different components of work are based on Mizoram PWD Schedule of Rates 2016 (for National Highways). Analysis of rates for items not given in the Standard Data Book has been carried out based on the Consultant's experience with similar nature of projects.

The project cost estimate is prepared based on SOR-2016

In proposed project cost is also included 18% of GST,

As SOR -2016 is already built-up with 6 % of Taxes like Vat, Excise, etc. therefore input item 6.0% of taxes excluded and to bring the input items tax-free.

Sand & Aggregate from Tlawng and Tuirial River and its tributaries.

b) Project Cost:

The total Project cost for civil construction works and other allied charges and the detail of cost breakup is given in the general abstract of cost in the DPR

Sr.No.	Items of work	Total quantity	Unit	Amount (Rs)
	CONSTRUCTION COST	4.60	Km	
a	Site Clearance			15,59,484.30
b	Formation Works	1362513.19	Cum	38,58,92,273.02
c	Protection Works	3750.00	Rm	16,45,78,043.80
d	Cross Drainage Works	8.00	Nos	6,93,79,301.00
e	Pavement Works	2.10	Km	12,27,08,993.42
f	Km Stones & Road Signs		Nos	1,80,42,111.00
g	Road Safety Measures	1500.00	Rm	95,07,000.00
h	Bridge Work	2	Nos	20,14,57,831.51
i	Tunnel	2500	Rm	7,96,47,63,019.67
1	**Civil Cost Total of (a to i)**			**8,93,78,88,058**
2	Cost of utility shifting			13,50,000

Sr.No.	Items of work	Total quantity	Unit	Amount (Rs)
3	**Cost of Civil work i/c utility shifting**			**8,93,92,38,058**
4	GST @18% on 3			1,60,90,62,850
5	Cost of LA&RR			58,25,90,704
6	Forest Clearance			3,11,43,416
7	Environmental Impact Assessment			23,15,000
8	Supervision Charge 2.5% of 2 + GST @ 18%			39,825
9	Contingency @ 1% of 1			8,93,78,881
10	Agency Charges @ (3% of 1 + 1% of 5) + GST @ 18%			32,32,75,808
11	Supervision Charge @ 3% of 1			26,81,36,642
12	Price Adjustment @ 5% per year for 3 years (15% of 1)			1,34,06,83,209
13	Maintenance for 10 years (0.25% for first 5 years plus 0.50% for last 5 years), total 3.75% of 1 + GST @ 18%			39,55,01,547
14	**Total Project Cost**			**13,58,13,65,940**
15	Total Civil Cost per km			**1,94,30,19,143**
16	Total Project Cost per km			**2,95,24,70,857**

1.13. IMPLEMENTATION SCHEDULE

(a) The whole project is divided into three packages as given below.

Package No	Package description	Length (km)	Cost (Rs in cr.)	Construction Period
Package-2	Km 10+600 to Km 15+200	4.600	1358.14	36 Month

(b) Procurement / Implementation Strategies:

The general conditions of Contract will be as per EPC contract Document of Ministry of Shipping, Road Transport and Highways, Government of India, works.

(c) Technical Specifications:

The Technical Specifications shall be the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" FIFTH REVISION 2013, of the Ministry of Road Transport and Highways, Government of India. However special Technical Specifications have been framed wherever MoRT&H specifications required changes. Where MoRT&H specifications are silent with regard to certain specifications for the material in question, in that case, specifications under Bureau of Indian Standards / AASHTO / ASTM / BS or any other international standard shall apply. But where these specifications are also silent, the specifications based on sound engineering practices have been resorted to.

(d) Phasing of Construction:

The total cost of the project is **1358.14 Cr.** which covers costs for formation work, Slope protection and cross drainage works, construction of bridges and pavement works. Construction period of 18 months has been proposed, considering the quantum of activities to be performed including mobilization period needed and four intervening rainy seasons in between.

The project is proposed for commencement during the financial year 2023-2024 with target completion by the year end of 2026-2027. Since the project will be executed through a period

of 3.0 years there will be cost escalation during the period of construction. Considering the rate of price escalation at an average rate of 5% per annum compounded annually after the initial year, the cost of construction and physical and financial phasing of the project is given in the table below:

Cumulative					
Year	**Physical targets %**	**Construction including centages (Rs. in Crore)**	**Pre-construction activity (Rs. in Crore)**	**Maintenance (Rs. in Crore)**	**Financial progress (Rs. in Crore)**
2023-24	Preliminary	0.000	1.00		1.00
2024-25	15%	137.05	60.74		197.79
2025-26	60%	791.15			791.15
2026-27	100%	1318.59			1318.59
2027-28	100%			2.64	1321.22
2028-29	100%			2.64	1323.86
2029-30	100%			2.64	1326.50
2030-31	100%			2.64	1329.13
2031-32	100%			2.64	1331.77
2032-33	100%			5.27	1337.04
2033-34	100%			5.27	1342.32
2034-35	100%			5.27	1347.59
2035-36	100%			5.27	1352.86
2036-37	100%			5.27	1358.14

1.14. CONCLUSION & RECOMMENDATIONS

- Proposed bypass passing through green field land.
- Avoid built Up Areas and seamless Traffic flow without interference from city traffic.
- Reduce Congestion in the built-up Area.
- To enhance Road Safety inside the Built-up Areas
- Lesser Cost of Land Acquisition and no serious resettlement problems.
- Faster transportation will ultimately lead to massive savings in the form of reduced wear and tear of vehicles, reduced vehicle operating costs (VOCs) and total reduction in transportation costs etc. With the improvement of road surface, the traffic congestion due to obstructed movement of vehicles will be minimized and thus wastage of fuel emissions from the vehicles will be reduced. Increased road landscaping and safety features.
- Enhanced connectivity between rural & urban population which will benefit the all sections of the society like general population, small-medium-large scale industries, farmers, businessmen etc.
- Improved access -to higher education facilities & modern health facilities.
- Strengthening of both rural & urban economies which in turn will improve economic scenario of the state and country.
- With improvement in economy, more generation of employment opportunities. Overall improvement of the region.

- Provide pavement markings, traffic signs and illumination where warranted.

1.15. ACKNOWLEDGEMENTS

The Consultants gratefully acknowledge the co-operation, assistance, and guidance extended to them by NHIDCL officials, MoRT&H officials, PWD, and other provincial departments of the Government of Mizoram at different stages of this study.

The consultants' thanks are also due to various Authorities of the Directorate of Economics and Statistics, Planning Department, Transport Authorities, Directorate of Industries and Commerce, and other concerned officials of the Government of Mizoram for furnishing us the valuable reports and data for the preparation of this study.

2. INTRODUCTIONS

2.1 BACKGROUND:

The Govt. of India has acknowledged the importance of better road infrastructure and launched several programs and initiatives to extend and improve India's highway network. Road development is pivotal to sustain the country's economic growth. National Highways and Infrastructure Development Corporation Ltd (NHIDCL) premium organization under the aegis of Ministry of Road Transport & Highways (MORTH) has undertaken formulation of Detailed Project Reports (DPR) for **2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojna**

NH-6 is 667 Km and passes through Assam, Meghalay and Mizoram.NH-6 begins in Jorabat, Assam at the intersection of NH-27 and generally runs southward passing Shillong, Jowai, Badarpur, Panchgram, Kolasib, Kanpui , Aizawl, Seling, Kawlkulh, Khawzawl, Champhai and terminates near Zokhawthar at Indomyanmar border. Before renumbering of national highways NH-6 was variously numbered as old national highways 40, 44,154 & 54. NH-6 enters Mizoram from Bairabi. The existing NH-6 (Old NH-54) within the state of Mizoram was originally constructed as ODR Standard Road during the early part of seventies later on it was developed as intermediate lane by the BRO. The road was upgraded to the status of National Highway in the year 1986.No substantial improvement of the road other than normal renewal works and improvement of blind curve have been carried out from Sairang to Aizawl section since the road was declared a National Highway.

NH-6 passes through the heart of Aizawl City and pass through its goose neck at Bawngkawn saddle. With the ever-increasing traffic volume, the existing road network within and around Aizawl city could no longer accommodate the smooth flow of traffic. No-Entry for Heavy Motor Vehicle has to be introduced during peak hour within Aizawl city which is a big setback for the development of the whole state of Mizoram. Aizawl Municipal area is 150 SqKm having 4.50 lakhs population and still growing. NH-6 within the city is 17.00Kms. Due to these reasons, it was felt absolutely necessary to bypass the Aizawl City.

National Highways and Infrastructure Development Corporation Ltd (NHIDCL) has awarded **M/s. CM Engineering & Solution in with JV Anandjiwala Infra Advisory in association with Anandjiwala Technical Consultancy for Consultancy Services** for preparation of Detailed Project Reports (DPR) for 2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojna.

The proposed realignment of the existing road take off from Sairang on NH 6 and merging with existing road Near Phaibawk Village on NH-6 to avoid the numbers of sharp curve on existing road and to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Aizawl City. It's running from North to south on the Eastern side of the hill

The proposed realignment take off points are very near due to which ,it will not effected and deprived the connectivity with City and hence, the villagers would be the beneficiaries with the proposed alignment. The re-alignment also passes through an area with a much better topographical as well as soil conditions.

2.2 OBJECTIVE OF THE PROJECT

The objectives of the project as per the TOR are:

2.2.1. The main objective of the consultancy service is to establish the technical, economical, and financial viability of the project and prepare detailed project reports for rehabilitation and upgrading of the existing road to 2-lane / 2-lane with paved shoulder configuration.

2.2.2. The viability of the project shall be established taking into account the requirements with regard to rehabilitation, upgrading and improvement based on highway design, pavement design, provision of service roads wherever necessary, type of intersections, rehabilitation and widening of existing and / or construction of new bridges and structures, road safety features, quantities of various items of works and cost estimates and economic analysis within the given time frame.

2.2.3. The Detailed Project Report (DPR) would inter-alia include detailed highway design, design of pavement and overlay with options for flexible or rigid pavements, design of bridges and cross drainage structures and grade separated structures, design of service roads, quantities of various items, detailed working drawings, detailed cost estimates, economic and financial viability analyses, environmental and social feasibility, social and environmental action plans as appropriate and documents required for tendering the project on commercial basis for international / local competitive bidding.

2.2.4. The DPR consultant should ensure detailed project preparation incorporating aspects of value engineering, quality audit and safety audit requirement in design and implementation. The Consultant shall ensure to carry out Road Safety Audit at various stages as per supplement-III (Additional Requirement for Safety Audit) of TOR.

2.2.5. The consultant should, along with Feasibility Report, clearly bring out through financial analysis the preferred mode of implementation on which the Civil Works for the stretches are to be taken up. The consultant should also give cost estimates along with feasibility report / detailed Project Report.

2.3 SCOPE OF SERVICES

General Scope of Services shall cover but be not limited to the following major tasks:

i) Review of all available reports and published information about the project road and the project influence area,

ii) Environmental and social impact assessment, including such as related to cultural properties, natural habitants, involuntary resettlement etc.

iii) Public consultation, including consultation with Communities located along the road, NGOs working in the area, other stake-holders and relevant Govt. departments at all the different stages of assignment (such as inception stage, feasibility stage, preliminary design stage and once final designs are concretized),

iv) Detailed reconnaissance

v) Identification of possible improvements in the existing alignment and bypassing congested locations with alternatives, evaluation of different alternatives comparison on techno-economic and other considerations and recommendations

regarding most appropriate option,

vi) Traffic studies including traffic surveys and Axle load survey and demand forecasting for next thirty years,

vii) Inventory and condition surveys for road

viii) Inventory and condition surveys for bridges, cross-drainage structures, other Structures, river Bank training / Protection works and drainage provisions,

ix) Detailed topographic surveys using Total Stations and GPS,

x) Pavement investigations,

xi) Sub-grade characteristics and strength: investigation of required sub-grade and sub-soil characteristics and strength for road and embankment design and sub soil investigation;

xii) Identification of sources of construction materials!

xiii) Detailed design of road, its x-sections, horizontal and vertical alignment and design of embankment of height more than 6m and also in poor soil conditions and where density consideration require, even lesser height embankment,

xiv) Detailed design of structures preparation of GAD and construction drawings, cross-drainage and underpasses etc.

xv) Planning and investigation for road tunnel alignment

xvi) Detail study of topography showing Terrain and Geological feature for tunnel alignment ,orientation and preparation PAI DIAGRAM and ROSE DIAGRAM

xvii) Detail study of Geo-physical investigation for fixing of Tunnel alignment and portal location.

xviii) Detailed design of Tunnel structure and Portal of Tunnel based on physical and mechanical properties of borolog sample.

xix) Identification of the type and the design of intersections,

xx) Design of complete drainage system and disposal point for storm water!

xxi) Value analysis / value engineering and project costing,

xxii) Economic and financial analyses!

xxiii) Contract packaging and implementation schedule.

xxiv) Strip plan indicating the scheme for carriageway widening, location of all existing utility services (both over- and underground) and the scheme for their relocation, trees to be felled, transplanted and planted and land acquisition requirements including schedule for LA: reports documents and drawings arrangement of estimates for cutting/ transplanting of trees and shifting of utilities from the concerned department,

xxv) To find out financial viability of project for implementation and suggest the preferred mode on which the project is to be taken up,

xxvi) Preparation of detailed project report, cost estimate, approved for construction drawings, rate analysis, detailed bill of quantities, bid documents for execution of civil works through budgeting resources,

xxvii) Design of toll plaza and identification of their numbers and location and office

cum residential complex including working drawings,

xxviii) Design of weighing stations, parking areas and rest areas,

xxix) Any other user-oriented facility enroute including toll facility,

xxx) Tie-in of on-going/sanctioned works of MORT&H/ NHIDCL/ other agencies,

xxxi) Preparation of social plans for the project affected people as per policy of the lending agencies/ Govt. of India R & R Policy.

2.4 PROJECT DELIVERABLES

The following are the major deliverables of the project as per the requirements of Terms of Reference.

- Inception Report
- Feasibility Report
- LA and Clearances
- Detailed Project Report
- Technical Schedules

2.5 SCOPE OF DETAILED PROJECT REPORT

As decided by Client and in line with Terms of references (TOR) the Preparation of Detailed Project Report of 2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojna is now being submitted. Report would include Alignment option study, Design Standards, Development Proposals, Traffic survey analysis, Preliminary cost estimates etc.

2.6 STRUCTURE OF THE REPORT

The structure of the Detailed Project Report is presented as below as per TOR:

VOLUME - I	**:**	**MAIN REPORT**
Section –1	:	Executive Summary
Section –2	:	Introductions
Section –3	:	Project description
Section –4	:	Engineering Surveys and Investigations
Section –5	:	Socio Economic Profile
Section –6	:	Design standards and Specifications
Section –7	:	Traffic surveys and analysis
Section –8	:	Construction Proposals
Section –9	:	Environmental screening and preliminary environmental assessment
Section –10	:	Initial social assessment and preliminary land acquisition/ resettlement plan
Section –11	:	Cost estimates
Section –12	:	Economic and financial analysis
Section –13	:	Conclusions and recommendations
Volume - II	:	Design Report

Volume – III	:	Materials Report
Volume – IV	:	Environmental Assessment Report including Environmental Management Plan (EMP) & Resettlement Action Plan (RAP)
Volume – V	:	Technical Specifications
Volume - VI	:	Rate analysis
Volume - VII	:	Cost estimates
Volume – VIII	:	Bill of quantities
Volume – IX	:	Project Drawings

3. PROJECT DESCRIPTION

3.1. INTRODUCTION

The objective of the Route alignment study is to determine various alternative alignment options and to identify relative acceptable and preferable alignment. With a view to appreciate the feasibility and relative strength, weakness of the alternative proposals marked on the topo sheets, and site evaluation of the same have been carried out. This was manifested through identifying the problems, shortcomings along with probable route.

3.2. SITE APPRECIATION

NH-6 (Old NH 54) passes through many villages and towns, starting from the Northern end of Mizoram and travelling all through the State in the central part of Mizoram and ends in the Southern end of the State. The international border between India and Myanmar is not far away from the end point of the NH-2 (Old NH – 54). This NH-6 (Old NH-54) along its journey through the State serves directly for more than half the population of the State, which is the lifeline for the State of Mizoram.

NH-6 passes through the heart of Aizawl City and pass through its goose neck at Bawngkawn saddle. With the ever-increasing traffic volume, the existing road network within and around Aizawl city could no longer accommodate the smooth flow of traffic. No-Entry for Heavy Motor Vehicle must be introduced during peak hour within Aizawl city which is a big setback for the development of the whole state of Mizoram. Aizawl Municipal area is 150 SqKm having 4.50 lakhs population and still growing. NH-6 within the city is 17.00Kms.

NH-6 from Sairang to Zemabawk passes through heavily built-up areas which involve costly of Land Acquisition and serious resettlement problems in the existing road. The existing alignment also passes through numbers of sharp blind curve and landslide prone area at many locations which could also posed serious problems in future. Due to these reasons, it is necessary to re-align the existing stretch of the NH-6 between Sairang to Zemabawk. The proposed alignment passes through mostly virgin land and will have lower cost of rehabilitation. Therefore, the re-alignment does not pass through heavily built-up area and would involve much less L.A cost as well as resettlement problem as compared to the existing alignment. The re-alignment also passes through an area with a much better topographical as well as soil conditions. Hence, apart from the reduction in length of road by Km 29.00, which would greatly benefit both Future Boarder Trade Route in terms of vehicle operating cost and travel time, the proposed re-alignment is technically far better and financially cost effective in the long run.

The proposed realignment of the existing road take off from Sairang on NH 6 and merging with existing road outskirts of Bung Bangla on NH-6 to avoid the numbers of sharp curve on existing road and to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Aizawl City. It's running from North to south on Eastern side of hill.

The proposed realignment take off points are very near due to which, it will not effected and deprived the connectivity with City and hence, the villagers would be the beneficiaries with the proposed alignment. The re-alignment also passes through an area with a much better topographical as well as soil conditions.

3.3. AIZAWL CITY PROFILE

Aizawl, the capital city of Mizoram, is the political, commercial, educational and cultural hub of the state. Situated in the northeastern region of India, Aizawl is situated on a ridge of 1,132 meters (3,715 ft) above sea level, with the Tlawng River valley to its west and the Tuirial River valley to its east. Aizawl is relatively remote, connected to its surrounding cities and regions mainly by air and road (Figure 2.1). The nearest rail connection, at Silchar, is 184 km away.

As the administrative center of the state, Aizawl houses all important government offices, including the State Assembly and Secretariat. Even though the city's economy is primarily sustained by public administration services and complementary banking services, the city has attracted considerable economic investment in the previous decade. The state of Mizoram is one of the fastest growing economies in the country, having reported a Gross State Domestic Product (GSDP) of 11% during the 2007-2012 Five Year Plan, far exceeding the national average of 7.9%.

The construction and service sectors, primarily located in Aizawl are the largest contributors to the GSDP. In addition to economic opportunities, Aizawl offers relatively outstanding opportunities for education. This makes Aizawl an extremely attractive location for economic investment and a magnet for migrants from the north-eastern states of India. Growing levels of in-migration has resulted in rapid urbanization and haphazard development. The city is currently grappling with finding ways to grow sustainably in order to accommodate the growing population and economic activities.

3.4. ADMINISTRATIVE STRUCTURE AIZAWL URBAN AREA

The city extents of Aizawl have expanded substantially in the last two decades. Many villages located in the sub-urban and fringe areas of the city have become part of Aizawl, collectively known as the Aizawl Urban Area (AUA). The Aizawl Development Authority (ADA) and AUA were established in 2005. AUA constitutes 82 Local Council and 14 Village Council areas. The total AUA planning area equals 291.91 sqkm. Figure 2.3 shows the AUA and AMC administrative boundaries. The AMC area measures 129.91 sqkm and is divided into 19 wards, and further divided into 82 localities each having an elected representative.

The Greater Aizawl City Development Planning Area was notified in 2011 and included the built-up city core, peripheral developed areas, intermediate areas, and the immediate hinterland. The City Development Plan notification aimed at developing Aizawl to become an engine of growth for the state. The other objectives of this notification were: to protect the city against natural disasters; to preserve catchment areas; and to reserve land for future development. The delineation of a larger planning area and the constitution of the AMC have provided the opportunity of planning an integrated land use and transport infrastructure at the citywide scale. As a key step to meet the requirement of the 74th Constitutional Amendment 1992, the Aizawl Municipal Council (AMC) was constituted in 2008. It is governed by the Board of Councilors and the Executive Council is headed by the Chairman assisted by Vice Chairman and three other Executive Councilors.

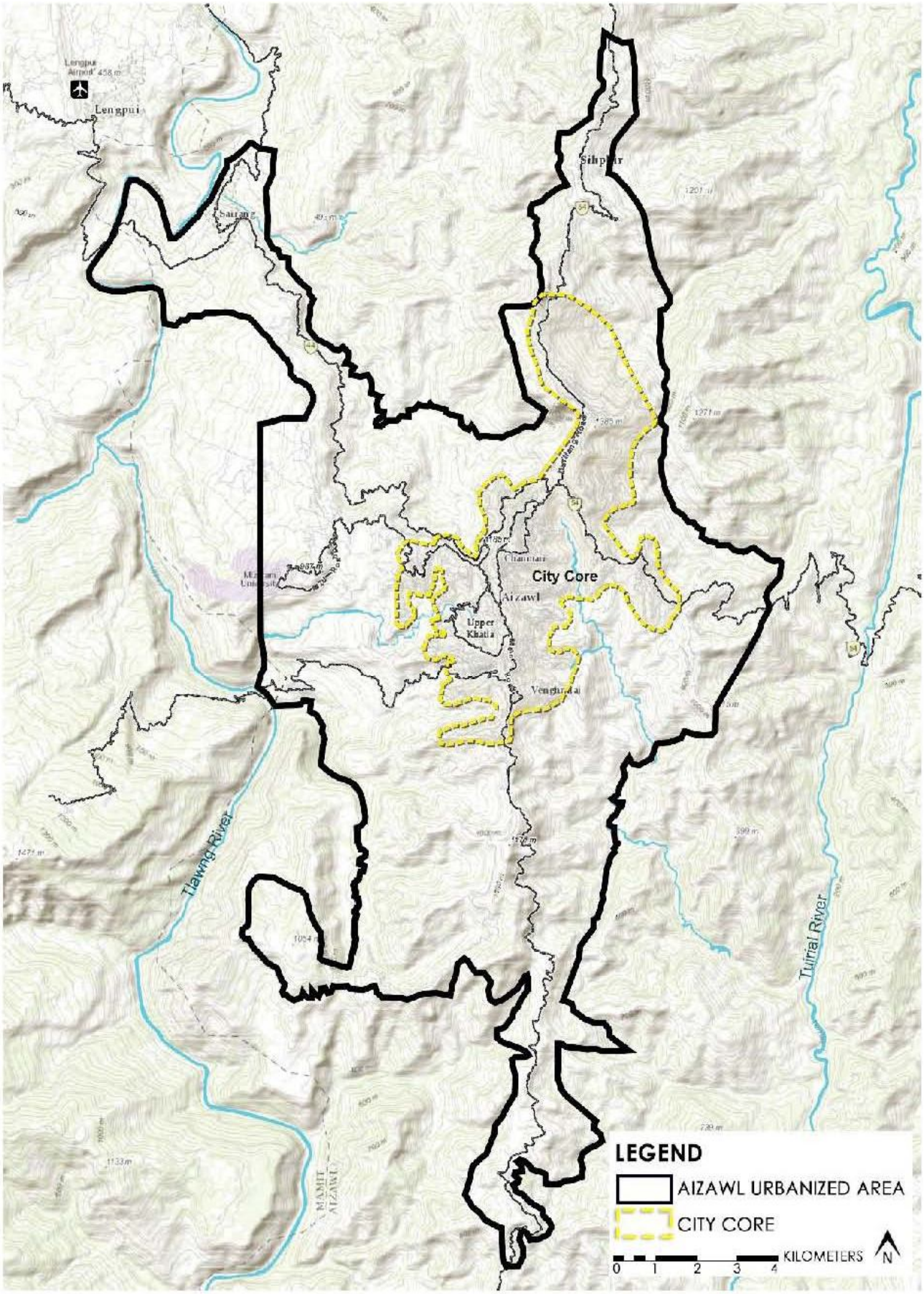


Figure 2.1: Administrative boundary of Aizawl

Source: Adapted from Terrain Base Map, ESRI 2015

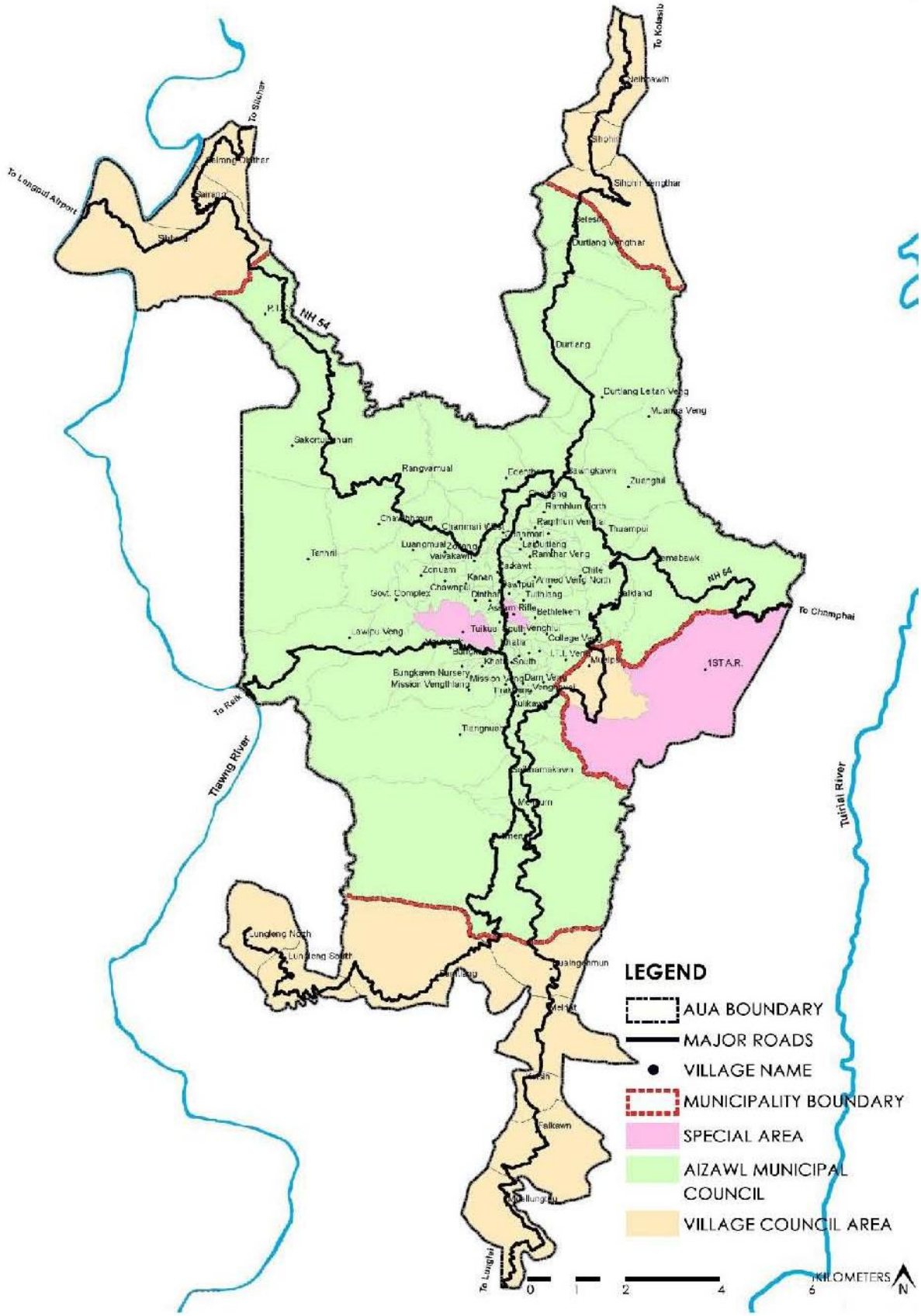


Figure 2.3: Planning area boundary

Source: Modified based on the original map form Master Plan for Aizawl: VISION 2030, Aizawl Development Authority, 2011

3.5. NESSESITY OF AIZAWL BYPASS

- To reduce congestion on NH-6 for free flow of through traffic
- To avoid Built Up Areas and seamless Traffic flow without interference from city traffic
- To improve road safety.
- To reduce travel time and vehicle operating cost.
- To reduce the length of the NH
- To Reduce Total Transportation Cost within the State of Mizoram & for NE Region utilizing Multi-modal Transport through NH-502A.
- Costly Land Acquisition and serious resettlement problems in the existing road.
- To maintain the NH standard Geometry cutting & filling will be required due to which some houses & town internal road will affect.
- Due to cutting for curve improvement some portion within town area will become land slide zone.
- Due to national highway passes through with in the town area lots of unforeseen problem may be raise in future.
- Heavy and fast traffic movement will affect roadside buildings due to vibration generated from traffic movement.
- If national highway passes through with in the town area, then pollution level will be affected. It will not be good for public's health.
- Enhance the international trading. International border of Indo Bangladesh and Indo Myanmar.

3.6. ALIGNMENT OPTION STUDY

The objective of the Route alignment study is to determine various alternative alignment options and to identify relative acceptable and preferable alignment. With a view to appreciate the feasibility and relative strength, weakness of the alternative proposals marked on the topo sheets, and site evaluation of the same have been carried out. This was manifested through identifying the problems, shortcomings along with probable route.

3.7. CRITICAL FACTORS IN ALIGNMENT SELECTION

The critical factors to be considered in the selection of the alignment are as follows:

- The alignment should meet the geometric standards, particularly the gradients and curvature.
- It should avoid acquisition of commercial and residential establishments.
- It should avoid costly land acquisition.
- It should be as directional as possible, i.e., least distance.
- It should facilitate smooth traffic dispersal.
- It should be environment friendly.
- It should have minimum provision of structures.

During the initial topographical survey, the trace-cut has been marked on the ground and survey details have been obtained on the trace-cut. However, in hard rock and hazardous areas the trace-cut is serving as reference line only.

3.8. THE METHODOLOGY ADOPTED:

Step – 1: Contour Map Study

Contour sheets are very important for fixing the alignment of the road and to design the road geometric, particularly in the hill road. Based on the contours, approximate alignment options have been studied taking into account the level difference between take-off and the terminal points. This exercise was done with a view to have an approximate understanding of the alignment options. The alignment marked on the contour sheets are planned to achieve the required length

Step-2: Satellite image study

Satellite image is very useful for fixing of the new alignment. Satellite image gives three-dimension picture of the project area. Based on the contours, clear view of water channel & terrain condition, approximate alignment option has been studied. This exercise was done with a view to have a better understanding of the alignment option.

Step-3: Fly Level Survey / Ghat Tracer

After the detailed study of the contour sheets and the available data, fly level survey of the entire road was carried out by using Ghat Tracer and the support instruments in order to finalization alignment.

3.9. ALIGNMENT OPTIONS

Based on the above study, 4 alignment options have been selected. The details of the options are given below:

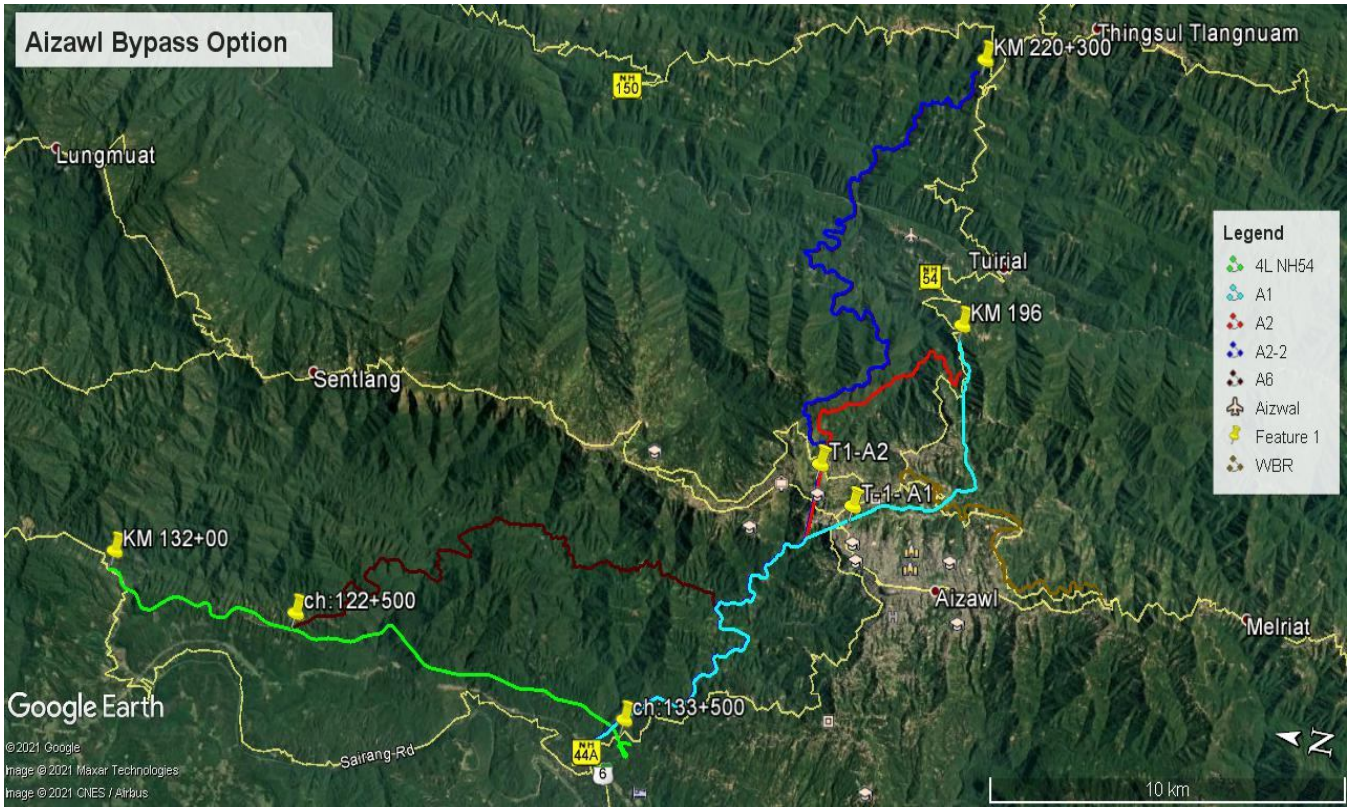


Figure 3: Google image Showing Option of Aizawl Bypasses

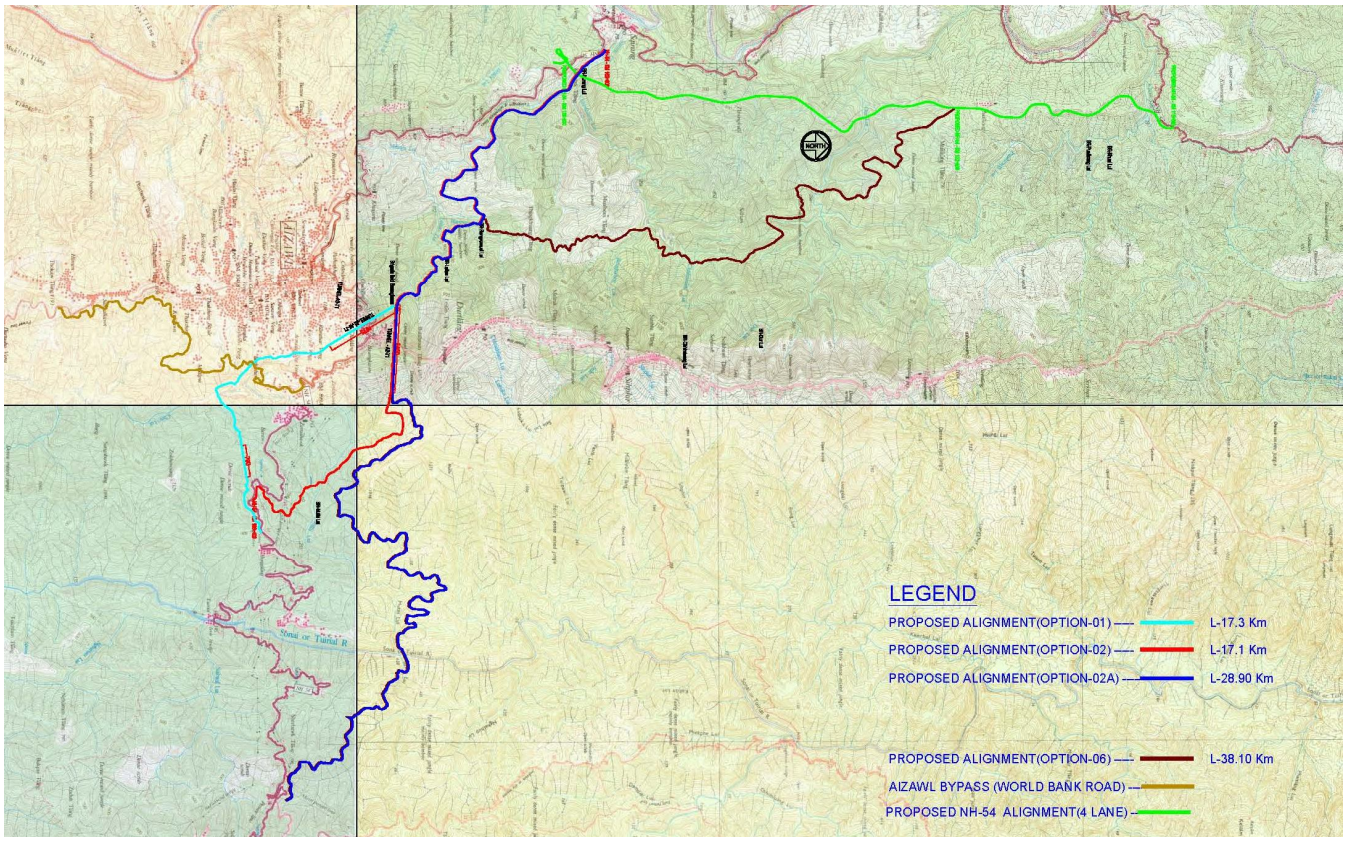


Figure 4: Topo-map Showing Option of Aizawl Bypass

List of Local Administrative office

Administrative Structure				Alignment Option			
District	**Tehsil**	**Village**	**Village Name**	A1	A2	A2A	A6
Kolasib	**Tlangnuam**	**Village**	Khamrang				
			Mualkhang			A5	A6
Aizawl			Sairum	A1	A2	A5	A6
			Sairang	A1	A2		
			Selesih				
			Muthi		A2		A6
			Bung IB	A1	A2	A5	A6
		Aizawl Municipal Council (AMC	Edenthar	A1	A2	A5	A6
			Bawngkawn	A1	A2	A5	A6
			Durtlang	A1	A2	A5	A6
			Zuangtui		A2	A6	A6
			Chite	A1			
			Falkland	A1			
			Zemabawk	A1			

Sr. No.	Description	Option-1	Option-2	Option-2A	Option-6
1	**Takeoff Point (Km)**	163+900 (Old NH-54)	163+900 (Old NH-54)	163+900 (Old NH-54)	122+500 (Proposed 4L)
2	**Start Location**	Near NH-108 (Old NH-44A) and NH-6 (Old NH-54) Junction (Airport Junction Road)			Near Mualkhang Village
3	**Merging Point (Km)**	197+200	196+400	220+300	220+300
4	**End Location**	Near Bung Bangla	Near Bung Bangla	Near Phaibawk Village	Near Phaibawk Village
5	**Elevation Start (m) msl**	208	208	208	450
6	**Elevation End (m) msl**	700	680	700	700
7	**Survey Length (Km)**	21.64	21.42	36.10	47.65
8	**Design Length (Km)**	17.31	**17.14**	28.90	**38.15**
9	**Existing road Length (Km)**	33.30	32.50	56.40	88.30
10	**Length of NH reduced(Km)**	**15.99**	**15.36**	**27.50**	**50.15**
11	**Nos of Tunnels**	2	1	1	1
12	**Tunnel Length**	T1 - 1975 m T2 - 790 m	T1 - 2450 m	T1 - 2450 m	T1 - 2450 m
13	**Depth of overburden on Tunnel from built-up end**	T1 - 182 m to 263 m, T2-115 m to147 m	T1 – 468 m to 491m	T1 – 468 m to 491m	T1 – 468 m to 491m
14	**Proposed Gradient in Tunnel**	3%	3%	3%	3%

Sr. No.	Description	Option-1	Option-2	Option-2A	Option-6
15	**Tunnel Location**	A1-T1 from Bawngkawn to Chite Lui (Below Aizawl city)	T1 from Bawngkawn to Muthi Lui (Below outskirt of Aizawl city)	T1 from Bawngkawn to Muthi Lui (Below outskirt of Aizawl city)	T1 from Bawngkawn to Muthi Lui (Below outskirt of Aizawl city)
		T2 from Near New Shifted Assam Rifle Camp			
16	**Nos of Bridges**	4 (2 Major& 2 Minor)	5 (2 Major& 3 Minor)	7 (3 Major& 4 Minor)	9 (4 Major& 5 Minor)
17	**Alignment Details**				
	Segment-1	6.34 Km common alignment at grade up to Rangvamual Lui			15.60 Km from takeoff point to Rangvamual Lui
	Segment-2	3.50 Km common Alignment at grade upto Tunnel-1(A1-T1 / A2-T1)			Same as option-01
	Segment-3	Tunnel-1(A1-T1)	Tunnel-1(A2-T1)	Tunnel-1(A2-T1)	Tunnel-1(A2-T1)
	Segment-4	5.92 Km including Tunnel-2(A1-T2)	5.32 Km road at grade	17.64 Km road at grade	17.64 Km road at grade
18	**Bridge Locations**	Kurung, Rangvamual, Leitan & Chite Lui	Kurung , Rangvamual Leitan & Muthi Lui	Kurung ,Rangvamua, Leitan ,Muthi Lui ,Tuirial& Sakei Lui	Dur, Chhimluang, Bengbawng, Rangvamua, Leitan ,Muthi Lui ,Tuirial& Sakei Lui
19	**Nos of Culvert**	35	32	105	145
20	**Terrain Condition**	Passing through entire virgin land area with Mountainous to Steep terrain	Passing through entire virgin land area with Mountainous to Steep terrain	Passing through entire virgin land area with Mountainous to Steep terrain	Passing through entire virgin land area with Mountainous to Steep terrain
21	**Alignment**	Start of alignment few huts		Open portion	
		From takeoff point to Tunnel(T1) passing through entire virgin land			

Sr. No.	Description	Option-1	Option-2	Option-2A	Option-6
		In between Tunnel (T1) and Tunnel (T2) alignment passing through built-up portion			
		End of alignment very thin built-up portion			
22	**Horizontal Alignment**	No sharp Curve (Radius of curvature varies from 50m to 200m)			
23	**Vertical alignment**	Ruling Gradient varies from 4% to 6%			
24	**Land Slide Zone**	At present based on physical verification there is no sign of land slide or vulnerable Zone			
25	**Drainage System**	Main drainage system Kurung Lui which one of the distributor of Tlawng River and Muthi Lui and Sakei Lui distributor of Tuirial River			
26	**Land Use**	Mostly Greenfield alignment passing through Forest and Jhum cultivated land			
27	**Issue on Proposed alignment**	As Tunnel (A1-T1) is proposed below the Aizawl City, It may be possible that Local people oppose the Tunnel below the city	As Tunnel (A2-T1) is proposed below the outskirt of Aizawl City		
		Proposed alignment providing the proper connectivity with Lengpui Airport ,Proposed Sairang railway Station and NH-108 (Connecting to Agartala)			Need to constructed additional Link road for a length of 6.5 Km from Rangvamual Lui to Sairang for connecting Lengpui Airport ,Proposed Sairang railway Station and NH-108

Sr. No.	Description	Option-1	Option-2	Option-2A	Option-6
28	**Advantage**	Proposed alignment may be serving as ring road for Aizawl city. As proposed alignment is connecting World Bank Aizawl Bypass Road.	There is proposal from Mizoram PWD ,NH for realignment of (Old NH150) from Aizawl to Imphal		
		Short length of link required to connect the Aizawl city road with Tunnel (T1) inlet side from (1) Hunthar Side and Outlet side from Chite Lui	Proposed alignment link the Aizawl city (1) Hunthar Side Tunnel(T1) inlet side and (2) Zuangtui-Muthi road from Tunnel outlet side		
29	**Proposed Development Plan**		Mizoram PWD have proposal to construction New road to connect Khawruhlian		
30	**Land acquisition**	Comparatively higher than option-02 and 04	Minimum	Comparatively higher than option-02	Comparatively higher than option-02
31	**Forest Land**	Yes	Yes	Yes	Yes
32	**Civil Cost (Rs.)**	658.77	607.02	715.50	1037.25
33	**Preference**	**Third**	**Second**	**First**	**Fourth**

In view of the above, Option -2A is considered the select option. Details are:

- Reduction of length highway about 27.5 Km
- Lesser amount of Compensation will be required
- Lesser no of cross drainage
- Comparing to all four option -02A have better option for future extension of Aizawl city.

The date of start of work was reckoned as 01-02. 2021.Intial there was dispute for Takeoff point of Aizawl Bypass, as it was planning to take from Vairengte to Sairang 4 Lane alignment for Package No -07 & 08. However later, it was decided that first fixed the alignment of Aziawl Bypass as 4 Lane alignment was under consideration. Based on it ,**M/s. CM Engineering & Solution in with JV Anandjiwala Infra Advisory in association with Anandjiwala Technical Consultancy** has submitted 4Nos of Alignment option study Report to the NHIDCL on 26-05-2021.Subsequently it was presented to Mizoram PWD and Hon'ble Chief Ministry of Mizoram. Hon'ble Chief Ministry office having some observation about the takeoff point and Tunnel crossing. To resolve these issues several meeting and site visit was conducted. Based on that Alignment option study presentation given to Hon'ble Chief Ministry of Mizoram on dated 18-08-2021. From four (4) option alignment, Honorable Chief Minister suggested as below:

- Option-2A as first Choice (Take-off from Sairang after that it's passing through Muthi Side Tunnel and terminate near Phaibawk (Seling) Village)
- Option-01 as second Choice (Takeoff from Sairang after that it's passing through Chite Side Tunnel and terminate near Bung Bangla village.

Thereafter alignment option Study presentation made on NHIDCL (HQ) on dated 23-09.2021 and 3rd Week of Non-2021 and subsequently NHIDCL conveyed their acceptance on the alignment (option 2A) dated 08-12-2021.

Consultant Team started ground detailed survey work Immediate after getting approval of alignment from NHIDCL. While conducting the detailed ground survey consultant Team further study three options on the same approval alignment (2A) for optimization of alignment-based site natural feature and ground conditions

4. ENGINEERING SURVEY AND INVESTIGATION

4.1. INTRODUCTION

The Consultant has carried out various field studies, engineering surveys and investigations to collect the necessary data for use in detailed design and subsequent preparation of DPR for the project. The investigations were carried out to generate adequate supportive database for preparing the most appropriate proposal to meet the functional and structural efficiency and safety requirements. The various engineering surveys and investigations have been carried out following the relevant MORT&H / IRC codes and QAP Standards.

4.2. PRELIMINARY SURVEYS & INVESTIGATIONS

The various investigations and surveys, which have been carried out by the Consultant, are as follows:

A) Reconnaissance survey.

B) Road Inventory.

C) Material Investigations and Surveys.

D) Traffic Survey.

E) Engineering Surveys and Investigations

F) Environmental And Social Screening

4.3. RECONNAISSANCE SURVEY

The main objective of reconnaissance survey is to examine the general characteristics of the area, along the project road, for the purpose of identification of the cost effective method of widening of existing Single lane roads to two lane highway, and feasible realignment route for further investigations and detailing. Prior to taking up the ground reconnaissance survey, maps and secondary data, pertaining to project influence area, were collected and studied. All fieldwork involving topographic surveys and engineering investigations were primarily based on the information obtained from the reconnaissance survey

4.4. ROAD INVENTORY

The inventory of the project road for assessment of the road has been carried out through measurements and visual inspection. Features like land use, settlements, terrain, width of pavement and shoulders, geometric deficiencies, junctions, utilities etc. were recorded.

4.5. MATERIAL INVESTIGATIONS AND SURVEYS

During preliminary surveys and investigations suitable source of all construction materials was identified. Samples were collected from all the identified sources. Based on the results of the investigations it was confirmed that sufficient sources of construction materials are available in and around the project site as given below:

1. Granular Deposit for construction of Sub-Base - Local
2. Aggregates (For Pavement work and concrete work) - Local
3. Sand - Local
4. Water - Local
5. Bitumen – Guwahati
6. Cement - Guwahati
7. Steel - Guwahati

4.5.1. Borrow soil

The soil material excavated in the process of road construction is of sufficient quantity. Samples of these soils have been collected from pits and tested in the laboratory for their characteristics and strength. These materials conform to the MORTH specification clause 305.2 and can be used as embankment, subgrade, and miscellaneous backfills.

4.6. TRAFFIC SURVEYS

To appreciate the characteristics of traffic along the project road sections in terms of size, desire, speed, load and lead, number of surveys were carried out. Traffic surveys primarily consist of manual classified mid-block counts namely to determine the existing volume and composition of traffic using key links and nodes within the study area. Such counts provide verification of existing counts and significant gaps in count data is plugged. All types of traffic surveys and studies done for feasibility study are discussed below:

4.6.1. Classified Traffic Volume Count

The count stations were identified at each bypasses starting and merging point .The Consultants conducted each of the manual classified mid-block counts over seven consecutive days for 24 hours. Vehicles have been classified in three ways: by direction, time (using an hourly subdivision) and vehicle type. But importantly the methodology was based upon numbers of wheels and axles, such that distinction is drawn between two-axle four-wheeled vehicles and two-axle six-wheeled vehicles, both passenger and goods classification system as given in TOR as well as that in IRC codes was also kept in mind.

PWD were approached to reveal the extent of available past traffic data relating to the study area so as to compile the relevant data from secondary source. It is important to make full use of available data, especially those relating to the last five years. Having received the available data, CPC is able to assess its quality in terms of comprehensiveness and consistency and come to an opinion on its reliability and consequent suitability for use in the current study.

4.6.2. Origin- Destination and Commodity Movements Survey

The Consultant carried out one day (24 hours, both directions) of OD and Commodity movement surveys at two locations finalized in consultation with NHIDCL. The roadside interviews were done on random basis and covered all four-wheeled vehicles. The OD survey included vehicle, cargo, journey purpose (to assist in the assessment of the value of time), vehicle information such as manufacturer, model age, and usage in addition to the start and end points of the journey. This additional information was required for the economic analysis.

4.6.3. Survey Programme

The following table gives the traffic survey program:

Type of Survey	Location of Survey	No. Days	Survey Objective
Classified Traffic Volume Survey	Start & End of Bypass (Sairang-Bawgnkawn-Zemabawk)	7 days	The objective of Surveys is to establish accurate base line traffic volume
Origin and Destination Survey	Start & End of Bypass (Sairang-Bawgnkawn-Zemabawk)	1day	To know the trip patterns, Socio-economic characteristics. Trip length distributions.

4.7. TRAFFIC FORECAST

An assessment of historic traffic data indicated recent levels of traffic growth. This has been compared with recent growth in the national economy, most notably Gross Domestic Product, and the forecasts of future short to medium term growth produced by the Government of India and international agencies such as the Asian Development Bank and the World Bank. The forecast growth of the national economy was used as a guideline for the derivation of traffic growth forecasts for the study road, taking account of any significant historic discrepancies between the two. Adopting traffic forecasts significantly different to national economic predictions will require careful justification. Given the uncertainty inherent in such predictions the consultant recommends the use of high, medium and low growth scenarios. It was advisable to have four growth periods representing the immediate, short, medium and long term.

4.8. ENGINEERING SURVEYS AND INVESTIGATIONS

4.8.1. Reconnaissance and Alignment

The consultant made an in-depth study of the available land width (ROW), topographic survey maps of the project area and other relevant information collected.

A detailed topographical survey was conducted for four bypasses. Detail features such as land use, habitation, water routes, intersecting roads, utilities such as electrical lines (HT/LT), etc. This enabled the Consultants to visualize the possible problems to be encountered while selecting the realignment. The detailed ground reconnaissance of project influence area is utilized for planning and programming the detailed surveys and investigations.

4.8.2. Topographic Surveys

The topographical survey forms the basis of almost all-subsequent highway design work and sufficient time was be allowed to ensure the survey results are accurate and can be used with confidence.

Detailed level scope of works and quality procedures were given (for data logging accuracy and independent checks) for carrying out the topographical survey, which was to be targeted at capturing only the essential ground features as the availability of digitized terrain mapping is the most critical field activity for this project program.

Level-1

Major Control: A network of major control points was established at approximately IKm intervals along the route. These were initially established using differential GPS equipment. These Major Control Points were connected to the existing National Grid points. A comprehensive station description is provided under the Final Topographical Report to ensure ease of relocation / reinstatement at subsequent stages.

Minor Control: Minor Control Points were established to carry out the topographic survey. These were generally being at 250-500m intervals along the route. The Minor Control Points were connected to the Major Control Points. Station descriptions were again provided for relocation purposes. The Minor Control Points were observed at the same time as the Detail Survey with Total Stations.

Level-2

Detail survey

Roads: A detailed ground survey of all project significant physical features was carried out using Total Stations. In general a survey string was observed along each feature line, points will be observed at suitable intervals. The survey confirms to the requirements of NHIDCL where

relevant. The survey extends nominally 45m on either side of the centre line of the proposed bypasses and nominally 90m at key intersections.

At locations where the existing alignment crosses or meets with other key roads the survey was carried out upto a relevant and appropriate distance up the adjoining road(s) and across a width sufficient to allow for any necessary improvements. The data was stored on data loggers and downloaded daily for processing. All features were coded in the field to allow maximum use of standardized software packages relating to automated mapping techniques and highway design.

Structures: Topographic surveys along the alignment were conducted for bridges over rivers / streams and Junction.

A topographic survey junction was carried out so as to be able to arrive at a good conceptual and feasible layout. In order to achieve this, it was required to extend the surveys to about approximately 250m to 300m beyond the center line of the Junction.

In case of bridges over rivers / canals / streams the requisite cross-sections / L-sections were obtained as laid down in the IRC codes. Office Processing

The field survey was processed in the office to provide a digital output file for the design engineers. The Surveyor carried out for a proof survey on a statistical sample to check the digital maps in the field.

With the assistance of the local relevant authorities roadway strip plans will be produced from the survey data which will identify the proposed/existing Right of Way (ROW) along the road corridors. In addition the plans shall identify all existing installations within the proposed ROW that require relocation by the new road design. Action Plans covering the relocation of these obstructing installations and public utilities will be prepared on a Km/Km basis

The format of the resulting data is such that it will readily promote the calculation of earthworks and other quantities required for the evaluation of detailed cost estimates.

4.8.3. Road and Pavement Investigations

Road Inventory

A detailed road inventory was carried out at 200m intervals mainly for alternative alignments and visual inventory survey for other road network. Detail information was collected and utilized for planning, design and cost estimate.

Pavement Investigations

Pavement Composition: Trial pits were taken along the project road at every 500m to ascertain pavement composition and subgrade type.

Pavement Condition Surveys: Detailed field studies were carried out to collect pavement condition, shoulder condition, embankment condition and drainage condition.

4.8.4. Sub-grade Characteristics and Strength

Test pits were done for pavement investigation, soil samples were collected from these pits at every 1Km **intervals** for laboratory investigations. Dynamic Cone Penetrometer (DCP) apparatus was used to find the field CBR. Sand Replacement apparatus was used to derive the field density and Moisture meter was used for field moisture content.

4.8.5. Hydraulic and Hydrological Investigation

Topographical map scale 1:50,000 or equivalent along with the surface runoff estimation parameters such as rainfall statistics, storm duration, soil characteristics and vegetation cover would be studied in detail to demarcate the catchment boundaries and drainage basins. The

general hydraulic condition of Cross drainage structures like bridges, causeways and culverts would be investigated with information like overtopping, lowest bed level, highest Flood level, disposal point of storm drainage system. The capacity of the hydraulic structures to pass the design flood of specified return period would be assessed so that no overtopping take place for hindrance to the traffic movement. The local official and residents would be consulted to obtain the required data. like hydraulic data, drawing and details of existing bridges and highest flood level and inundated areas. Longitudinal and cross sections for major and minor streams as per recommendations contained in IRC Special Publication No. 13 (Guidelines for the Design of Small Bridges and Culverts

Field investigations were made to establish drainage characteristics of the catchment areas in terms of vegetative cover, land use, soil characteristics, slope control, bed slope, size of the bed material, bed widths and areas subject to annual flooding. The detailed drainage pattern for all cross and side drainage were established. Peak design flows had estimated as per IRC codes and CWC design flood study report no 3(f) for the rivers and rivulets The location of proposed cross-drainage structures had confirmed. For bridges the general and local scour will be calculated. Recommendations for appropriate erosion control at culvert inlets and outlets, along embankments, road side-drains and catch water areas will be made.

4.8.6. Engineering for Tunnels

(a) General Design Criteria

As per the guidelines of the TOR the design of Tunnel shall primary based on IRC publication. However different design methods are first reviewed and it is important to note that all the methods have their own limitations.

There are basically two design approaches for design of underground tunnels / caverns. One is the empirical method, which is based upon the past experience and RMR or Q system of rock mass classification. A good knowledge of various geological and geotechnical parameters and their appreciation to understand the rock mass behavior under a given circumstances are the key for an efficient design by the designers using this approach. The other design approach called as "Design as you proceed" i.e. New Austrian Tunneling Method or Norwegian Method of Tunneling are based upon the observational data obtained through instrumentation.

For underground excavations the designer's aim is to make rock mass a self-sustaining structure by itself. Tunneling in Himalayan region is itself complex in nature. It is to be understood that underground excavation alters the stress field around the openings and the surface of the opening becomes one of the principal stress plane with stress equal to zero. This would cause the movement of the rock mass into the opening. The object of the design is to minimize and limit the movement of the rock within safe and permissible limits. For this purposes various type of rock supporting system such as rock bolts and cable anchors, shotcrete, steel ribs etc. are provided. Sequence of excavation and installation of immediate rock supporting system (within the stand up time estimated for the opening) to arrest the dilation of rock mass, plays an important role.

Appropriate and controlled blasting must be adopted to minimize the fracture and disturbance to the zone behind the surface of the opening. A rough surface with considerable over breaks and overhangs may cause concentration of stresses leading to a large depth and thus reducing the self-sustaining capability of the rock.

Design of support system for Tunnels

For the design of support system, the rock mass around the tunnels can be classified as Very Good, Good, fair , poor and very poor rock in accordance with Barton's 'Q' system. The Tunnel Quality Index (Q) varies on a logarithmic scale from 0.001 to a maximum of 100 and is defined by Q = (RQD / Jn) * (Jr / Ja) * (Jw / SRF) Where,

RQD = the Rock Quality Designation

Jn = joint set number

Jr = the joint roughness number

Ja = joint alteration number

Jw = joint water reduction factor

SRF = the stress reduction factor

Based upon the 'Q' values, Barton has classified the rock mass in to different categories as follows:

'Q' Values		Rock Type	'Q' Values		Rock Type
From	To		From	To	
40	100	Very Good rock	1	4	Poor rock
10	40	Good rock	0.1	1	Very Poor rock
4	10	Fair rock	0.01	0.1	Extremely Poor rock
			0.001	0.01	Exceptionally Poor rock

The maximum support pressure can be calculated based on the empirical formulae given by Barton Proof = (2 * (Jn) ^0.5) / (3*Jn)* Q^ (-1/3) and accordingly, the spacing of the rock bolts can be finalized. The bolt length is calculated as L = 2 + 0.15*B, where B = Excavation width of Tunnel.

The rock bolts are tensioned to a designed load and are resin end cement grouted.

(b) Finalization of Alignment and Portal Locations

Based on geological model developed and Alignment finalized using survey data, the Consultant shall suggest the most viable, economical alignment after carrying out Risk Assessment. As far as possible, portal locations shall not be near slide prone areas.

(c) Geometric Design and Constructability Cross Section

A road tunnel cross section must be able to accommodate the horizontal and vertical traffic clearances, as well as the other required elements. The typical cross section elements include:

- Travel lanes
- Shoulders
- Sidewalks / Curbs
- Tunnel drainage
- Tunnel ventilation
- Tunnel lighting
- Tunnel utilities and power
- Water supply pipes for fire-fighting

- Cabinets for hose reels and fire extinguishers
- Signals and signs above roadway lanes
- CCTV surveillance cameras
- Emergency telephones
- Communication antennae / equipment
- Monitoring equipment of noxious emissions and visibility
- Fire & Life Safety Provisions
- Emergency egress illuminated signs at low level
- Additional elements may also be needed under certain design requirements and should be taken into consideration when developing the tunnel geometrical configuration.

(d) Horizontal and Vertical Alignments

Planning and design of road tunnel alignments must consider Maximum grade, horizontal and vertical curves, and other requirement / constraints for road tunnel

(e) Maximum Grades

Road tunnel grades should be evaluated on the basis of driver comfort while striving to reach a point of economic balance between construction costs and operating and maintenance expenses. Maximum effective grades in main roadway tunnels preferably should not exceed 3% as per IRC SP-91.

(f) Horizontal and Vertical Curves

Horizontal and vertical curves shall satisfy IRC's geometrical requirements. The horizontal alignment for a road tunnel should be as short as practical and maintain as much of the tunnel length on tangent as possible, which will limit the numbers of curves, minimize the length and improve operating efficiency. When horizontal curves are needed, the minimum acceptable horizontal radii should consider traffic speed, sight distances, and the super-elevation provided.

(g) Sight and Braking Distance Requirements

Sight and braking distance requirements cannot be relaxed in tunnels. When designing a tunnel with extreme curvature, sight distance should be carefully examined, otherwise it may result in limited stopping sight distance.

(h) Tunnel Configuration

Based on the traffic studies and safety requirement, the consultant shall suggest the Tunnel Configuration.

(i) Travel Clearance Profile (TCP)

Clearance profile of all potential vehicles traversing the tunnel shall be established using dynamic vehicle envelopes which consider not just the maximum allowable static envelope, but also other dynamic factors such as bouncing, suspension failure, overhang on curves, lateral motion, resurfacing, etc. The clearance profile should take into consideration potential future vehicle heights, vehicle mounting on curbs, construction tolerances, and any potential ground and structure settlement. Ventilation equipment, lighting, guide signs, and other equipment should not encroach within the clearance profile. Vertical clearance should be selected as per IRC's recommendations. The vertical clearance shall also take into consideration for future resurfacing of the roadway once. Consideration should also be given for potential truck mounting on the

barrier in the tunnel or on low sidewalk and measures shall be used to prevent such mounting from damaging the tunnel ceiling or tunnel system components mounted on the ceiling or the walls.

4.8.7. Geo-tech Investigation

(i) Finalization of Sub-Soil Investigations Programme

The locations for carrying out sub-soil investigations at the structures for selected alternative would be listed out keeping in view the ToR requirements.

(ii) Carry out Sub-Soil Investigations

Sub-soil investigations are called for, to determine the nature of the strata, its strength characteristics and based on such information; determine the type of foundations, depth of foundation and allowable bearing capacity for bridges and interchanges. The depth of boreholes is a function of the nature subsurface formation, which also influences the techniques used for recovery of samples from the location. In addition, information concerning the nature of soil and formation along the road alignment needs to be obtained for pavement design purposes as well as for design of embankment if any. The relevant activities are therefore:

- Conducting borings at locations of bridges and unstable zone / landslide zone.
- Testing of sub surface rock and soil samples
- Specifying allowable bearing capacity, depth and type of foundation
- Preparation of Sub-soil Profile and interpretation of soil Properties for slope Stability Analysis

4.8.8. Geo-physical Investigations

Resistivity based Geo-physical investigations are required to be carried out at the portals locations of tunnel to determine the physical-mechanical parameters of sub-soil or rock mass. The results so obtained from the Geo-physical investigations need to be combined/compared with the Geo-logical investigations like borehole investigations so that a complete image can be obtained for interpreting the geological structures of the investigated area at the portals of tunnel. The results obtained from the Geo-physical investigations and preliminary borehole investigations will be useful in defining the type of layers of investigated area, to determine the depth of bedrock, ground water table, rock mass cavities and caverns, etc.

4.9. ENVIRONMENTAL AND SOCIAL SCREENING

4.9.1. Environmental Screening

An Environmental Impact Assessment (EIA) was undertaken. An Environmental Assessment Report (EAR) was prepared which includes a Mitigation Plan that sets out feasible and cost-effective measures that will reduce potentially significant adverse environmental effects, if any, to an acceptable level.

A Preliminary Environmental Desk Study focuses on the Environmental Assessment of key impacts, issues and alternatives, including information necessary for proposed development.

The following issues were identified:

- The information necessary for decision making;
- The important environmental issues and concerns;
- The significant effects and factors and alternatives to be considered; and
- The appropriate content and boundaries of an EIA study

The program included:

- Field surveys;
- Consultation exercises with official and non-official sources; identifying existing relevant baseline data;
- Identifying the scope of baseline surveys required;
- Identifying key issues to be addressed within the EIA,
- Providing a technical brief for the EIA

To identify any potential environmental conflicts arising from the widening of the existing road information was collated and plotted on to strip plans to arrive at the environmental constraints for the proposed scheme.

The main issues included as appropriate local settlements and communities traffic and access agriculture, ecology landscape, land-use and soils, water, archaeology heritage, cultural and religious sites and planning issues.

This part of the study was undertaken in parallel with the economic and engineering analyses in order to determine any significant social or environmental issues, which could require further in-depth study. The approach and methodology to be adopted for environmental assessment would conform to the requirement of the Environmental Impact Assessment notification, MOEF, 1994, Environmental Guidelines for Rail/Road/Highway Project, MOEF, 1989 and relevant World Bank Operational Directives, Source Book and Hand Book.

Secondary data collection

Secondary data collection including relevant maps for all the corridors was collected from various government/ semi-government departments/ agencies, research institutions/ universities and NGOs regarding:

- Physical resources
- Flora and fauna
- Critical natural habitats
- Built-up areas
- Water bodies
- Other critical environmental indicators
- Policy, legal and administrative framework etc.

The available data was used for environmental screening. The results of this screening was plotted on strip maps and presented in tabular formats.

The results of the preliminary screening will lead to identification of the nature and extent of environmental issues needing more detailed examination, which may be dealt as a full EA.

4.9.2. Social Screening

Social screening survey was carried out in order to understand socio-economic features along the project road. The purpose of the survey was to identify structures falling in proposed ROW and to assess the physical and social and cultural impacts. In this regard, the relevant information was gathered by interview with peoples and the self-assessment of the issues involved.

Secondary data collection

Available information was collected from various agencies that have worked in the state. The information included constitutional provision, conventions and protocols on human rights and indigenous people, status of social related legislation and policies of the Central Government and the state of Uttar Pradesh, key factors in RAR planning, guidelines for entitlement framework and community, social, ethnic and economic indicators of the population.

Social Impact Screening

During this preliminary screening stage, the Consultants made an initial visit to the site under consideration. This helped in developing a clear understanding of the proposed road changes that may be undertaken and to identify the impact on housing, business and agricultural activities expected to arise out of the changes to be adopted. The social impact screening concentrated on the areas where there is likely to be the greatest impact on the population.

The data was analyzed and screening was done initially through a reconnaissance survey. The various indicators considered are:

- Community Life and Economic Activities
  Severance of community
  Encroachment on local community facilities
  Encroachment on local economic activities

  Encroachment on the access to and rights of resources

  Cultural heritage / property

  Social structure, institution and customs

  Cultural shock

  Road safety

  Public health

  Waste
- Land acquisition and resettlement
  Expropriation of resources Involuntary resettlement

  Conflict between target population and host population
  Indigenous or traditional population

The results of the screening will be plotted on maps and tabulated to identify any major conflicts and extent of conflicts.

4.10. SCHEME DEVELOPMENT AND ASSESSMENT

From the existing field data a few scheme alternatives were evolved. This task made use of available data, site reconnaissance desk studies and preliminary findings. The standards, codes of practice and other relevant controlling documents were listed thereby establishing the procedures, design controls and general engineering practice required. In the review of project alignment due consideration was given to the environmental implications land take and impact on project affected people, using information provided in the discipline Desk Study Reports undertaken earlier.

4.10.1. Widening and strengthening scheme

The project section under the scope of study has multidimensional facets in terms of geometry, pavement composition / condition, existing utilities, religious structures, etc. and considering all

these aspects the section-wise policy was adopted for strengthening and widening based on the initial investigations.

4.10.2. Bypasses

The proposal for bypassing the existing road was based on the detailed study on features pertaining to congestions, local traffic, sanctuary, mosque, graveyard, study of tehsil, taluk, district headquarter etc.

4.10.3. Homogeneous Section

The project road has been divided into homogeneous road sections on the basis of following and traffic generation, and dispersal nodes located along the project road.

- Traffic
- Pavement Composition and thicknesses

4.10.4. Pavement Design

Pavement is the most significant component of a road and therefore its design strengths must be assured to support the projected traffic loading throughout the design period. The pavement option study consist of analysis of different pavement alternatives to provide a basis for selection of the most advantages solution, considering all costs occurring during the life of the pavement, viz., construction costs, future maintenance costs and future costs for the road users. In pavement option study, following has been studied in detail:

- Flexible pavement over the existing pavement
- New flexible pavement
- Flexible Pavement for full reconstruction stretches of existing pavement.

4.10.5. Bridges and Culverts

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

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

Hence, bridge is planned at 11 location

4.10.6. Tunnel

NH54 bypass route is planned passing through mountainous area. In order to cross steep hills among mountains, cross structures such as Tunnel are required.

Hence, Twin tube Tunnel is planned at one location having length 2500m

4.11. LAND ACQUISITION

The land required for the proposed road development will be acquired following the provisions of the National Highways Act, 1956. The following are the major provisions of the act for the land acquisition.

- Section 3A provides for notification to landowners[1] about the interest of the Government to acquire the notified land;

[1] Notification should be published in two daily newspapers; one in the regional language and the other in English. The same should be published in the Government Gazette.

- Section 3B&3F provides power and right to the person authorized by the central government to make inspection, survey, measurements, valuation or inquiry;
- Section 3C permits landowners to express their objections against such land acquisition;
- Section 3D declaration of acquisition if no objections has been made to the competent authority;
- Section 3E provides power to take possession of land once the amount determined by the competent authority has been deposited under sub-section (1) of section 3H;
- Section 3G allows the competent authority to decide on the compensation to be paid;
- Sections 3H provision for deposit of payment determined under section 3G in the manner as may be laid down by rules made in this behalf of the central government;
- Under section 3J as per the provision of this section nothing in the Land acquisition act 1894 would apply to an acquisition under this act.

In order to determine the extent of private property that will be acquired under the project, the Consultant has requested the respective District Magistrates of the two districts to arrange

The process followed for preparation of Land acquisition plans is presented below:

STEP-1: Project Initiation: As a part of the present studies the consultants will prepare the LAP on behalf of the MORT&H. MORT&H issues request letters to the concerned District Collectors, informing them about the project and to provide necessary assistance and documents to consultants. District Collectors issue letters to Tehsildars, who in turn directs Amins to provide respective Village Maps, Revenue Records and Cost of Land to the consultants for preparation of LAP.

STEP-2: Identification of Villages: The Consultant identifies the villages through which the corridor passes.

STEP-3: Identification of Affected Plots: Affected plots will be identified with Amin and preparation of Cadastral Map .

STEP-4: Demarcation: After identification of affected plots, the specific area of the affected part will be demarcated.

STEP-5: Collection of Land Records: Land records of the affected plots will be collected from Amin, which fulfills the requirements of 3A.

STEP-6: Compilation: After collecting land records for all the plots from respective Amins, the same will be sorted out for affected plots.

STEP-7: Final Land Acquisition Plan: All the information collected from Amins will be worked out based on the proposed alignment plan. This forms the basis of the final land acquisition plan.

The concerned officers from the Revenue Department will be approached to obtain copy of village maps with the demarcated individual plot.

4.12. DETAILED COST ESTIMATES

The cost estimates of the project have been prepared based on various items of work required for the Construction of bypasses and priced at the Schedule of Rates (SOR) -2016 of Mizoram PWD. The items not included in the SOR have been taken from prevailing market rates.

5. SOCIO ECONOMIC PROFILE

5.1 INTRODUCTION:

The proposed realignment of the existing road take off from Sairang on NH 6 and merging with existing road near Phaibawk village on NH-6 to avoid the numbers of sharp curve on existing road and to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Aizawl City. This entire road runs through Aizawl District. The area is steep terrian and hilly with a small strip of low lying riverine plain along the Eastern side of the Tuirial Valley. It two lane road with formation width about 10.0 to 12 m .

Project Location:

- Country : India
- State : Mizoram
- District : Aizawl District

Project Country: India

India occupies a strategic position in Asia, looking across the seas to Arabia and Africa on the west and Burma, Malaysia and the Indonesian Archipelago on the east. Geographically, the Himalayan ranges keep India apart from the rest of Asia.

Project State: Mizoram

Mizoram State is bordering Myanmar in the east & south and Bangladesh in the West.

The Location Map of Project road:



Mizoram at a glance

Name of the State		: Mizoram
State Capital		: Aizawl
Area		: 21,087 Sq.km
(a)	North South	: 277 kms
(b)	East-West	: 121 kms
Inter State Border		: Assam, Tripura and M (284 Km)
International Border		: Myanmar and Bangla (722 Km)
No. of Districts		: 11
No. of Autonomous Dist Councils		: 3
No. of Sub Divisions		: 23
No. of R.D Blocks		: 26

Means of communication

By Air : Lengpui Airport

By Road : Via Silchar

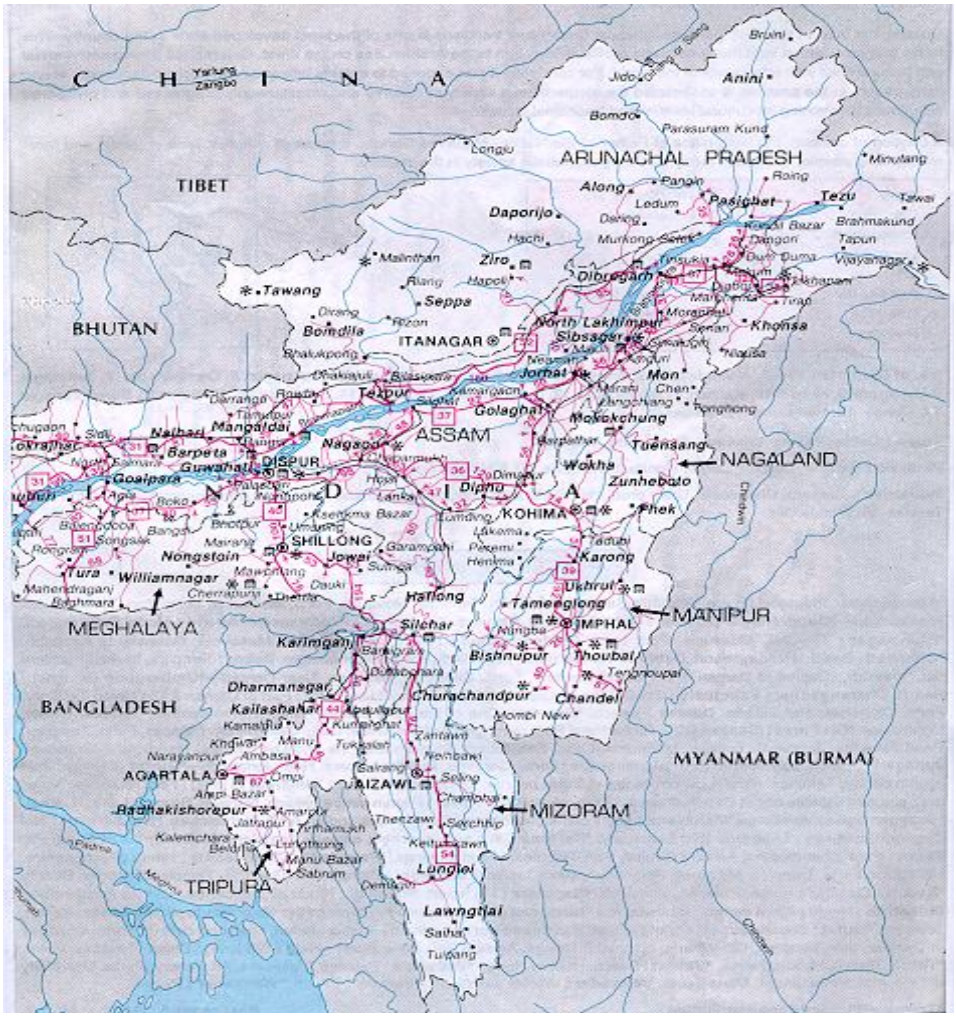
Major Festivals : Chapchar Kut, Pawl Kut, Mim Kut, Christmas & New Year

Major Dances : Cheraw, Khuallam, Parlam, Sarlamkai, Chailam, Rallulam, Chheihlam

Other Statistics

- Population (2011) 10,97,206
- Languages Mizo
- Literacy (2011) 91.33%
- Per Capita income Rs 54,689 during 2011-12
- Roads length 7437 Km

LOCATION MAP OF NORTH-EASTERN STATES (including Mizoram)



Mizo People

Mizoram name derived from Mi (Peoples), Zo (Hills) & Ram (Land) thus Mizoram implies *'land of the hilly peoples'*. The meaning itself shows the social structure of the Mizoram state. The Mizos are broadly divided into 5 major tribes and 11 minor tribes. The 5 major tribes are Lushai, Ralte, Hmar, Paite and Pawi. Mizo is the official language and most widely used language for verbal interactions, but English being important for education, administration, formalities, and governance, is also widely used. The Duhlian dialect, also known as the Lusei, was the first language of Mizoram and has come to be known as Mizo language. All the tribes still have their own unique dialects which are slightly different from the dominant Mizo (Duhlian), but they can

understand each other without problems. As per the 2011 census, the total population of Mizoram is 1,097,206. Out of these, the numbers of male and female are 555,339 and 541,867 respectively. The Lushai tribes constituted the majority of the Mizo population. Population density of Mizoram is 52 per km2. The literacy rate in Mizoram is 91.3% as per the 2011 census. District-wise and Tribe-wise population of Mizoram is shown below. Out of 8 districts, districts where four bypasses are located are highlighted in the table below.

Table 6.1 District –wise Population and Literacy Rate

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

The Mizo ancestors had no written language and the British missionaries, F.W. Savidge and J.H. Lorrain, created the Mizo alphabets based on the Roman scripts. The arrival of these two missionaries marked the formal origin of education in Mizoram. After only two and half months, Savidge started the first school on 1st April, 1894. They also prepared a Grammar and Dictionary of the Lushai language (Duhlian dialect) in 1898, which became the foundation of Mizo language. Today, Mizoram enjoys one of the highest rate of literacy in India, at 91.3%

The Mizo ancestors had no written language and were completely devoted to animism, worshipping all sorts of objects and natural phenomena. The British has to simply modernise them. The first missionary who came to Lushai hill was Rev. William Williams, a Welsh missionary for investigative visit for a week. On 11th January, 1894, F.W. Savidge and J.H. Lorrain arrived at Aizawl and this marked the origin of formal Christianity in Mizoram.

The majority of the Mizo people are Christian. The major Christian denominations are Presbyterian, Baptist, United Pentecostal Church, Roman Catholic, the Salvation Army, Congregational Church of India (Maraland), Seventh-day Adventist, among others. There are other religions like Buddhism, Hinduism, Muslim and Sikh. There are few people who practice Judaism claiming to be one of the lost Judaic tribe group Bnei Menashe and a modernized traditional Mizo religion called Hnam sakhua, which put a particular emphasis on Mizo culture and seeks to revive traditional Mizo values. There are also few tribal religions such as Lalchhungkua, Lalhnam and Nunna Lalchhungkua.

The Mizo celebrate many festivals among which the Chapchar kut and the Pawl kut are the most important. Chapchar kut is celebrated in the month of March and it is a spring festival. Pawl kut is a harvest festival celebrated in the months of December and January. They also celebrated Mim kut in the month of September. This festival is for the dead members of the family and they used to prepare foods for them. The Mizo people celebrated the festivals with many dances among which Cheraw is the most colorful dance. All the festivals are connected with agricultural activities.

Table 6.3 Composition of Various Mizo Tribes in the State

Tribe	Number	Percentage (%)
Lushai	646,117	77
Chakma	71,283	8.5
Pawi	42,230	5
Lakher	36,018	4.3
Any Kuki tribes	21,040	2.5
Hmar	18,155	2.2

Source: 2001 Census[2]

5.2 MIZO ECONOMY

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

Table 6.4 Economic Growth of Mizoram

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

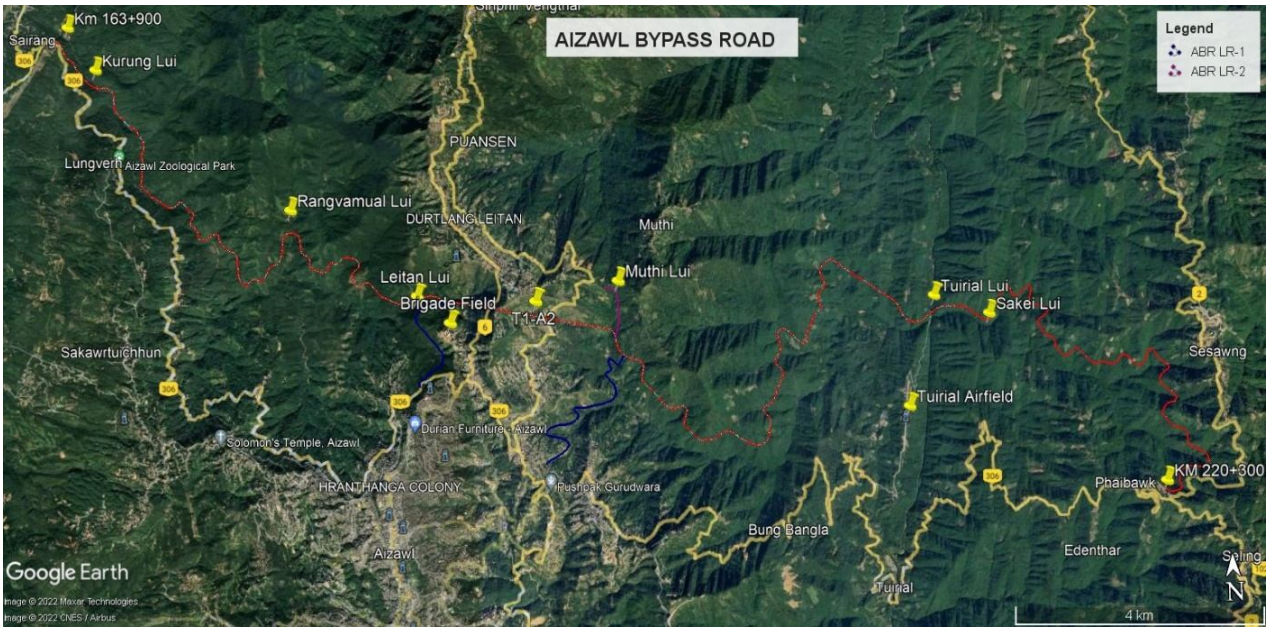
The main occupation of the people is agriculture. About 80% of the populations are agriculturist. Rice is the main crop of Mizoram and besides rice, maize, potato, ginger, tumeric, black pepper, chilies and a variety of fruits are grown. In Mizoram, the ownership of land is vested with the government,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

Land: Mizoram is a mountainous region, which became the 23rd State of the Indian Union in February 1987. It was one of the districts of Assam till 1972 when it became a Union Territory. Sandwiched between Myanmar (Burma) in the east and south and Bangladesh in the west,

[2] 2001 Census is the latest data available as per-tribe population data is not included in 2011 Census

Mizoram occupies an area of great strategic importance in the northeastern corner of India. It has a total of 630 miles boundary with Myanmar (Burma) and Bangladesh.

Terrain: Mizoram has the most variegated hilly terrain in eastern part of India. The hills are steep and are separated by rivers, which flow either to the north or south creating deep gorges between the hill ranges. The average height of the hills is about 900 m. The highest peak in Mizoram is the Blue Mountain (Phawngpui) with a height of 2210 m.



Climate: Mizoram has a pleasant climate. It is generally cool in summer and not very cold in winter. During winter, the temperature varies from 8° C to 21°C and in the summer it varies between 20°C and 35°C. The entire area is under the direct influence of the monsoon. It rains heavily from May to September and the average rainfall is 2540 mm. per annum. The average rainfall in Aizawl is 2080 mm and Lunglei in Southern Mizoram has 3500 mm. Winter in Mizoram is rain-free and is very pleasant; the skies are wonderfully blue, and in the morning the mist formed between the hills gives an enchanting view of wide stretches of a vast lake of cloud.

Flora and Fauna: Mizoram has great natural beauty and an endless variety of landscape and is very rich in flora and fauna. Almost all kinds of tropical trees and plants thrive in Mizoram. The hills are marvelously green. Some of the common trees and shrubs grown in the forest of the project area are Teak, Putli, Khair, Shingle Tree, Red Wood, Goat Weed, Australian Wattle etc. The state has a wide forest resource and it is also exported to various parts of the country for various purposes.

People: The word Mizo is a generic term and is used to mean hillmen or highlanders. The Mizos are a distinct community, and the social unit was the village. Around it revolved the life of a Mizo. In olden days, Mizo village is usually set on top of a hill with the chief's house at the centre and the bachelor's dormitory called Zawlbuk, prominently located in a central place. In a way the focal point in the village was the Zawlbuk where all young bachelors of the village slept. Zawlbuk was the training ground, and indeed, the cradle wherein the Mizo youth was shaped into a responsible adult member of society.

Social Life: The fabric of social life in the Mizo society has undergone tremendous changes over the years. Before the British moved into the hills, for all practical purposes the village and the clan formed units of Mizo society. The Mizo code of ethics or Dharma moved round "Tlawmngaihna" an untranslatable term meaning on the part of everyone to be hospitable, kind, unselfish and helpful to others. 'Tlawmngaihna' to a Mizo stands for that compelling moral force which finds

expression in self-sacrifice for the service of others. Mizos are a close-knit society with no class distinction and no discrimination on grounds of sex. 80% of them are cultivators and the village exists like a big family. Birth of a child, marriage in the village and death of a person in the village or a community feast arranged by a member of the village are important occasions in which the whole village is involved.

Administration: The Capital of Mizoram is Aizawl. Mizoram is divided into 8 districts -Aizawl District with headquarters at Aizawl, Lunglei District with headquarters at Lunglei and Saiha District with headquarters at Saiha, Lawngtlai District with headquarters at Lawngtlai, Serchhip District with headquarters at Serchhip, Mamit District with headquarters at Mamit, Champhai District with headquarters at Champhai, Kolasib District with headquaters at Kolasib.

Connectivity: Aizawl, the Capital of Mizoram is 180 Kms. from Silchar, which is the nearest railhead. The bus journey from Silchar to Aizawl usually takes about 6 hours. Mizoram State Transport Buses ply between Aizawl and Silchar daily. There is daily Air Service between Calcutta and Aizawl and between Guwahati and Aizawl.

Logistic – Road Distance: The road distance of important places in N.E. Region from Aizawl are as given below:

Place	Distance in Kms
Shillong	423
Agartala	440
Dibrugarh	751
Dhuburi	808
Diphu	372
Dispur	523
Haflong	260
Imphal	307
Jorhat	591
Jowai	370
Kohima	430
Nagaon	443
Silchar	180

Mizoram Road Network: It consists of 7437.128 kms (2011) with road categories mentioned below:

Road Category	Length (kms)
National Highway	886.03
State highways	699.64
Major District roads	935.65
Other District Roads	1384.90
City Road	355.487
Town & Satellite Town Road	591.645

Road Category	Length (kms)
Village Road	1108.981
Others Road	1474.795
Total	7437.128
No of district	8 Nos

As per the economic survey 2011 -2012, the increase in the population of vehicles has been 11.68%, the transport has observed tremendous increase. The heavy traffic pressures on the deficient roads are rendering the quality of pavement very poor.

Important roads in the State of Mizoram are given below:

Sn	Name of Some Important Road Sectors	Length in Km
01	Aizawl-Thenzawl-Lunglei	163.60
02	Kawnpui-Aizawl via Lungdai	44.290
03	Bairabi-Zamuang	28.00
04	Lawngtlai-Saiha Feeder road	25.00
05	Seling-champhai	150.300
06	Seling-tipaimukh	140.00
07	Sairang-Tuipuibari	154.00
08	Champhai-N. Vanlaiphai-Keitum	155.00
09	Kawlkulh-Ngopa-Tuivai	96.00
10	Serchhip – thenzawl – Bunghmun	126.00
11	Hnahthial-South Vanlaiphai-sangau-Saiha	142.750
12	Lunglei-Tlabung	91.00
13	Kanhmun-Zamuang-Tuilutkawn	96.00
14	Tut-Mamit-Tuidam-R. Langkaih	78.00
15	Serkhan-Bhaga Bazar	117.00
16	W. Phaileng-Phuldungsei-Marpara	80.00
17	Tuipuibari-W. Kawnpui	18.00
18	Lawngtlai-Diltlang	269.130
19	Lawngtlai-Nalkawn-Chamdur valley (NCV)	60.00
20	Marpara-Tlabung	41.400
21	Demagiri-Borapansury-Parva	120.00
22	Vairente-Phainuam-Saiphai	24.00
23	Bilkhawthlir-Saiphai-Saipum	35.00
24.	Vairengte-Phaisen-Buchangphai	20.00
25	Bilkhawthlir-Buhchangphai-Kolasib	35.00

Sn	Name of Some Important Road Sectors	Length in Km
26	Kawlkulh-Lungpho-serchhip	110.00
27	Champhai-Sasaiphai-Vaphai-Farkawn-Khawbung	140.00
28	Haulawng-Chhipphir-Pangzawl	60.00
29	Muallungthu-Khumtung	35.00
30	Keitum-N. Vanlaiphai-Thingsai-Bualpui-S. Vanlaiphai	140.00
31	Leite-Mualthuam-Thingfal	110.00
32	Lungsen-Chawngte	48.00
33	Bairabi-Mamit	36.00
34	Rawpuichhip-Buarpui	89.000
35	Buarpui-Lunglei	75.00
36	Chawngte-Borapansury	32.00
37	Aibawk-Darlung	33.00
38	Aizawl-Tlawng-Reiek-W.Lungdar	37.00
39	Hnathial-Thingsai Road	57.720
40	Saiha-Chhuarlung-Siata-Tuipang	122.00
41	Kawlchaw-Phura-tawngkolong-Berami-Khopai-Zawngling	160.00
42	Chawngte-Diltlang	32.00
43	Zobawk-Haulawng	35.00
44	Kawnpui-Hortoki	20.00
45	Khawzawl-Rabung-Lamzawl-Ngopa	64.00
46	Saitual-Phullen-E.Phaileng	135.00
47	Phairuang-Bunghmun	69.00
48	Kawlchaw-serkawr-Phura	44.00
49	Thenzawl-Chhipphir	22.500
50	Lunglei-Nghasih	10.00
51	Aizawl-Samtlang-Lungleng	20.00
52	Khawzawl-Biate	60.00
53	Chekkawn-Artahkawn	9.00
54	Champhai-Hnahlan-Mimbung	120.00
55	E. Phaileng – Suangpuilawn – Phullen	80.00
56	New vervek – Sakawrdai – Tuivai	20.00
57	Sakawrdai – Zohmun	14.00

Sn	Name of Some Important Road Sectors	Length in Km
58	Ratu – Suangpuilawn	40.00
59	Chhingchhip – Hmuntha	27.461
60	Khawzawl – Phaisen	10.00
61	Champhai – Hmunhmeltha – N. Khawbung	30.00
62	Ngopa-Mimbung	52.500
63	Kolasib-N. Hlimen	40.00
64	Road within Towns	82.00

6. DESIGN STANDARDS AND SPECIFICATION

6.1. INTRODUCTION

6.1.1. Approach

Design standards form the basis of the design for various elements of a particular project. Formulation of design standards is required in order to avoid any inconsistency in design from one section to the other and provide a desirable level of service and safety.

The aim is to provide maximum safety to the road users, in defining the highway geometry, carriageway, shoulder widths, embankments and other pertinent components for an uninterrupted and smooth flow of traffic. The approach adopted in achieving the safety is as follows:

- Provide appropriate cross traffic facilities without impeding traffic flow;
- Use ROW only and recommend land acquisition where absolutely essential;
- Minimize impact on roadside settlements and environment;
- Avoid adverse impacts of crowded areas along the stretch of Project road;
- Provide cost-efficient, but readily constructible facility with least hindrances, namely, land acquisition, resettlement and rehabilitation.

6.1.2. Reference Standards

IRC Standards will be used in general. However, where IRC does not cover any particular feature or aspect appropriately, AASHTO and other International Standards will be used for providing additional safety, namely, length of vertical curves in view of likely modernization of goods trucks in India (height of driver's eye), super elevation and radii of curve beyond which no super elevation is needed and extra widening on horizontal curves for smaller radii. AASHTO Standards for transition curves will be considered as appropriate.

6.2. CAPACITY STANDARDS

The main reference for determination of standard capacities for roads in India is the Indian Road Congress code (IRC: 64 – 1990). The capacity standards and design service volumes for various configurations of roads for peak hour traffic in the range of 8-10% and design service level corresponding to Level of Service "B" is summarized in Table 6-1.

Table 6-1: Design Service volume (PCU / Day) for 8-10 % peak hour share

Configuration	Plain Terrain		Rolling Terrain		Hilly Terrain	
	Curvature (degree per km)		Curvature (degree per km)		Curvature (degree per km)	
	0-50	>50	0-100	>100	0-200	>200
Single Lane	2000	1900	1800	1700	1600	1400
Intermediate Lane	6000	5800	5700	5600	5200	4500
Two Lane	15000	12500	11000	10000	7000	5000
Two Lane with 1.5m Paved Shoulder	17250	14375	12650	11500	8050	5750
4 Lane	35000	29000	25500	23000	16000	11500

Configuration	Plain Terrain		Rolling Terrain		Hilly Terrain	
	Curvature (degree per km)		Curvature (degree per km)		Curvature (degree per km)	
	0-50	>50	0-100	>100	0-200	>200
4 Lane with 1.5m Paved Shoulder	40000	33500	29500	26500	18500	13000

As per Ministry circular: Capacity augmentation of NH from Two lane to four lane

Nature of Terrain	Traffic at which up-gradation to four lane will trigger (in PCU per day) RW/NH-33044/28/2015/S&R(R) ,dated 29th June 2015	Traffic at which up-gradation to four lane will trigger (in PCU per day) RW/NH-33044/28/2015/S&R(R) ,dated 26th May 2016
Plain	15,000	10,000
Rolling	11,000	8,500
Mountainous / Steep	8,000	6,000

6.3. HIGHWAY ROAD APPURTENANCES

6.3.1. Geometric Design Standards

Geometric Design Standards has been largely extracted from IRC: 73 – 1980 and The Hill Road Manual (IRC: SP: 48 – 1998). Since IRC standards do not specify standards for median widths, raised or sunk median, shyness strips etc., these will be recommended as per MOST circulars.

For this Highway Project, Geometric Design Standards shall be as per the following:

- IRC: 73-1980 Geometric Design Standards for Rural (Non-Urban) Highways.
- IRC:38-1988 Guidelines for Design of Horizontal Curve for Highways and Design Tables (First Revision)
- IRC: SP: 19-2020: Manual for survey, investigations and preparation of road projects.
- IRC: 52-2019: Guidelines for the Alignment survey and Geometric Design of Hill Roads (3rd Revision).
- IRC-SP-48-1998: Hill Road Manual
- IRC-SP-73-2018:Manual of Specification & Standards for two Lanning of Highway with Paved Shoulders (Second Revision)
- IRC-SP-73-2018:Manual of Specification & Standards for two Lanning of Highway with Paved Shoulders (Second Revision)
- IRC-SP-84-2019:Manual of Specification & Standards for four Lanning of Highway with Paved Shoulders (Second Revision)

Terrain Classification:

Terrain as pertinent to the road structure is classified as given in the following table:

Terrain	Cross Slope (%)
Plain	0 - 10
Rolling	> 10 upto 25
Mountainous	> 25 upto 60
Steep	> 60

This Road Corridor is generally in mountainous to steep terrain.

Design Speed:

Sr/No	Mountainous Terrain		Steep Terrain	
	Ruling	Minimum	Ruling	Minimum
1.	50	40	40	30

The ruling design speed should generally be the criterion for correlation of the various design features.

Minimum design speed may be adopted in sections where site conditions or economic do not permit a design based on the ruling design speed. The adopted design speed is 40 Km/hr.

Cross Section Elements:

- **Right of Way (ROW)**

IRC: 73-1980 Table recommends the following land width for National Highways:

ROW Width

Sl. No.	Road Classification	Mountainous and Steep Terrain	
		Open areas	Built-up areas
		Normal	Normal
1	National & State Highways	24	20

The existing ROW along the project road is not uniform. . The width of ROW 24 m and 20 m have been adjusted to accommodate the public concern provided. However there are stretches where the ROW has been temporarily encroached. However, for improvement of junctions, relocation, etc, design will be as per functional requirement. Additional land acquisition shall be kept to the minimum for these areas

➢ **Roadway Details**

- **Total Road Width :** Total roadway width shall be 12.00 m**.**
- **Carriageway Width:** The National Highway shall be designed as a 2- lane carriageway. The width of two lane shall be 7.0 m.
- **Shoulder :** The carriageway width of 7.0m and paved shoulder width of 1.5 m on each side shall have the same pavement as the carriageway. The remaining 1.0m on each side shall be used to accommodate side drain on hill side or parapet/soft shoulder on valley side. In the hill side, depending on the total width of side drain, there is a small width remaining between the wall of side drain and paved shoulder, therefore it is also paved to avoid erosion by surface water

- **Cross-Slope** : Each carriageway shall have cross slope of 2.50 percent. The shoulder shall have a slope of 3.0 percent.

- **Stopping Sight Distance:**

Sufficient stopping distance is made available for drivers to stop their vehicles when faced with an unexpected obstruction in the carriageway. The safe stopping sight distance, overtaking sight distance as recommended in the manual is as below:

Minimum Recommended Sight Distances

Speed (Km/h)	Safe Stopping Sight Distance (m)	Intermediate Sight Distance (m)
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120

Horizontal Alignment:

- **Super-elevation:**

No super elevation is proposed when its value obtained is less than the road camber e.g. radii beyond which super elevation is not proposed are as mentioned below:

Radius Beyond Which Super elevation Not Required

Design Speed (km/hr)	Radii (Meters) For Camber of				
	4%	3%	2.5%	2%	1.7%
20	Proposed as per IRC: SP: 48-1998	50	60	70	90	100
25		70	90	110	140	150
30		100	130	160	200	240
35		140	180	220	270	320
40		180	240	280	350	420
50		280	370	450	550	650

As per IRC guidelines the value of super elevation provided in horizontal curves to counter the effect of centrifugal force will be calculated using the following formula:

$$e = \frac{V^2}{225R}$$

e = Superelevation;

v = Design Speed in kmph; and

R = Radius of Curve in m.

The value of super elevation thus obtained will be limited to the following values:

- In plain and rolling terrain : 7 percent; and
- In hilly terrain : 10 percent.

The length of transition curve is larger of the two values arrived at on the basis of the following criteria:

- Rate of change of centrifugal acceleration; and
- Rate of change of super elevation (not steeper than 1 in 150 for plain / rolling &not steeper than 1 in 60 for Mountainous / Steep terrain).
- **Radius**

Radii for horizontal curves corresponding to ruling minimum and absolute minimum design speeds are as given below:

Minimum Radius for National Highways

(As per IRC: SP: 48-1998)

Mountainous Terrain		Steep Terrain	
Ruling Min Radius (m)	**Absolute Minimum Radius (m)**	**Ruling Min Radius (m)**	**Absolute Minimum Radius (m)**
80	50	50	30

There will be corresponding speed limit in case the radii are less than the above due to hill physical features and economic consideration.

Widening of Pavement at Curves

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passers of vehicle. Extra width to be provided on horizontal curve is given below (refer clause 6.8.5 of IRC: SP: 48: 1998).

Radius of Curve (m)	Upto 20°	20° to 40°	41° to 60°	61° to 100°
Extra width (m) 2 Lane	1.5	1.5	1.2	0.90

Wherever the radius is less than the specified minimum design speed, the transition curve, superelevation and pavement widening will be introduced. This will minimize the intrusion of vehicles on to adjacent lanes, tend to encourage uniformity of speed and increase vehicle speed at the curves.

- **Transition Length**

The transition length, in meters, thus obtained is given in Table 6-2 below.

Table 6-2: Length of Transition Curves (M)

(As per IRC: SP: 48-1998)

Plain and Rolling Terrain				
Curve Radius (m)	**Design Speed in Kmph**			
	100	**80**	**65**	**50**
45				
60				NA
90				75
100			NA	70
150			80	45
170			70	40

Mountainous and Steep Terrain					
Curve Radius (m)	**Design Speed in Kmph**				
	50	**40**	**30**	**25**	**20**
14				NA	30
20				35	20
25			NA	25	20
30			30	25	15
40		NA	25	20	15
50		40	20	15	15

Plain and Rolling Terrain				
Curve Radius (m)	Design Speed in Kmph			
	100	80	65	50
200		NA	60	35
240		90	50	30
300	NA	75	40	25
360	130	60	35	20
400	115	55	30	20
500	95	45	25	NR
600	80	35	20	
700	70	35	20	
800	60	30	NR	
900	55	30		
1000	50	30		
1200	40	NR		
1500	35			
1800	30			
2000	NR			

Mountainous and Steep Terrain					
Curve Radius (m)	Design Speed in Kmph				
	50	40	30	25	20
55		40	20	15	15
70	NA	30	15	15	15
80	55	25	15	15	NR
90	45	25	15	15	
100	45	20	15	15	
125	35	15	15	NR	
150	30	15	15		
170	25	15	NR		
200	20	15			
250	15	15			
300	15	NR			
400	15				
500	NR				

Vertical Alignment:

- **Codal Provisions**

The gradients to be maintained in the design are as per following guidelines:

Codal Reference	Clause No.
IRC : SP-48 – 1998, Hill Road Manual	12.2.1
IRC : 52-2019, Guidelines for the Alignment survey and Geometric Design of Hill Roads	6.9.1.3

- **Gradients for Different Terrain**

The gradients to be adopted for different terrains are given in Table 6-3

Table 6-3: Gradients for Roads

Terrain	Gradient in percentage		
	Ruling	Limiting	Exceptional
Plain or Rolling Terrain	3.3	5	6.7
Hilly Terrain upto 3000m above MSL	6	7	8

- Gradients upto the ruling gradient may be used as a matter of course in design (Ref. Clause No. 6.9.1.4 of IRC-SP: 48 – 1998).

- The limiting gradients may be used where the topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. In such cases, the length of continuous grade steeper than the ruling gradient should be as short as possible. (Ref. Clause No. 6.9.1.5 of IRC-SP:48 – 1998).

- Exceptional gradients are meant to be adopted only in very difficult situations and for short lengths not exceeding 100 m at a stretch. Successive stretches of exceptional gradients must be separated by a minimum length of 100 m having gentler / flatter gradient (Ref. Clause No. 6.9.1.6 of IRC-SP: 48 – 1998).

The available standards for vertical profile do not specify the minimum distance between two Points of Vertical Intersection (PVIs). However, a minimum distance of 150m will be followed. This distance may be reduced to 80m for the existing widened carriageway in case the profile correction becomes excessive.

The minimum length of vertical curve along with the maximum grade change not requiring vertical curve is given in Table 6-4.

Table 6-4: Minimum Length of Vertical Curve

Design Speed in Kmph	Max. grade change not requiring vertical curve in percent	Minimum length of vertical curve in meters
Upto 35	1.5	15
40	1.2	20
50	1	30
65	0.8	40
80	0.6	50
100	0.5	60

6.3.2. Grade Compensation at curves

At horizontal curves .the gradients should be eased by an amount known as grade compensation which is intended to offset the extra tractive effort involved at curves. This is calculated by following formula Hill Road Manual (IRC: SP: 48 – 1998). Clause 6.9.2

Grade compensation (per cent) = (30+R / R) subject to maximum of 75 / R

Where, R is radius of the curve in meters. Since grade compensation correction, the gradients need not be eased beyond 4 per cent.

6.3.3. Design Criteria for Hair Pin Bends

The design standards to be adopted for hair-pin bends are given in Table 6-5. This will be extracted from the Hill Road Manual (IRC: SP: 48 – 1998) clause 6.10

Table 6-5: Design Criteria for Hair-Pin Bends

Design Speed	20 Kmph
Minimum Carriageway Width	11.5 m for two lanes
Minimum Radius of Inner Curve	14.0 m
Minimum Length of Transition Curve	15.0 m
Maximum Gradient	2.50%
Minimum Gradient	0.50%
Superelevation	10%
Roadway Flaring	Concentric w.r.t. Center Line

Design Speed	20 Kmph
Distance between two Hair Pin Bends	60m
Type of Full Roadway Width	Surfaced

6.3.4. At – Grade Intersections

Design standards for at-grade intersections will be in accordance with IRC: SP: 41 – 1994, 'Guidelines for the Design of At-grade Intersections in Rural and Urban Areas' and the MOST Type Designs for Intersections on National Highways.

6.3.5. Surface Drainage

For surface drainage the following points will be collected

- General condition
- Connectivity of drainage turnouts into the natural topography
- Condition in cut sections
- Condition at high embankments

Based on reconnaissance and detailed field survey of the existing drainage system, new system or modification to existing drainage system will be recommended. Some basic principles, which will be taken into consideration in order to meet IRC standards, are described below:

- The surface water from the carriageway, paved shoulders, embankment slopes and the adjoining land must be effectively drained off without allowing it to percolate into the sub-grade.
- The drains must have sufficient capacity and adequate longitudinal slope to drain away the entire collected surface water to the nearest natural surface stream, river or nallah.
- No longitudinal side drains are proposed where the road runs over the canal bank. The rainwater will directly go to the canal.
- No roadside drains are proposed where the longitudinal water bodies are present parallel to the road.

The roadside drainage system will be designed as per IRC SP: 42 and IRC SP: 50. In the project alignment, the following types of drains will generally be proposed:

i) Side ditches of required cross Section for area Drainage on Both Sides of carriageway in rural section.

ii) Covered pucca drains underneath the sidewalk in the urban section

iii) Covered pucca drains in the median between main carriageway and service road in the urban section with proper connection to the outfall location.

iv) Chute drains along with shoulder drains in high embankment (3m and above)

v) Median drains at super elevated sections with proper outfall connections, and

vi) Covered pucca drains underneath the sidewalk of proposed facility (bus bays) in rural sections

The hydraulic adequacy of the drains will be checked as per IRC SP-42 "Guidelines on Road Drainage".

The provision of Rainwater Harvesting will be provided as per IRC at every interval @500m c/c.

6.3.6. Bus Bays

The lay out for bus bays will be in accordance with Manual of Standards and Specifications for Two Laning of National Highways. Minor modifications will be made in the layout plan to take care of ROW constraints, if any.

6.3.7. Safety Barriers, pedestrian Guard Rails and Pedestrian Facilities

The safety barriers will be provided at outer edges of roadways wherever the embankment height is more than 3m in plain terrain, at valley sides in hilly terrain and at major bridge approaches. Pedestrian facilities will be adequately provided in urban sections and at major intersections.

6.3.8. Slope Protection

Embankments less than 3m in height will be turfed; sections where embankment height is greater than 3m will be protected with stone pitching. Slope protection in cut sections of hilly terrain will be provided as per standards given in the Hill Road Manual (IRC: SP: 48 – 1998).

6.3.9. Traffic Control Devices

Road markings and road signs are provided as per relevant IRC codes and MORT&H specifications. Lane markings and object markings will be in accordance with Clause – 803 of MORT&H specifications 2013 (fifth revision). Road markings will be in accordance with IRC: 35 – 2015 and the median kerb and kerb separator painting will be in accordance with Clause 803.3 of MORT&H specifications. The road signs will be in accordance with IRC: 67 – 2012, Code 600 of Addendum to Ministry's technical circular, directives on NH and centrally-sponsored bridge projects, 1996 and IRC: SP: 31. Traffic signboards are to be painted as per IRC: 67 – 2012 and the text in sign boards are to be as per IRC: 30 – 1968.

While the preceding sections discuss details of proposed standards for different constituents, these along with additional pertinent standards for carriageway configuration four-lane divided carriageway are précised in Table 6-6.

Table 6-6: Design Standards for Highway and Road Appurtenances

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
1	**Design Speed, kmph** **i) in plains/rolling terrain** **ii) in mountainous terrain/ steep terrain**	100 -80 60-40	40 (Steep terrain)
2	**RoW, m (desirable)**	30-60 m	53-98 m
3	**Carriageway**		
i)	Width per lane for widening	3.5 m	-same-
ii)	Cross-slope / Camber		
	a) Flexible pavement having bituminous concrete surfacing	2.5%	-same-
	b) Cement Concrete pavement	2.0%	-same-

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
4	**Paved Shoulder (on Outer Side)**		
i)	Width (rural sections)	1.5 m	-same-
ii)	Width (urban sections)	2.5 m	
iii)	Cross-slope / Camber	2.5%	-same-
5	**Earthen Shoulder (on Outer Side)**		
i)	Width(rural sections)	1.0 m	-same-
ii)	Cross-slope / Camber	3.0%	-same-
	Earthen Shoulder (Mountainous & Steep)		
i)	Width (Hill Side) exclusive of parapets &drain	1.0 m	-same-
ii)	Width (Valley Side) exclusive of parapets &drain	2.0 m	-same-
iii)	Cross-slope / Camber	3.0%	-same-
6	**Edge Strip**		
i)	Rural section - on median side	….	0.250m
ii)	Urban section - on median side	….	0.250m
7	**Stopping Sight Distance**		
i)	Desirable	360m	60 m
ii)	Minimum	180m	50 m
8	**Horizontal Curvature**		
i)	Minimum Radii, m (desirable)	60 to 360 depends on terrain conditions	-same-
ii)	Minimum Radii, m (Absolute)	30 to 230 depends on terrain conditions	-same-
iii)	Desirable requiring no super elevation	depends on terrain conditions	-same-
iv)	Minimum requiring 7% super elevation	….	400
v)	Absolute minimum requiring 7% super elevation	….	360
9	**Vertical Alignment**		

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
i)	Minimum distance between PVI	…..	For Existing Carriageway, a minimum distance of 80m and for new carriageway a minimum distance of 150m
ii)	Minimum length of vertical curve	IRC: 73	-same-
iii)	Maximum grade change not requiring vertical curve	IRC: 73	-same-(0.5%)
10	**Gradient, %**		
i)	Maximum	3.3%	7.0 %
ii)	Minimum		
	a) In cut and kerbed sections	0.5-1.0%	-same-
	b) On unkerbed sections on embankment	Near level grades	0.05%
11	**Super elevation,%**		
i)	Minimum	2.0% (Camber)	-same-
ii)	Maximum	10%	-same-
12	**Width of Side Walk (in urban stretches), m**	1.5	-same-
13	**Median Width, m**		
i)	Rural sections	----	----
ii)	Urban / other sections	----	----
iii)	Cross-slope / Camber (5m wide)	----	----
14	**Width of side walk (in urban stretches)**	1.5m	-same-
15	**Intersections**	IRC: SP: 41 and IRC: 92	-same-
i)	Length of storage lane (including taper) for right turning	…..	…..
ii)	Minimum length of acceleration lane	…..	…..
iii)	Minimum length of deceleration lane	…..	…..
iv)	Maximum radius for left turn	…..	30m
v)	Minimum radius for right turn	…..	15m

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
vi)	Width of turning lane (inner radius of 30 m)	…..	…..
vii)	Rate of taper (min)	…..	1 in 10
16	**Bus Bay**		
i)	Min. length of bus bay, m	15	15
17	**Truck Lay-bye**		
i)	Min length of lay-bye	….	….
ii)	Min parking length for each vehicle	….	….
iii)	Min parking width for each vehicle	….	….
iv)	Min. width of raised separator between layby and carriageway	….	….
v)	Rate of taper (min)	….	….
18	**Traffic Control and Road Safety Devices**	IRC: 35, IRC: 67 and MOSRTH guidelines.	-same-
19	**Roadside Furniture**	IRC: 25, IRC: 8, IRC: 103, IRC: 35, MOSRTH guidelines	-same-
20	**Clearance for Utility Lines**		
	Horizontal		As per IRC 32-1969
i)	Street lighting poles		
	a) Roads with raised kerbs	…..	300mm min from edge of kerb
	b) Roads without raised kerbs	…..	1.5m min from edge of carriageway
ii)	Overhead power and telecommunication lines	…..	It will be as per the cross section submitted for urban area
	Vertical		As per IRC 32-1969
i)	Ordinary wires / lines carrying voltage upto and including 110 volts and telecommunication lines	…..	5.5m min.
ii)	Electric power lines carrying voltage upto and including 650 volts	…..	6.0m min.

S.No.	Item	Design Standard proposed to be followed	Proposed Standards for Adoption
iii)	Electric power lines carrying voltage exceeding 650 volts	…..	6.5m min.

6.4. FORMATION WORK

Earth Embankment

i) The fill material, compaction and other requirements shall conform to IRC: 36-2010. Where these specifications are in variance with the MORT&H specifications, the later shall govern and accordingly followed.

ii) Side slope of 2:1 is provided

Side Slopes Formation in Cutting

The following values are adopted as per IRC: SP: 48:1998 Clause 7.4.

Side Slope in Cutting

Sl.No.	Item	Slopes of Cutting
1	Ordinary Soil / Heavy Soils	1:1 to 1 : 2
2	Ordinary / Soft Rock	1 : 4 to 1:8
3	Hard rock	80^0 to 90^0

(Explanation: The slope 1: 2 signifies 1 in the horizontal direction and 2 in the vertical)

6.5. PAVEMENT DESIGN

The detailed design of pavement will involve:

- Pavement design for new pavement for main carriageway (flexible or rigid)
- Overlay design for existing flexible pavement
- Maintenance, Repair and Rehabilitation of existing pavement
- Pavement design for paved shoulder

The design of pavement will primarily be based on IRC publications. The design alternatives will include both rigid and flexible design options. The most appropriate design option will be established on life-cycle costing by using HDM-IV and techno-economic consideration.

6.5.1. Pavement design for new flexible pavement of main carriageway

The design of flexible pavement for main carriageway will be in accordance with the method prescribed in IRC: 37 – 2018(Guidelines for the Design of Flexible Pavements). Flexible pavement will be designed for a design period of 15 years.

6.5.2. Pavement design for new rigid pavement of main carriageway

Rigid pavement will be designed for a period of 30 years, in accordance with the method prescribed in IRC: 58-2015 (Guidelines for the design of plain jointed Rigid Pavements for highways) or the Portland Cement Association (PCA) method. Contraction joints with dowel bars and longitudinal joints with tie bars will be provided.

The Pavement Quality Concrete (PQC) will rest over Dry Lean Concrete (DLC) sub-base of 150mm thickness. The DLC will be M10 concrete (7days' strength) as prescribed in IRC: SP: 49 – 2014. A properly designed drainage layer of Granular Sub-Base (GSB) of 150-200mm thickness will be provided.

6.5.3. Overlay design for existing flexible pavement

IRC: 81-1997(Guideline for strengthening of flexible road pavements using Benkelman Beam Deflection technique) will be followed for design of strengthening treatment. The guidelines provide the method for determining the characteristic deflection using Benkelman Beam and then working out the overlay thickness for the design traffic. The design period will be the same as specified for new pavement sections.

6.5.4. Maintenance, Repair and Rehabilitation of existing rigid pavement

The maintenance, repair and rehabilitation of the existing rigid pavement will be in accordance with IRC: SP: 83-2018 in conjunction with IRC: SP: 17-1977(Recommendations about Overlays on Cement Concrete Pavements).

6.5.5. Pavement design for paved shoulder

The paved shoulders will be designed as integral part of the pavement for the main carriageway. Paved shoulder will have same composition and thickness as that of main carriageway pavement.

The periodicity and timing of future maintenance and strengthening requirements will be predicted based on road deterioration model of HDM-IV taking pavement roughness as indicator of pavement condition.

6.6. DESIGN STANDARDS FOR STRUCTURES

This section gives the detailed design standards considered for new construction as well as repair and rehabilitation work of structures.

6.6.1. Codes of Practices

Design standards and the loading to be considered are generally based on the requirements laid down in the latest versions of IRC/ IS codes of practices and standard specifications, and guidelines issued by MoRT&H. Additional technical references will be made wherever the provisions of IRC/IS codes are found inadequate. The following IRC/ IS codes are proposed to be used in the design of structures:

- **IRC: 5 - 2015:** Standard Specifications & Code of Practice for Road Bridges, Section I - General Features of Design (Seventh Revision)
- **IRC: 6 - 2017:** Standard Specifications & Code of Practice for Road Bridges, Section II - Loads and Stresses (Third Revision)
- **IRC: 22-2015 :**Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Third Revision)
- **IRC: 24-2010:** Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method) (Third Revision)

- **IRC: SP-64-2016**: Guidelines for the Analysis and Design of Cast-in-Place Voided Slab Superstructure (First Revision)
- **IRC: SP-65-2018**: Guidelines for Design and Construction of Segmental Bridges (First Revision)
- **IRC:SP-66-2018:**Guidelines for Design of Continuous Bridges (First Revision)
- **IRC:SP-71-2018:**Guidelines for Design and Construction of Precast Pre-tensioned Girders for Bridges (First Revision)
- **IRC: 112 - 2020:** Standard Specifications & Code of Practice for Concrete Road Bridges
- **IRC: 78 - 2014:** Standard Specifications & code of Practice for Road Bridges, Section VII- Foundations & Substructure (First Revision)
- **IRC: 83 (Part I) – 2015:** Standard Specifications & Code of Practice for Road Bridges, Section IX - Bearings, Part I: Roller and Rocker Bearings.
- **IRC: 83 (Part II) - 2018:** Standard Specifications & Code of Practice for Road Bridges, Section IX - Bearings, Part II: Elastomeric Bearings.
- **IRC: 83 (Part III) - 2018:** Standard Specifications & Code of Practice for Road Bridges, Section IX - Bearings, Part III: POT, PIN, Metallic Guide and Plane Sliding Bearing.
- **IRC: 89 - 2019:** Guidelines for Design & Construction of River Training and Control Works for Road Bridges (Second Revision)
- **IRC: SP 13 - 2004**: Guidelines for Design of Small Bridges & Culverts.
- **IRC: SP 40 - 2019**: Guidelines on Techniques for Strengthening and Rehabilitation of Bridges

For items not covered in the above specifications, provisions of the following standards will be followed in the given order of priority:

- Provisions of IS codes of practices; followed by
- Relevant provisions of BS codes of practices; followed by
- Sound engineering practice, international best practices, technical literatures/ papers and provisions of relevant codes of other nations.

6.6.2. Design Standards

The general standards for design of structures will be as presented in Table 6-7 below:

Table 6-7: General Design Standards for Structures

Sr. No.	Item	Standard
1	**Geometry**	Highway alignment and cross-section will be followed. Crash Barrier will be kept outside the roadway width.
2	**Widening**	
	a. Extent of Widening	Widening will be decided by Centre-Line (CL) of proposed road, cross-section of road and width of existing structure.
	b. Material for Widening	In case of widening, all components of new structure will be of RCC or PSC.
3	**Connection between existing and widened portion**	a. Widening of Girder bridges will be done by separate structure at distance considering stability of existing foundation. b. In case of Slab type bridge widening, the superstructure, substructure and foundation will be extended monolithically on either side. c. in case of slab bridge, The superstructure will be widened by RCC however Substructure and foundation will be widened by PCC.
4	**Reconstruction of Existing Bridge or New Construction: Major/ Minor Bridges and Culverts**	a. Reconstruction will be as per the findings and recommendations of the Condition Survey report. Hydrological inadequacy of structures will be reviewed based on detailed hydrological study and recommendations.
		b. Bridges up to 10 m span will be of RCC box type.
		c. Bridges above 10 m and up to 13 m span will be of RCC solid slab on RCC pier / abutments.
		d. Bridges above 13 m and up to 25m span will be of RCC T-girder and RCC deck slab on RCC pier / abutments.
		e. Bridges above 25 m and below 40 m span will be of PSC T-girder and RCC deck slab on RCC pier / abutments.
		f. Bridges of span 40 m and above will be of PSC box girder on RCC pier / abutments.
		g. All new culverts will of RCC box / NP4 Pipe type
		h. (a) All existing culverts in good condition will be widened with same type. (b) All existing pipe culverts less than 0.9m dia. will be replaced with 1.2m dia pipe.
5	**Cross-Slope**	a. For culvert same cross-slope as that of the road will be followed.
		b. Fill over culvert will depend on highway profile.
		c. Profile corrective course will be as per pavement composition.
		d. For new structure deck slab will follow a minimum cross-slope of 2.5 %

Sr. No.	Item	Standard
6	**Wearing Course**	Bituminous Wearing Course of 65 mm thickness as per MoRT&H Specifications.
7	**Bearing**	POT / PTFE bearing shall be used for girder bridges.
8	**Reinforcement**	FE-500D shall be used in correlation to MORT&H specifications.
9	**Expansion Joint**	Strip seal and filler type expansion joint to be used as per MORT&H standard drawings.
10	**Approach Slab**	a. RCC approach slab as per MoRT&H will be provided in Flyovers, Major Bridges, Minor Bridges and Underpasses. Approach slab may be avoided in underpasses having earth cushion more than 200mm.
		b. No approach slab for Culvert. IRC:SP: 13 - 2004
11	**Bed Protection**	All culverts and box type minor bridges will have proper bed protection, as per IRC: 89 - 1997.
12	**Retaining Walls**	a. Embankment toe wall will be of PCC M-15.
		b. Other cases- RCC / PCC retaining wall.
13	**Crash Barrier**	RCC M-40 around 0.9 m ht for all structures. (as per IRC: 5 – 2015)

6.6.3. Material Properties

6.6.3.1Concrete

Following material properties are proposed to be used for various RCC components of bridge structures:

- Coefficient of Thermal expansion: 11.7×10^{-6} / °C as per IRC: 6 - 2017
- Poisson's Ratio: 0.2
- Modulus of Elasticity: As per Table 6.5 of IRC: 112 - 2020
- PSC members. IRC 112:- 2020
- Creep & Shrinkage: As per IRC112:-2020 codes
- Concrete Grade: Refer: Durability Consideration in Design

6.6.3.2Reinforcement

The reinforcement to be used shall confirm to HYSD Fe 500 D.

i) Pre-Stressing Steel System

All ducts and anchorages will be suitable for 19T13 stress relieved low relaxation strands conforming to IS: 14268 – 95. The properties of the strands will be as follows:

- Nominal Diameter : 12.7mm
- Nominal Steel area : 98.7mm^2 per strand
- Ultimate Load : 183.71 KN per strands

- Modulus of Elasticity : 1.95 x 10^5Mpa
- Friction Coefficient : 0.25 / radian
- Wobble Coefficient : 0.002/m
- Anchorage Slip : 6mm average
- Loss of force due to relaxation : 2.5% at 0.7 UTS after 1000 hrs.

ii) Structural Steel

Structural steel will conform to IS: 226 with yield stress of 23.6 Kg / cm2.

6.6.3.3Bearings

Depending upon the type of structure, span length of each superstructure, skew angle either Pot fixed / Pot-cum-PTFE sliding bearings or elastomeric bearing will be suggested.

6.6.3.4Expansion Joints

Strip seal / Tar paper expansion joint shall be used depending upon the length and type of structure.

6.6.4. Load and Load Combinations

6.6.4.1 Dead Loads

Following unit weights will be considered for dead load computations in the design:

- Reinforced Concrete : 2.4 t / m^3
- Pre-stressed Concrete : 2.5 t / m3
- Plain Cement Concrete : 2.2 t / m^3
- Structural Steel : 7.85 t / m^3
- Dry Density of soil : 2.07 t / m^3
- Saturated Density of Soil : 2.2 t / m^3
- Wearing Coat : 2.2 t / m^3
- Crash Barrier : From Design (i.e., 40 kg / m per side)

6.6.4.2 Live Loads

- Pedestrian Live Loads : Minimum 400 kg / m^2 on entire clear footpath width & appropriately considered depending upon the span length as per IRC:6 (Cl.209).
- Live Loads : One / Two lanes of IRC Class A.
- Impact factor shall be taken as per IRC: 6 2017 for the relevant load combinations.

6.6.4.3 Longitudinal forces due to Bearing Friction

The coefficient of friction for the sliding bearings will be taken to be 5%. When considering the effects of differential friction on bearings on either side of the fixed piers, the friction on one side of the bearing will be taken as 5% while on the other side it is taken as 2.5%.

6.6.4.4 Horizontal Forces due to Water Currents

The water current forces will be taken as per IRC: 6 – 2017.

6.6.4.5 Seismic Loading

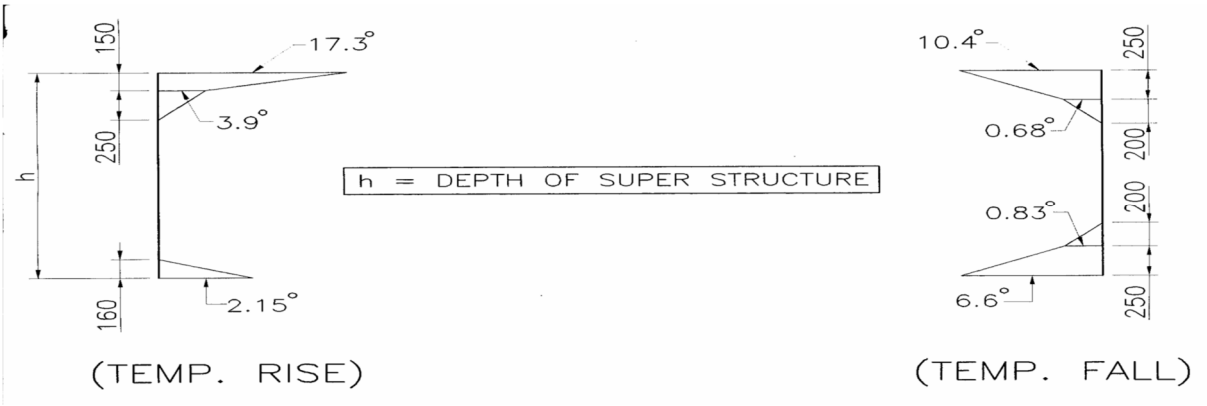
The bridges are located in Seismic Zone - V as per the relevant IRC code. Hence, seismic forces will be considered only for those bridges having span greater than 15m or overall length of the bridge is more than 60m.

6.6.4.6 Wind Loading

As per IRC: 6 – 2017, the project corridor falls under "single intensity" zone based on which the wind intensity to be taken as per the values given in IRC: 6 – 2017. A wind velocity of 198 Km / hr will be considered for the design of structures.

6.6.4.7 Temperature Loading

- The bridge superstructure / components i.e. bearings and expansion joints will be designed for a temperature variation of + / - 17°C, considering the severe climatic conditions;
- The superstructure has also been designed for effect of distribution of temperature across the deck depth as given in Sketch - A enclosed. These are based on the stipulations of BD 37 / 88.



- Temperature effect will be considered as follows :
- Effects of non-linear profile of temperature are combined with 50% live load. The value of modulus of elasticity for concrete, "E_c" is taken as "$E_i / 2$"; and
- Effects of global rise and fall of temperature is combined with 100% live load and value of modulus of elasticity for concrete, "E_c" is taken as equal to "E_i".

6.6.4.8 Load Combination

All members are designed to sustain safely the most critical combination of various loads and forces that can co-exist. Various load combinations as relevant with increase in permissible stresses considered in the design are as per of IRC: 6 – 2017 and of IRC: 78 – 2014.

6.6.5. Exposure Condition

The project corridor is located in interior part of Mizoram and the condition of exposure is considered as "Normal" for the purpose of structural design.

6.6.6. Cover to Reinforcement

Following concrete covers are proposed to be used for various structural components:

- Foundation : 75mm
- Substructure : 75mm
- Superstructure : 50 mm

6.6.7. Durability Considerations in Design

In view of the severity of the environment, which subjects the bridge to additional loads, considerations will be given for reducing the need for general and long term maintenance and to achieve a durable structure.

The following items will be identified as requiring special attention in this regard:

- Concrete Grade to be used is as follows :

  Minor Bridges / Culverts

  - RCC Structure M35 / M30 / M25
  - PCC Structure M25 / M20

- The design and detailing of various components are such that ease of access for inspection and maintenance operation is addressed for all aspects; and
- Easy access to bearings at pier locations will be provided from well cap level.

6.6.8. Design of Culverts

Following are the major design standards / strategies for new construction of culverts:

- IRC Standard Box culverts will be provided where box culverts are recommended; and
- IRC: SP: 13 – 2004 will be followed for new construction of pipe culvert.

6.7. GEOTECHNICAL

The geotechnical engineering of the project includes carrying out a comprehensive exploration program at selected locations of the project corridor. The subsoil data obtained during exploration will be used for analyzing the stability of existing and proposed structures and roadway embankments.

The geotechnical design, in general, conforms to the applicable IRC and / or IS codes of practice. In addition, some international design manuals and popular technical books will be referenced. The design will be based on the serviceability loads criterion with a safety factor adopted on the ultimate design value. The geotechnical recommendations include the adequacy of foundations of the existing structures, allowable bearing capacity for the foundations in the widening areas and new structures, ground improvement, if any, for increasing the shear strength of foundation soils & limiting post-construction settlements of structures and roadway pavements, compaction control of fill used in the embankments & foundation / utility trenches and erosion control of embankment side slopes. The proposed design methodology is itemized in the Table 6-8 below:

Table 6-8: Proposed Design Methodology of Geotechnical Aspects

Sl. No.	Item	Standards
1.	**Sub-soil Investigation**	The field and laboratory tests will be conducted for structure locations in compliance with Contract Agreement. The procedure for testing will be in accordance with relevant BIS codes.
2.	**Seismic Zone**	Zone and Peak ground acceleration (PGA) will be decided based on IS: 1893 (Part 1): 2002. However, cross reference will be made for Peak ground acceleration (PGA) on

Sl. No.	Item	Standards
		report of National Geophysical Research Institute (NGRI), Hyderabad, under The Global Seismic Hazard Assessment Program (GSHAP).
3.	**Embankment**	
	i) *Fill Material*	
	a) Embankment material properties (c, ϕ, γ)	Property will be determined based on laboratory test data on approved fill material. Fill material in the vicinity of embankment stretches will be considered for construction. Guidelines from MORT&H, IRC: 36-2010, IRC: SP 58 – 2001 will be followed.
	b) Pavement material properties (c, ϕ, γ)	Based on grain size and index properties, strength parameters will be estimated.
	ii) *Embankment Stretches*	
	Approach Embankment	Generally following stretches considered based on the height of the embankment i) 75 - 100m on either side of Pile supported structure ii) 25 - 50m on either side of open / well foundation supported structure
	b) Running Embankment	Other than approach embankment
	iii) Embankment Geometry	
	a) Design Road Top Width	Depending upon proposed highway c/s either a) Width of widened part or, b) Total proposed road width
	b) Design Height	Average of heights measured from ground level to finished road level along the c/s and then maximum of all those average heights along the stretch based on proposed highway c/s and l/s.
	iv) *Traffic Load*	Generally 1.50 t/m^2 depending upon traffic volume
	v) *Ground Water Table*	For analysis, generally the ground water will be assumed at ground level. However, GWT will be confirmed from Geotechnical Investigation Report as well as from existing well in the vicinity with judgment of seasonal variation
	vi) *Sub-soil Profile and Properties*	Based on Geotechnical Investigation Report and engineering judgment and interpretation.
	vii) *Stability Analysis*	Following standards and criteria will be adopted / used: MORT&H approved HED software package / "XSTABL" (version 5) software package (developed by Interactive Software Designs, Inc, USA) for static analysis. For seismic analysis, "XSTABL" (version 5) software package (developed by Interactive Software Designs, Inc, USA) Simplified Bishop's method as per IRC 75 Undrained unconsolidated condition analysis

Sl. No.	Item	Standards
		Slope, toe and deep seated base failure analysis Min F.O.S – 1.25 (for short term), 1.5 (for long term) & 1.00 (for seismic) Slope – Generally 1(v): 2(H) wherever ROW is available
	viii) *Settlement Analysis*	Following standards and criteria will be adopted / used: a) MORT&H approved HED software package b) One dimensional consolidation settlement for cohesive and partly cohesive deposition as per IRC: 75 Permissible Total Settlement Limits as per IRC: 75: 400 – 600mm for Running Embankment, 100-125mm for open / well foundation and 30 to 45mm for pile foundation.
	ix) *Bearing Capacity Analysis*	For bearing capacity, the method recommended by IRC: 75, Pilot, Silvestri and Meyerhof will be followed.
	x) *Sand Drainage Blanket*	Based on sub-soil type, position of ground water table and embankment fill material, the requirement, if any, will be decided.
	xi) *Slope protection*	For ≥3m high embankment, stone pitching / geomeshes / geonets / geogrids / jute or coir Geotextile, if any, as per detailed site condition. For <3m high embankment, natural plantation / artificial vegetative turfing.
	xii) *Ground Treatment*	Based on analysis, suitable ground improvement technique, if any, will be proposed.
	xiii) *Instrumentation*	Based on suggested ground improvement method, suitable instrumentation, if required, will be provided.
	xiv) *Mechanically Stabilized Walls*	Following criteria will be adopted: Geogrid / metallic reinforcement Discrete concrete panel and segmental block Design for static condition – BS 8006 Design for seismic condition – French Standard NF 94-220, FHWA publication No. 43 Material and construction – MORT&H Specification
	xv) Ground treatment for pond, water logged and marshy areas	Treatment will be indicated on the basis of extent, depth of water, location, land use in the neighborhood.
4	**Foundation**	
	i) *Open Foundation*	
	a) Foundation shape	Based on site condition and structural requirement
	b) Foundation size	Based on sub-soil profile and properties, site condition, structural requirement etc.

Sl. No.	Item	Standards
	c) Foundation depth	Based on sub-soil profile and properties, structural requirement, ground water table, scour level etc as per IRC: 78, IS: 1904.
	d) Design procedure	a) Safe Bearing Capacity: For soil and completely disintegrated rock according to procedure given in IS: 6403(1981), IS: 1904(1986). For rock as per IS: 12070(1995), Standard Reference Books. F.O.S: Minimum 2.5 for soil, 6 or as recommended in above references for rock. b) For Total & Differential Settlement: According to IS: 8009(part-I)-1976,IS: 1904-1986, Schmertmann method, Standard Reference Books
	ii) Pile Foundation	
	a) Type of pile	Generally Bored cast in situ piles and Rock socketed piles
	b) Pile Shape	Generally circular.
	c) Pile Diameter	As per IRC: 78 – 2014.
	d) Design procedure	Following standards and criteria will be adopted / used: a) Vertical Compression, Vertical tension and Lateral load capacity - as per IS: 2911(part-I / sec-II)-1979, IS: 14593-1998, IRC: 78-2014, Standard Reference Books F.O.S - For soils: 2.5 – 3.0, For socketed piles: End bearing : 5.0 – 6.0, Skin friction= 10 Settlement – as per IS: 8009 (Part II), Standard Reference Books etc. Spacing – As per IS: 2911(part-I / sec-II)-1979, IRC: 78-2014. Negative drag - IRC: 78-2014, Standard Reference Books
	e) Depth of Pile	Based on sub-surface profile, structural load requirement, scour level etc. in accordance with above codal provisions. For socket length in rock, IS : 14593 and IRC: 78-2014 will be followed.
	f) Pile load tests	As per provision of IRC: 78 – 2014 and MORT&H Specification. Pile Integrity test if number of piles is substantial. Initial pile load test preferably by cyclic method
	iii) *Well Foundation*	
	a) Well Shape	Generally circular.
	b) Well Diameter	Based on sub-soil profile, scour level, structural load etc.
	c) Design procedure	Following standards and criteria will be adopted / used:

Sl. No.	Item	Standards
		a) Safe Bearing Capacity: For soil and completely disintegrated rock according to procedure given in IS: 6403(1981), IS: 1904(1986). For rock as per IS: 12070(1995), Standard Reference Books. F.O.S: Minimum 2.5 for soil, 6 or as recommended in above references for rock. b) For Total & Differential Settlement: According to IS: 8009(part-II)-1976,IS: 1904-1986, Schmertmann method, Standard Reference Book
5.	**Minimum Compaction Requirement**	
	i) Embankment a) For granular soils for c-ϕ soils	i) Minimum 75-80% Relative Density otherwise, 95% of MDD as per MORT&H specification ii) Minimum 95% of MDD as per MORT&H specifications
	ii) Sub grade	Minimum 97% of MDD as per MORT&H specifications
6.	**Tunnel**	
	Surface Mapping	Geological surface mapping of the tunnel portal and along the tunnel alignment
	Geo-physical investigations	Wenner 4-Point Test Electrical resistivity is the measurement of the specific resistance for land slide zone. Seismic refraction test: the desired depth of investigation equal to or less than 25m below ground level, the minimum required spread length is 115 m and sledge hammer as seismic source is commonly used.
	Drilling Nx size core drilling	The geo-technical investigations shall be carried out by drilling atleast three drill holes at the location of each tunnel upto the proposed tunnel invert. Permeability tests shall be carried out in the hole at different elevations. The core samples shall be logged and their properties shall be determined in the laboratory

6.8. DRAINAGE

The road drainage system will be planned as per IRC SP: 42 and IRC SP: 50. A camber of 2.5% will be provided in main carriageway, service road as well as in truck lay-by and bus bay locations. Longitudinal unlined drain will be provided along the highway in rural sections with outlets towards cross drainage structures. Longitudinal lined drains will be provided in between Main Carriage Way (MCW) and Service Road (SR) to cater surface runoff from MCW and SR. Chute drains at a distance of 25 m will be provided in stretches having embankment height more than 3.0m. At the location of high embankment where Retaining wall will be provided, the water from

MCW will be carried out by 150 mm diameter PVC down take pipe provided at spacing of 20m c/c. whenever there is less space in between toe of MCW/SR and ROW a RCC rectangular lined drain with 0.6 widths will be provided

Sl. No.	Item	Standards
1	Design Return Period	
a)	Unlined drains (rural sections)	25 years
b)	Covered pucca drain underneath side walk and median between carriageway & service road; chute drains, median drains at superelevated sections and other important locations.	5 years
2	Unlined drains in rural sections	
a)	Berm	Will be beyond 4H: 1V line drawn from edge of shoulder (as per IRC SP-42) or at ROW but not less than 1.0m from toe of embankment depending on height of embankment.
b)	Side slopes	2H:1V
c)	Base width	0.6-1.0m (based on hydraulic calculations)
3	Chute drain	
a)	Height of embankment	3m and above
b)	Spacing	20-25 m, depending upon hydraulic calculations
4	Balancing culverts	Additional balancing culverts will be provided if it is required either for planning adequate drainage system or in the overtopping stretches after raising the profile, to pass the water across.

6.9. TUNNEL

(i) Design of Tunnel

Road tunnels are feasible alternatives to cross through physical barriers such as mountains, existing tunnels, existing roadways, rail lines etc. In addition, road tunnels are viable means to minimize excessive length of road particularly in hilly areas apart from potential environmental impact such as traffic congestion, pedestrian movement, air quality, noise pollution, or visual intrusion to protect areas of special cultural or historical value such as places of worship, forts or palaces or private properties or for other sustainability reasons such as to avoid the impact on natural habitat or reduce disturbance to surface land. It should be noted that the life expectancy of tunnels are significantly longer than those of other facilities.

There are three main shapes of highway tunnels i.e rectangular, circular and horse shoe. The shape of the tunnel is largely dependent on the method used to construct the tunnel and the ground conditions i.e. rectangular tunnels are often constructed by cut and cover method. Circular tunnels are constructed by using either tunnel boring machine (TBM) or by conventional method of drill and blast in rock. Horse shoe configuration tunnels are constructed using drill and blast in rock or by following sequential excavation method (New Austrian Tunnelling Method).

Road tunnels are generally lined with concrete and internal finished surfaces. Rock reinforcement is often needed. Rock reinforcement for initial support includes the use of rock bolts, un-tensioned steel dowels or tensioned steel bolts. To prevent small fragments of rock from spalling, wiremesh, shotcrete or a thin concrete lining is generally used. Shotcrete is often used as initial lining prior to installation of final lining. Segmental linings are generally made of cast iron, steel or concrete. The walls and the ceilings often receive a finish surface while the roadway is often paved with asphalt pavement.

Functional/Safety Requirements Based on Length of Tunnels

Classification of Tunnel	Single Tube Bi-Directional					Double Tube Uni-Directional				
	CP	Vent	Light	Comm	Fire Safety	CP	Vent	Light	Comm	Fire Safety
Short upto 500 m	-	-	Yes	-	-	-	-	Yes		
Medium 500 -1500 m	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Long tunnel >1500 m	NA	NA	NA	NA	NA	Yes	Yes	Yes	Yes	Yes

Fire safety - Fire extinguisher at spacing of 100 m

Communication - Telephone at spacing about 100 m

Lighting - All Urban Tunnels and for tunnels longer than 100 m in non-Urban areas.

Cross Passages - Cross passages where applicable, will be provided at 500 m spacing

Note 1: -

in case of long tunnels, provision of refuge to park at least 6 vehicles along the length of tunnel with one-lane width, proper informatory signs, transitions, and line of sight shall be planned at opposite side of each cross passage.

Note 2: -

In case of twin tube tunnels, each tunnel tube with uni-directional traffic, cross passages connecting the two tubes shall be planned at a spacing of about 500 m. In the event of an incident / accident in one of the tubes, the other tube shall be used as an escape and rescue route by diverting the traffic through cross passages to the extreme right lane of the other tube, so as to clear the tunnel in case of emergencies.

Note 3: -

For installation of facilities in expressway tunnels refer "Guidelines for Expressways Volume-II: Design"

The tunnels are generally equipped with various systems such as ventilation, lighting, communication, firefighting system and life safety, drainage, traffic operation and control systems etc.

Generally, the tunnel geometrical configuration should accommodate all potential vehicles that is expected to use the roads leading to the tunnel including over height vehicles such as military vehicles. Road tunnels should have atleast the same traffic capacity as that of surface roads. Studies suggest that in tunnels where traffic is controlled, if traffic is more than that in uncontrolled surface road suggesting that a reduction in the number of lanes inside the tunnel may be warranted. However, traffic will slow down, if the lane width is less than standards and may strike with tunnel walls if insufficient lateral clearance is provided inside the tunnel. Also, very low ceilings give an impression of speed and tend to slow the traffic flow. Therefore, it is important to provide adequate lane width and height in the tunnel comparable to those of approach road.

(ii) Codes of Practices

Design standards and the loading to be considered are generally based on the requirements laid down in the latest versions of IRC/ IS codes of practices and standard specifications, and guidelines issued by MoRT&H. Additional technical references will be made wherever the provisions of IRC/IS codes are found inadequate. The following IRC/ IS codes are proposed to be used in the design of structures:

- **IRC:SP-91-2019:** Guidelines for Road Tunnel
- For items not covered in the above specifications, provisions of the following standards will be followed in the given order of priority:
- Provisions of IS codes of practices; followed by
- Relevant provisions of BS codes of practices; followed by
- Sound engineering practice, international best practices, technical literatures/ papers and provisions of relevant codes of other nations.

(iii) Geological Investigations

Geological and Geotechnical investigations are critical for proper planning of a tunnel. Selection of the alignment cross section, and construction methods is influenced by the geological and geotechnical conditions, as well as the site constraints. Good knowledge of the expected geological conditions is essential. The impact of geological features on the tunnel alignment is the presence of active or inactive faults. During the planning phase, it is necessary to avoid crossing a fault zone and preferred to avoid being in a close proximity of any active fault. Geotechnical issues such as soil or rock properties, ground water regime, ground cover over tunnel, presence of underground utilities and obstructions such as boulders or buried objects should be taken into consideration while fixing tunnel alignment. Tunnel alignment is sometimes changed based on the results of the geotechnical to minimize construction cost or to the reduce risks. The profile can also be adjusted to improve constructability or accommodate construction technologies as long as the road geometrical requirements are not compromised.

It is necessary that the geotechnical investigations may start as early as possible during the initial planning phase of the project. The investigations should address not just the soil and rock properties but also their anticipated behaviuors during excavation. For example in sequential excavation or New Austrian Tunneling Method (NATM), ground standup time is critical for its success.

(iv) Environmental Friendly

Road tunnels are more environmental friendly than other surface facilities. Air quality would be improved because traffic generated pollutants are captured and disposed off away from the public. Similarly, noise would be reduced and visual aesthetic and land use would be improved.

(v) Ground Water Control

A dry tunnel provides a safer and friendlier environment and significantly reduces operational and maintenance cost. Advancement in tunnelling technology in the last few decades in general and in the water proofing field in particular have facilitated the implementation of strict water infiltration criteria and the ability to build dry tunnel. Tunnel water proofing system is used to prevent ground water inflow into an underground opening. This system is commonly installed between an initial tunnel support (initial lining) and the final support (permanent lining).

There are two basic types of water proofing system, drained (open) and un-drained (closed), open water proofing systems allows ground water inflow into a tunnel drainage system. The tunnel vault area is equipped with a water proofing system forming an umbrella like protection that drains the water seeping towards the cavity around the arch into a drainage system that is located at the bottom of the tunnel sidewalls and in the tunnel invert. The open system is commonly used in rock tunnels where water infiltration rates are low.

Closed water proofing system (closed system) extend around the entire tunnel perimeter and aim at excluding the ground water from flowing into the tunnel drainage system completely. Thus, no ground water drainage is provided. The secondary linings, therefore, have to be designed for full hydrostatic water pressures. These systems are often applied in permeable soils where ground water discharge into the tunnels would be significant.

(vi) Tunnel Portals

Construction of portals and its long term maintenance is very important & their locations are made based on safety consideration. Portals are located such that they satisfy environmental and air quality requirements as well as the geometrical configuration of the tunnel & hill slopes. At portals, it may be necessary to extend the dividing wall between traffic travelling in opposite directions to reduce recirculation of pollutants from the exit tunnel into the entry tunnel. If possible, portals should be oriented to avoid drivers being blinded by the rising or setting of the Sun. Special lighting requirements at the portal are needed to address the 'black hole' effect. In mountain tunnels, the portals should be as close to the face of the mountain as practically constructible.

(vii) Design Process

The basic process used in the design of a road tunnel is:

a) Functional requirements including design life and durability requirements.

b) Investigations and analyses of the geological & geotechnical data.

c) Determination of the most appropriate method of tunnelling.

d) Appropriate initial and final ground support and lining system critical for the tunnel

design, considering both ground conditions and proposed method of construction.

e) Establishing tunnel alignment, profile and cross section.

f) Preparation of project document including planning, construction method schedule, specifications, estimate and geotechnical report.

(viii) Fire Protection & Life Safety Requirements

The fire protection and life safety requirements for road tunnels are as follows:

a) **Fire Protection:** Stand pipe, fire hydrants, water supply, portable fire extinguisher, fixed water-base firefighting system etc.

b) **Tunnel Drainage System:** Good design anticipates drainage needs. Usually sump-pump systems are provided at the portals and low points. Roadway drainage throughout the tunnel using drain inlets and drainage pipes should be provided. The drainage system should be designed to deal with surface drainage as well as any ground water infiltration into the tunnel. Other areas of tunnels, such as ventilation ducts and potential location for leakage should have provision for drainage.

c) **Emergency Egress:** Emergency egress for persons using the tunnel should be provided at regular intervals. Exists should be clearly marked and the spacing of exists into escape routes should not exceed 300 m. The emergency egress walk ways should be a minimum 1.2 m wide and should be protected from incoming traffic. Signage indicating both direction and distance to the nearest escape door should be mounted at one of the emergency walk ways and be visible in an emergency.

d) **Emergency Ventilation, Lighting and Communication:** An emergency ventilation system should be provided to control smoke and to provide fresh air for the evacuation of passengers. The emergency ventilation system is often the normal ventilation system operated at higher speeds. The fans should be connected to an emergency power source in case of failure of primary power.

The risk of fire spreading through power cable ducts should be eliminated by dividing cable ducts into fire proof sections. Placing cables in ducts are using fire proof cables where applicable and other preventative measures being adopted.

Emergency telephones should be provided in the tunnels and connected to the emergency power supply. When such a telephone is used, the location of the caller should be identified both at the control centre and by a warning light visible to rescuing personnel. Telephones should be provided at cross passage doors and emergency exits. Communication system should give the travelling public the possibility of summoning help and receiving instructions and ensuring coordinated rescue. Systems should raise the alarm quickly and reliably when unusual operating conditions or emergency situations arise.

(ix) Geometrical Configuration of Road Tunnel

The geometrical design of road tunnel is based on design speed, shoulder width, tunnel width, horizontal and vertical alignments, grade, stopping sight distance, cross slope, super elevation, horizontal and vertical clearances. In addition to the above design standards, the geometrical design for road tunnels should also consider tunnel systems such as firefighting & life safety elements, fire detection and protection , ventilation, lighting, traffic control, drainage, escape route, communication etc.

(x) Maximum Grade

The tunnel gradients be limited to 4 percent in short tunnels and to around 3 percent if length exceeds 500 m Long or steep uphill grades may result in a need for climbing lane for heavy vehicles. However for economic and ventilation reasons, climbing lane should be avoided within tunnels.

(xi) Horizontal Curve

The horizontal alignment for a road tunnel should be as short as practical and maintain as much of the tunnel length on tangent as possible, which will limit the numbers of curves, minimize the length and improve operating efficiency. When horizontal curves are needed, the minimum acceptable horizontal radii should consider traffic speed, sight distances and super elevation provided. In general, for planning purpose, the curve radii should be as large as possible and not less than 250-300 metres.

In case of twin tube tunnel, crossing of central median shall be planned at suitable locations at approaches of both tunnels so as to allow emergency services to gain immediate access to either tube and also to send back diverted traffic to proper traffic lanes.

(xii) Super Elevation

Super elevation which is the rise in the road way surface elevation from the inside to the outside edge of the road, should preferably be in the range 1% to 6%.

(xiii) Travel Clearance

The clearance should consider vehicle height, vehicle mounting on curbs, construction tolerances, structural settlement, ventilation equipment, lighting etc. The vertical clearance should be selected as economical as possible & should be consistent with the vehicle size. General recommendation is that the minimum vertical clearance to be maintained of the order of 5.5 m for highways. The minimum clearance for two lane tunnel from curb to curb and wall to wall should not be less than 7.2 m and 9.0 m respectively. The desirable distance for curb to curb and wall to wall may be 11.7 m and 13.2 m respectively.

The vertical clearance shall also take into consideration for future resurfacing of the roadways. Although it is recommended in roadways tunnels only after the previous surface has been removed, it is resurfaced once without removal of the old pavement.

(xiv) Travel Lane and Shoulder

For planning and design purposes, each lane width within a road tunnel should not be less than 3.5 m. It is preferable to carry the full left and right shoulder widths of the approach freeway through the tunnel. It is suggested for unidirectional road tunnels that the right shoulder be 1.2 m and left shoulder be atleast 0.6m. Sometimes shoulder are eliminated and replaced by barriers.

(xv) Footpath

Minimum width of footpath will be kept as 1.5 m with railing. Two footpaths (one each side) to be catered per tunnel tube. One of the footpaths in each tunnel tube will be raised from the road level by minimum 900 mm so that it can be used as inspection path. This will be the one which is away from cross passage.

(xvi) Tunnel Drainage

Road tunnels must be equipped with a drainage system consisting of pipes, channels, sump/ pump, oil/water separators and control system for the safe and reliable collection, storage, separation and disposal of liquid/ effluent from the tunnels that might otherwise collect together.

Drainage must be provided in tunnels to deal with surface water as well as water leakage. For the safety reason, PVC, fibre glass pipes or other combustible materials should not be used. Sumps and pumps should be located at low points of a tunnel and at portals to handle water that might otherwise flow into the tunnel.

(xvii) Ventilation Requirement

The ventilation system of a tunnel operates to maintain air quality levels for short terms exposure within the tunnel. The design may be driven either by fire/safety considerations or by air quality; which one governs depends upon many factors including traffic, size and length of tunnel and any special features such as underground interchanges. It is determined using two primary criteria (i) handling of noxious emissions from vehicles using the tunnel (ii) handling of smoke during a fire. The two main ventilation system options for tunnels are longitudinal ventilation and transverse ventilation.

A longitudinal ventilation system introduces air into, or removes air from a tunnel, with the longitudinal flow of traffic at a limited number of points. It can be sub-classified as either using a jet fan system or a central fan system with a high velocity nozzle. Generally, it includes a series of axial, high velocity jet fans mounted at the ceiling level to induce a longitudinal air flow through the length of tunnel.

A transverse ventilation system can be either a full or semi full transverse type. With full transverse ventilation, air supply ducts are located above, below or to the side of the tunnel and inject fresh air at regular interval. Exhaust ducts are located above or to the side of the tunnel and remove air and contaminants. With semi transverse ventilation, the supply duct is eliminated with its “duties” taken over by the traffic opening.

(xviii) Lighting Requirement

Lighting in tunnels assists the driver in identifying hazards or disabled vehicles within the tunnel while at a sufficient distance to safely react or stop. High light levels (portal light zone) are usually required at the beginning of the tunnel during the day time to compensate for the ‘Black Hole Effect’ that occurs by the tunnel structure shadowing the roadway. These high light levels will be used only during day time. Tunnel light fixtures are usually located in the ceiling or mounted on the walls near the ceiling.

For improved safety during a fire, it is suggested that strobe lights be placed to identify exit routes. If used, they should be placed around exit doors, especially at lower levels which might then be under the smoke level. The strobe lights would be activated only during tunnel fires.

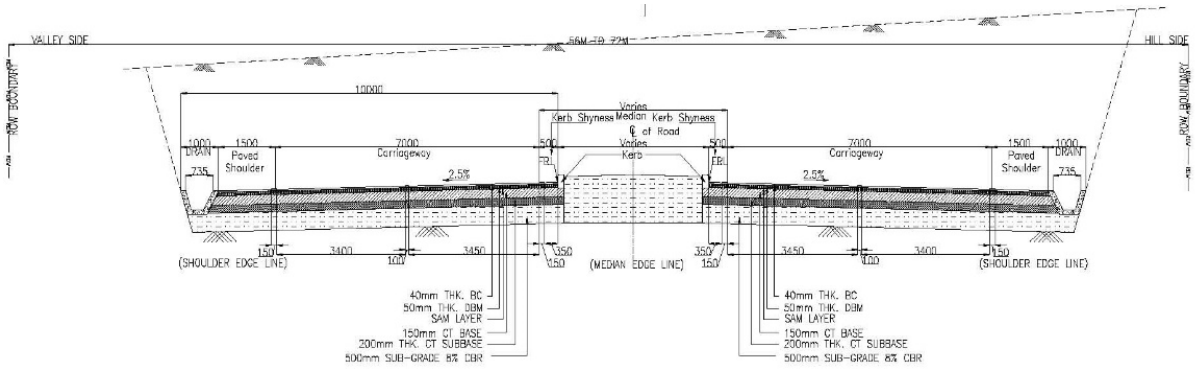
(xix) Portals and Approach

Tunnel portals may require special design considerations. Portal sites need to be located in stable ground with sufficient space. Orientation of the portals should avoid, if possible direct East and West to avoid blinding sunlight. Ameliorating measures should be taken where drivers might otherwise be blinded by the rising or

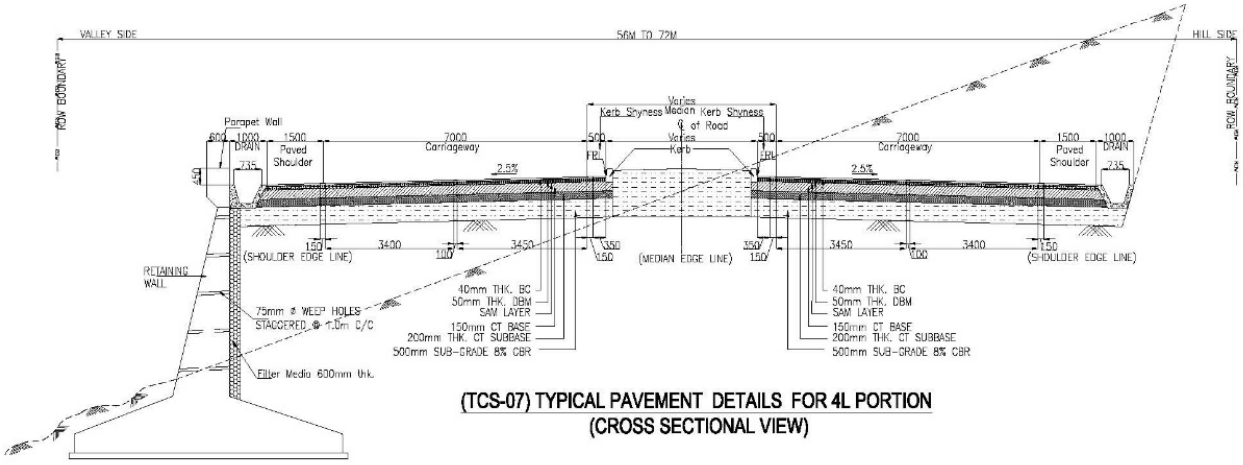
setting sun. A central dividing wall sometimes is extended some distance out from the portal to prevent re-circulation of polluted air.

6.10. TYPICAL CROSS-SECTIONS

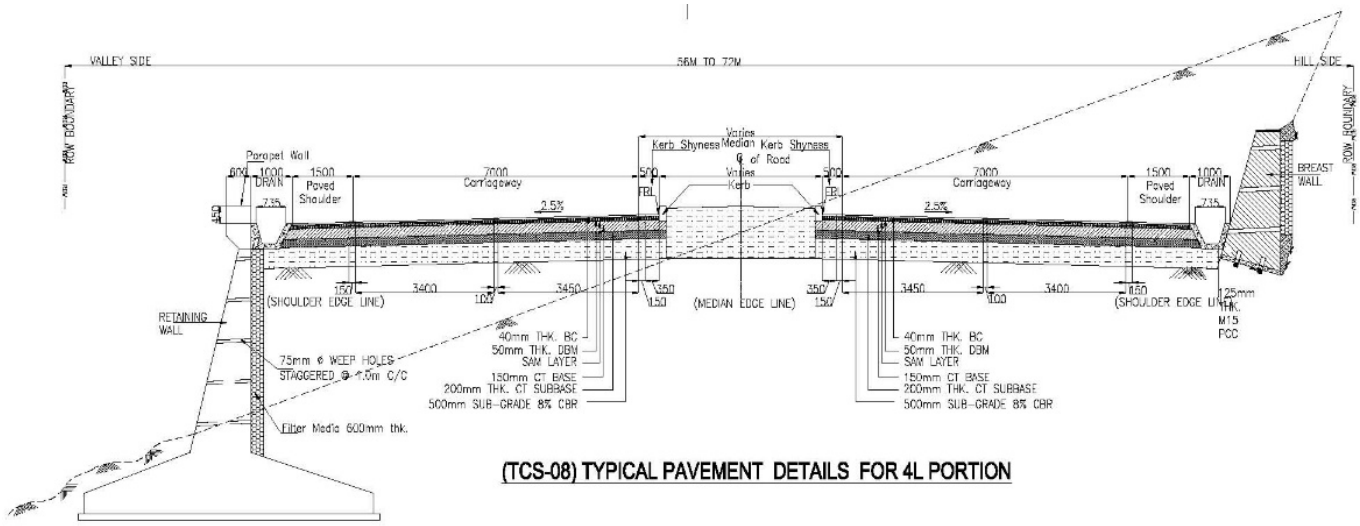
Typical cross sections for four laning with paved shoulders to be adopted is shown below.



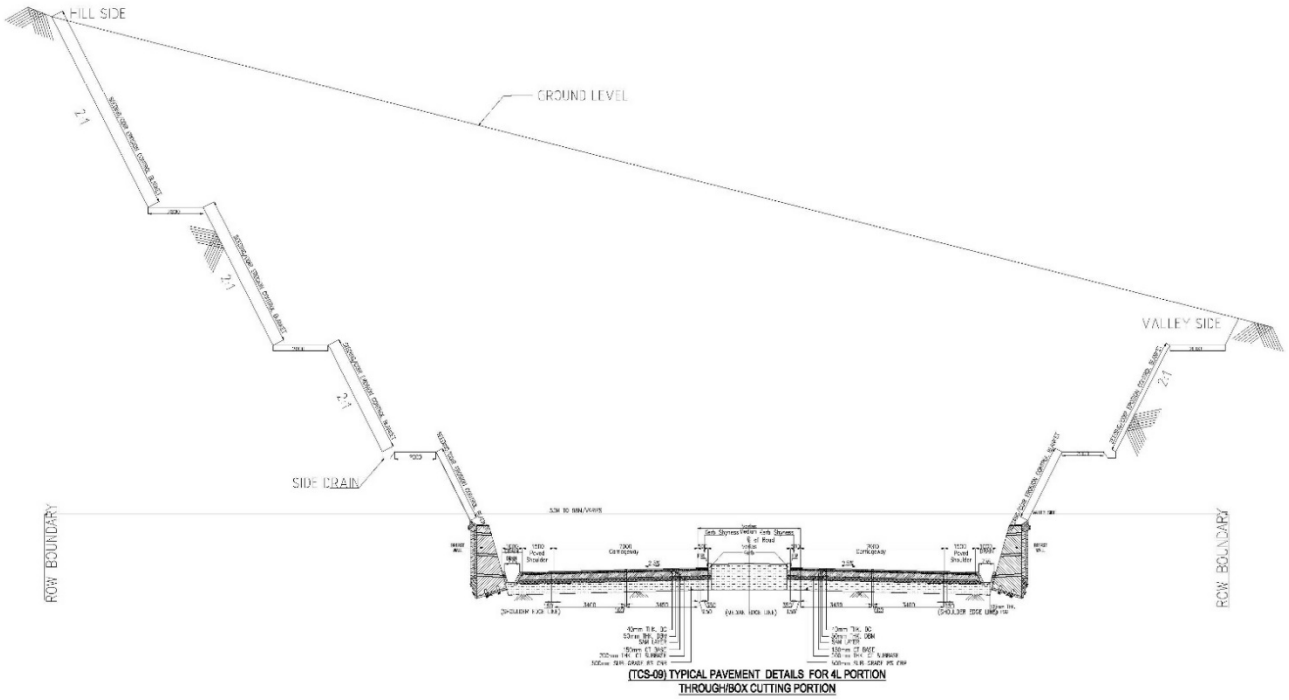
(TCS-06) TYPICAL PAVEMENT DETAILS FOR 4L PORTION



(TCS-07) TYPICAL PAVEMENT DETAILS FOR 4L PORTION
(CROSS SECTIONAL VIEW)



(TCS-08) TYPICAL PAVEMENT DETAILS FOR 4L PORTION



Through/Box Cutting Portion

7. TRAFFIC SURVEYS AND ANALYSIS

7.1. INTRODUCTION

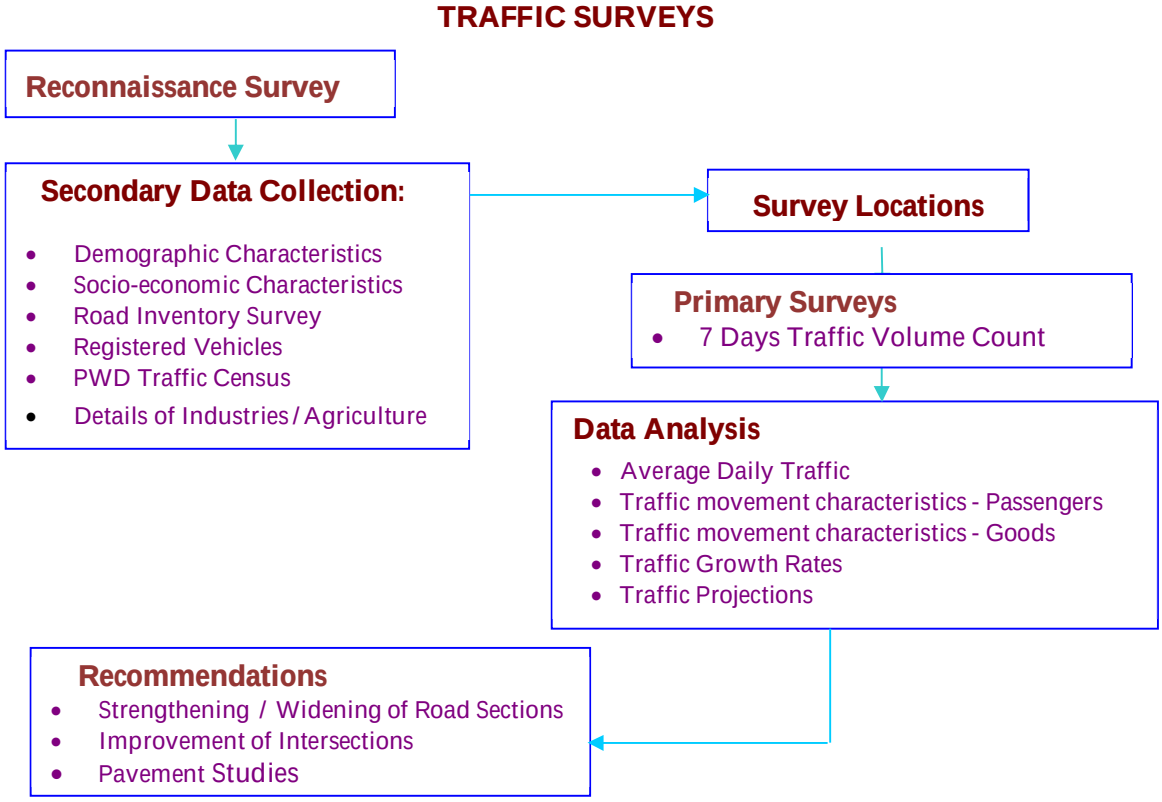
Traffic Survey, Analysis and Forecasting

This Chapter deals with various traffic studies carried out and the analysis of the data obtained from these studies. In planning and design of a highway, an appreciation of the existing traffic and traffic expected to use the highway is important. This is to assess the capacity requirements, pavement design, identify present and likely future traffic conditions and to have provisions for future improvements. As part of this study, a systematic methodology has been followed to assess the characteristics of the traffic on the project road.

Traffic count surveys carried out to establish the base year for traffic. The baseline traffic characteristics are very important for the assessment of future traffic and travel pattern.

7.2. TRAFFIC SURVEY AND STUDY METHODOLOGY

A comprehensive data has been collected from various departments/ organizations/ agencies/ institutions and other sources related to the Traffic census & socio-economic indicators. The Classified Traffic Volume Count surveys have been conducted for 24 hours for seven days. The Detailed Methodology is pictorially depicted in Figure.



Study Methodology Flow Chart for Traffic Survey

- **Site Reconnaissance**

  Immediately after the award of work a team headed by traffic engineer and supervisors visited the site and got acquainted with the road and the road influence area and studied the traffic survey points along the project section.

- **Data Collection**

  Secondary Data Collection

  The Secondary data were collected regarding the traffic on the existing road. All other related demographic characteristics, socio economic characteristics, vehicle registration, PWD traffic census and other detailed industrial and agricultural data were collected from the concerned departments and compiled to extract the required results for the analysis of the project traffic scenario.

  Primary Data Collection

  Primary data collection was conducted using the manual method for classified traffic counts. The traffic counts were conducted at 60 minutes interval for 24 hours. The 60 minutes interval data were than complied as hourly. The traffic count was conducted as per IRC guidelines. The survey was conducted for both fast moving and slow moving vehicles plying on the project road. The following types of vehicles were counted.

  1. Fast moving

  1. Cars, jeeps and vans
  2. Two-wheelers
  3. Three-wheelers
  4. Buses
  5. Trucks
     - Light Commercial vehicles
     - Two axle standard trucks
     - Multi-axle trucks
     - Truck trailers

  2. Slow moving

  1. Cycles
  2. Cycle rickshaws
  3. Animal drawn carts
  4. Others

  Enumerators specially trained for this purpose noted data on the number of vehicles of different categories moving along the road in both directions.

- **Traffic Studies Homogeneous Sections**

  Homogeneous sections are the sections of the project road having similar traffic and travel characteristics. Major intersections / settlements have been considered as nodes for identification for various homogeneous sections.

7.2.1. Analysis

The collected data were analysed to get total daily traffic for the number of days during which Classified Traffic Volume Survey at each count station. The data analyses were calculated in terms of hourly traffic volumes, total PCU's values, traffic composition, Average Daily Traffic (ADT) and mode wise distribution of traffic. The analysis is represented in the form of Bar Charts, Pie Charts and other various graphical forms.

7.2.2. Factors for Seasonal Variation

The seasonal variation in traffic occurs due to various reasons such as higher traffic during harvest and festival seasons, lower traffic during rainy season etc. Estimation of seasonal variation factors requires time series traffic count data on a monthly basis.

Seasonal variation factor, which is the ratio of the traffic for a particular month of the year to the average monthly traffic for that year, was not available. Seasonal correction factor, which is used to moderate the traffic observed in any month of the year to AADT by multiplying the observed traffic with the factor, is the inverse of the seasonal variation factor. In absence of time series data, it was decided to obtain data for the district. The data suggests the month of February as an average month.

A seasonal correction factor of 1.0 is applied to arrive at AADT.

7.3. TRAFFIC SURVEYS

7.3.1. Classified Traffic Volume Count

In order to assess the variation of traffic levels and traffic composition over the week, traffic surveys were conducted continuously for one-week duration. The survey was carried out 24 hrs for one week using the standard proforma given in the SP: 19 - 2001.

The traffic was broadly grouped into Fast Moving Vehicles and Slow Moving Vehicles. Further the fast moving vehicles have been classified into Cars / Jeeps, Two wheelers, three wheelers, Buses (Mini & Full), Trucks and Agricultural Tractors. Slow Moving Vehicles are Cycles, Cycle Rickshaws and Animal Drawn Vehicles.

The surveys were conducted using well-trained enumerators, under the supervision of Traffic and transportation professionals. These surveys were normally conducted during dry weather conditions.

The primary objectives of the traffic count were to:

- Determine the motorised and non-motorised traffic volumes along the corridor.
- Determine Average Daily Traffic
- Determine the distribution of traffic during peak and non-peak hours.
- Establish the mode wise distribution.
- Determine the current traffic pattern on the project road

Traffic Volume counts were carried out for both directions separately. Two enumerators in three shifts were deployed and an experienced supervisor was kept in charge of each location.

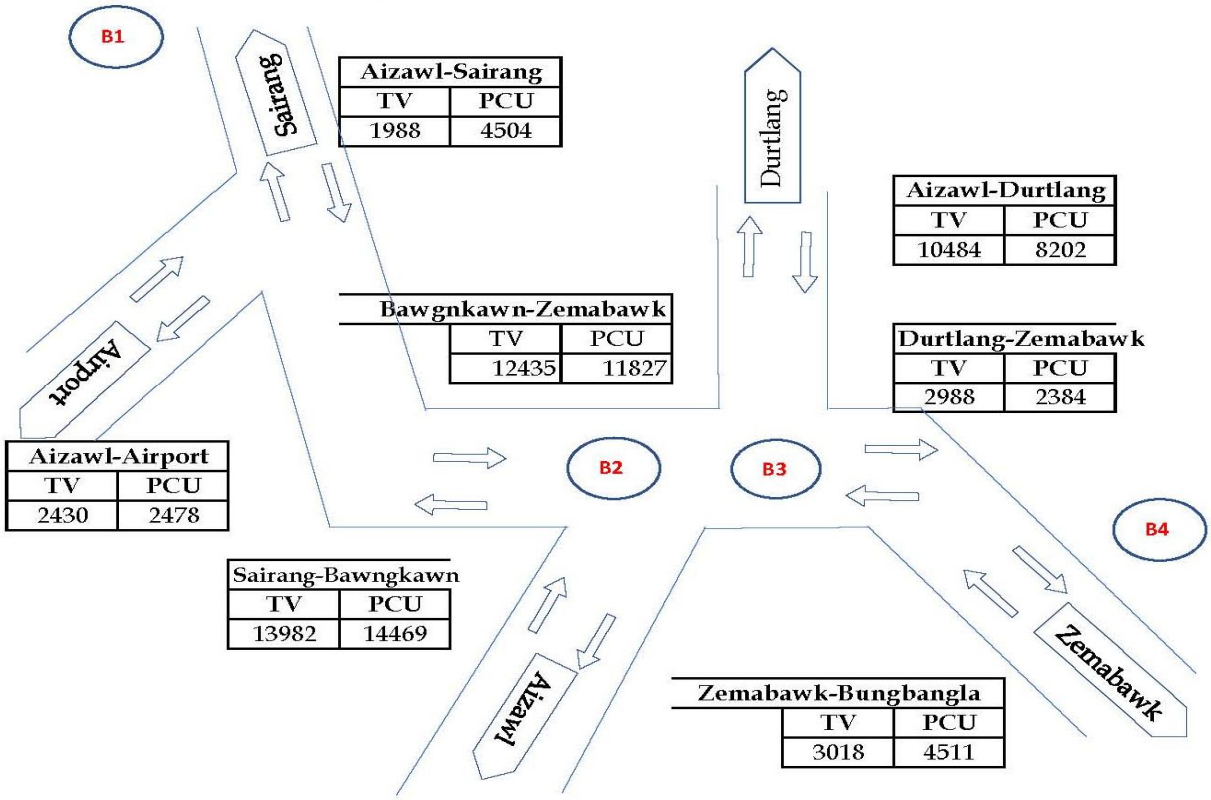
Traffic Survey Locations for Classified Volume Count

Type of Survey	Location of Survey	No. Days	Survey Objective
Classified Traffic Volume Survey	Start & End of Bypass (Sairang-Bawgnkawn-Zemabawk)	7 days	The objective of Surveys is to establish accurate base line traffic volume

Type of Survey	Location of Survey	No. Days	Survey Objective
Origin and Destination Survey	Start & End of Bypass (Sairang-Bawgnkawn-Zemabawk)	1day	To know the trip patterns, Socio-economic characteristics. Trip length distributions.

The traffic surveys were conducted in the month of Dec-2021

TRAFFIC SURVEY SUMMARY



Different classes of vehicles which were obtained from the field surveys were converted into Passenger Car Units (PCU's) by using the PCU factors given in IRC: 64-1979 "Guidelines for Capacity of Roads in Rural Areas".

7.3.2. Recommended PCU values for different Types of Vehicles

Sl No.	Vehicle Type	Equivalency Factor
	Fast Vehicles	
1	Motor Cycle or Scooter	**0.50**
2	Car / Jeep, Van / Taxi or auto-rickshaw	**1.00**
3	Agricultural Tractor, LCV	**1.50**
4	Truck or Bus	**3.00**
5	Truck -Trailer, Agricultural Tractor-Trailer Unit	**4.50**
	Slow Vehicles	
6	Cycle	**0.50**
7	Cycle Rickshaw	**2.00**

Sl No.	Vehicle Type	Equivalency Factor
8	Hand Cart	**3.00**
9	Horse -Drawn Cart	**4.00**
10	Bullock / Camel Cart	**8.00**

7.3.3. Data Tabulation and result interpretation

The data collected have been tabulated hourly. This gives the detailed traffic count for each day and each direction for the one count locations. The tabulations also give traffic in Passenger Car Units (PCU's) per day in addition to vehicles per day for the survey locations.

From traffic volume counts the following observations are made,

Sr.No.	Vehicle Type	Aizawl-Airport	Aizawl-Sairang	Sairang-Bngkawn	Bgkawn-Zbawk	Aizawl-Durtlang	Durtlang-Zembawk	Zebawk-Bubangla
1	Cars / Jeep	867	308	4039	3185	3155	737	873
2	3 Wheeler	40	50	0	0	0	1	108
3	2 Wheeler	714	365	6933	6929	6176	1868	683
4	Mini Bus	11	0	237	26	10	2	3
5	Full Bus	0	37	63	344	33	5	9
6	LCV	799	257	1567	1247	1002	287	678
7	Truck 2-Axle	0	602	715	610	106	86	566
8	Multi Axle Truck	0	368	428	93	2	1	97
9	Tractor With Trailer	0	0	0	1	0	0	0
10	Cycle	0	0	0	0	0	0	0
11	Cycle Rickshaw	0	0	0	0	0	0	0
12	Hand Cart	0	0	0	0	0	0	0
13	Horse Cart	0	0	0	0	0	0	0
14	Bullock Cart	0	0	0	0	0	0	0
15	Others	0	0	0	0	0	0	0
Total Vehicle	Motorised Traffic	2430	1988	13981	12435	10484	2987	3017
	Non-Motorised Traffic	0	0	0	0	0	0	0
	Total	2430	1988	13981	12435	10484	2987	3017
Total PCUs	Motorised Traffic	2478	4504	14469	11827	8202	2384	4511
	Non-Motorised Traffic	0	0	0	0	0	0	0
	Total	2478	4504	14469	11827	8202	2384	4511
CVD	Vehicles	810	1265	3010	2321	1152	382	1354
Peak hr traffic	Vehicles	1375	1042	8025	7195	5990	1891	1716
	PCUs	1412	2270	6943	6487	4675	1416	2236
Time of peak traffic		1-2 PM	5-6 PM	12-1 PM	2-3 PM	3-4 PM	10-11 AM	2-3 PM
Peak hour traffic ratio in %		8.08%	7.49%	8.20%	8.27%	8.15%	9.04%	8.13%

Sr.No.	Vehicle Type	Aizawl-Airport	Aizawl-Sairang	Sairang-Bngkawn	Bgkawn-Zbawk	Aizawl-Durtlang	Durtlang-Zembawk	Zebawk-Bubangla
Projected Traffic upto Year 2036	Vehicles	7195	5885	41363	36792	31052	8842	8922
	PCUs	7337	13334	42811	34973	24240	7060	13338
Projected Traffic upto Year 2051	Vehicles	21280	17407	113845	108849	91873	26156	26388
	PCUs	21700	39444	117826	103447	71713	20881	39441
Road user in %	2 Wheeler	29.4%	18.4%	49.6%	55.7%	58.9%	62.5%	22.6%
	Passenger Vehicles	37.8%	19.9%	31.0%	28.6%	30.5%	24.9%	32.9%
	Goods Vehicles	32.9%	61.7%	19.4%	15.7%	10.6%	12.5%	44.5%

From traffic volume counts the following observations are made,

(vi) There are large numbers of 2-wheeler using the road (42.40%).

(vii) Traffic is dominated by the passenger vehicles (29.40%)

(viii) The Goods vehicle traffic (28.20%) .

Recent traffic data included in Annexure as Traffic Survey Details.

7.4. TRAVEL PATTERN & COMPOSITION

7.4.1. Travel Pattern

An understanding of the travel pattern is key to transportation planners, researchers, engineers and policy analysts. The travel patterns relates to the changes in directionality, purpose, mode and time of the trip. Traffic counts, which directly measure volumes, are a more accurate measure of traffic pattern on specific facilities.

The traffic scenario at all the sections is influenced by the local traffic. Cars and 2-wheelers form an important means of traffic in this region. The hourly variation at the count location, traffic is more during the morning hours.

7.4.2. Traffic Composition

From traffic volume counts the following observations are made,

(i) There are large numbers of Cars, bus and two wheelers using the road

(ii) Traffic is dominated by the passenger vehicles (cars and two wheelers).

(iii) The heavy vehicle traffic is very low as compared to the passenger traffic

7.5. TRAFFIC FORECAST

It is very essential to accurately estimate the future traffic, as the development of the highway is totally dependent upon the future demand of the traffic.

7.5.1. Methods of Forecasting:

Traffic forecasts are generally prepared using one or a combination of the following methods:

- Time series trend in traffic growth
- Temporal trends in vehicle registrations
- Socio-economic characteristics
- Transport Demand Elasticity Approach

Depending upon the character of the study area and the objectives of the study, a judicious selection of the forecast methodology would be adopted as each of the above methods has inherent advantages and disadvantages, which are briefly described below:

7.5.2. Time Series Trends:

This is the most reliable tool available presently for long-term projections. It has been observed that the growth of traffic over a large time frame preferably over a period of about ten years in the past gives a reasonably accurate forecast for the horizon year, though in itself is a large time frame. The main shortcoming of this method is that it does not take into account the effect of induced developments, which have a pronounced effect over a shorter time frame.

Nevertheless this tool has been proven reliable for traffic forecasting on intercity corridors, where the effect of local development does not have much influence over the long-term traffic.

The data available from the department is insufficient and shows an inconsistent growth of traffic along the road corridor. Hence this method cannot be relied upon to be used for forecasting the future traffic.

7.5.3. Growth in vehicle registrations:

The growth of vehicle registration in the influence region is generally a good indicator in as much as it is found to correlate reasonably well with traffic growth. This holds true especially in urban areas, and in those cases, it is possible to establish a definite trend and correlation between traffic growth and vehicle registration. However, when traffic corridors are considered, the correlation between vehicle registration growth and traffic growth rates has been found to be not valid, as traffic growth along an inter-urban is influenced by many other factors in addition to the number of vehicle registrations.

7.5.4. Socio-economic parameters:

Socio-economic parameters including population, employment, vehicle ownership, per capita income and development proposals (with or without land use changes) have all been found to produce good correlation with the traffic growth. These above parameters have been described.

7.5.5. Transport Demand Elasticity Approach:

Elasticity of traffic demand is defined as the rate at which traffic intensity varies due to changes in the corresponding economic variables selected. Therefore, to estimate the elasticity traffic demand, it is necessary to establish the relationship between the growth in the number of a given category of vehicle with any one of the economic variables considered, such as NSDP, per capita income and population growth. The econometric model and the form of equation for estimation of traffic demand elasticity as recommended in IRC-108 of is as follows:

$\log_e (P) = A_o + A_1 \log_e (EI)$ where

P = Number of vehicles of any particular category

EI = Economic indicator such as NSDP, Per Capita Income or population.

A_o = a constant

A_1 = a Co-efficient (Elasticity Value)

Due to non-availability of the required data in a definitive manner in the concerned departments, no relevant data could be collected so as to fulfill the requirement of traffic forecast. So this method could not be used in the current forecast.

7.6. FUTURE TRAFFIC GROWTH RATE

The traffic forecast is developed in three components:

i) Normal growth in traffic

ii) Diverted traffic

iii) Induced traffic.

The normal growth in traffic conceptually corresponds to the historical growth of traffic without taking any capital investment in the project road. For determining the normal growth in traffic, a study of past trends in traffic growth is undertaken. However, the traffic growth rate established for this study are based on elasticity approach, wherein a relationship is established between past traffic volume data and socio-economic indicators. In absence of time series data on classified traffic, vehicle registration data has been used for determining transport demand elasticity.

Normal Traffic

The normal traffic is the base traffic currently moving on the project road section and will continue to use the project road section, even if it is not improved. Its forecast requires an assessment of the current and projected rates of traffic growth in the absence of road improvement.

Induced Traffic

In addition to normal growth of traffic, the improvement of highway would tend to induce traffic generation. The induced traffic is a function of price elasticity. Freight and passenger vehicles are sensitive to reduction in journey costs. For passengers the lower costs encourage more trips for both business and personal reasons. Lower costs enlarge the market for both intermediate and finished goods. The freight transport in the region will increase multifold and the socio-economic activities improve in the project road influence area.

Due to insufficient data and inconsistency of the available data the consultant has adopted the growth rate of 7.5% as per the Indian Road Congress (IRC: SP: 48-1998).

7.7. TRAFFIC PROJECTIONS

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

Step I: Determining Vehicle-wise Elasticity

Step 2: Estimating Vehicle Growth Rates

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

Table 7.7-1 Step of Traffic Projection

Item	Function	Parameters
Step-1		
Elasticity	Log e (P) = A0 + Al Log e (El)	• P = Traffic volume (of any vehicle type) • El = Economic Indicator GDP / NSDP / Population / PCI) • AO = Regression constant; • Al = Regression co-efficient (Elasticity Index)
Step2		

Table 7.7-1 Step of Traffic Projection		
Item	Function	Parameters
Passenger Vehicles	Grp = [(1+Rp) (1+ rpci x Em) - 1]	• Grp- Growth Rate Passenger Vehicle • Rp= Population Growth • Rpci= Per capita Income Growth
Goods Vehicles	Grg = Em * R(nsdp)	• Grg- Growth Rate Goods Vehicle • Em= Elasticity Value • R(nsdp) = NSDP Growth Rate

Source: Derived from IRC: 108-1996

7.7.1. Registered Vehicles

In absence of the traffic count figures data series for the project road sections, the Registered Vehicle data series (year 2007 to 2012) was used as a surrogate for traffic volume. The state - level registered vehicle data is presented in Table 7.7-2 for Mizoram State.

Table 7.7-2 Registered Vehicles - Mizoram State

Year	Two Wheeler	Autos Rickshaw	Cars/ Jeep	Bus	Truck	LCV
2007	27776	1758	20870	907	3000	2566
2008	30062	1931	22367	954	3167	2981
2009	32267	2105	23551	1003	3343	3397
2010	39902	2219	25660	1036	3507	4003
2011	47978	2477	28040	1088	3844	4862
2012	60278	2955	31233	1141	4285	6194
CAGR(%)	13.79%	10.40%	11.55%	7.54%	0.16%	17.25%

Source: NEC, Shillong

7.7.2. Economic Indicators

Net State Domestic Product (NSDP) at constant prices has been used as independent variable for estimating the elasticity of the goods vehicles such as trucks, LCVs etc. The Per Capita Income (PCI) data was used as independent variables for estimating elasticity for passenger vehicles, such as cars, buses, two wheelers etc. The data series of NSDP & PCI at constant prices is presented in Table 7.7-3.

Table 7.7-3 NSDP & PCI (at Constant Prices)

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

Year	NSDP (Mn. INR)	PCI (INR)
2010-11	45389	40072
2011-12	44053	37921

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

7.7.3. Traffic Demand Elasticity

Considering the data series on Registered Vehicle and NSDP/ PCI, the elasticity estimates and its projections for the vehicle categories are given in Table 7.7-4.

Table 7.7-4 Vehicle-wise Demand Elasticity Values

Year/ Period	2014-17	2017-20	2020-25	2025-30	2030 -40
NSDP Growth Rate (%)	7.91%	7.11%	6.40%	6.08%	5.78%
Population Growth Rate (%)	2.03%	1.62%	1.46%	1.31%	1.25%
PCI Growth Rate (%)	5.88%	5.51%	4.97%	4.80%	4.57%
Elasticity w.r.t PCI					
Two Wheeler, (y=1.766x-7.831, R^2= 0.902)	1.59	1.43	1.29	1.16	1.05
Autos Rickshaw, (y = 1.299x - 5.834, R^2 = 0.875)	1.24	1.17	1.11	1.11	1.11
Cars / Jeep Taxi, (y = 1,425x - 4.741, R^2= 0.809)	1.35	1.28	1.22	1.22	1.22
Bus y = 0.929x- 2.774, (y = 0.929x - 2.774, R^2= 0.772)	0.93	0.93	0.93	0.93	0.93
Elasticity w.r.t NSDP					
Truck. (y = 0.584x +2.031, R^2 = 0.875)	0.73	0.83	0.96	0.96	0.96
LCV, (y=1.475x- 7.219, R^2 = 0.904)	1.32	1.19	1.07	1.02	0.97

7.7.4. Traffic Projections

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

Traffic projections have been made by using methodology elaborated in earlier section of this chapter. The growth rates for the horizon year up to 2040 are set out in Table7.7-5

Table 7.7-5 Vehicle-wise Future Traffic Growth Rates

Year/ Period	2014-17	2017-20	2020 - 25	2025-30	2030-40
Two Wheeler	11.58%	9.65%	7.97%	6.96%	6.08%

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

7.7.5. Projected Traffic:

Year	Growth factor in %	Cars/Jeep	3 Wheeler	2 Wheeler	Mini Bus	Full Bus	LCV	Truck 2-Axle	Multi Axle Truck
2021		1881	28	3381	41	70	834	384	141
2022	7.5	2022	31	3635	45	76	897	413	152
2023	7.5	2174	33	3908	48	82	964	444	164
2024	7.5	2337	36	4201	52	88	1036	477	176
2025	7.5	2512	38	4516	56	94	1114	513	189
2026	7.5	2700	41	4855	60	101	1198	551	203
2027	7.5	2903	44	5219	64	109	1287	592	218
2028	7.5	3120	48	5610	69	117	1384	637	235
2029	7.5	3354	51	6031	74	126	1488	685	252
2030	7.5	3606	55	6483	80	135	1599	736	271
2031	7.5	3876	59	6969	85	145	1719	791	292
2032	7.5	4167	64	7492	92	156	1848	850	313
2033	7.5	4480	68	8054	99	168	1987	914	337
2034	7.5	4815	73	8658	106	180	2136	983	362
2035	7.5	5177	79	9307	114	194	2296	1056	389
2036	7.5	5565	85	10005	122	208	2468	1135	418
2037	7.5	5982	91	10755	132	224	2653	1221	450
2038	7.5	6431	98	11562	141	240	2852	1312	483
2039	7.5	6913	105	12429	152	258	3066	1410	520
2040	7.5	7431	113	13361	163	278	3296	1516	559
2041	7.5	7989	121	14363	176	299	3543	1630	600
2042	7.5	8588	130	15440	189	321	3809	1752	645
2043	7.5	9232	140	16598	203	345	4094	1883	694
2044	7.5	9924	151	17843	218	371	4401	2025	746
2045	7.5	10669	162	19181	234	399	4731	2176	802
2046	7.5	11469	174	20620	252	429	5086	2340	862

7.7.6. Bypass Traffic

Adopting the methodology described earlier in Section 8.6 of this chapter, the vehicle-wise diversion, in percentage terms, for the Aizawl by-passes were estimated through analysis of CVCS and NPS data. It was found that the percentage diversion estimated by using CVCS data was more consistent than NPS data. Therefore, to obtain the diverted traffic (traffic that is expected to use the by-passes), the percentage diversion values (vehicle-wise) based on CVCS data, presented in Table 7.7-8 were applied to the

total traffic projections given in the previous table. The bye-pass traffic projections are set out in Table 7.7-9.

Table 7.7-8 Percentage Traffic Diversion to By-pass

By-Pass	Cars/ Jeep/ Taxi	Bus	Three Wheeler	Two Wheeler	LCV	Truck
Aizawl Bypass	63%	75%	45%	50%	80%	71%

7.7.7. Design of Lanes

Capacity analysis is fundamental to the planning, design and operation of roads and provides among other things the basis for determining the carriageway width to be provided at any point in a road network with respect to the volume and composition of traffic. It is also a valuable tool for evaluation of the investments needed for future road construction and improvements and for working out priorities between competing Projects. The NH road has been considered for two lane.

- Therefore, No of commercial vehicles per day for design taking into consideration 7.5% per annum growth rate and a pavement life of 15 years
- Design life PCU per day in yeat-2036 : 20442

As per Ministry circular: Capacity augmentation of NH from Two lane to four lane

Nature of Terrain	Traffic at which up-gradation to four lane will trigger (in PCU per day) RW/NH-33044/28/2015/S&R(R) ,dated 29th June 2015	Traffic at which up-gradation to four lane will trigger (in PCU per day) RW/NH-33044/28/2015/S&R(R) ,dated 26th May 2016
Plain	15,000	10,000
Rolling	11,000	8,500
Mountainous / Steep	8,000	6,000

- . In view of above proposed bypass having 2 Lane Paved shoulder and Tunnel having Twin Tube.

7.7.8. CVD for design of pavement

As per traffic count survey, average commercial vehicle per day (CVD) works out to 3010. Traffic intensity CVD 3010 has been considered for pavement design.

8. CONSTRUCTION PROPOSALS

8.1. INTRODUCTION

The Govt. of India has acknowledged the importance of better road infrastructure and launched several programs and initiatives to extend and improve India's highway network. Road development is pivotal to sustaining the country's economic growth. National Highways and Infrastructure Development Corporation Ltd (NHIDCL) premium organization under the aegis of the Ministry of Road Transport & Highways (MORTH) has undertaken the formulation of Detailed Project Reports (DPR) for **2 laning of Aizawl Bypass including Tunnel (Connecting Sairang on NH-306 to NH-02) in the State of Mizoram under Bharatmala Pariyojna.**

The proposed realignment of the existing road takes off from Sairang on NH 6 and merging with existing road Near Phaibawk Village on NH-6 to avoid the numbers of sharp curve on existing road and to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Aizawl City. It's running from North to south on the Eastern side of the hill

8.2. SALIENT FEATURES OF THE PROJECT

Salient features based on design are as below:

Sr. No.	Description	Package – 2
1	Length of project road	4.600 Km (Green Field Alignment)
2	Proposed ROW	Varies from 53.0 m to 98.0m
3	Formation width	46.30 m for 4 Lane with Paved Shoulder including 26.30 m wide median for service building and emergence parking , utility and equipment
4	Carriageway	• 2Lane CH:10+600 to CH: 10+900 • Transition Zone from CH:10+900 to CH: 11+050 • 4 Lane Carriageway from CH:11+050 to CH 11+600 • Tunnel Twin Tube Unidirectional 2Lane carriageway from CH:11+600 to Ch:14+100 • 4 Lane Carriageway from CH:14+100 to CH 14+650 • Transition Zone from CH:14+650 to CH: 14+800 • Flaring Zone from 4Lane to 2Lane From CH:14+800 to CH:15+200
5	Type of Pavement	Flexible pavement
6	Type of shoulder	Paved shoulder 1.5 m and Earthen Shoulder 1.0 m on valley side and 1.0 m for side drain
7	Take off point	Near DurtlangLui
8	End Point point	Near Muthi Lui

Sr. No.	Description	Package – 2
9	Drain	Surface Line drain 2360 Rm Catch water Drain 1410 Rm, Chute Drain 1050 Rm
10	Landslide	Nil
11	Junction	Nil
12	Bridge	2 Nos of Minor Bridge
13	Tunnel	2500 m Twin Tube Tunnel with 2 Lane Carriageway with uni-direction traffic with 4 Nos of Cross Passes as Per IRC:SP-91:2019
14	Culvert	8 Nos of Box Culvert
15	Retaining Wall	230.00 Rm
16	Breast Wall	1760.00 Rm
17	Gabion RE Wall	6700.00 Sqm
18	Gabion Wall	1300.00 Rm
19	Toe Wall	460.00 Rm
20	User amenities	4 Nos of bus shelter and layby

a) Cross Section Elements:

The design standards of relevant Indian Roads Congress for Roads and Bridges are adopted for cross-section designs of the project road. The earlier items of construction may involve the construction of the road formation, and cross-drainage works including the construction of major bridges for 2-lane standard and protection work. The later stage of the construction will cover the construction of Pavement for double lane (7.00 m wide) NH standard. The proposed cross-section element with dimensions is shown in the table below:

Sl.No.	Design elements	Dimensions
1	Roadway width	
	At roads and culverts*	46.30.00 m
	At bridges**	2x10.50m
2	Carriageway width	2 x 7.50 m
3	Cross slopes / Camber at straight reaches	2.5%

**Roadway width is inclusive of side drain and parapet wall/crash barrier (IRC SP: 48)*

***Roadway width is exclusive of kerbs*

b) Road Geometry:

The project corridor passes through steep to mountainous then rolling terrain. The design speed adopted is 40km / hour (IRC: 52-2019) for steep and mountainous terrain. Along the proposed alignment, there will be no hair-pin bend. However minimum design speed has been considered on technical grounds. The vertical and horizontal alignments of the proposed road can be summarized as shown in table below:

Horizontal curve details:

Sr. No	Bypass Name	Project Road length	No. of Curves with Design Speed in km/h				No. of Curves with Radius (m)		
			<30	30-40	40-50	>50	<30	30-50	>50
	Aizawl Bypass	34.500 Km	0	152	0	0	0	17	135
P2	Km 10.60 to Km 15.20	4.60 Km	0	0	0	8	0	0	8

Vertical curve details:

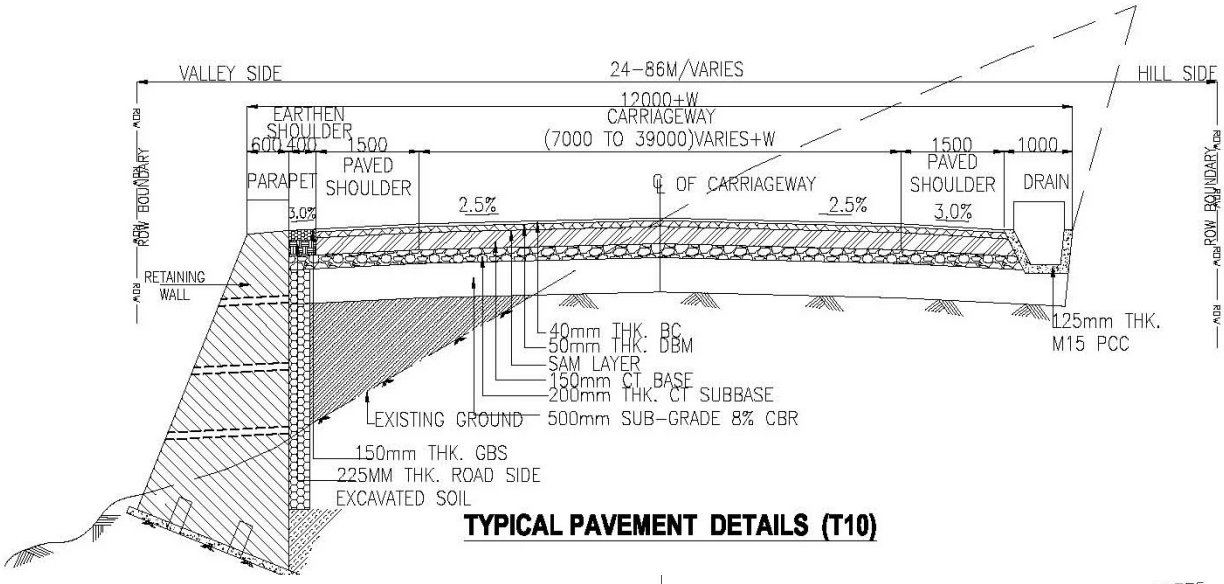
Sr. No	Bypass Name	Project Road length	Length Distribution (km) and Gradient Class				
			<4%	4%-5%	5%-6%	6%-7%	7%-8%
1	Aizawl Bypass	34.500 Km	6.820	10.140	17.550	0.000	0.000
P2	Km 10.60 to Km 15.20	4.60 Km	2.95		1.65		

c) Design of Embankment / Hill Cutting

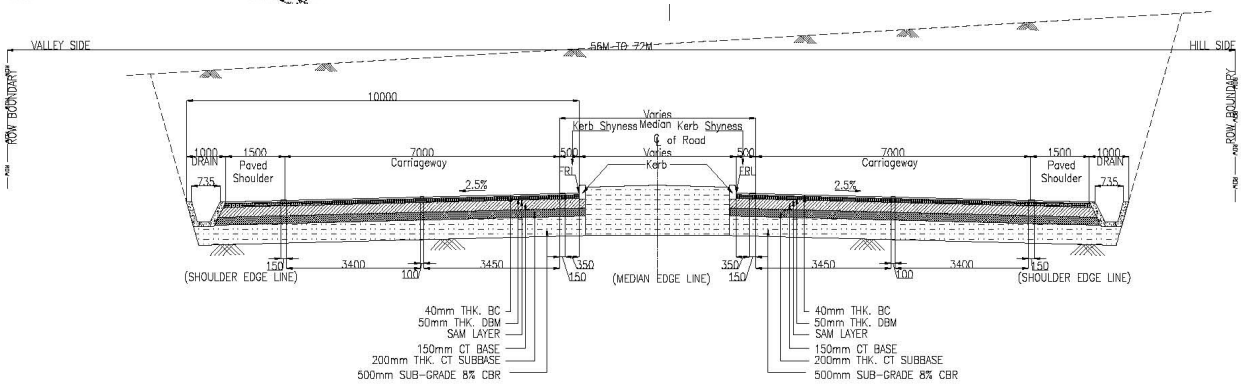
Considering the physical features, particularly the terrain, soil classification, and hill slope line, typical cross-section (Type 06 to Type 10) has been developed for hill road cutting /embankment building.

The concept Plan of the design of the embankment/hill cutting (stretch-wise) has been developed with specific mention of the formation building methodology / type to be adopted.

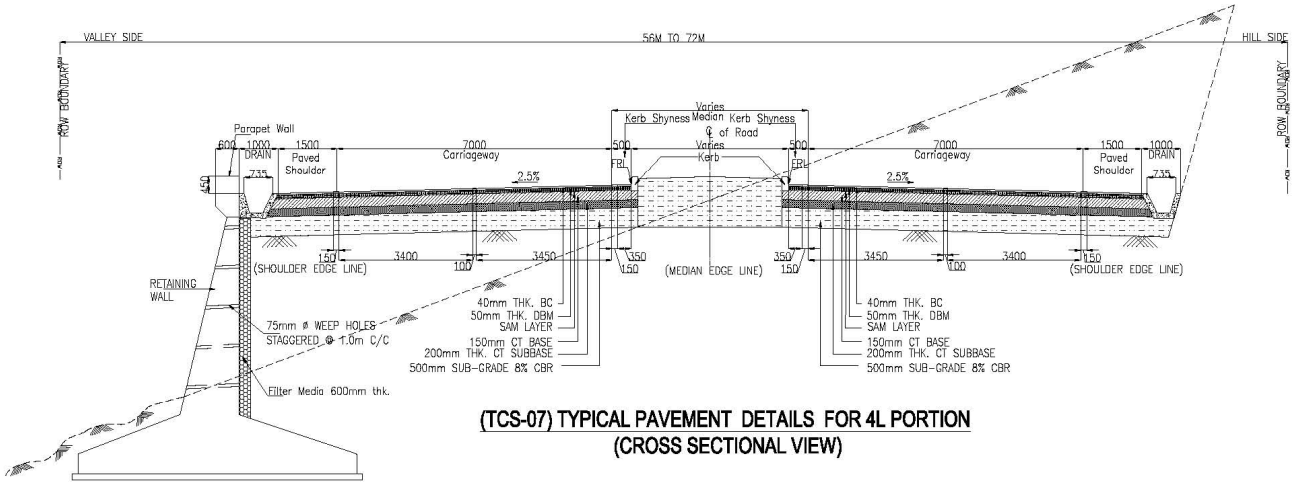
Sr.No	Description	Chainage	Typical Section
1	Flaring Zone from 2Lane to 4Lane	From CH:10+600 to CH: 10+900	Type-10 & Ref Location R/W &B/W
2	Transition Zone	From CH:10+900 to CH: 11+050	Type-10 & Ref Location R/W &B/W
3	4 Lane Carriageway	From CH:11+050 to CH 11+600	Type-6-7-8-9 & Ref Location R/W &B/W
4	Tunnel Twin Tube Unidirectional 2Lane carriageway	From CH:11+600 to Ch:14+100	Ref Tunnel section
5	4 Lane Carriageway	From CH:14+100 to CH 14+650	Type-6-7-8-9 & Ref Location R/W &B/W
6	Transition Zone	From CH:14+650 to CH: 14+800	Type-10 & Ref Location R/W &B/W
7	Flaring Zone from 4Lane to 2Lane	From CH:14+800 to CH:15+200	Type-10 & Ref Location R/W &B/W



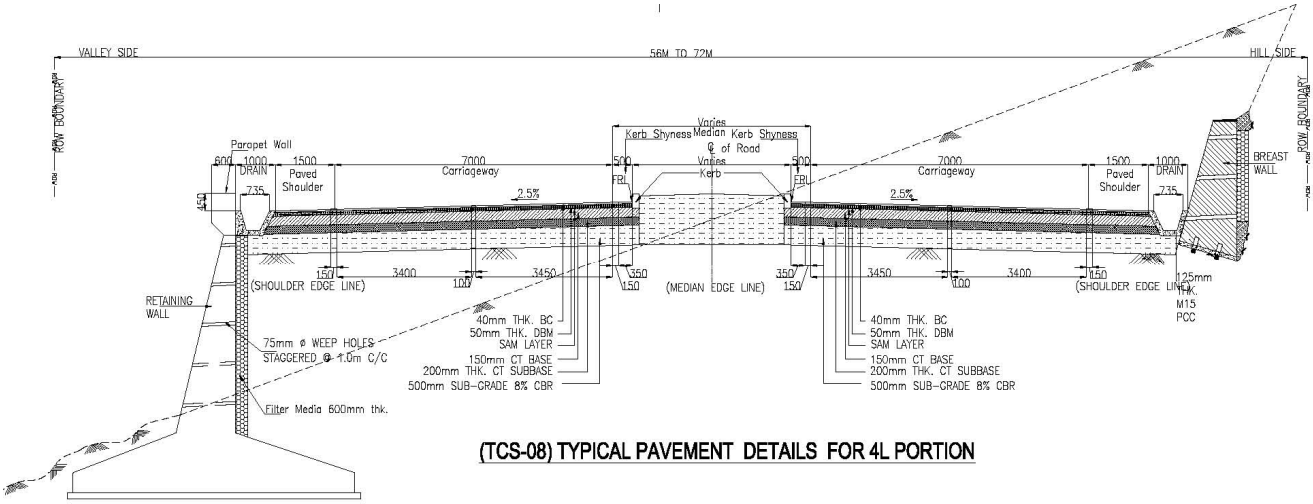
TYPICAL PAVEMENT DETAILS (T10)



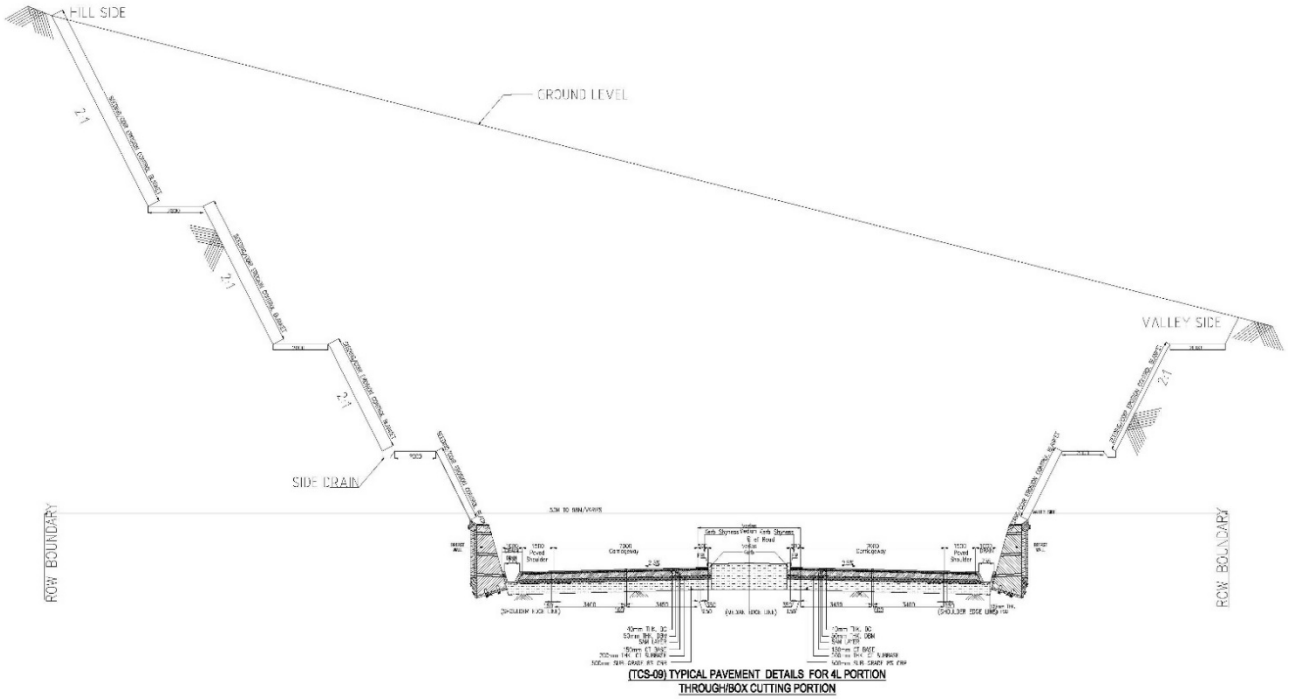
(TCS-06) TYPICAL PAVEMENT DETAILS FOR 4L PORTION



(TCS-07) TYPICAL PAVEMENT DETAILS FOR 4L PORTION
(CROSS SECTIONAL VIEW)



(TCS-08) TYPICAL PAVEMENT DETAILS FOR 4L PORTION



(TCS-09) TYPICAL PAVEMENT DETAILS FOR 4L PORTION THROUGH/BOX CUTTING PORTION

d) Dumping area identified on the Proposed Road

It has been estimated that about 22.96 Lakhs cum of spoil will be generated due to widening of this road. Only 13.70% of the spoil will be reused during construction of the road rest will be disposed off 10nos. identified disposal sites which are selected based on consultation with communities.

This earth shall be disposed off as per an environmentally suitable manner.

(iv) Certain guidelines for debris disposal are given below.

- The debris generated shall be disposed of within designated areas only.
- The filled-up area shall be used for designated purposes such as Playground.

(v) Condition of dumping area selection

- Ground shape with concavity topography

- Less ground gradient than 22 degrees which assumes the average angle of spoil bank slope with necessary steps.
- No built-up area
- No national sanctuary area.

(vi) Protect dumping area as recommendations and suggestions have been made THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH, NEW DELHI on 01-11- 2018

e) Pavement Design

It is based upon CVD-3010, CBR-8%, Traffic msa -10, Design period – 15 years, VDF-1.7, Annual Growth of traffic rate 7.5%, and Design speed of 40.00 Km/hr for hilly portion. However, the proposed pavement composition is based on CBR-8% and msa -20.

Pavement composition is designed as under:

Proposed pavement.

BC	:	40 mm
DBM	:	50 mm
Stress Absorbing Membrane (SAM) with crack width 6 mm to 9 mm in one layer		
Cement Treated Base (CTB)	:	150mm
Cement Treated Sub-base (CTSB)	:	200 mm
Total	:	440 mm

Proposed pavement for Tunnel Portion

- Dry Lean Cement Concrete: 150 mm
- Cement Concrete Pavement: 350 mm

f) Shoulder Design

Paved Shoulder 1.5m width on either side having the same composition of the Main carriageway and Earthen shoulder having the width of 1.0m the on valley side and a hillside 1.0m shall be used to accommodate for side drain.

g) Culverts:

The project road traverses through mountainous and steep terrains with several natural drainages such as deep gorges, depressions, etc., where perennial water and rainwater runoff are collected. Sometimes the storm runoff is accompanied by large quantities of debris from the stream side of the nullahs. Cross-drainage structures/culverts are required at these locations. From the field survey and investigations and geometric design of alignment requirement of culverts for the whole length of the project has been identified.

Sr.No	Description of Item	Unit	Package-2
A	**Box Culvert**	**No**	**8**
1	Type -1 - 2 x 2	No	5
2	Type -2 - 3 x 3	No	2
3	Type -3 - 4 x 4	No	1

h) Slope Protection works:

Adequate Protective structures are proposed for retaining of cut / fill slopes to ensure stability of the road formation at locations where required. The proposed type and length of each structure are shown in the table below:

Sl.No.	Description	Unit	Quantity
1	Vetiver grass	Sqm	20000.0
2	Seeding and Mulching	Sqm	13440.00
3	Non-woven Coir Erosion Control Blanket	Sqm	13440.00
4	Turfing with Sods	Sqm	10000.00
5	Vegetated bamboo crib wall	Rm	5000.00
6*	Shotcreting with welded wire mesh	Cum	525.00
7*	25 mm diameter 3-meter-long steel rock bolts	Nos	585.00
8	Retaining wall for 3.0 m Height	Rm	80.00
9	Retaining wall for 4.0 m Height	Rm	00.00
10	Retaining wall for 5.0 m Height	Rm	80.00
11	Retaining wall for 6.0 m Height	Rm	70.00
12	Gabion RE Wall	Sqm	6700.00
13	Breast Wall 2.00m high	Rm	850.00
14	Breast Wall 3.00m high	Rm	910.00
15	Gabion Wall 2.00 m high	Rm	700.00
16	Gabion Wall 3.00 m high	Rm	600.00
17	Toe Wall 2.00 m high	Rm	220.00
18	Toe Wall 3.00 m high	Rm	240.00

*Note: Shotcreting with welded wire mesh & 25 mm diameter 3-meter-long steel rock bolts Outside of Tunnel portal

Retaining wall Location

Sr.No.	Chainage		Length in m	Height in m	Remarks	Type
	From	To				
1	10600	10630	30	5	RHS	Plum Concrete
2	10950	11000	50	3	RHS	Plum Concrete
3	11000	11070	70	6	RHS	Plum Concrete
4	11070	11100	30	3	RHS	Plum Concrete
5	11260	11310	50	5	RHS	Plum Concrete
6	14780	14880	100	12	RHS	Gabion RE Wall
7	14910	15160	250	22	RHS	Gabion RE Wall

Breast wall Location

Sr.No.	Chainage		Length in m	Height in m	Remarks
	From	To			
1	10630	11040	410	3	RHS
2	11100	11250	150	2	RHS
3	11290	11520	230	3	RHS
4	11520	11600	80	3	RHS
5	11500	11600	100	2	LHS
6	14100	14290	190	3	RHS
7	14100	14290	190	2	LHS
8	14350	14760	410	2	RHS

i) Bridge

It is proposed to construct 2 major bridges along the bypass as per relevant IRC standards and MoRT&H guidelines.

j) Tunnel

Road tunnels are feasible alternatives to cross through physical barriers such as steep mountains / vertical cliff, existing tunnels, existing roadways; rail lines etc. In addition road tunnels are viable means to minimize potential environmental impact such as traffic congestion, Pedestrian movement, air quality, noise pollution or visual intrusion to protect areas of special culture or historical values, private properties etc.

There are three main shapes of highway tunnels i.e. rectangular, circular and horse shoe shape. The geometrical configuration of tunnel should accommodate all potential vehicles that are expected to use the roads leading to the tunnel including over height vehicles such as military vehicles, if needed. The tunnels are generally equipped with various systems such as ventilation, lighting, communication, fire life safety, traffic operation and control system.

Good knowledge of the expected geological conditions is essential for proper planning of a tunnel alignment and its shape. Geotechnical issues such as soil or rock properties, ground water regime, ground cover over tunnel, presence of underground utilities and obstructions such as boulders or buried objects should be taken into consideration while fixing tunnel alignment. Construction of portals and its long term maintenance is very important and their locations are made based on safety consideration. The portals should be as close to the face of the rock as practically constructive.

It is proposed to construct one twin tube 2 Lane Tunnel as per specification configuration of IRC: SP-91-2019 and relevant IRC standards and MoRT&H guidelines.

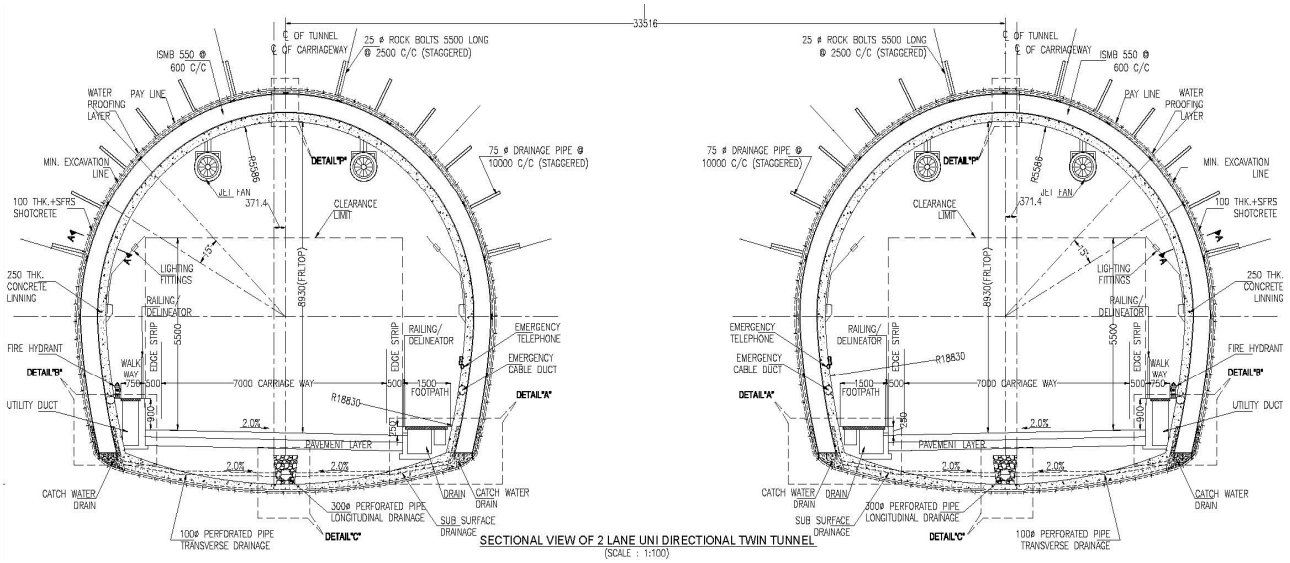
- **Functional/Safety Requirements Based on Length of Tunnels**

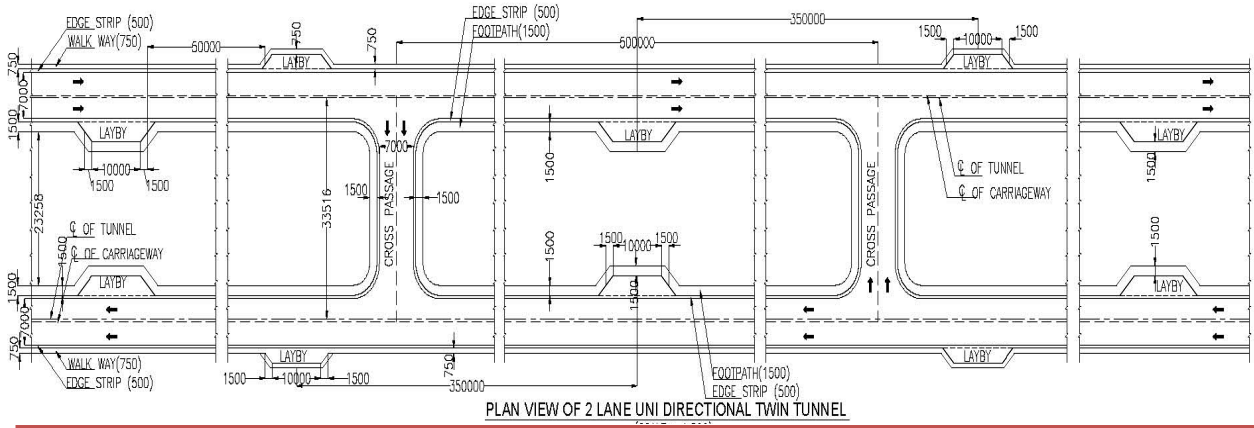
Classification of Tunnel	Double Tube Uni-Directional				
	CP	Vent	Light	Comm	Fire Safety
Long tunnel >1500 m	Yes	Yes	Yes	Yes	Yes

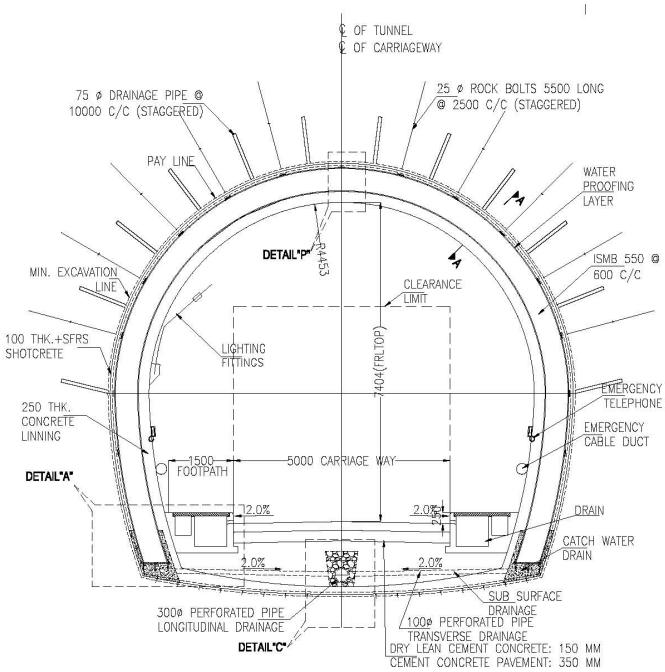
- Fire safety - Fire extinguisher at spacing of 100 m
- Communication - Telephone at spacing about 100 m

- Lighting - Tunnels Lighting as IRC:SP-91-2019
- Cross Passages - Cross passages provided at 500 m spacing

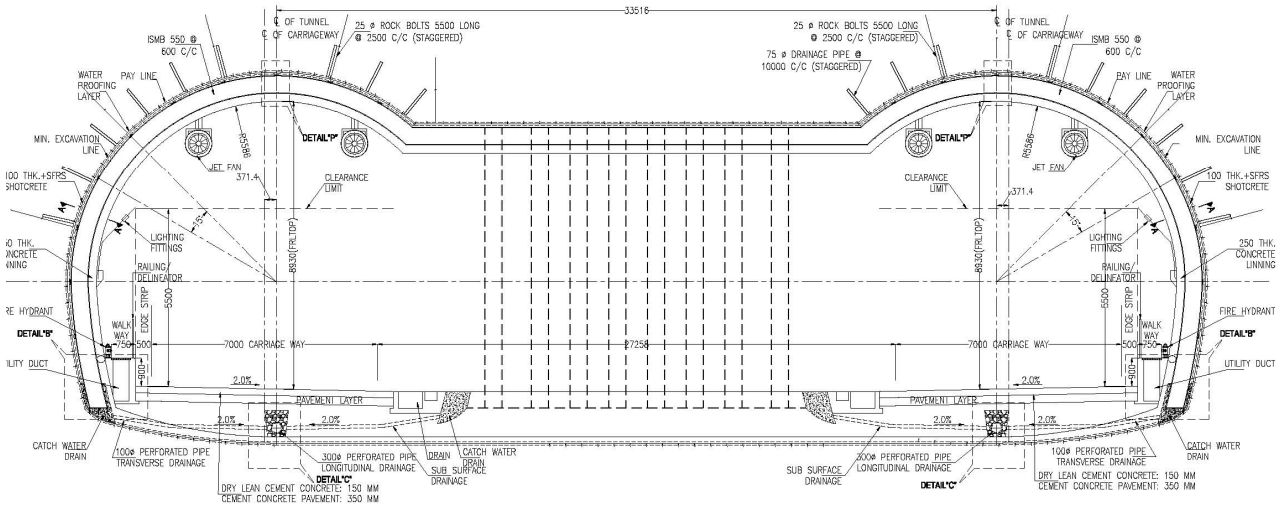
I.No	Chainage	Length	Carriageway	Remarks
1	CH: 11600 to CH: 14100	2500.00m	7.0 m (Walkway &utility 750+Edge strip 500+Carriageway 7000+Edge Strip 500+ Footpath cum drain & utility 1500) mm	Twin Tube Tunnel, having Inlet Portal 100.0 m and Outlet Portal 100.0 m Rigid Pavement composition within the Tunnel portion DLC – &utility 150 mm PQC – 350 mm
2	Cross Passage	4x22.7m	(Footpath cum drain & utility 1500+Edge strip 500+Carriageway 5000+Edge Strip 500+ Footpath cum drain & utility 1500) mm	Rigid Pavement composition within the Tunnel portion DLC – &utility 150 mm PQC – 350 mm







SECTION OF CROSS PASSAGES TUNNEL
(SCALE : 1:100)



SECTIONAL VIEW OF 2 LANE UNI DIRECTIONAL TWIN TUNNEL CROSS PASSAGES
(SCALE : 1:100)

- **Tunnel Ventilation and Fire Fighting System:**

The ventilation system of a tunnel operates to maintain acceptable air quality level within the tunnel. The design is driven either by fire/safety consideration or by air quality. A longitudinal ventilation system introduces air into or removes air from the tunnel roadways at the portals, thus creating a longitudinal flow of air with in the roadway, with discharge at the existing portal. Longitudinal ventilation is created with a series of axial fans mounted at the ceiling level of the tunnel. They are used to introduce air into the tunnel roadway at the portals, thus creating a longitudinal flow of air within the roadway with discharge at the tunnel portals. The fans, due to the effects of high velocity discharge, induce a longitudinal airflow through the tunnel.

Tunnel ventilation installed in road tunnel is an important element of fire protection. Jet fan units are axial type fans with direct drive motors designed to deliver a wide range of thrust capabilities in both the forward and reverse direction. The thrust produced is governed by size, blade angle and brake horse power.

The ventilation system chosen is longitudinal ventilation with Jet Fans . 13 Nos Jet in tube.(1487 N Thrust). Fresh air demand can be provided to the tunnel without exceeding the maximum airspeed in tunnel (10 m/s according to RVS 09.02.31).

- Fire thermal power of 50 MW.
- The defining parameter here is the fire power, that depends on inflammable goods, fuels, vehicle fire etc. that will be transported through the tunnels.
- 70% light vehicles (35% petrol, 35% diesel), and 30 % heavy vehicles (trucks, busses,)
- Twin tube unidirectional tunnels having 2 lane for each direction.

The longitudinal (Jet) fans need to comply with fire rating (250°C - 2 hrs/400 °C - 2 hrs) in accordance with design of the tunnel

The concentration of CO inside the tunnel should not exceed 70 ppm for normal flowing traffic. This concentration may be permitted up to 100 ppm during traffic congestion. If the CO concentration reaches 200 ppm, tunnel operations should be immediately suspended.

It is recommended to permit a maximum average in-tunnel concentration of 1.0 ppm NO_2 along the length of the tunnel at any one time. For a short-time working exposure a limit of 5 ppm is recommended.

- **Automatic Tunnel Fire Detection and Warning Systems**

The key objective of the automatic tunnel fire detection and warning systems is to provide prompt, accurate, and reliable fire detection while preventing nuisance alarms. Prompt and accurate fire detection will result in timely activation of tunnel ventilation system in the predetermined mode of operation to maintain tenable environment for evacuees. The successful management of tunnel fires requires that fires are detected quickly and accurately while they are still at a controllable size (in the order of 1 - 5 MW [3-17 MBtu/hr]).

- **Fire Fighting Systems**

Fire Suppression Systems with the goal to reduce the fire HRR by sufficient application of water, e.g., Deluge system with adequate water storage inside/ outside tunnel.

The stand pipe system for firefighting shall be a Class – I" automatic Wet" type system. It contain water at all times that is attached to a water supply capable of supplying the system demand at all times and that requires no action other than opening loose valve to provide water at loose connections. 150 mm main waterline shall be laid on one side of the walkway of tunnel wherein standpipe system shall be installed at an interval of 80 m. The required flow rate for the standpipe system shall be 1920 l/minute. It shall be connected to a reliable water supply storage tank which is capable of supplying the system demand for a minimum of 1 hour.

- **Passive fire protection systems**

Tunnel lining and interiors may be coated with fireproof coatings to keep the strength of structural elements and concrete lining within safe temperature ranges.

- **Tunnel lighting system**

The lighting requirements of a tunnel are totally different by day and by night. At night the problem is relatively simple and consists in providing luminance level on lit routes inside the tunnel at least equal to those outside the tunnel. The design of lighting during daytime is particularly critical because of human visual system. The driver outside the tunnel cannot simultaneously perceive details on the road under lighting levels existing in a highly illuminated exterior and a relatively dark interior. When the visual system can adapt to rapid

reduction in ambient illumination such as that produced when passing from daylight into the darkness of a tunnel these adjustments are not instantaneous. The adaptation process takes a certain time, depending on the amplitude of the reduction, the greater the difference, the lighting level outside and that inside the tunnel.

It is practical to distinguish different zones in the tunnel in order to determine the longitudinal lighting level at daytime lighting i.e. the access zone, the threshold zone, the transition zone, the interior zone and the exit zone.

Safety in the event of a fire is of paramount importance in a tunnel. The catastrophe consequence of the tunnel fires not only resulted in loss of life, property but also concerns of the lack of fire life safety protection in the road tunnels. Minimum fire protection requirements are based on tunnel length. Where tunnel length is 240 m and where the maximum distance from any point within the tunnel to an area of safety exceeds 120m, all safety measures are taken.

Road tunnels require a dependable power supply and a flexible power distribution system that will provide maximum reliability and power continuity for tunnel ventilation, lighting and water pumping etc. Minimum illumination level is to be maintained without interruption. During the daytime, when vehicle do not have their headlights on, a sudden loss of all tunnel illumination can cause driver confusion and result in an accident.

In order to provide reliability and continuity, diversity is needed in the power distribution system so that an alternate power source is available upon failure of the normal power source. The tunnel lighting can be provided from alternate source of emergency i.e. solar power voltalic calls.

For the two-service system, two services from separate and independent sources of the power are needed. The primary power source i.e. sub-station is existing near site. The power line can be drawn from sub-station to provide the necessary power required for the tunnels. The secondary source is anticipated to come from Alternate source of energy i.e. solar power voltalic cell.

The electric power shall be required of the order of 2.6 MW. The limitations of solar power system are the following:

- During continuous rainfall days or in cloudy weather conditions, the array cannot be charged. Under such situation main power supply from sub-station shall be restored.
- Shadow free area is necessary for installation of array.

➢ **Tunnel Drainage**

Drainage is needed inside the tunnels to remove water and other liquids introduced during firefighting, washing of tunnel interiors, flushing of pavements and water dripping from vehicle during rainy season. Water will drain from the roadway into drainage inlets along each side of the tunnel. Inlets will be connected to longitudinal drain provided in concrete below the walkway leading to the portal of the tunnel. Near the portal, covered trench culvert shall be constructed to pass the discharge. Closed spaced drain inlets are preferred as they help to prevent propagation of fire by burning fuel in case of serious accident.

➢ **Emergency Communication:**

Emergency telephones should be provided in the tunnels and connected to the emergency power supply. When such a telephone is used, the location of the caller should be identified both at the control centre and personnel by a warning light visible to rescuing personnel.

Telephones shall be provided at suitable places such as near the portals and at emergency exists. Communication system should give the traveling public the possibility of summoning help and receiving instructions and should ensure co-ordinate rescue. Systems should raise the alarm quickly and reliably when unusual operating conditions or emergency situations arise.

(viii) Supplying, installation, testing and commissioning of basic security system comprising of PTZ / fixed camera, cabling, digital recording , HD display system in the tunnel to include control room at the gate and intercom connection to each dwelling unit, and basic IP based CCTV system to be installed at the entry and exit points, parking areas, entry point of each dwelling unit and other common areas as required including CCTV control room, required under ground cabling, digital recording system and monitor/ monitors with minimum display of 5" x 8" per camera in the control room

(ix) Supplying, installation, testing and commissioning of LAN system comprising of core switches & L2 switches with 10 G, 10 giga SFP modules, WIFI access points, WIFI controller, network management software, racks, CAT 6A cable, patch panels, OFC etc.

(x) Supplying, installation, testing and commissioning of IP based EPABX system comprising of core switches & L2 switches with 10 G, 10 giga SFP modules, industry standard appliance server, cloud-based, enterprise-grade UC solution, MID/ENTRY level IP/SIP phone with, dual 1 gig ports, racks, CAT 6A cable, patch panels, OFC etc.

(xi) Supplying, installation, testing and commissioning of driver face and automatic number plate recording system / recognition system including high resolution camera and software set for the driver face capture and automatic number plate recording.

(xii) Baggage scanner big: computer based multi energy X-Ray baggage inspection system capable of passing through bags/parcels of dimension 940mm (W) x 640mm (H) with Belt Height- 750mm-850mm with 22'724" LCD Monitor, Input/ Output rollers with frames etc. as required.

(xiii) Electromechanical boom barrier with all accessories upto 6 meter length.

(xiv) SCADA systems & network devices and instruments for 3D monitoring

- **Service building and utility Building for Tunnel operation & Maintenance**

During operation and Maintenance period of Tunnel several utilities required to installation and continuous supervision of security official and Tunnel maintenance engineer and supervision staff need to stay 24x7 Hour. Therefore, either end of Tunnel 4 story building having floor area 2x37.2m x 15m is proposed with all necessary amenities as per CPWD Manual

- **Water proofing**

Water proofing (Umbrella System water proofing for tunnel geotextile/ drainage layer nailed at intervals onto tunnel wall using PVC-disk, 2pcs/sq.ya. membrane 3.0mm welded to PVC disk. Joints are welded by hot wedge machine or hot air. water barrier welded to the membrane as required including cost of all materials, machinery, labour, ventilation, lighting, drainage etc., complete.)

- **Energy Supply 2 Nos of 2.6 MW Substation**

Supplying, installation, testing and commissioning of 33 kV substation comprising 33 kV HT panel, transformers 33kV/11 kV, 11 kV HT panel, inter connections, 11 kV HT underground cabling to the distribution substations on ring main system, substation earthing, substation safety equipment including civil work component.

Power Distribution

Supplying, installation, testing and commissioning of 33 kV/0.433 kV or 11 kV/0.433 kV substation equipment comprising HT panel, dry lypc/Oil type transformers, HT cable, bus trunking from transformer to LT panel, LT panels, automatic power factor correction panel, active harmonic fdters, TVSS (transient voltage suppression system), SPD (surge protection system), essential panel, earthing, required inter-connections, substation safety equipment including LT cabling from substation to the buildings fed by the substation including civil work component.

Emergency Power Supply

Supplying, installation, testing and commissioning of DG sets, AMF panel, bus ducting/ cables from DG sets to essential panel, DG set enclosure room sound insulation/ ventilation/smoke exhaust as required, earthing of DG set system, control cabling, fuel tank/piping, DG set exhaust piping/ exhaust chimney as per CPCB norms, civil works connected with DG sets including foundation as required.

Providing and supply of 11 kV Line from Luangmual Sub-station to Aizawl Bypass inlet substation (7Km length) and Zuangtui Sub-station to Aizawl Bypass Tunnel outlet substation (2Km length) including civil works foundation as required

k) Drainage Design

A cardinal rule while planning drainage is the least interference with natural drainage. Minimum interference with natural drainage means stable earth face / surface with some kind of vegetative cover preventing erosion and allowing free drainage. While aligned towards the road surface the water may be diverted and guided to flow in a definite path and the flow on the valley side controlled so that stability may not be affected. It helps in protecting the road bed and pavement. A network of drains helps in confining and controlling flow of water run and check adverse effects on road structure. In the case of hill the road acts as an interceptor and its longitudinal cut on hill slope obstructs the natural drainage and the road ledge and therefore acts as a collection area of all water from hill side. As such adequate drains in the form of catch water drains collecting flow from hill side to bring it to side drain leading to cross drains and further discharge in into natural drainage channels through valley side drains / chutes, are essential for stability of road.

In view of the above, the drainage system should consist of the following:

- Pavement drainage
- Roadside drains
- Chutes drain
- Catch water drains
- Cross Drainage
- Rain cut drain
- Pavement Drainage

For quick dispersal of precipitation on road surface, it would be necessary that water travel the least distance. However, steep cross slope is objectionable from traffic comfort consideration. Thus, a judicious balance has to be kept between two conflicting requirements. A unidirectional camber of 2.5% away from the center of carriageway has been considered.

In the case of re-entrants, it is necessarily to have cross drainage points, cross-fall is given towards the valley side. The surface run-off, which is mostly due to local rainfall on the roadway, is allowed to flow down quickly to the adjacent natural ground where appropriate cross fall is available.

Adequate care has to be taken in geometric to ensure channelized drainage to avoid damage to road shoulders. 3.0 % slopes have been considered for drainage for the shoulders.

- **Chutes**

Surface run off on a hill slope flows down in the form of natural gulleys / chutes. The water entrapped in the catch water drains is also brought down by connecting them with existing natural gulleys. It is therefore desired to provide lined chutes to lead the discharge to the catch pit of culvert or to a natural drainage channel. The chutes of the culverts form a part of the culvert structure and are given in the respective drawings of culverts.

Sr.No	Description of Item	Unit	Package-2
1	Concrete lined side drain	Rm	2360
2	Catch Water Drain	Rm	1410
3	Chute Drain	Rm	1050

l) Road Signs, Marking, and Furniture

The provisions of following road fixtures have been considered in this project:

(a) Mandatory / Regulatory Signs,

(b) Cautionary /Warning Signs and

(c) Information Signs.

(d) Route Marker Signs are provided.

(e) KM Stones are included as per type design.

m) Street Furniture

Traffic Safety Posts and Parapet Walls are included. Traffic Signs Marking & other Road Appurtenances

n) Roadside Amenities

Continuous long-distance travel on highways at speed is liable to cause fatigue as also mental tension to the road users. Moreover, the monotony of driving over long sections in rural areas with no likelihood of any cross traffic brings a sense of complacency in many drivers and such distractions could result in serious accidents.

Sr.No	Description of Item	Unit	Package-2
1	Bus Shelter & Layby	Nos	4

9. ENVIRONMENTAL SCREENING AND PRELIMINARY ENVIRONMENTAL ASSESSMENT

9.1. GENERAL

While Planning and Design, Construction and Operation Stages of the project, various components of the environment has been evaluated and the road alignment has been studied thoroughly with respect to the provisions of realignment, side of widening, along the existing road alignment, requirement of bypasses, construction details, materials of construction etc., which ultimately decides the impacts during later phases. Most of the impacts are during construction and operation phases and out of all the impacts, very few are long term in nature rest all are short to medium term. Most of the operation phase impacts are continuous in nature. Important criterion for identification of impacts is the identification of the impact zone. For present studies, a 'Corridor of Impact (COI)' based upon the GIS based model extending from one ridge line to the other ridge line of the valley and through which the road passes has been considered.

Physical environment includes; Weather Quality, Water Resources, Water Quality, Air Quality, Noise and Land Environment. The Biological Environment includes; Forest Cover, Plantation, Horticulture, Sericulture and Agricultural Environment, Wild life in all forms, their habitat and migration and associated relations with Flora and Fauna and Issues related with the Animals. Social Environment includes Rehabilitation, Employment, Agriculture, Housing, Culture etc. Reviewing the project activities and baseline conditions, the design was improved to consider environmental aspects. The impacts can be assessed both qualitatively and quantitatively. Project impacts on different environmental components are generally identified in a checklist matrix (known as Leopold Matrix also) method, which is a qualitative approach. The present trend is to quantify the impact using a common unit of measurement. This methodology called weighing scaling checklist method has been developed by a number of groups. The approach assigns some relative value to the environmental components also called valued environmental components (VEC). Then it assigns importance weights to impact scales for each alternative activity relative to each environmental component. The basic concept can be expressed as:

$$EIV = \Sigma\, m\, I = 1\, \Sigma n\, j=1\, (IS)\, I\, (PI)\, j$$

Where,

EIV = Environmental Impact Value

(IS)I = Impact Scale Value for the activity

(PI) j = Environmental Component Value for Environmental Component

m = No. of activities

n = No. of environmental Components

However actual quantification is difficult because of subjective nature of the valuation of environmental component and the impacts. Both environmental and social impacts are difficult to quantify, specifically to judging a project. So quantification approach has not been considered further. However valued environmental components have been identified and the impact assessed based on the impacts on these components. Environmental components considered for assessment of impacts for this project are given in Table - 9.1 below:

Table - 9.1: Valued Environmental Components

Environmental Components	Detail of Components
Physical Environment	Climate and Weather
	Air Quality
	Land Resources
	Soil Resources
	Water Resources
	Noise
Ecological Environment	Roadside Plantation
	Forest Cover
	Non-forest Flora
	Wildlife (Fauna)
Social Environment	Land Acquisition
	Rehabilitation
	Employment
	Housing
	Agriculture
	Culture

9.2. MITIGATION MEASURES:

Mitigation measures have been suggested based on environment and social criteria and also relying on best engineering practices. Besides the mitigation measures, environmental enhancement programmes have also been coincided.

Table 9.2: Impact Potential Evaluation

Environmental Parameters	Mitigation Measures	Locations
Air and Noise Quality Improvements	(i) By improving intersections. (ii) By removing traffic bottlenecks and straightening of the road (iii) By maintaining a steady stream flow of traffic and by segregating slow- and fast-moving traffic, (iv) Noise barriers and plantation at sensitive areas	At all congested location
Drainage and Runoff water	(i) Provision of adequate size and number of cross drainage structures to ensure efficient cross-drainage.	All long the project road
Contamination of water quality	(i) Construction work near water bodies will be avoided especially during monsoon periods. (ii) All waste arising due to project activities will be disposed off, as per State Pollution Control Board norms	At all Water bodies
Loss of Trees	(i) Through proper re-alignment and width of median to minimize cutting of trees, (ii) Compensatory afforestation @ 1:2 of the trees which	Trees which are going to be felled

Environmental Parameters	Mitigation Measures	Locations
	are going to be cut.	
Road Safety - Improvement	(i) Design improvement at curves (ii) Segregation of slow traffic in congested areas by providing service roads Provision of proper signage & proper lighting arrangement to avoid accidents. (iii) Traffic management plans will be prepared for congested locations	

9.3. ENVIRONMENTAL MANAGEMENT PLAN (EMP)

In order to mitigate the adverse effects of the proposed construction a through 'Environmental Management Plan (EMP)' has been prepared and being presented as an key to ensure that the environmental quality of the project influence area, which is subjected under impact, so that it does not deteriorate beyond the expected level due to the construction and operation of the project. The details of the operation phase have also been considered in quite a length with a number of recommendations for 'Environmental Enhancement'. The road design, construction and operation activities may impose various levels of environmental impacts, they have been estimated in qualitative and quantitative terms and the 'Environmental Management Plan (EMP)' has been drafted in consideration of every aspect of the Design / Pre-construction, construction and operational phases related to the environment and the environmental enhancement issues. The recommendations in the 'Environment Management Plan (EMP)' are expected to be implemented right from the conception till the commissioning and in operational phases. For the sake of implementation the plan has been divided into three phases- (a) Design Phase, (b) Construction Phase and (c) Operation Phase. An Additional section on environmental enhancement has also been considered as a part of the mitigation measures.

9.4. INSTITUTIONAL REQUIREMENT - CAPACITY BUILDING

A separate environmental management group will be established to implement the management plan. The group shall be headed by General Manager and it shall ensure the suitability, adequacy and effectiveness of the Environment Management Programme. The management review process will ensure that the necessary information is collected to allow management to carry out its evaluation. This review will be documented. Besides proper implementation of EMP and monitoring, the group will be equipped to develop following services;

9.5. TRAINING

Training is of much importance in the environmental management. Environmental management is a developing subject and the people implementing environmental strategies should remain update with the environmental control processes. Besides in absence of environmental awareness, the implementing engineers and workers will not be able to implement the mitigation measures property. This group will arrange environmental engineers to train the construction engineers and supervising engineers on implementation of environmental measures. Contractors' personnel should also be given training.

9.6. DOCUMENTATION

Documentation of the environmental activities is one of the important steps in Environment Management Plan. All monitoring activities details, results, standards, statutory requirements documents, plantation details, equipment performance, road activities related to environment etc. will be documented in a proper manner so that the relevant information are quickly available as required.

The documentation will include:

- Major technical information in road construction and operation (Similar to the process information for a manufacturing unit)
- Organizational Charts
- Environmental Monitoring Standards
- Environmental and related legislation
- Operational Procedure
- Monitoring Records
- Complaint Records
- Training Records
- Incident Records
- Quality Assurance Plan for Monitoring
- Emergency Plans

9.7. DOCUMENTATION CONTROL

Documentation Control is very important and it reviews of the management programme. Main elements of document control are;

- Accessibility: They must be assessable and can be easily located. General Manager of NHIDCL will decide the locations for each document. Some of the documents will be at a number of places at a time but those locations will be mentioned. Environmental Monitoring standards and 'Quality Assurance Plan' should be available at project site officers as well as at the headquarter.
- They will be periodically reviewed, revised as necessary and approved for adequacy by authorised personal.
- Current versions of relevant documents are available at all the locations where operations essential to the effective functioning of the system are performed.
- Obsolete documents will be promptly removed of all points of issues and points of use or otherwise will be assured against unintended use.

9.8. ENVIRONMENTAL COST

A budgetary cost estimated for the environmental management activities is presented in Summary of cost, Volume V-II- Cost Estimates. Environmental mitigation measures which are part of engineering activities such as slope stabilization, road construction in bypasses or implementation of air pollution control by crusher etc. are not included in this estimate.

9.9. ENVIRONMENTAL CLEARANCE

In accordance to the Environmental Impact Assessment Notification, 1994 under Environment (Protection) Act, 1986 the 'Environmental Clearance' for the project is issued, for which the project proponent is required to make an application through the Specified Performa, accompanying the 'Environmental Impact Assessment (EIA) Report/Environmental Management Plan' prepared in accordance with the guidelines issued by Ministry of Environment and Forest (MoEF), Government of India. The notification in Schedule-I of the Environmental Impact Assessment Notification, 1994 lists 30 categories of projects which require preparation of the 'Environmental Impact Assessment Report (EIA) and Environmental Management Plan Report', for the

clearance from MoEF if the investment is more than Rs. 1000 million for the project. The EIA application also requires 'No Objection Certificate (NOC)' from respective 'State Pollution Control Board', Public Hearing at district level is also requited and these are conducted by respective 'State Pollution Control Board'.

There is no specific environmental act or law exclusively governing road and highway projects. However the item no.21 of 'Schedule-I' of the 'EIA Notification' specifies that any highway project needs environmental clearance from the central government in the form of an approved EIA. In April 1997, a notification was issued by MoEF amending Schedule-I of the EIA Notification, 1994 which lists projects requiring Environmental Clearance. The April, 1997 notification amended Item 21 of the Schedule and stated;

As per MOEF EIA Notification dated 14.09.2006 (as amended in August 2013), any highway project falls under Category A if the project entails *i) New National Highways; and ii) Expansion of National Highways greater than 100km involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on re-alignments and bypasses.* The proposed bypasses do not trigger these requirements and therefore, the project does not require environmental clearance from MOEF[3].

9.10. RECOMMENDATIONS

Environmental Enhancement Measures

The following enhancement measures will be proposed for the project:

- Enhancement of road-side facilities;
- Improvement of aesthetic qualities of the project (landscaping, selective tree plantation);
- Management of existing problems {lack of shade to slow moving traffic);
- Landscaping along the road corridor;
- Landscaping and reclamation of quarry wastes;
- Improvement of the natural resources for the local population and,
- Enhancement of cultural properties along the road.

Appropriate enhancement/ landscaping plan will be proposed for the natural environment, water bodies, rest areas, junctions, bus stops, flyovers, service roads and medians.

9.11. ENVIRONMENTAL AND SOCIAL BASELINE

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

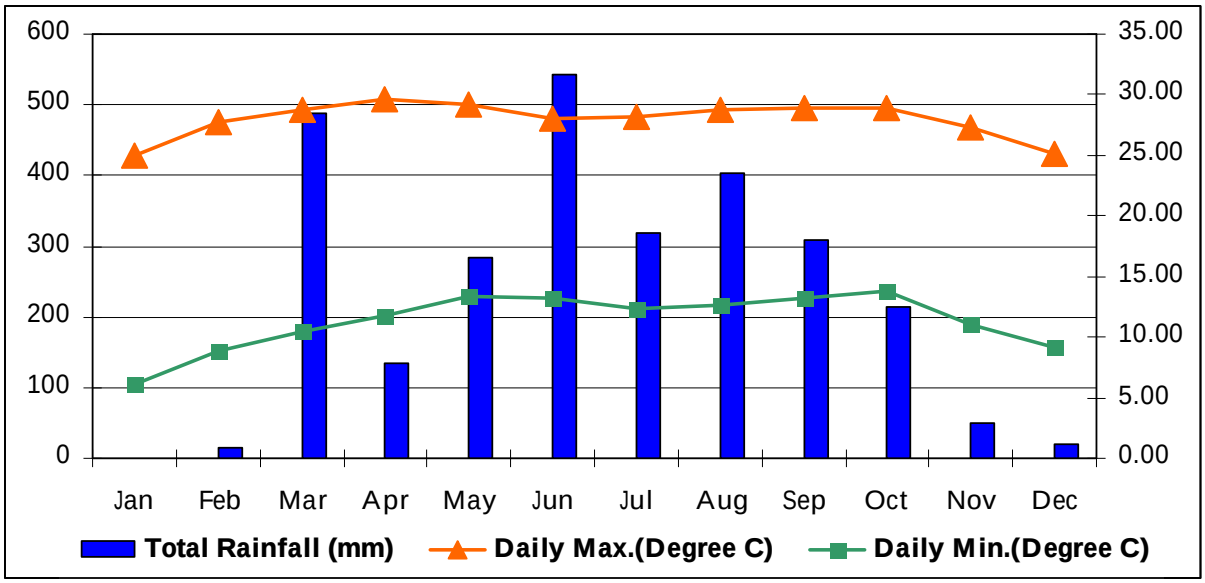
9.11.1 Natural Environment

(a) Climate

Mizoram has a mild climate; relatively cool in summer 20 to 29 °C (68 to 84 °F)[4] and winter temperatures range from 7 to 22 °C. The region is influenced by monsoon, raining heavily from May to September with little rain in the dry-season. The climate pattern is moist tropical to moist sub-tropical, with average state rainfall 2540 mm per annum

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

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



Source: Meteorological Data of Mizoram

Figure 9.11.1 Monthly rainfall and daily max/min temperature in Aizawl (Average between 2020 and 2021)

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

Table 9.11.1 Annual Rainfall Soil Structures in Project Area

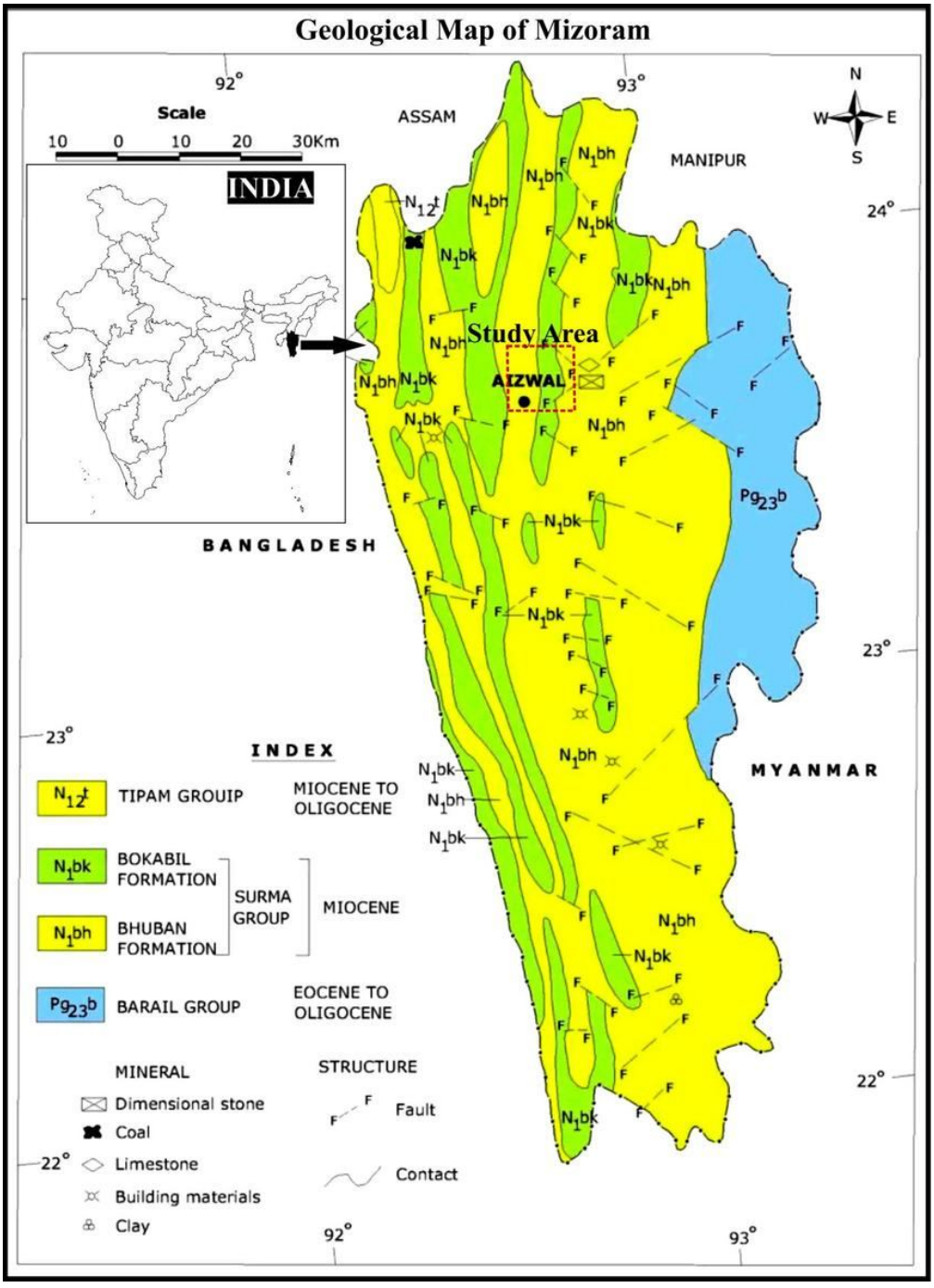
Report Centre	Annual Rainfall in mm			
	2018	2019	2020	2021
Aizawl	1663	1677	1601	1872

Source: Meteorological Data of Mizoram 2022

9.11.2 Topography, Geology and Soil

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

Mizoram state is predominately composed of mountainous terrain of tertiary rocks. The mountain ridges strike north to south direction in parallel series. The mountain ranges are separated from one another by narrow deep river valleys. The elevation ranges from 40 meters to 2,157 meters, the highest point at Phawngpui. There are only a few and small patches of flat lands, which are mostly intermontane basins. Figure 9.11.2 shows the geological map of the Mizoram state. According to this map, the geology along NH54 consists of Bokabil formation and Bhuban formation of Surma groups.



Source: Geological Survey in India

Figure 9.11.2 Geological Map of Mizoram

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

Table 911.2 Soil Structures in Project Area

District	Soil pH	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potash (Kg/ha)
Aizawl	5.53	264	12	277

Source: Soil Information System

9.11.3 Flora and Fauna

Mizoram is the highest forest cover state in the India, having about 90 % of the total geographical area is under forest (India State Forest Report FSI, 2013). Mizoram is a hilly region receiving heavy rainfall with soil characteristics conducive for luxuriant growth. Flora and fauna assessment were carried out for all the three districts that the targeted section of NH54 by-passes through. Floral/Vegetation assessment carried out through quadrate methods; for trees 10m x 10m, for shrubs 5mx5m and for Herbs 1mxlm square shaped quadrats were used. Quadrates were laid randomly in the corridors upside and downside of the road. All species in the quadrats were recorded & ecological parameters such as density and frequency were calculated. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. The flola and fauna survey was carried out twice, during the dry season (from Dec 2021 to Feb 2022) and the rainy season (from April to June 2022).

(1) Flora

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

(i) The tropical wet evergreen with tall dense trees.

(ii) The tropical, semi-evergreen with deciduous species.

(iii) The Montane sub-tropical with broad leaved evergreen species

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

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

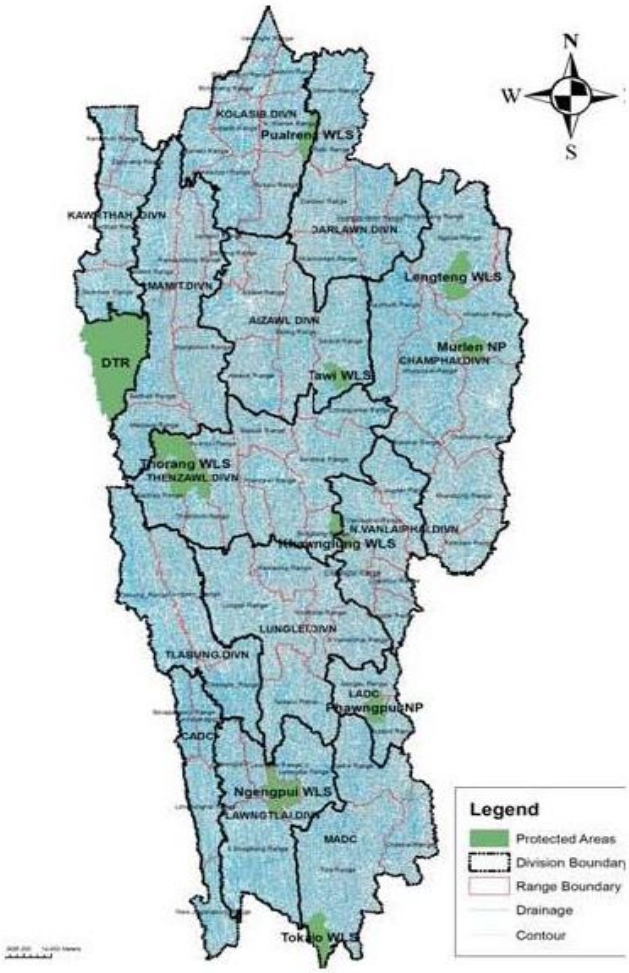
Maize, palms and oil seeds, pulses, peas, ginger, groundnut, papaya, pineapple, cash crops like tapioca and vegetables like potato, tomato and beans are grown in the study area. A small patch of tea plantation was also found in the study area of Aizawl Bypass Alignment.

(2) Fauna

Since the study area has extensive forests, the area can support fairly large variety of wild life. Various vertebrate and invertebrate animals are found in the forest. Mammals, avifauna, reptiles and insects species are varied and are commonly found in the forests of the study area. During the field study snakes, squirrels and birds were spotted. Majority of the mammalian wildlife is limited to the deeper areas of the forest.

9.11.4 Protected Area

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



Source: Department of Environment and Forests, Government of Mizoram

Figure 9.11.3 Protected Areas in Mizoram

According to the discussion with the official in State Environment and Forest Department, three Wildlife Sanctuaries, namely Tawi, is located near the proposed bypasses. Tawi WLS is located about 80 km south west of Aizawl Bypass .While no direct impacts to these WLSs are expected due to this project, their baseline condition and the list of key species in each WLS is shown below, against which, potential indirect impact can be monitored.

(1) Tawi Wildlife Sanctuary

The Tawi Wildlife Sanctuary is located between 23°29'N - 23°34'North and 92°54'E- 92°59' East, approx. 80 km from Aizawl, and its covering area is 35.75 km2. This sanctuary provides

shelter and protection of five rare and endangered species of wildlife mentioned in the Red Data Book of IUCN.

Table 9.11.5 Outline of Tawi Wildlife Sanctuary

No.	Item	Description	
1	Location	Approx. 80 km East of Aizawl (between 23°29'N - 23°34'North and 92°54'E-92°59'East)*)	
2	Area	35.75 km²*)	
3	Principal Species	Flora	- *Quercus species* - *Betula species* - *Wild orchids* - A few clumps of *Chimnobambusa collasa etc*
		Fauna	- Clouded Leopard (Threatened) - Leopard Cat (Endangered) - Hoolock Gibbon (Endangered) - Serow (Threatened) etc.

Note: *) Finally notified in 2001 vide Government of Mizoram letter No.B.12012/l/91-FSTDt. 16thNov/2001

Source: "Review Management Plan of Tawi Wildlife Sanctuary Mizoram for the period (2006-2007 to 2015-2016)", Wildlife

Wing Environment & Forest Department Government of Mizoram

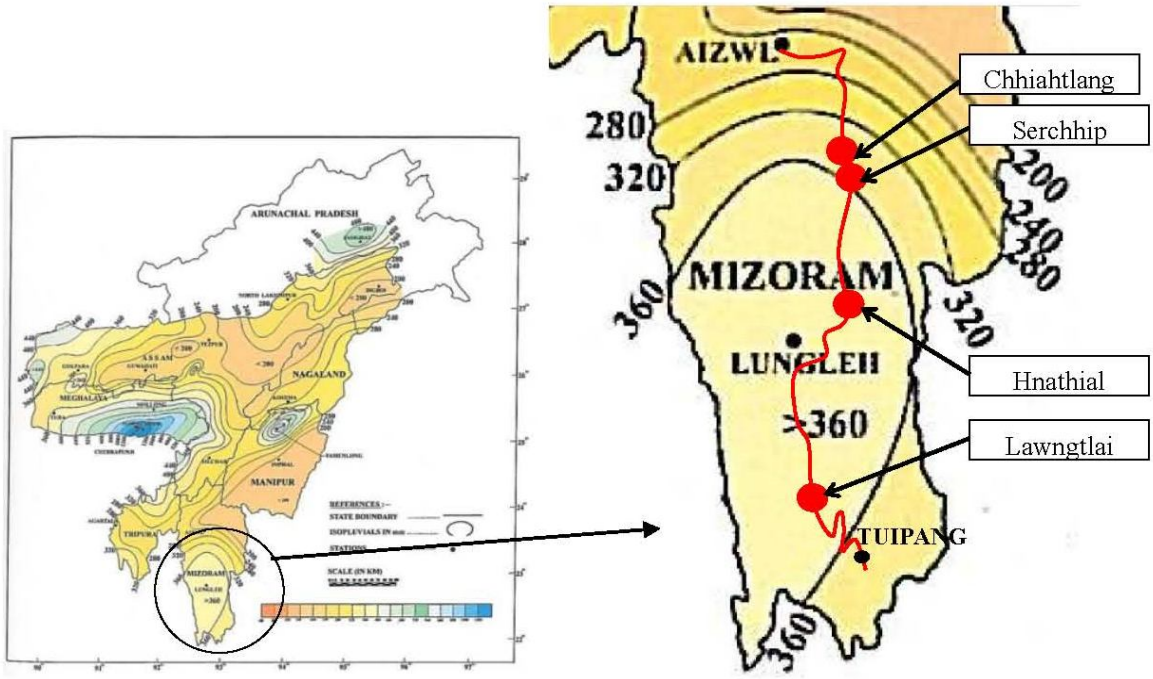
9.11.5 Hydrology

The hydrological study is conducted based on IRC:SP:13 "Guidelines for the design of small bridges and culverts" which is well used technical standard for hydrological study in Indian highway design. The analysis is conducted based on Rational Formulae for peak-off from catchment. The size of the flood are determined by factors such as rainfall intensity, distribution in time and space, duration, catchment area, shape, slope and permeability of the soil and vegetable cover.

The rainfall intensity is based on the ATLAS of Statewise Generalized ISOPLUVIAL MAPs of Eastern India (Part-II), published by India Meteorological Department, Government of India. Rainfall intensity for each sections in Aizawl Bypass is shown in Table 9.11.6 and the isopluvial map with the project location is shown in Figure 9.11.6. It is sectioned by range of rainfall intensity which value is read from higher edge of counter value.

Table 9.11.8 Rainfall Intensity for Each Bypass Section

Aizawl City	**50Years- 24hours Rainfall intensity**	240mm/hr



Source: ATLAS of State wise Generalized ISOPLUVIAL (Return Period) Maps of Eastern India (Part - II)

Figure 9.11.4 Isopluvial Map with Project Location for NH54 Bypass (For 50years)

9.11.6 Mineral Resources

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

Table 9.11.9 Number of Quarry Permit Issued and Mineral Production

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

Source: Statistical Abstract of Mizoram 2011

Table 9.11.10 District-wise Number of Quarry Permit Issued and Mineral Production, 2010-11

District	No. of Quarry Permit Issued	Production form Quarry (Stone) (Cu.M)	Rs. in Lakh)	Sand Production (Cu.m)	Rs. in Lakh
Mamit	4	11087.50	4.43	1980.00	0.99
Kolasib	6	11594.90	4.64	11312.20	5.66
Aizawl	**28**	**171776.73**	**68.71**	**67189.04**	**33.59**
Champhai	15	4913.95	1.97	29825.70	14.91
Serchhip	8	4799.70	1.92	5435.00	2.72
Lunglei	31	8294.55	3.32	20562.00	10.28
Lawngtlai	5	470.00	0.19	-	-
Saiha	-	-	-	-	-
Total	**97**	**212937.325**	**85.18**	**136303.94**	**68.15**

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

9.11.7 Living Environment

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

(a) Air Quality

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

Polltech $PM_{2.5}$ & PM_{10} ADS Fine Dust Sampler and Ecotech AAS Sampler with gaseous sampling attachment were used for ambient air quality monitoring. The results of PM_{10}, PM_{25}, SO_2, NO_X and lead concentration measurements during the study period are presented in the tables below. On the basis of tabulated data it can be inferred that the concentrations of the measured parameters complies the limits of the National Ambient Air Quality Standards, CPCB notification dated 18th November, 2009.

Table 9.11 National Ambient Air Quality Standards

Parameters	Participate Matter (PM_{10}) in μg/Nm³	Particulate Matter ($PM_{2.5}$) in μg/Nm³	Sulphur Dioxide (SO_2) in μg/Nm³	Nitrogen Dioxide (NO_2) in μg/Nm³	Lead (Pb) in μg/Nm³
Time Weighted Average	60	40	50	40	0.5

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

A) Particulate Matter (Size less than 10 μm) PM_{10}

The concentration of PM_{10} at the AAQM station in Aizawl ranged from 50 μg / Nm³ to 56 μg / Nm³ in the dry season, and ranged from 31μg / Nm³ to 38μg / Nm³ in the monsoon season.

B) Particulate Matter (Size less than 2.5 μm) $PM_{2.5}$

The concentration of $PM_{2.5}$ at the AAQM station ranged from 26 μg / Nm^3 to 35 μg / Nm^3 in the dry season, and ranged from 20 μg / Nm^3 17 μg / Nm^3 in the monsoon season.

C) Sulphur Dioxide (SO_2)

The concentration of SO_2 ranged from 7 μg / Nm^3 to 12 μg / Nm^3 in the dry season and ranged from <5 μg / Nm^3 to 9 μg / Nm^3 in the monsoon season.

D) Nitrogen Oxide (NO_x)

The concentration of NO_x ranged from 12μg / Nm^3 to 17μg / Nm^3 in the dry season and ranged from 8 μg / Nm^3 to 14μg / Nm^3 in the monsoon season.

E) Lead

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

Table9.11.14 Air Quality in Aizawl in Dry Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in μg/Nm^3	Particulate Matter (PM_{25}) in μg/Nm^3	Sulphur Dioxide (SO_2) in μg/Nm^3	Nitrogen Dioxide (NO_2) in μg/Nm^3	Lead (Pb)in μg/Nm^3
Sairang Junction 5.0 m (approx.) From Edge of the Pavement	07/03/2022 to 08/03/2022	50	30	8	13	<0.01
	08/03/2022 to 09/03/2022	52	26	7	12	<0.01
	10/03/2022 to 11/03/2022	50	27	8	13	<0.01
	11/03/2016 to 12/03/2016	51	28	8	14	<0.01
Rangvamual 10 m (approx.) From Edge of the Pavement	07/03/2022 to 08/03/2022	54	34	9	16	<0.01
	08/03/2022 to 09/03/2022	56	32	10	17	<0.01
	10/03/2022 to 11/03/2022	53	33	9	16	<0.01
	11/03/2022 to 12/03/2022	52	32	9	17	<0.01
Near Zemabawk pray ground 5.0 m (approx.) From Edge of the Pavement	07/03/2022 to 08/03/2016	56	35	10	15	<0.01
	08/03/2022 to 09/03/2022	55	34	12	16	<0.01
	10/03/2022 to 11/03/2022	53	32	11	15	<0.01
	11/03/2022 to 12/03/2022	54	34	12	17	<0.01

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm³	Particulate Matter (PM_{25}) in µg/Nm³	Sulphur Dioxide (SO_2) in µg/Nm³	Nitrogen Dioxide (NO_2) in µg/Nm³	Lead (Pb)in µg/Nm³
Number of Sample		12	12	12	12	12
Max		56	35	12	17	<0.01
Min		50	26	7	12	<0.01
98thPercentile		56	34	12	17	<0.01

Table 9.11.15 Air Quality in Aizawl in Monsoon Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm³	Particulate Matter (PM_{25}) in µg/Nm³	Sulphur Dioxide (SO_2) in µg/Nm³	Nitrogen Dioxide (NO_2) in µg/Nm³	Lead (Pb)in µg/Nm³
Sairang Junction 5.0 m (approx.) From Edge of the Pavement	16/06/2022 to 17/06/2022	37	23	<5	10	<0.01
	17/06/2022 to 18/06/2022	34	21	8	13	<0.01
	19/06/2022 to 20/06/2022	32	22	9	14	<0.01
	20/06/2022 to 21/06/2022	31	24	7	12	<0.01
Rangvamual 10 m (approx.) From Edge of the Pavement	16/06/2022 to 17/06/2022	36	25	6	12	<0.01
	17/06/2022 to 18/06/2022	31	24	7	11	<0.01
	19/06/2022 to 20/06/2022	34	19	7	14	<0.01
	20/06/2022 to 21/06/2022	38	22	6	14	<0.01
Near Zemabawk pray ground 5.0 m (approx.) From Edge of the Pavement	16/06/2022 to 17/06/2022	37	22	<5	9	<0.01
	17/06/2022 to 18/06/2022	33	20	6	11	<0.01
	19/06/2022 to 20/06/2022	35	27	8	10	<0.01
	20/06/2022 to 21/06/2022	34	21	7	8	<0.01
Number of Sample		12	12	12	12	12
Max		38	27	9	14	<0.01

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm³	Particulate Matter (PM_{25}) in µg/Nm³	Sulphur Dioxide (SO_2) in µg/Nm³	Nitrogen Dioxide (NO_2) in µg/Nm³	Lead (Pb)in µg/Nm³
Min		31	19	<5	8	<0.01
98thPercentile		37	25	8	14	<0.01

(b) Ground and Surface Water Quality

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

The collected water sample was analyzed for selected physical and chemical parameters. The analyzed parameters of the physico-chemical properties of the water samples meet desirable limits as per IS 10500:2012. The odor, taste and smell are acceptable for all areas. Oil and grease and fluoride were below detectable limit. Hardness of water, determined by the dissolved salts calcium and magnesium, was found to be in the range from 18 to 56 mg/l. The water of the samples analyzed can be classified as soft water (Durfer and Backer classification of Hardness). The total dissolved solid (TDS) of water represents the amount of soluble inorganic substances in the water source. The TDS of the water samples varied from a minimum of 80 mg/1 to 510 mg/1. The iron content of the water samples was lower in the surface water sample as compared to the ground water samples. The concentration of the trace metals and soluble inorganics like sulphate and nitrate analyzed was within the permissible limits as per IS 10500:2012.

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

Table 4.22 Surface Water Quality in Aizawl in Dry Season

LOCATION: Aizawl			24/05/2022					LIMIT IS: 10500:
SL. NO.	Parameters	Unit	Sample 1 Water Tank	Sample 2 Ground Water	Sample 3 Ground Water	Sample 4 Ground Water	Sample 5 Surface Water	
1	Color	Hazen unit	1	1	1	1	1	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable

LOCATION: Aizawl			24/05/2022					LIMIT IS: 10500:
SL. NO.	Parameters	Unit	Sample 1 Water Tank	Sample 2 Ground Water	Sample 3 Ground Water	Sample 4 Ground Water	Sample 5 Surface Water	
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	PH	value	8.1	8.3	7.2	7.1	8.1	**6.5-8.5**
6	Temperature	Celsius	27.6°C	26.1°C	27.4°C	26.5°C	27.6°C	**-**
7	Total Suspended Solids	mg/1	55	127	35	116	55	**-**
8	Total Dissolved Solids	mg/1	108	134	89	93	108	**500**
9	BOD in mg/1 (5 days 20°C)	mg/1	<1	<1	<1	<1	<1	**-**
10	COD in mg/1	mg/1	<1	<1	<1	<1	<1	**-**
11	Conductivity	µS/cm	0.32	0.19	0.42	0.56	0.32	**-**
12	Alkalinity	mg/1	28	32	22	25	28	**200**
13	Oil & Grease	mg/1	<1	<1	<1	<1	<1	**-**
14	Total Hardness $CaCO_3$	mg/1	44	28	24	Nil	44	**200**
15	Chlorides as (Cl)	mg/1	34	28	22	26	34	**250**
16	Residual free Chlorine	mg/1	<0.1	<0.1	<0.1	<0.1	<0.1	**0.2**
17	Calcium as Ca	mg/1	36	32	18	14	36	**75**
18	Magnesium as	mg/1	19.5	18	12.5	14.5	19.5	**30**
19	Fluoride as F	mg/1	BDL	BDL	BDL	BDL	BDL	**1**
20	Nitrate as NO_3	mg/1	10	10	8	7	10	**45**
21	Sulphates as	mg/1	5.9	5.5	4.9	3.6	5.9	**200**
22	Iron (Fe)	mg/1	0.2	0.3	0.3	0.3	0.2	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	Absent	Absent	Absent	Absent	Absent	**Absent**

Note: <1 indicate No Colony developed in 1 ml.Sample

<10 indicate No Colony developed in 0.1 ml. Sample

<100 indicate No Colony developed in 0.01 ml. Sample

Table 9.11.23 Surface Water Quality in Aizawl in Monsoon Season

LOCATION: Aizawl			9/06/2022 & 17/06/2022					LIMIT IS: 10500: 2012
SL. NO.	Parameters	Unit	Sample 1 Water Tank	Sample 2 Ground Water	Sample 3 Ground Water	Sample 4 Ground Water	Sample 5 Surface Water	
1	Color	Hazen unit	1	1	1	1	1	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	PH	value	8.1	8.3	7.2	7.1	8.1	**6.5-8.5**
6	Temperature	Celsius	27.6°C	26.1°C	27.4°C	26.5°C	27.6°C	**-**
7	Total Suspended	mg/1	55	127	35	116	55	**-**
8	Total Dissolved Solids	mg/1	108	134	89	93	108	**500**
9	BOD in mg/1 (5 days 20°C)	mg/1	<1	<1	<1	<1	<1	**-**
10	COD in mg/1	mg/1	<1	<1	<1	<1	<1	**-**
11	Conductivity	µS/cm	0.32	0.19	0.42	0.56	0.32	**-**
12	Alkalinity	mg/1	28	32	22	25	28	**200**
13	Oil & Grease	mg/1	<1	<1	<1	<1	<1	**-**
14	Total Hardness	mg/1	44	28	24	Nil	44	**200**
15	Chlorides as (Cl)	mg/1	34	28	22	26	34	**250**
16	Residual free Chlorine	mg/1	<1	<1	<1	<1	<1	**0.2**
17	Calcium as Ca	mg/1	36	32	18	14	36	**75**
18	Magnesium as Mg	mg/1	19.5	18	12.5	14.5	19.5	**30**
19	Fluoride as F	mg/1	BDL	BDL	BDL	BDL	BDL	**1**
20	Nitrate as NO_3	mg/1	10	10	8	7	10	**45**
21	Sulphates as (SO_4)	mg/1	5.9	5.5	4.9	3.6	5.9	**200**
22	Iron (Fe)	mg/1	0.2	0.3	0.3	0.3	0.2	**0.3**
23	Total *Coliform*	MPN / 100 ml	Absent	Absent	Absent	Absent	Absent	**Absent**

Note: <1 indicate No Colony developed in 1 ml.Sample

<10 indicate No Colony developed in 0.1 ml. Sample

<100 indicate No Colony developed in 0.01 ml. Sample

(c) Noise

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

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

Table 9.11.28 Ambient Standard for Noise

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

Note: 1. Day time is reckoned in between 6:00 a.m and 10:00 p.m. 2. Night time is reckoned is between 10:00 p.m and 6.00 a.m. 3. Silence Zone is defined as areas upto 100 m around such premises as hospitals, educational, institutions and Courts.

The Silence Zones are to be declared by the competent authority.

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

In the dry season, the maximum Leq was 70.6 and minimum was 53.5 during day time, and the maximum and minimum Leq are 58.5 and 42.3 during night time. The ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change. In the monsoon season, the maximum Leq was 70.7 and minimum was 53.8 during day time. During night time the maximum and minimum Leq are 52.4 and 37.8 respectively. The sampling locations are in the commercial area with activity during the daytime so the ambient sound level are found to be higher.

Table 9.11.31 Noise Level in Dry Season

Sl. No.	Sampling Location	Sampling Date	Ambient Noise Level Leq.dB(A)					
			Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
			L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	Sairang	07/03/2022 to 08/03/2022	54.6	65.7	62.2	42.3	53.7	49.6

Sl. No.	Sampling Location	Sampling Date	Ambient Noise Level Leq.dB(A)					
			Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
			L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
2	Rangvamual	07/03/2022 to 08/03/2022	55.7	70.6	63.5	45.8	58.5	52.5
3	Zamabawk	07/03/2022 to 08/03/2022	53.5	68.6	62.2	46.5	58.5	52.5
	Minimum		53.5	65.7	62.2	42.3	53.7	49.6
	Maximum		55.7	70.6	63.5	46.5	58.5	52.5

Table 9.11.32 Noise Level in Monsoon Season

Sl. No.	Sampling Location	Sampling Date	Ambient Noise Level Leq.dB(A)					
			Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
			L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	Sairang	07/03/2022 to 08/03/2022	55.2	70.7	67.2	43.2	52.4	50.1
2	Rangvamual	07/03/2022 to 08/03/2022	53.8	65.4	59.5	37.8	46.3	45.1
3	Zamabawk	07/03/2022 to 08/03/2022	55.5	65.5	60.8	40.7	46.8	42.1
	Minimum		53.8	65.4	59.5	37.8	46.3	42.1
	Maximum		55.5	70.7	67.2	43.2	52.4	50.1

(d) Vibration

Generally, ground-borne vibration from highway traffic is not an environmental concern unless there is a significant discontinuity in the road surface. Vehicles travel on properly maintained roadways does not generate vibration of concern. Because the net average of vibration signal is zero, the root mean square (rms) amplitude is used to describe the "smoothed" average vibration amplitude. Decibel notation is frequently used to compress the range of rms value used to describe vibration, and rms velocity values used in evaluating human responses are typically expressed in terms of the metric of VdB (velocity level in decibels) The term "VdB" is used to indicate velocity decibel values. The corresponding VdB values of in/sec (rms= root mean square) using a 0 VdB reference value of 1 x 10" 6 cm/sec (rms) (equal to 0.394 x 1CT6 in/sec (rms). When measuring vibration in velocity relative to a chosen reference level, use the term VdB.

$VdB = 20 \log_{10} (Vm/Vr)$

Where:

Vm = measured vibration velocity

Vr = internation reference 1 x 10^{-6} cm / sec (rms) or 0.394 x 10^{-6} in / sec (rms)

= 20 *LOG_{10} (Vm / 0.394*10^{-6})

Reference 0VdB = 0.394 x 10^{-4} in / sec (rms)

= 1X 10^{-6} cm sec (rms)

Table 9.11.39 Vibration Level in Dry Season

Sampling Station	Start Point Sairang 1.5 m(approx.) (From Edge of the Pavement)				End Point Zamabawk 1.5 m(approx.) (From Edge of the Pavement)			
Date of Sampling	07/03/22 to08/03/22	08/03/22 to 09/03/22	10/03/22 to 11/03/22	11/03/22 to12/03/22	07/03/22 to 08/03/22	08/03/22 to 09/03/22	10/03/22 to 11/03/22	11/03/22 to 12/03/22
Duration	Day Time 6hr-22hr		Night Time 22hrs- 6 hrs		Day Time 6hr-22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	2.35	107	0.02	66	1.98	106	0.02	66
Minimum	<0.01	<60	<0.01	<60	<0.01	<60	<0.01	<60

Table 9.11.40 Vibration Level in Monsoon Season

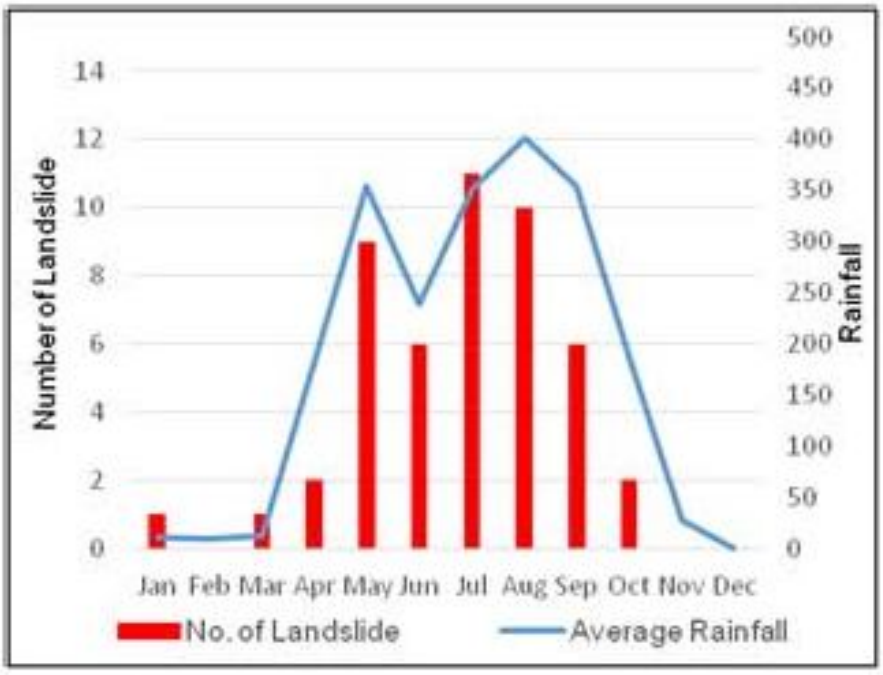
Sampling Station	Start Point Sairang 1.5 m(approx.) (From Edge of the Pavement)				End Point Zamabawk 1.5 m(approx.) (From Edge of the Pavement)			
Date of Sampling	16/05/22 & 17/05/22	17/05/22& 18/05/22	19/05/22& 20/05/22	20/05/22& 21/05/22	16/05/22& 17/05/22	17/05/22& 18/05/22	19/05/22& 20/05/22	20/05/22& 21/05/22
Duration	Day Time 6hr-22hr		Night Time 22hrs- 6 hrs		Day Time 6hr-22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	2.12	107	0.08	78	1.98	106	0.05	74
Minimum	<0.01	<60	<0.01	<60	<0.01	<60	<0.01	<60

(e) Hazards

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

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

These disasters often cause severe disruption in the lifeline, which deprive the local population along NH54 of supply of essential commodities.



Source: JICA Study Team

Figure 9.11.9 Frequency of Landslide in Mizoram

In September 2014, a large landslide occurred near PWD office at Laipuitang in Aizawl and killed 17 people and destroyed 15 houses including PWD office buildings. As above, landslide has often occurred in this area and clearly tends to increase in monsoon season from May to September.

10.SOCIAL ASSESSMENT AND PRELIMINARY LAND ACQUISITION PLAN

10.1. DESCRIPTION OF THE PROJECT ROAD

NH-6 passes through the heart of Aizawl City and pass through its goose neck at Bawngkawn saddle. With the ever increasing traffic volume, the existing road network within and around Aizawl city could no longer accommodate the smooth flow of traffic. No-Entry for Heavy Motor Vehicle has to be introduced during peak hour within Aizawl city which is a big setback for the development of the whole state of Mizoram. Aizawl Municipal area is 150 SqKm having 4.50 lakhs population and still growing. NH-6 within the city is 17.00Kms. Due to these reasons, it was felt absolutely necessary to bypass the Aizawl City.

The proposed realignment of the existing road take off from Sairang on NH 6 and merging with existing road Near Phaibawk Village on NH-6 to avoid the numbers of sharp curve on existing road and to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Aizawl City. It's running from North to south on the Eastern side of the hill.

As proposed Aizawl Bypass passes through Greenfield alignment hence affected households and commercial structures are nil however, agricultural land will be affected.

10.2. OBJECTIVES OF THE RESETTLEMENT ACTION PLAN

The Resettlement Plan has been prepared keeping the following broad objectives:

a. The negative impact on persons affected by the project would be avoided or minimized.
b. Affected people and the beneficiary population will be informed and consulted about the project and its design where the negative impacts are unavoidable.
c. People's participation will be undertaken in planning and implementation of the project.
d. All information related to resettlement plan and implementation will be disclosed to PAPs.

Resettlement action plan (RAP) is based on socio-economic assessments of the potentially affected households, agricultural land and commercial structures due Bypass In view of the human dimension involved the possible social impacts have been integrated into the improved alternative engineering designs to minimize resettlement and displacement. These benefits have been achieved by adopting engineering solutions, like bypasses, raised pavement, and reduced median and road width at congested segments. A key prerequisite of the RAP is a policy framework for resettlement containing categories of impacts and their corresponding entitlements. The RAP provides detailed guidance on how to implement provisions in the policy framework, including institutional arrangements and budgets based on enumeration of project-affected people with entitlements under the framework.

10.3. LAND ACQUISITION AND PROJECT IMPACT

(a) Location and Area

The project road takeoff from Sairang (Km. 163+9000) and merging with existing near Phaibawk village (Km 221+600). The project road passes mainly through Greenfield Alignment entirely in Aizawl District.

(b) Right of Way/Land Requirement

The existing ROW of the project road varies 53 m to 98 m.

Sl.No.	Land Area Details		From	To	Area in Ha
1	Open Area portion	Road portion including part of portal portion	10600	14300	10.515
2		Tunnel portion including part of portal portion (CH:10650 to CH:14050)			***14.400****
3	Muthi Community Reserve Forest		14300	15200	5.922
				Total	**16.437**

***** Area above the Tunnel portion including part of portal portion (CH:10650 to CH:14050) not considered for Land Acquisition.***

(c) Measures to Minimize Impacts

Efforts have been undertaken by adopting appropriate engineering design while finalizing the road alignment to minimize the resettlement impact on the existing structures and additional land acquisition. Public consultations and field visits helped in getting better planning and designing inputs towards minimizing negative social impacts.

(d) Acquisition of Land and Resettlement Principles

For Two laning of the project road, fresh land and structures acquisition will be required. To provide the compensation and other resettlement benefits to the project affected persons, resettlement action plan have been prepared as per National Highways Act (Amendment) 1997 and NRRP 2013.

(e) Utility Shifting

No major utility shifting along the proposed alignment as passes through Greenfield alignment however it will required takeoff point and merging point with existing road.

10.4. CONSULTATION AND DISCLOSURES

A number of public consultations were held with various sections of the project affected population. People in general agreed on the construction of bypasses for avoid the built-up portion which helps them for further expansion of village/town portion. The process of information was highly appreciated by the local inhabitants. During public consultation issues related to safely, compensation, employment generation, information flow, grievance redressal, role of administration etc. were discussed. Issues were also raised about the transparency in the project implementation process.

Aiming at building confidence and good rapport among the potential affected people and to incorporate their feasible needs and suggestions in the design, drainage system and signage at the intersections, etc. the focused group discussions technique was used to elicit their absorbing capacity and the opinions about the project road. The detailed facts and perception of both the likely affected persons (APs) and other stakeholders are given below:

1. Local people are in favour of the project and requested for early completion of the project.
2. Local people wanted to know about the processes and procedures on land acquisition, resettlement, compensation and assistance which will be provided to affected families for land acquisition.
3. People requested to pay compensation for acquired land as per market rate.
4. Local people insisted that construction should be started only after paying compensation and resettlement benefits.
5. Local people were concerned about compensation to be paid to those who are encroachers and squatters living and doing business on the government land along the project road,
6. Most the villagers requested for giving priority in employment for local people.
7. Some people were interested in petty contracts during construction phase.
8. Many local people requested to provide longitudinal drains along the project road, at least in settlement area for proper drainage so that flooding can be avoided during rains.
9. At the time of consultation local people have laid emphasis over safety measures

11.COST ESTIMATES

11.1. GENERAL

The cost estimate presented in this Section is based on the detailed proposals given in the estimate. It is envisaged that the project would involve site clearance, construction of new formations in cutting, slope protection works, cross-drainage structures and bridges, tunnels, pavement, and road furniture etc. The detailed cost estimate presented in this report has been worked out using quantities of different items of work derived from the detailed design, drawing, and unit rates.

Estimation of Quantities

In arriving at the quantities, the following items of civil works have been computed for the total length of the road:

* Earthwork Works
* Slope Protection Works
* Culverts and Bridges Works
* Tunnel Works
* Pavement Works
* Road appurtenances

Detailed estimate of quantities and costs are presented in "Volume – VII: Cost Estimate" of the report. Methodology followed for various items are based on Technical Specifications of Ministry of Road Transport and Highways (MoRT&H) for material laying, its quality, measurements, etc. and it has been illustrated in brief in the subsequent paragraphs.

Earthwork: Earthwork quantities in cutting and small quantities of filling are calculated by highway design software Mx-Road for the entire length of the project road. The formation cutting consists of earth cutting to get a formation width of double lane standard. Cutting has also been proposed in some locations, especially in curves where the existing alignment has been followed to ease the curves while going around spurs. Embankments has also been proposed at some stretches.

The classification of soil in cutting has been made in three categories:

Soil: includes ordinary soil, hard, soil mixed with boulder
Ordinary Rock does not require blasting
Hard Rock requiring blasting.

Locations along the road alignment passing along the above given three were noted down during field surveys and the total quantities of earthwork in cutting have been worked out accordingly.

Slope Protection Works: Quantities for retaining walls, breast walls, parapet walls, toe walls, etc. have been worked out based on the design proposals. Gabion walls have also been proposed at specified locations and quantities have been worked out.

Culverts & Bridges: Quantities of culverts and bridges have been worked out for all the stretches of the road based on the structure proposed at each location of the cross-stream or

river. The proposal also includes quantity for the construction of chutes to protect the adjoining areas from further erosion.

Pavement: The provision for pavement includes different layers of sub-base, base, and surfacing course as appropriate throughout the whole stretch of the road.

The new pavement construction project road Sub-grade having a CBR > 8 % will be taken from borrows area.

- Cement Treated Sub-base (CT): 200.00 mm thick sub-base layer of crushed stone aggregate has been proposed. The sub-base course has been extended up to the edge of the formation. The shoulder portion of 1.50m on both sides of the pavement would also be paved.
- Cement Treated Base (CT): 150.00 mm thick base layer of Cement Treated Base is proposed for 10.0m width.
- Stress Absorbing Membrane (SAM) with crack width 6 mm to 9 mm in one layer.
- DBM of 50mm thick as the surfacing course has been proposed.
- BC of 40mm thick as the surfacing course has been proposed.

  Extra quantities for widening at curves, and major and minor junction locations are calculated separately, and final quantities are worked out.

Tunnel Work: This item includes quantities of Underground excavation, Backfill concrete, Shotcreting, Concrete lining work, Rock bolting, Steel Ribs, contact/ consolidation grouting, Waterproofing, and Jet fans, electric fittings, fire hydrant & water tank, etc based on the Guidelines for Road Tunnels, IRC: SP:91-2019.

Junctions Improvement: This item includes quantities of kerbs, railings, median, etc. at the location of junctions. Other items of road works 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 tailgates 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.

Drainage and Protection work: Provision under this sub-head has been made for surface, subsurface roadside drains, and open Transverse drains on the shoulder. This item covers for unlined, open lined and covered drains.

Project Facilities: provision under this subhead has been made for Truck lay-by & Bus bays with Bus Shelters based on the Manual of Standards & Specifications of two laning, IRC: SP:84-2009.

Miscellaneous Items: Lump sum amounts for cross utility ducts and Planting of trees by the roadside (Avenue trees) have been provided and drainage chutes in cement concrete & stone pitching at outfalls/escapes for drainage in high embankment locations.

Other Charges: Other charges include Centages for the civil works are taken as follows:

- Contingency = 1.0%
- Construction Supervision Charge = 3.0%
- Maintenance for 10Years = 3.75%
- Escalation for 3 Years = 3 x 5.0% =15%
- Agency (NHIDCL) Charge = 3.0 %

Unit Rates

The unit rates for arriving at cost of different components of work are based on Mizoram PWD Schedule of Rates 2016 (for National Highways). For those items of work that are not available in the SOR, separate Analyses of Rates have been carried out and incorporated into this DPR. The following considerations have been made regarding the basic inputs of rate analysis:

- Material
- Labour
- Machineries

Material

The sources of material are as follows:

Bitumen	:	Guwahati, Assam (530.00 Km)
Emulsion	:	Guwahati, Assam (530.00 Km)
Steel	:	Guwahati, Assam (530.00 Km)
Cement	:	Jaintia Hills, Meghalaya (480.00 Km)
Borrow Soil	:	Borrow areas along the project
Aggregates	:	Bung Bangla/Tuirial quarry in Project Corridor
GSB	:	Bung Bangla/Tuirial quarry in Project Corridor
Coarse Sand	:	Tlawng / Tuirial Riverbed Material
Fine Sand	:	Tlawng / Tuirial Riverbed Material

Source	**Jaintia Hills**	**Guwahati**	**Guwahati**	**Guwahati**
Distance	480	530	530	530
Base Location	**Aizawl**	**Aizawl**	**Aizawl**	**Aizawl**
Material	**Cement**	**Steel**	**Bitumen**	**Emulsion**

Source	Jaintia Hills	Guwahati	Guwahati	Guwahati
Basic in Rs.	4950.0	70800.0	58294.0	43240.0
Carriage of Materials in Rs.	4224.0	4664.0	4664.0	4664.0
Total in Rs.	9174.0	75464.0	62958.0	47904.0

Haulage rate for material from Guwahati to Aizawl for the surface road is considered based on Assam PWD SOR 2018-19 i.e Rs.8.80

One Hot Mix Plant has been proposed to be erected at mid of the project road during construction. An Avg. lead of 10.0 km has been assumed from the HMP. The lead considerations for the different

Sr. No.	Material	Unit	Location	Distance
1	Bitumen	Km	Aizawl	10
2	Emulsion	Km	Aizawl	10
3	Steel	Km	Aizawl	10
4	Cement	Km	Aizawl	10
5	Boulder / Masonry Stone	Km	Project Corridor	5
6	HP Pipe	Km	Chawnte	40
7	Aggregates	Km	Bung Bangla / Tuirial quarry	10
8	GSB	Km	Bung Bangla / Tuirial quarry	10
9	Coarse Sand	Km	Tlawng / Tuirial Riverbed	10
10	Fine Sand	Km	Tlawng / Tuirial Riverbed	10

Labour: Labour rates for rate analysis have been based on the Schedule of Rates (SOR) -2016 of Mizoram PWD

Machineries: The rates of machineries have been taken Schedule of Rates (SOR) -2016 of Mizoram PWD

The project cost estimate is prepared based on SOR-2016

In proposed project cost is also included 18% of GST,

As SOR -2016 is already built-up with 6 % of Taxes like Vat, Excise etc. therefore input item 6.0% of taxes excluded and to bring the input items tax-free.

Construction Cost Items

For the construction of the project road, the cost items include various elements, which added together, will give the total cost. The elements of the cost considered for the project are under the following major heads:

* Site Clearance
* Earthwork
* Pavement Works
* Slope Protection Works
* Culverts / Bridges Works

* Tunnel Work
* Miscellaneous Works
* Provisional Sum

Based on the unit rate of various items as per rates adopted as mentioned earlier and quantities calculated, a detailed cost estimate has been prepared under the above-mentioned major heads.

11.2. PROJECT COST

The project cost has been worked out for option of flexible pavement

Sr.No.	Items of work	Total quantity	Unit	Amount
A.	**SITE CLEARANCE**	**TOTAL 'A'**	=	**15,59,484.30**
1	Cutting of Trees	160.00	Nos	1,65,073.00
2	Clearing Grass and Removal of Rubbish	4.60	Km	7,81,103.40
3	Clearing and Grubbing Road Land	14.91	Ha	6,13,307.90
B.	**FORMATION WORK**	**TOTAL 'B'**	**=**	**38,58,92,273.02**
1	Ordinary soil	692670.10	Cum	14,55,71,549.93
2	Soft rock	599576.00	Cum	18,59,64,492.16
3	Hard rock	70267.09	Cum	2,72,63,630.92
4	Construction of Embankment	113355.94	Cum	2,48,24,950.86
5	Preparation of Sub-Grade	7694.05	Cum	42,85,585.85
6	Compacting of OGL supporting subgrade	60912.00	Cum	77,35,824.00
7	Construction of Earthen Shoulders	5583.60	Cum	31,10,065.20
8	Spreading & Compaction of Roadway cutting	931365.70	Cum	1,58,33,216.90
9	Recover	28106.80		-2,86,97,042.80
C.	**PROTECTION WORKS :**	**TOTAL 'C'**	=	**16,45,78,043.80**
1	Vetiver grass	20000.00	Sqm	46,80,000.00
2	Seeding and Mulching	13440.00	Sqm	38,43,840.00
3	Erosion Control Blanket	13440.00	Sqm	90,56,275.20
4	Turfing with Sods	10000.00	Sqm	9,60,000.00
5	Vegetated bamboo crib wall	5000.00	Rm	46,90,000.00
6	Shotcreting with welded wiremesh	525.00	Cum	87,99,525.00
7	25 mm dia. 3 m long steel rock bolts	585.00	Nos	17,78,985.00
8	Retaining wall for 3.0 m Height	80.00	Rm	24,18,078.40
9	Retaining wall for 4.0 m Height	0.00	Rm	0.00
10	Retaining wall for 5.0 m Height	80.00	Rm	50,44,876.00
11	Retaining wall for 6.0 m Height	70.00	Rm	57,36,831.80
12	Gabion RE Wall	6700.00	Sqm	4,70,13,900.00
13	Breast Wall 2.00m high	850.00	Rm	1,30,05,850.00
14	Breast Wall 3.00m high	910.00	Rm	2,44,12,570.00
15	Gabion Wall 2.00 m high	700.00	Rm	84,92,533.00
16	Gabion Wall 3.00 m high	600.00	Rm	1,45,89,408.00
17	Toe Wall 2.00 m high	220.00	Rm	34,42,214.60
18	Toe Wall 3.00 m high	240.00	Rm	66,13,156.80
D.	**DRAINAGE WORKS :**	**TOTAL 'D'**	=	**6,93,79,301.00**

Sr.No.	Items of work	Total quantity	Unit	Amount
a	Concrete lined side drain	2360.00	Rm	51,51,266
b	Catch Water Drain	1410.00	Rm	2,72,130
c	Chute Drain	1050.00	Rm	1,43,37,079
2	**Box Culvert**			
a	Type -1 - 2 x 2	5.00	No	1,98,12,154
b	Type -2 - 3 x 3	2.00	No	1,48,31,144
c	Type -3 - 4 x 4	1.00	No	1,49,75,528
E.	**PAVEMENT WORKS**	**TOTAL 'E'**	=	**12,27,08,993.42**
1	Granular Sub-base	504.00	Cum	17,08,560.00
2	Cement Treated Crushed Rock (CTSB)	7023.23	Cum	2,81,98,268.45
3	Cement Treated Crushed Rock (CTB)	5267.43	Cum	2,04,63,965.55
4	Penetration Coat	35116.20	Sqm	18,26,042.40
5	Stress Absorbing Membrane (SAM)	35116.16	Sqm	50,56,727.04
6	Tack Coat	35116.20	Sqm	8,42,788.80
7	Dense Graded Bituminous Macadam	1755.82	Cum	2,44,39,258.58
8	Bituminous Concrete	1404.65	Cum	2,18,61,972.60
9	Carriage of materials			1,83,11,410.00
F.	**KM STONE & ROAD SIGN**	**TOTAL 'F'**	=	**1,80,42,111.00**
1	Traffic Sign	120.00	Nos	12,30,080.00
2	Pavement marking	3,864.00	Sqm	53,90,280.00
3	Direction and Place Identification signs upto 0.9 sqm size board.	25.00	Sqm	6,75,050.00
4	Boundary stone, km stone,5th km stone, & hectometre stones	44.00	Nos	62,782.00
5	Traffic blinker LED Delineator, stud, reflective payment marker, tree reflector	200.00	Nos	10,24,200.00
6	Road furniture	194.00	Nos	3,02,640.00
7	Cast in Situ Cement Concrete M 20 Kerb	2,450.00	Rm	22,93,200.00
8	Road Amenity	4.00	Nos	22,37,480.00
9	Bus Bay	4.00	Nos	48,26,399.00
G.	**ROAD SAFETY MEASURES**	**TOTAL 'G'**	=	**95,07,000.00**
	Steel Crash Barrier	1500.00	Rm	95,07,000.00
H.	**BRIDGE WORK**	**TOTAL 'I'**	**=**	**20,14,57,831.51**
1	CH: 11+530 (1X8)	Durtlang Lui	Rs.	10,45,94,141.39
2	CH: 14+320 (1X10)	Muthi Lui	Rs.	9,68,63,690.12
I.	**TUNNEL WORK**	**TOTAL 'J'**	**=**	**7,96,47,63,019.67**
	CH:11+600 TO CH:14+100		Rs.	7,96,47,63,019.67
J.	**UTILITY RELOCATION & SHIFTING**	**TOTAL 'K'**	**Rs.**	13,50,000.00
		GRAND TOTAL=	**Rs.**	**8,93,92,38,057.7**
		Say =	**Rs.**	**8,94,00,00,000.0**

The total Project cost for civil construction works and other allied charges is **Rs 1458.14Cr.** which covers costs for formation work, Slope protection and cross drainage works, construction of bridges, construction of tunnels and pavement works. Construction period of 36 months is proposed, considering the quantum of activities to be performed including mobilization period needed and four intervening rainy seasons in between.

ABSTRACT OF COST ESTIMATE

Sr.No.	Items of work	Total quantity	Unit	Amount (Rs)	Share
	CONSTRUCTION COST	4.60	Km		
a	Site Clearance			15,59,484.30	0.017%
b	Formation Works	1362513.19	Cum	38,58,92,273.02	4.317%
c	Protection Works	3750.00	Rm	16,45,78,043.80	1.841%
d	Cross Drainage Works	8.00	Nos	6,93,79,301.00	0.776%
e	Pavement Works	2.10	Km	12,27,08,993.42	1.373%
f	Km Stones & Road Signs		Nos	1,80,42,111.00	0.202%
g	Road Safety Measures	1500.00	Rm	95,07,000.00	0.106%
h	Bridge Work	2	Nos	20,14,57,831.51	2.254%
i	Tunnel	2500	Rm	7,96,47,63,019.67	89.112%
1	**Civil Cost Total of (a to i)**			**8,93,78,88,058**	**100.00%**
2	Cost of utility shifting			13,50,000	
3	**Cost of Civil work i/c utility shifting**			**8,93,92,38,058**	
4	GST @18% on 3			1,60,90,62,850	
5	Cost of LA&RR			58,25,90,704	
6	Forest Clearance			3,11,43,416	
7	Environmental Impact Assessment			23,15,000	
8	Supervision Charge 2.5% of 2 + GST @ 18%			39,825	
9	Contingency @ 1% of 1			8,93,78,881	
10	Agency Charges @ (3% of 1 + 1% of 5) + GST @ 18%			32,32,75,808	
11	Supervision Charge @ 3% of 1			26,81,36,642	
12	Price Adjustment @ 5% per year for 3 years (15% of 1)			1,34,06,83,209	
13	Maintenance for 10 years (0.25% for first 5 years plus 0.50% for last 5 years), total 3.75% of 1 + GST @ 18%			39,55,01,547	
14	**Total Project Cost**			**13,58,13,65,940**	
15	Total Civil Cost per km			**1,94,30,19,143**	
16	Total Project Cost per km			**2,95,24,70,857**	

12.ECONOMIC AND FINANCIAL ANALYSIS

12.1. GENERAL

The project cost and benefits have been estimated for the project analysis period of 30 years, including 2.5 years construction period. At the terminal year of the analysis period a salvage value of 10% has been considered. The social discount rate for the purpose of working out net present value (NPV) is taken at 12%. This is the rate considered for similar kinds of projects in developing countries, and also reflecting the premium on 'decision to invest today' vis-a-vis 'saving it for future consumption'.

Constant base year (Yr. 2022) prices are used for economic evaluation. Since the project costs such as capital, vehicle, consumables, etc., are based on the market prices, these costs have been converted into economic costs by applying appropriate factors established for resource costs. For this, all the costs items (under 'with' and 'without' project cases) estimated at base year prices are adjusted for transfer of payments such as taxes, duties and subsidies on materials and equipment's. Standard conversion factor (SCF) of 0.80 for road construction and for road maintenance has been used for converting the cost estimates at market prices to economic prices. The project capital cost comprises the costs relating to physical works implemented under the project.

12.2. APPROACH

The economic evaluation has been carried out within the broad framework of social cost-benefit analysis. The kernel of the concept of economic feasibility obviously is maximizing the returns on investment. This objective is accomplished by determining the appropriate improvement proposal that leads to the minimum total transport costs, defined as comprising two basic components shown below.

Total Transport Costs

Road Costs	Road User Costs
Construction Maintenance	Vehicle Operating Costs (VOC) Other User Costs (like travel time costs)

The economic analysis has been based on incremental costs and incremental benefits, i.e. comparing the total transport costs "with the Project" and "without the Project", which is the base case or the "do minimum" case. All costs and benefits considered in the study have been valued in monetary terms and expressed in economic prices for avoiding distortion in the input prices of labour, materials, equipment's, equipment and foreign exchange due to market imperfections.

Comparisons between the total transport costs for the project road, section wise for "with the Project" and "without the Project" situations have been worked out on yearly basis for the entire analysis period. The concept behind the approach is that if the Project is implemented, the benefits will be the decreased costs when compared to the costs of the alternative foregone, i.e. the base case or without Project situation. The results have been expressed in terms of Economic Internal Rate of Return (EIRR) and Net Present Value (NPV).

The economic analysis has been carried out using the World Bank developed "Highway Design and Maintenance Standards Model" (HDM) – its latest version HDM-4. The HDM Model has been used for analysing flexible pavement by generating economic cost streams and computing the EIRR and NPV for economic evaluation.

12.3. HDM MODEL INPUT DATA

The main inputs for HDM relate to road and pavement characteristics, traffic volume and its composition, traffic growth rate, vehicle characteristics, pavement construction and maintenance policies. In addition, economic prices for vehicles, tyres and tubes, fuel, maintenance crew labour, passenger time and cargo time have been considered. Fuel prices, particularly diesel and petrol, are "border" prices. For other items these are net of taxes and duties.

12.4. VEHICLE FLEET DATA INPUTS

Vehicle fleet data is used for estimating the operating cost of the vehicles. The inputs relate to vehicle cost, cost of tire, fuel prices, maintenance labor cost, and crew cost, etc., details on vehicle specification and performance. These input costs are given in Table 12.4-1. All the cost items are at economic cost, estimated on the basis of the method described earlier in this chapter.

Table 10.4-1 Unit Economic Cost and Vehicle Fleet Data

Item	Car	Two Wheel	Three Wheel	Bus	Mini Bus	2-Axle Truck	Multi Axle	LCV	Tractor
Vehicle Price (Rs. 000)	420.0	54.0	139.0	924.0	651.0	1008.0	1117.0	680.0	454.0
No. of Wheels	4.0	2.0	3.0	6.0	4.0	6.0	10.0	4.0	4.0
No. of Axles	2.0	2.0	1.0	2.0	2.0	2.0	3.0	2.0	2.0
Passengers	4.0	1.0	3.0	30.0	15.0	-	-	-	-
Tire(Rs.000)	3.3	0.8	1.0	9.2	9.2	9.2	9.2	5.9	9.2
Fuel Per / Lt. (Rs.)	38.6	38.6	38.6	39.8	39.8	39.8	39.8	39.8	39.8
Maint. Labor (Rs. per hr.)	105.0	63.0	105.0	189.0	157.5	189.0	210.0	157.5	210.0
Crew Wages (Rs. per hr)	16.8	0.0	14.7	67.2	41.0	37.8	43.1	28.4	0.0
Annual Overhead (Rs 000)	21.0	0.0	10.5	42.0	31.5	31.5	42.0	31.5	10.5
Interest Rate (%)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Pass. Time Value* (Rs. per / hr.)	80.1	64.0	64.0	53.7	53.7	0.0	0.0	0.0	0.0
PCSE	1.0	0.5	1.0	1.8	1.5	1.8	2.4	1.5	2.4
Working Hours	850.0	240.0	950.0	2200.0	1400.0	2600.0	2800.0	1400.0	650.0
Annual km (000)	40.0	12.0	25.0	75.0	55.0	85.0	85.0	50.0	10.0
Avg. life (Yrs)	8.0	8.0	8.0	8.0	8.0	10.0	10.0	8.0	8.0

Source: Market Survey & Previous Studies in India

12.5. PROJECT COST

The cost estimates for the Aizawl Bypass were prepared by consultant. It may be noted that the proposed construction works is only applicable for construction of Widening existing Road ('with' the project cases) and are not applicable for the base case alternative ('without' the project case).

The first year of construction period is considered as Yr. 2023; with the construction period lasting for 3.0 years (i.e. up to Yr.2027). The opening year of traffic operations is expected to be Yr. 2026. The construction is expected to be completed in a phased manner as indicated as follows.

Table 12.5-1 Investment Schedule for Construction

Construction Year	Percentage Investment
2023 – 24	15%
2024 - 25	60%
2025-26	100%

12.6. MAINTENANCE STANDARDS AND CAPITAL COSTS

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

The capital costs (market prices) for the one package are presented in Table 12.6-1.

Cumulative					
Year	**Physical targets %**	**Construction including centages (Rs. in Crore)**	**Pre-construction activity (Rs. in Crore)**	**Maintenance (Rs. in Crore)**	**Financial progress (Rs. in Crore)**
2023-24	Preliminary	0.000	1.00		1.00
2024-25	15%	137.05	60.74		197.79
2025-26	60%	791.15			791.15
2026-27	100%	1318.59			1318.59
2027-28	100%			2.64	1321.22
2028-29	100%			2.64	1323.86
2029-30	100%			2.64	1326.50
2030-31	100%			2.64	1329.13
2031-32	100%			2.64	1331.77
2032-33	100%			5.27	1337.04
2033-34	100%			5.27	1342.32
2034-35	100%			5.27	1347.59
2035-36	100%			5.27	1352.86
2036-37	100%			5.27	1358.14

The salvage value of 15% of capital cost at the end of the analysis period has been considered.

Routine and Periodic Maintenance Costs

The pavement maintenance costs for flexible pavement have been generated by the HDM Model. Periodic pavement maintenance has been suggested after 10th year other annual routine maintenance costs have been taken @ Rs. 3,19,800.0 per km for two-lane highway. Both routine and periodic maintenance costs have been converted into economic costs by applying the standard conversion factor.

12.7. Project Benefits

The direct benefits of road improvement considered in the study include VOC savings for vehicular traffic using the project road and time savings for passengers and goods (carried) in transit. The benefit streams have been computed annually over the analysis period.

- **VOC Savings**

The unit VOC by vehicle type and VOC savings "with" and "without" the project, section wise, have been computed by the Model. The VOC computation takes into account pavement characteristics, roughness, traffic characteristics, geometric conditions and vehicle characteristics. For flexible pavement, the roughness progression have been estimated by the Model. The unit VOC saving have been taken in full for building up annual streams of VOC savings for the projected volume of traffic.

- **Time Value of Passengers and Goods in Transit**

The HDM Model has generated average speeds in km / hr by vehicle type, in the existing (without Project) and the improved (with Project) road conditions. The time savings for passengers and goods vehicles have been derived using an average occupancy by vehicle type (for vehicle group weighted by their number), such as Car – 3.5 persons, Bus - 40 persons, LCV – 2.1 tonnes, HCV – 6.4 tonnes and MAV -10.68 tonnes.

The value of time for passengers and goods considered in this analysis has been based on earlier studies carried out in recent years. For the average car passenger, time value has been taken as Rs. 40 per hour, and for the average bus passenger as Rs. 15 per hour. The value placed on time is rather on the conservative side. For goods in transit, time value has been worked out using the inventory cost method with a 12% interest rate, considered as an opportunity cost of capital. It worked out to Rs. 15 per tonne per hour.

12.8. ECONOMIC EVALUATION

The economic analysis based on the method elaborated above, allowed the Study Team to obtain the economic indicators for each of the by-passes. The economic indicators such as economic internal rate of return (EIRR) are important for judging the economic feasibility of projects. The annual cost and benefit streams are used to derive the net cash flow for the project. The EIRR is determined using the discounted cash-flow technique for with and without time savings. The results of economic analysis are set out in Table 12.8-1.

Table 12.8-1 Results of Economic Analysis of Aizawl Bypass

Name of Road	EIRR (%)	Cost benefit ratio
NH - 06	12.11%	1.12

The rate of return considered desirable for transport infrastructure projects in India is 12 percent. As EIRR of all the sections and total project road is above 12 percent cut-off rate, the project sections as well as total project road are economically viable. Based on the financial analysis carried out for the road, the project is not viable under Toll (PPP) mode and can be taken up in EPC mode of implementation. The total operational expenditure will not be met from the toll collected. The traffic is very less with the majority of the traffic being non toll-able. Hence, Toll (PPP) mode is not feasible

13.CONCLUSIONS AND RECOMMENDATIONS

13.1. GENERAL

The preceding Chapters of this report well on the various aspects of the study carried out by the Consultants for widening to two laning with geometric improvement of the project road. The status of the project road, the surveys carried out, the proposals, findings of the technical evaluation of widening proposals and the recommendations are summarized in this chapter.

13.2. STATUS OF THE PROJECT ROAD

The road pavement condition has been surveyed and investigated. The pavement condition in carriageway portion is generally fair. The shoulders are damaged at many places. It has been observed that the condition of the pavement is unable to cope up with the current traffic loading. The geometric of the project road is poor.

13.3. IMPROVEMENT PROPOSALS

- Proposed bypass passing through green field land.
- Avoid built Up Areas and seamless Traffic flow without interference from city traffic.
- Reduce Congestion in the built-up Area.
- To enhance Road Safety inside the Built up Areas
- Lesser Cost of Land Acquisition and no serious resettlement problems.
- Provide pavement markings, traffic signs and illumination where warranted
- The design standards have been formulated for design speed of 30-40 kmph, in general. A carriageway of 7.0 m with Paved shoulder.
- Design standards for highway have been framed based on IRC standards, codes, MORT&H circulars and specifications as applicable to national highways for providing the desirable levels of service and safety.
- As completely free land are not available, needs to acquire from the land owners to make the road to two lane having ROW of 24/45 m hilly portion /cutting toe line and a formation width of 12 m.
- Provide pavement markings, traffic signs and illumination where warranted

13.4. PROJECT COST

The cost of construction of 2 Lane Paved shoulder Aizawl bypass including Twin Tube Tunnel, social settlement, and shifting of utilities costs, etc. have been worked out at current rates. The total cost of this stretch works out to Rs1480.96 crores.

13.5. RECOMMENDATIONS

According to the results of traffic study, project costs and economic analyses of the project, EIRR of the project of bypass is work out 12.11% which shows that project is economically viable, and it is proposed to be taken in EPC mode. Based on the financial analysis carried out for the road, the project is not viable under Toll (PPP) mode and can be taken up in EPC mode of implementation. The total operational expenditure will not be met from the toll collected. The traffic is very less with the majority of the traffic being non toll-able. Hence, Toll (PPP) mode is not feasible

COST ESTIMATE FOR PERIODICAL RENEWAL PER KM PER YEAR AS PER SOR NH-2016

DETAILED ESTIMATE

Sl. No./ SOR	Description of item	No	Area (m^2)	Depth (m)	Quantity	Unit	Rate in `	Amount in `
1	*2*	*3*	*4*	*5*	*7*	*6*	*8*	*9*
1/3.12	Scarifying Existing Granular Surface to a Depth of 50 mm by Manual Means (Scarifying the existing granular road surface to a depth of 50 mm and disposal of scarified material within all lifts and leads upto 1000	1	7700.00	-	7700.00	Sqm	52.00	4,00,400.00
2/4.8	Water Bound Macadam (Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with vibratory roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite type of screening/ binding Materials to fill up the interstices of coarse aggregate, watering and compacting to the required density)							
	A) By Manual Means							
	ii) Grading- II							
	b) Using Screening Type-B (11.2mm Agg.)	1	7700.00	0.075	577.50	Cum		
	Adding 10% for profile correction :				57.75	Cum		
	Total				635.25	Cum	4755.00	30,20,614.00
3/5.1	Prime Coat (Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate shown in 500-1 using mechanical means.)							
	i) Low Porosity	1	7700.00	-	7700.00	Sqm	25.00	1,92,500.00
4/5.2	Tack coat (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 kg per sqm on the prepared bituminous/granular surface cleaned with mechanical broom)							
	iii) Granular Surface Treated with Primer	1	7700.00	-	7700.00	Sqm	16.00	1,23,200.00
5/5.2	Tack coat (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 kg per sqm on the prepared bituminous/granular surface cleaned with mechanical broom)							
	ii) Dry and Hungry Bituminous Surface	1	7700.00	-	7700.00	Sqm	14.00	1,07,800.00

Sl. No./ SOR	Description of item	No	Area (m^2)	Depth (m)	Quantity	Unit	Rate in `	Amount in `
6/5.6	Dense Graded Bituminous Macadam (Providing and laying dense bituminous macadam with 100-120 TPH batch type HMP producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder @ 4.0 to 4.5% by weight of total mix of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 507 complete in all respects.)	1	7700.00	0.04	308.00	Cum	11442.00	35,24,136.00
7/5.5	Bituminous Concrete (Providing and laying bituminous concrete with 100-120 TPH batch type hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 to 5.6 % of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 509 complete in all respects) Case I : Using Bitumen 60/70 grade ii) For Grading-II (10mm nominal size)	1	7700.00	0.03	231.00	Cum	12393.00	28,62,783.00
7/3.16	Construction of Subgrade and Earthen Shoulders (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	1	4400.00	0.03	132.00	Cum	619.00	81,708.00
8/3.22	Surface Drains in Soil (Construction of unlined surface drains of average cross sectional area 0.40 sqm in soil to specified lines, grades, levels and dimensions to the requirement of clause 301 and 309. Excavated material to be used in embankment within a lead of 50 metres (average lead 25 metres)) A) Mechanical means	1	1000.00		1000.00	m	56.00	56,000.00
							Construction cost =	**1,03,69,141.00**

Sl. No./ SOR	Description of item			No	Area (m^2)	Depth (m)	Quantity	Unit	Rate in `	Amount in `
Ref Item no	Description	Requirement for	Bitumen	Aggregate	Crushed Sand	Total requirement from estimate				
						Total requirement from estimate		Bitumen	Aggregate	Sand
			ton	m^3	m^3			ton	m^3	m^3
2/4.12	WBM	360 m^3		522.00		635.25	m^3		921.11	
3/5.1	Primer coat	3500 m^2	2.100			7700.00	m^2	4.62		
4/5.2	Tack coat	3500 m^2	1.050			15400.00	m^2	4.62		
5/5.6	DBM	195.00 m^3	19.13	281.50	5.750	308.00	m^3	30.22	444.63	9.08
6/5.8	BC	191.00 m^2	22.50	279.300	5.750	231.00	m^2	27.21	337.79	6.95
							Total requirement for the whole length of the road =	**66.67**	**1703.53**	**16.04**
							Ton/Unit quantity	1	1.74	1.84
							Total weight	**67.00 ton**	**2964.00 ton**	**30.00 ton**
9/1.1	Loading and unloading of stone boulder/stone aggregates						2964.00	Cum	230.00	6,81,720.00
10/1.3	Loading and unloading of sand/ kanker/moorum.						30.00	Tonne	230.00	6,900.00
11/1.4	Loading and Unloading of Bitumen by Manual Means						67.00	Tonne	176.00	11,792.00
12/1.6 & 1.7	Cost of Haulage Excluding Loading and Unloading									
	Total Lead for Agggregate = 100 + 38 = 138 Km									
	Total Lead for Stone Screening = 100 + 38 = 138 Km									
	Total Lead for Bitumen/ Cement = 209+38= 247 Km									
	(i) Surfaced Road				Lead (Km)					
	a) Aggregates :				10.00	x	2964.00	T.Km	11.90	3,52,716.00
	b) Stone Screening :				10.00	x	30.00	T.Km	11.90	3,570.00
	c) Bitumen :				10.00	x	67.00	T.Km	11.90	7,973.00
									Carriage cost :Rs.	**10,64,671.00**
									Say : Rs.	**1,14,33,812.00**

COST ESTIMATE FOR STRENGTHING OF PAVEMENT PER KM PER YEAR AS PER SOR NH-2016

DETAILED ESTIMATE

Sl. No./ SOR	Description of item	No	Area (m^2)	Depth (m)	Quantity	Unit	Rate in `	Amount in `
1	*2*	*3*	*4*	*5*	*7*	*6*	*8*	*9*
1/3.12	Scarifying Existing Granular Surface to a Depth of 50 mm by Manual Means (Scarifying the existing granular road surface to a depth of 50 mm and disposal of scarified material within all lifts and leads upto 1000	1	7700.00	-	7700.00	Sqm	52.00	4,00,400.00
2/4.1	Construction of granular sub-base by providing close graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401	1	12000.00	0.15	1800.00	Cum	3061.00	55,09,800.00
3/4.8	Water Bound Macadam (Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with vibratory roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite type of screening/ binding Materials to fill up the interstices of coarse aggregate, watering and compacting to the required density) A) By Manual Means ii) Grading- II b) Using Screening Type-B (11.2mm Agg.) Adding 10% for profile correction : Total	1	7700.00	0.075	577.50 57.75 635.25	Cum Cum Cum	4755.00	30,20,614.00
4/5.1	Prime Coat (Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate shown in 500-1 using mechanical means.) i) Low Porosity	1	7700.00	-	7700.00	Sqm	25.00	1,92,500.00
5/5.2	Tack coat (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 kg per sqm on the prepared bituminous/granular surface cleaned with mechanical broom) iii) Granular Surface Treated with Primer	1	7700.00	-	7700.00	Sqm	16.00	1,23,200.00

Sl. No./ SOR	Description of item	No	Area (m^2)	Depth (m)	Quantity	Unit	Rate in `	Amount in `
6/5.2	Tack coat (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 kg per sqm on the prepared bituminous/granular surface cleaned with mechanical broom)							
	ii) Dry and Hungry Bituminous Surface	1	7700.00	-	7700.00	Sqm	14.00	1,07,800.00
7/5.6	Dense Graded Bituminous Macadam (Providing and laying dense	1	7700.00	0.04	308.00	Cum	11442.00	35,24,136.00
8/5.5	Bituminous Concrete (Providing and laying bituminous concrete with 100-120 TPH batch type hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 to 5.6 % of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 509 complete in all respects)							
	Case I : Using Bitumen 60/70 grade							
	ii) For Grading-II (10mm nominal size)	1	7700.00	0.03	231.00	Cum	12393.00	28,62,783.00
9/3.16	Construction of Subgrade and Earthen Shoulders (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	1	4400.00	0.03	132.00	Cum	619.00	81,708.00
10/3.22	Surface Drains in Soil (Construction of unlined surface drains of average cross sectional area 0.40 sqm in soil to specified lines, grades, levels and dimensions to the requirement of clause 301 and 309. Excavated material to be used in embankment within a lead of 50 metres (average lead 25 metres))							
	A) Mechanical means	1	1000.00		1000.00	m	56.00	56,000.00
							Construction cost =	**1,58,78,941.00**

Sl. No./ SOR	Description of item			No	Area (m^2)	Depth (m)	Quantity	Unit	Rate in `	Amount in `
Ref Item no	Description	Requirement for	Bitumen	Aggregate	Crushed Sand	Total requirement from estimate				
						Total requirement from estimate		Bitumen	Aggregate	Sand
			ton	m^3	m^3			ton	m^3	m^3
	GSB (Drainage layer)	225 m^3		201.00	86.40	1800.00	m^3		1608.00	691.20
2/4.12	WBM	360 m^3		522.00		635.25	m^3		921.11	
3/5.1	Primer coat	3500 m^2	2.100			7700.00	m^2	4.62		
4/5.2	Tack coat	3500 m^2	1.050			15400.00	m^2	4.62		
5/5.6	DBM	195.00 m^3	19.13	281.50	5.750	308.00	m^3	30.22	444.63	9.08
6/5.8	BC	191.00 m^2	22.50	279.300	5.750	231.00	m^2	27.21	337.79	6.95
Total requirement for the whole length of the road =								**66.67**	**3311.53**	**707.24**
						Ton/Unit quantity		1	1.74	1.84
						Total weight		**67.00 ton**	**5762.00 ton**	**1301.00 ton**
11/1.1	Loading and unloading of stone boulder/stone aggregates						5762.00	Cum	230.00	13,25,260.00
12/1.3	Loading and unloading of sand/ kanker/moorum.						1301.00	Tonne	230.00	2,99,230.00
13/1.4	Loading and Unloading of Bitumen by Manual Means						67.00	Tonne	176.00	11,792.00
14/1.6 & 1.7	Cost of Haulage Excluding Loading and Unloading									
	Total Lead for Agggregate = 100 + 38 = 138 Km									
	Total Lead for Stone Screening = 100 + 38 = 138 Km									
	Total Lead for Bitumen/ Cement = 209+38= 247 Km									
	(i) Surfaced Road				Lead (Km)					
	a) Aggregates :				10.00	x	5762.00	T.Km	11.90	6,85,678.00
	b) Stone Screening :				10.00	x	1301.00	T.Km	11.90	1,54,819.00
	c) Bitumen :				10.00	x	67.00	T.Km	11.90	7,973.00

Carriage cost :Rs. 24,84,752.00

Say : Rs. 1,83,63,693.00

ESTIMATE FOR MAINTENANCE OF NATIONAL HIGHWAY PER KILOMETRE UP TO THE THIRD YEAR (SOR 2016)

Length = 1000.00 m

Width = 7.00 m

Total Area = 7000.00 m^2

Sl.No	Item	Unit	Rate (Rs.)	Length (m)	Width (m)	Thickness(m)	Quantity	Amount(Rs.)
1/10.2	Maintenance of earthen shoulder							
	Valley side	m^2	116.00	1000.00	2.50		2500.00	
	Hill side			1000.00	1.90		1900.00	
						Sub total	**4400.00**	**510400.00**
2/10.4	Filling pot holes and patch repair with OGPMC	m^2	375.00				7000.00	2625000.00
3/10.8D	Surface Dressing by 19mm nominal chipping size	m^2	128.00				7000.00	896000.00
						Sub total (A)		**4031400.00**
4/2.3	Clearing and Grubbing Road land (average height upto 4m)	Ha	107954.00	1000.00	4.00		0.40	43181.60
5/10.11	Hill side drain clearance	Rm	75.00	1000.00				75000.00
						Sub total (B)		**118181.60**
						Grant Total		**4149581.60**

Cost of Maintenance of Flexible pavement per kilometre upto third year

Sl.No	Description	Cost / Km (Rs.)	Remark
1	First year (5% of sub-Total A plus sub-Total B)	319800.00	Rate Escalation @ 10% per annum is assumed)
2	Second year (15% of sub-Total A plus sub-Total B)	795200.00	
3	Third year (25% of sub-Total A plus sub-Total B)	1351200.00	

LIFE CYCLE COST ANALYSIS
MAINTENANCE COST NATIONAL HIGHWAY PER KILOMETRE PER YEAR

Sl.No	Description	Maintenance cost/km/year (Rs.)	Remark
		Flexible Pavement	
1	Year 1	0	Construction period
2	Year 2	0	
3	Year 3	0	
4	Year 4	0	Maintenance period by contractor under the contract
5	Year 5 (Normal Maintenance)	0	
6	Year 6 (Normal Maintenance)	0	
7	Year 7 (Normal Maintenance)	0	
8	Year 8 (Normal Maintenance)	0	
9	Year 9 (Normal Maintenance)	3,19,800.00	Same escalation @ 10% per annum is assumed for both Flexible and Rigid pavements for the sake of comparision. Normal maintenance for year 5 is from year 1, year 6 is from year 2 and year 7 is from year 3. Similarly, The year 8 PR is from year 4. The pattern is repeated through out the life cycle of flexible pavement
10	Year 10 (Normal Maintenance)	7,95,200.00	
11	Year 11 (Normal Maintenance)	13,51,200.00	
12	Year 12 (Normal Maintenance)	13,51,200.00	
13	**Year 13 (Periodic Renewal)**	**1,14,33,812.00**	
14	Year 14 (Normal Maintenance)	4,79,700.00	
15	Year 15 (Normal Maintenance)	12,72,320.00	
16	Year 16 (Normal Maintenance)	22,97,040.00	
17	Year 17 (Normal Maintenance)	24,32,160.00	
18	**Year 18 (Periodic Renewal)**	**1,60,07,336.80**	
19	Year 19 (Normal Maintenance)	7,19,550.00	
20	Year 20 (Normal Maintenance)	20,35,712.00	
21	Year 21 (Normal Maintenance)	39,04,968.00	
22	Year 22 (Normal Maintenance)	41,34,672.00	
22	**Year 23 (Strengthening)**	**1,83,63,693.00**	
	Total of Maintenance cost / km	6,68,98,363.80	
	For total length (4.6 km)	**30,77,32,473.48**	

	LIFE CYCLE COST COMPARISION OF FLEXIBLE AND RIGID PAVEMENT		
Sl.No	**Type of Pavement**	**Construction cost (Rs.)**	
1	2	3	5
1	Construction cost	19,30,89,98,317.00	
2	Maintenance cost	30,77,32,473.48	
3	Life cycle cost difference	19,61,67,30,790.48	

EQUIVALENT ANNUAL COST ANALYSIS

(This analysis is done to compare projects with different Economic lives)

a)	Discount rate (%) =		12	(as per para 7.8 of IRC : SP-30:2001		
	(1+i)=		1.12			
b)	Salvage value =		Zero in both the proposals			
Proposal-I : Flexible Pavement						
1	Design Life	20	yrs			
2	Investment (`)	193089.98	lakh			
	Present Value (PV)					
	$PV_{cost} = PV_{investment} + PV_{maintenance}$				**Conclusion**	
	$(Pv_{investment})^0$	193089.98				
		Flexible				
	Year	$PV_{maintenance}$	Rs lakh / km / year		From the Equivalent Annual Cost analysis, it is evident that, the Capital recovery factor (CRF), which is apportioning the present value investment amount into an annuity, it is far advantageous with Rigid pavement over Flexible pavement. For the same purpose the two proposals are intended to serve, present value investment in annuity is lower with the Rigid pavement than that of Flexible pavement.	
	1	0.00				
	2	0.00				
	3	0.00				
	4	0.00				
	5	0.00				
	6	0.00				
	7	0.00				
	8	0.00				
	9	0.33				
	10	0.82				
	11	1.40				
	12	1.40				
	13	11.85				
	14	0.50				
	15	1.32				
	16	2.38				
	17	2.52				
	18	16.59				
	19	0.75				
	20	2.11				
	21	4.05				
	22	4.29				
	Sub-Total	50.31				
	PV_{cost}	193140.30				
I	Equivalent Annual Cost of Flexible = PV cost / $(PV)^{15}_{12\%}$					
		Rs.	**20022.23**		**lakh per year**	

INTERNAL RATE OF RETURN (IRR) ANALYSIS

1	TRAFFIC IN 2015							A-III
	Type of Vehicle			**ADT (existing)**		**% Bypassable**	**ADT (Bypass)**	**Balance on existing**
	Car (New Technology)			1881		63	1185	696
	LCV			834		80	700	134
	HCV			384		71	384	0
	Bus			111		75	80	31
	MAV			141		71	100	41
	Two Wheelers			3381		50	1690	1691

2	Traffic Growth Rate =	7.50%		
3	BREAKUP OF CONSTRUCTION COST			
	Total cost `	2574.06	Cr (Flexible)	
	2023-2024	20%	514.812	
	2024-2025	60%	1029.624	
	2025-2026	100%	1029.624	
4	Maintenance cost of Existing Flexible pavement for 15 yrs (in lakh)= Rs.		20022.23	perkm / year
5	Assuming 5% reduction after bypass constrcution = Rs.		19021.12	perkm / year
6	Assuming 95% reduction for new bypass maintenance=Rs.		1001.11	perkm / year
7	Length of Existing road		56.4	km
8	Length of proposed by-pass		34.5	km
9	The Road is through hilly terrain.			
10	Traffic volume in terms of PCUs per day			

	Type of Vehicle	**Equivalency Factor**	**Existing (Case-1)**	**Balance on existing (Case-2)**	**Bypass (Case-3)**
	Car (New Technology)	1	1881	695.97	1185.03
	LCV	1.5	1251	201	1050
	HCV	3	1152	0	1152
	Bus	3	333	93	240
	MAV	4.5	634.5	184.5	450
	Two Wheelers	0.5	1690.5	845.5	845
	Total		**6942**	**2020**	**4922.03**

10	Assuming 10% of total daily traffic to represent the peak hourly traffic			
	PCU / hr	Case-1	694	
	PCU / hr	Case-2	202	
	PCU / hr	Case-3	492	
11	Maximum Capacity of 2-lane road in Hilly terrain		6000	(Both dir)
12	NTC=	New Technology Cars		
	LCV =	Light Commercial Vehicles		
	HCV =	Heavy Commercial Vehicles (2-Axle)		
	MAV =	Multi-Axial Vehicles		
	TW=	Two Wheelers		
	VCR =	Volume / Capacity Ration		
		(PCU / hr) / Maximum Capacity but not more than 1		
13	Traffic Growth Rate =	$P(1+r)^n$		
		r =	0.1	
		n =	No of years	

TRAFFIC DATA ON EXISTING ROAD " FOR DO NOTHING" (CASE-1)

Year	n	NTC	LCV	HCV	BUS	MAV	TW	PCU/hr	VCR
2022	0	1881	834	384	111	141	3381	694	0.12
2023	1	2069	917	422	122	155	3719	764	0.13
2024	2	2276	1009	465	134	171	4091	840	0.14
2025	3	2504	1110	511	148	188	4500	924	0.15
2026	4	2754	1221	562	163	206	4950	1016	0.17
2027	5	3029	1343	618	179	227	5445	1118	0.19
2028	6	3332	1477	680	197	250	5990	1230	0.20
2029	7	3666	1625	748	216	275	6589	1353	0.23
2030	8	4032	1788	823	238	302	7247	1488	0.25
2031	9	4435	1967	905	262	332	7972	1637	0.27
2032	10	4879	2163	996	288	366	8769	1801	0.30
2033	11	5367	2379	1096	317	402	9646	1981	0.33
2034	12	5903	2617	1205	348	443	10611	2179	0.36
2035	13	6494	2879	1326	383	487	11672	2397	0.40
2036	14	7143	3167	1458	422	535	12839	2636	0.44
2037	15	7857	3484	1604	464	589	14123	2900	0.48
2038	16	8643	3832	1764	510	648	15536	3190	0.53
2039	17	9507	4215	1941	561	713	17089	3509	0.58
2040	18	10458	4637	2135	617	784	18798	3860	0.64
2041	19	11504	5101	2349	679	862	20678	4246	0.71
2042	20	12654	5611	2583	747	949	22746	4670	0.78
2043	21	13920	6172	2842	821	1043	25020	5137	0.86

TRAFFIC DATA ON BALANCE TRAFFIC USING EXISTING ROAD ROAD AFTER CONSTRUCTION (CASE-2)									
Year	n	NTC	LCV	HCV	BUS	MAV	TW	PCU / hr	VCR
2022	0	1881	834	384	111	141	3381	694	0.12
2023	1	2069	917	422	122	155	3719	764	0.13
2024	2	2276	1009	465	134	171	4091	840	0.14
2025	3	926	178	0	41	55	2251	269	0.04
2026	4	1019	196	0	45	60	2476	296	0.05
2027	5	1121	216	0	50	66	2723	325	0.05
2028	6	1233	237	0	55	73	2996	358	0.06
2029	7	1356	261	0	60	80	3295	394	0.07
2030	8	1492	287	0	66	88	3625	433	0.07
2031	9	1641	316	0	73	97	3987	476	0.08
2032	10	1805	348	0	80	106	4386	524	0.09
2033	11	1986	382	0	88	117	4825	576	0.10
2034	12	2184	421	0	97	129	5307	634	0.11
2035	13	2403	463	0	107	142	5838	697	0.12
2036	14	2643	509	0	118	156	6422	767	0.13
2037	15	2907	560	0	129	171	7064	844	0.14
2038	16	3198	616	0	142	188	7770	928	0.15
2039	17	3518	677	0	157	207	8547	1021	0.17
2040	18	3870	745	0	172	228	9402	1123	0.19
2041	19	4256	820	0	190	251	10342	1235	0.21
2042	20	4682	901	0	209	276	11376	1359	0.23
2043	21	5150	992	0	229	303	12514	1495	0.25

TRAFFIC DATA ON BYPASS ROAD AFTER CONSTRUCTION (CASE-3)									
Year	**n**	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**	**PCU/hr**	**VCR**
2022	0	0	0	0	0	0	0	0	0.00
2023	1	0	0	0	0	0	0	0	0.00
2024	2	0	0	0	0	0	0	0	0.00
2025	3	0	0	0	0	0	0	0	0.00
2026	4	0	0	0	0	0	0	0	0.00
2027	5	0	0	0	0	0	0	0	0.00
2028	6	2099	1240	680	142	177	2994	872	0.15
2029	7	2309	1364	748	156	195	3293	959	0.16
2030	8	2540	1501	823	171	214	3623	1055	0.18
2031	9	2794	1651	905	189	236	3985	1161	0.19
2032	10	3074	1816	996	207	259	4383	1277	0.21
2033	11	3381	1997	1096	228	285	4822	1404	0.23
2034	12	3719	2197	1205	251	314	5304	1545	0.26
2035	13	4091	2417	1326	276	345	5834	1699	0.28
2036	14	4500	2658	1458	304	380	6418	1869	0.31
2037	15	4950	2924	1604	334	418	7060	2056	0.34
2038	16	5445	3216	1764	368	459	7766	2262	0.38
2039	17	5990	3538	1941	404	505	8542	2488	0.41
2040	18	6589	3892	2135	445	556	9396	2737	0.46
2041	19	7248	4281	2349	489	612	10336	3010	0.50
2042	20	7972	4709	2583	538	673	11369	3311	0.55
2043	21	8770	5180	2842	592	740	12506	3642	0.61

CALCULATION OF CONGESTION FACTORS (CF)

Congestion factor Minimum value is 1 and Maximum Value is 2

Congestion factor for the Peak hour Traffic = 0.8

1. Distance related congestion factor						
i)	NTC	CF=	1.0	+	0.10	VCR
ii)	LCV	CF=	0.9	+	0.35	VCR
iii)	HCV	CF=	0.9	+	0.35	VCR
iv)	BUS	CF=	0.9	+	0.35	VCR
v)	MAV	CF=	0.9	+	0.45	VCR

Case-1

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.00	1.00	1.00	1.00	1.00	1.00
2023	1.00	1.00	1.00	1.00	1.00	1.00
2024	1.00	1.00	1.00	1.00	1.00	1.00
2025	1.00	1.00	1.00	1.00	1.00	1.00
2026	1.00	1.00	1.00	1.00	1.00	1.00
2027	1.00	1.00	1.00	1.00	1.00	1.00
2028	1.00	1.00	1.00	1.00	1.00	1.00
2029	1.00	1.00	1.00	1.00	1.00	1.00
2030	1.00	1.00	1.00	1.00	1.00	1.00
2031	1.00	1.00	1.00	1.00	1.00	1.00
2032	1.00	1.00	1.00	1.00	1.00	1.00
2033	1.00	1.00	1.00	1.00	1.00	1.00
2034	1.00	1.00	1.00	1.00	1.00	1.00
2035	1.00	1.00	1.00	1.00	1.00	1.00
2036	1.00	1.00	1.00	1.00	1.00	1.00
2037	1.00	1.00	1.00	1.00	1.00	1.00
2038	1.00	1.00	1.00	1.00	1.00	1.00
2039	1.00	1.00	1.00	1.00	1.00	1.00
2040	1.00	1.00	1.00	1.00	1.00	1.00
2041	1.00	1.00	1.00	1.00	1.00	1.00
2042	1.00	1.00	1.00	1.00	1.25	1.00
2043	1.00	1.00	1.00	1.00	1.29	1.00

Case-2

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.00	1.00	1.00	1.00	1.00	1.00
2023	1.00	1.00	1.00	1.00	1.00	1.00
2024	1.00	1.00	1.00	1.00	1.00	1.00
2025	1.00	1.00	1.00	1.00	1.00	1.00
2026	1.00	1.00	1.00	1.00	1.00	1.00
2027	1.00	1.00	1.00	1.00	1.00	1.00
2028	1.00	1.00	1.00	1.00	1.00	1.00
2029	1.00	1.00	1.00	1.00	1.00	1.00
2030	1.00	1.00	1.00	1.00	1.00	1.00
2031	1.00	1.00	1.00	1.00	1.00	1.00
2032	1.00	1.00	1.00	1.00	1.00	1.00
2033	1.00	1.00	1.00	1.00	1.00	1.00
2034	1.00	1.00	1.00	1.00	1.00	1.00
2035	1.00	1.00	1.00	1.00	1.00	1.00
2036	1.00	1.00	1.00	1.00	1.00	1.00
2037	1.00	1.00	1.00	1.00	1.00	1.00
2038	1.00	1.00	1.00	1.00	1.00	1.00
2039	1.00	1.00	1.00	1.00	1.00	1.00
2040	1.00	1.00	1.00	1.00	1.00	1.00
2041	1.00	1.00	1.00	1.00	1.00	1.00
2042	1.00	1.00	1.00	1.00	1.00	1.00
2043	1.00	1.00	1.00	1.00	1.00	1.00

Case-3

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.00	1.00	1.00	1.00	1.00	1.00
2023	1.00	1.00	1.00	1.00	1.00	1.00
2024	1.00	1.00	1.00	1.00	1.00	1.00
2025	1.00	1.00	1.00	1.00	1.00	1.00
2026	1.00	1.00	1.00	1.00	1.00	1.00
2027	1.00	1.00	1.00	1.00	1.00	1.00
2028	1.00	1.00	1.00	1.00	1.00	1.00
2029	1.00	1.00	1.00	1.00	1.00	1.00
2030	1.00	1.00	1.00	1.00	1.00	1.00
2031	1.00	1.00	1.00	1.00	1.00	1.00
2032	1.00	1.00	1.00	1.00	1.00	1.00
2033	1.00	1.00	1.00	1.00	1.00	1.00
2034	1.00	1.00	1.00	1.00	1.00	1.00
2035	1.00	1.00	1.00	1.00	1.00	1.00
2036	1.00	1.00	1.00	1.00	1.00	1.00
2037	1.00	1.00	1.00	1.00	1.00	1.00
2038	1.00	1.00	1.00	1.00	1.00	1.00
2039	1.00	1.00	1.00	1.00	1.00	1.00
2040	1.00	1.00	1.00	1.00	1.00	1.00
2041	1.00	1.00	1.00	1.00	1.00	1.00
2042	1.00	1.00	1.00	1.00	1.00	1.00
2043	1.00	1.00	1.00	1.00	1.00	1.00

2 Time related congestion factor

i)	V_{CN}	=	72.63	-	0.017	Q
ii)	V_{LCV}	=	56.07	-	0.013	Q
iii)	V_T	=	46.58	-	0.008	Q
iv)	V_{MAV}	=	35.40	-	0.006	Q
v)	V_B	=	52.76	-	0.013	Q
vi)	V_{TW}	=	40.75	-	0.007	Q

Where Q=PCU / hr

CF= Intercept of the above equation / Speed (Calculated from the equation)

Calculation of Speed

Case-1

year	V_{CN}	V_{LCV}	V_T	V_{MAV}	V_B	V_{TW}
2022	60.83	47.05	41.03	31.23	43.74	35.89
2023	59.65	46.14	40.47	30.82	42.83	35.40
2024	58.35	45.15	39.86	30.36	41.84	34.87
2025	56.92	44.06	39.19	29.86	40.75	34.28
2026	55.35	42.86	38.45	29.30	39.55	33.64
2027	53.62	41.54	37.64	28.69	38.23	32.92
2028	51.72	40.08	36.74	28.02	36.77	32.14
2029	49.63	38.48	35.76	27.28	35.17	31.28
2030	47.33	36.72	34.68	26.47	33.41	30.33
2031	44.80	34.79	33.48	25.58	31.48	29.29
2032	42.02	32.66	32.18	24.60	29.35	28.15
2033	38.96	30.32	30.73	23.52	27.01	26.89
2034	35.59	27.75	29.15	22.33	24.44	25.50
2035	31.89	24.91	27.41	21.02	21.60	23.97
2036	27.81	21.80	25.49	19.58	18.49	22.30
2037	23.33	18.37	23.38	18.00	15.06	20.45
2038	18.40	14.60	21.06	16.26	11.29	18.42
2039	12.98	10.46	18.51	14.35	7.15	16.19
2040	7.02	5.89	15.70	12.24	2.58	13.73
2041	0.45	0.88	12.61	9.93	-2.43	11.03
2042	-6.76	-4.64	9.22	7.38	-7.95	8.06
2043	-14.70	-10.71	5.48	4.58	-14.02	4.79

Case-2

year	V_{CN}	V_{LCV}	V_T	V_{MAV}	V_B	V_{TW}
2022	60.83	47.05	41.03	31.23	43.74	35.89
2023	59.65	46.14	40.47	30.82	42.83	35.40
2024	58.35	45.15	39.86	30.36	41.84	34.87
2025	68.06	52.57	44.43	33.79	49.26	38.87
2026	67.60	52.23	44.21	33.63	48.92	38.68
2027	67.10	51.84	43.98	33.45	48.53	38.47
2028	66.55	51.42	43.72	33.25	48.11	38.25
2029	65.94	50.95	43.43	33.04	47.64	37.99
2030	65.27	50.44	43.12	32.80	47.13	37.72
2031	64.53	49.88	42.77	32.54	46.57	37.42
2032	63.72	49.26	42.39	32.26	45.95	37.08
2033	62.83	48.58	41.97	31.94	45.27	36.72
2034	61.85	47.83	41.51	31.60	44.52	36.31
2035	60.78	47.00	41.00	31.22	43.69	35.87
2036	59.59	46.10	40.44	30.80	42.79	35.38
2037	58.29	45.10	39.83	30.34	41.79	34.84
2038	56.85	44.00	39.15	29.83	40.69	34.25
2039	55.27	42.80	38.41	29.27	39.49	33.60
2040	53.54	41.47	37.60	28.66	38.16	32.89
2041	51.63	40.01	36.70	27.99	36.70	32.10
2042	49.53	38.40	35.71	27.25	35.09	31.24
2043	47.22	36.64	34.62	26.43	33.33	30.29

Case-3

year	V_{CN}	V_{LCV}	V_T	V_{MAV}	V_B	V_{TW}
2022	72.63	56.07	46.58	35.40	52.76	40.75
2023	72.63	56.07	46.58	35.40	52.76	40.75
2024	72.63	56.07	46.58	35.40	52.76	40.75
2025	72.63	56.07	46.58	35.40	52.76	40.75
2026	72.63	56.07	46.58	35.40	52.76	40.75
2027	72.63	56.07	46.58	35.40	52.76	40.75
2028	57.81	44.73	39.60	30.17	41.42	34.65
2029	56.32	43.60	38.91	29.65	40.29	34.04
2030	54.69	42.35	38.14	29.07	39.04	33.36
2031	52.90	40.98	37.30	28.44	37.67	32.63
2032	50.93	39.47	36.37	27.74	36.16	31.81
2033	48.76	37.81	35.35	26.97	34.50	30.92
2034	46.37	35.99	34.22	26.13	32.68	29.94
2035	43.74	33.98	32.99	25.20	30.67	28.86
2036	40.85	31.77	31.63	24.19	28.46	27.67
2037	37.68	29.34	30.13	23.06	26.03	26.36
2038	34.18	26.67	28.49	21.83	23.36	24.92
2039	30.34	23.73	26.68	20.47	20.42	23.34
2040	26.11	20.49	24.69	18.98	17.18	21.59
2041	21.46	16.94	22.50	17.34	13.63	19.68
2042	16.34	13.02	20.09	15.53	9.71	17.57
2043	10.71	8.72	17.44	13.55	5.41	15.25

Time related Congestion factor

Case-1

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.00	1.00	1.00	1.00	1.00	1.00
2023	1.00	1.00	1.00	1.00	1.00	1.00
2024	1.00	1.00	1.00	1.00	1.00	1.00
2025	1.00	1.00	1.00	1.00	1.00	1.00
2026	1.00	1.00	1.00	1.00	1.00	1.00
2027	1.00	1.00	1.00	1.00	1.00	1.00
2028	1.00	1.00	1.00	1.00	1.00	1.00
2029	1.00	1.00	1.00	1.00	1.00	1.00
2030	1.00	1.00	1.00	1.00	1.00	1.00
2031	1.00	1.00	1.00	1.00	1.00	1.00
2032	1.00	1.00	1.00	1.00	1.00	1.00
2033	1.00	1.00	1.00	1.00	1.00	1.00
2034	1.00	1.00	1.00	1.00	1.00	1.00
2035	1.00	1.00	1.00	1.00	1.00	1.00
2036	1.00	1.00	1.00	2.97	1.00	1.00
2037	2.49	3.16	1.00	3.23	1.00	1.00
2038	3.16	3.98	1.00	3.57	1.00	1.00
2039	4.48	5.56	1.00	2.00	1.00	1.00
2040	8.28	9.86	3.70	2.00	22.49	4.23
2041	128.06	66.30	4.61	2.00	1.00	5.27
2042	1.00	1.00	6.30	2.00	1.00	7.21
2043	1.00	1.00	10.60	2.00	1.00	12.13

Case-2

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.00	1.00	1.00	1.00	1.00	1.00
2023	1.00	1.00	1.00	1.00	1.00	1.00
2024	1.00	1.00	1.00	FALSE	1.00	1.00
2025	1.00	1.00	1.00	1.00	1.00	1.00
2026	1.00	1.00	1.00	1.00	1.00	1.00
2027	1.00	1.00	1.00	1.00	1.00	1.00
2028	1.00	1.00	1.00	1.00	1.00	1.00
2029	1.00	1.00	1.00	1.00	1.00	1.00
2030	1.00	1.00	1.00	1.00	1.00	1.00
2031	1.00	1.00	1.00	1.00	1.00	1.00
2032	1.00	1.00	1.00	1.00	1.00	1.00
2033	1.00	1.00	1.00	1.00	1.00	1.00
2034	1.00	1.00	1.00	1.00	1.00	1.00
2035	1.00	1.00	1.00	1.00	1.00	1.00
2036	1.00	1.00	1.00	1.00	1.00	1.00
2037	1.00	1.00	1.00	1.00	1.00	1.00
2038	1.00	1.00	1.00	1.00	1.00	1.00
2039	1.00	1.00	1.00	1.00	1.00	1.00
2040	1.00	1.00	1.00	1.00	1.00	1.00
2041	1.00	1.00	1.00	1.00	1.00	1.00
2042	1.00	1.00	1.00	1.00	1.00	1.00
2043	1.00	1.00	1.00	1.00	1.00	1.00

Case-3

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.00	1.00	1.00	1.00	1.00	1.00
2023	1.00	1.00	1.00	1.00	1.00	1.00
2024	1.00	1.00	1.00	1.00	1.00	1.00
2025	1.00	1.00	1.00	1.00	1.00	1.00
2026	1.00	1.00	1.00	1.00	1.00	1.00
2027	1.00	1.00	1.00	1.00	1.00	1.00
2028	1.00	1.00	1.00	1.00	1.00	1.00
2029	1.00	1.00	1.00	1.00	1.00	1.00
2030	1.00	1.00	1.00	1.00	1.00	1.00
2031	1.00	1.00	1.00	1.00	1.00	1.00
2032	1.00	1.00	1.00	1.00	1.00	1.00
2033	1.00	1.00	1.00	1.00	1.00	1.00
2034	1.00	1.00	1.00	1.00	1.00	1.00
2035	1.00	1.00	1.00	1.00	1.00	1.00
2036	1.00	1.00	1.00	1.00	1.00	1.00
2037	1.00	1.00	1.00	1.00	1.00	1.00
2038	1.00	1.00	1.00	1.00	1.00	1.00
2039	1.00	1.00	1.00	1.00	1.00	1.00
2040	1.00	1.00	1.00	1.00	1.00	1.00
2041	1.00	1.00	1.00	3.10	1.00	1.00
2042	3.24	2.10	1.00	4.35	1.00	1.00
2043	4.84	2.42	1.00	7.80	1.00	1.00

VEHICLE OPERATING COST (Flexible)

VOC = VOC for uncongested condition X Congestion factor

RF factor for hilly terrain (30-50) = 40.00

Roughness = 4000mm/km

Length of existing Road 56.4 Km Length of bypass 34.5 Km

1	Distance related economic costs (Rs/km)						
		NTC	LCV	HCV	BUS	MAV	TW
i)	Fuel	0.71	0.68	0.78	0.72	1.89	0.22
ii)	Tyre	0.06	0.43	1.09	1.07	1.81	0.01
iii)	Lubricants	0.03	0.01	0.02	0.01	0.02	0.03
iv)	Spares	0.16	0.19	0.22	0.34	0.38	0.06
v)	Maintenance	0.14	0.08	0.11	0.19	0.22	0.04
	Total	1.1	1.39	2.22	2.33	4.32	0.36
2	Time related economic cost (Rs/km)						
		NTC	LCV	HCV	BUS	MAV	TW
i)	Fixed cost	0.8	3.13	2.16	1.29	3.47	0.31
ii)	Depreciation	0.08	0.19	0.33	0.27	0.7	0.04
	Total	0.88	3.32	2.49	1.56	4.17	0.35

3 Distance related VOC (Rs/km)

Case-1						
Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.1	1.39	2.22	2.33	4.32	0.36
2023	1.1	1.39	2.22	2.33	4.32	0.36
2024	1.1	1.39	2.22	2.33	4.32	0.36
2025	1.1	1.39	2.22	2.33	4.32	0.36
2026	1.1	1.39	2.22	2.33	4.32	0.36
2027	1.1	1.39	2.22	2.33	4.32	0.36
2028	1.1	1.39	2.22	2.33	4.32	0.36
2029	1.1	1.39	2.22	2.33	4.32	0.36
2030	1.1	1.39	2.22	2.33	4.32	0.36
2031	1.1	1.39	2.22	2.33	4.32	0.36
2032	1.1	1.39	2.22	2.33	4.32	0.36
2033	1.1	1.39	2.22	2.33	4.32	0.36
2034	1.1	1.39	2.22	2.33	4.32	0.36
2035	1.1	1.39	2.22	2.33	4.32	0.36
2036	1.1	1.39	2.22	2.33	4.32	0.36
2037	1.1	1.39	2.22	2.33	4.32	0.36
2038	1.1	1.39	2.22	2.33	4.32	0.36
2039	1.1	1.39	2.22	2.33	4.32	0.36
2040	1.1	1.39	2.22	2.33	4.32	0.36
2041	1.1	1.39	2.22	2.33	4.32	0.36
2042	1.1	1.39	2.22	2.33	5.40	0.36
2043	1.1	1.39	2.22	2.33	5.55	0.36

Case-2						
Year	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**
2022	1.1	1.39	2.22	2.33	4.32	0.36
2023	1.1	1.39	2.22	2.33	4.32	0.36
2024	1.1	1.39	2.22	2.33	4.32	0.36
2025	1.1	1.39	2.22	2.33	4.32	0.36
2026	1.1	1.39	2.22	2.33	4.32	0.36
2027	1.1	1.39	2.22	2.33	4.32	0.36
2028	1.1	1.39	2.22	2.33	4.32	0.36
2029	1.1	1.39	2.22	2.33	4.32	0.36
2030	1.1	1.39	2.22	2.33	4.32	0.36
2031	1.1	1.39	2.22	2.33	4.32	0.36
2032	1.1	1.39	2.22	2.33	4.32	0.36
2033	1.1	1.39	2.22	2.33	4.32	0.36
2034	1.1	1.39	2.22	2.33	4.32	0.36
2035	1.1	1.39	2.22	2.33	4.32	0.36
2036	1.1	1.39	2.22	2.33	4.32	0.36
2037	1.1	1.39	2.22	2.33	4.32	0.36
2038	1.1	1.39	2.22	2.33	4.32	0.36
2039	1.1	1.39	2.22	2.33	4.32	0.36
2040	1.1	1.39	2.22	2.33	4.32	0.36
2041	1.1	1.39	2.22	2.33	4.32	0.36
2042	1.1	1.39	2.22	2.33	4.32	0.36
2043	1.1	1.39	2.22	2.33	4.32	0.36

Case-3						
Year	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**
2022	1.1	1.39	2.22	2.33	4.32	0.36
2023	1.1	1.39	2.22	2.33	4.32	0.36
2024	1.1	1.39	2.22	2.33	4.32	0.36
2025	1.1	1.39	2.22	2.33	4.32	0.36
2026	1.1	1.39	2.22	2.33	4.32	0.36
2027	1.1	1.39	2.22	2.33	4.32	0.36
2028	1.1	1.39	2.22	2.33	4.32	0.36
2029	1.1	1.39	2.22	2.33	4.32	0.36
2030	1.1	1.39	2.22	2.33	4.32	0.36
2031	1.1	1.39	2.22	2.33	4.32	0.36
2032	1.1	1.39	2.22	2.33	4.32	0.36
2033	1.1	1.39	2.22	2.33	4.32	0.36
2034	1.1	1.39	2.22	2.33	4.32	0.36
2035	1.1	1.39	2.22	2.33	4.32	0.36
2036	1.1	1.39	2.22	2.33	4.32	0.36
2037	1.1	1.39	2.22	2.33	4.32	0.36
2038	1.1	1.39	2.22	2.33	4.32	0.36
2039	1.1	1.39	2.22	2.33	4.32	0.36
2040	1.1	1.39	2.22	2.33	4.32	0.36
2041	1.1	1.39	2.22	2.33	4.32	0.36
2042	1.1	1.39	2.22	2.33	4.32	0.36
2043	1.10	1.39	2.22	2.33	4.32	0.36

4 Time related VOC (Rs/km)

Case-1						
Year	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**
2022	0.88	3.32	2.49	1.56	4.17	0.35
2023	0.88	3.32	2.49	1.56	4.17	0.35
2024	0.88	3.32	2.49	1.56	4.17	0.35
2025	0.88	3.32	2.49	1.56	4.17	0.35
2026	0.88	3.32	2.49	1.56	4.17	0.35
2027	0.88	3.32	2.49	1.56	4.17	0.35
2028	0.88	3.32	2.49	1.56	4.17	0.35
2029	0.88	3.32	2.49	1.56	4.17	0.35
2030	0.88	3.32	2.49	1.56	4.17	0.35
2031	0.88	3.32	2.49	1.56	4.17	0.35
2032	0.88	3.32	2.49	1.56	4.17	0.35
2033	0.88	3.32	2.49	1.56	4.17	0.35
2034	0.88	3.32	2.49	1.56	4.17	0.35
2035	0.88	3.32	2.49	1.56	4.17	0.35
2036	0.88	3.32	2.49	4.63	4.17	0.35
2037	2.19	10.50	2.49	5.04	4.17	0.35
2038	2.78	13.21	2.49	5.57	4.17	0.35
2039	3.94	18.45	2.49	3.12	4.17	0.35
2040	7.29	32.73	9.21	3.12	93.77	1.48
2041	112.70	220.12	11.47	3.12	4.17	1.84
2042	0.88	3.32	15.69	3.12	4.17	2.52
2043	0.88	3.32	26.39	3.12	4.17	4.25

Case-2						
Year	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**
2022	0.88	3.32	2.49	1.56	4.17	0.35
2023	0.88	3.32	2.49	1.56	4.17	0.35
2024	0.88	3.32	2.49	0	4.17	0.35
2025	0.88	3.32	2.49	1.56	4.17	0.35
2026	0.88	3.32	2.49	1.56	4.17	0.35
2027	0.88	3.32	2.49	1.56	4.17	0.35
2028	0.88	3.32	2.49	1.56	4.17	0.35
2029	0.88	3.32	2.49	1.56	4.17	0.35
2030	0.88	3.32	2.49	1.56	4.17	0.35
2031	0.88	3.32	2.49	1.56	4.17	0.35
2032	0.88	3.32	2.49	1.56	4.17	0.35
2033	0.88	3.32	2.49	1.56	4.17	0.35
2034	0.88	3.32	2.49	1.56	4.17	0.35
2035	0.88	3.32	2.49	1.56	4.17	0.35
2036	0.88	3.32	2.49	1.56	4.17	0.35
2037	0.88	3.32	2.49	1.56	4.17	0.35
2038	0.88	3.32	2.49	1.56	4.17	0.35
2039	0.88	3.32	2.49	1.56	4.17	0.35
2040	0.88	3.32	2.49	1.56	4.17	0.35
2041	0.88	3.32	2.49	1.56	4.17	0.35
2042	0.88	3.32	2.49	1.56	4.17	0.35
2043	0.88	3.32	2.49	1.56	4.17	0.35

Case-3						
Year	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**
2022	0.88	3.32	2.49	1.56	4.17	0.35
2023	0.88	3.32	2.49	1.56	4.17	0.35
2024	0.88	3.32	2.49	1.56	4.17	0.35
2025	0.88	3.32	2.49	1.56	4.17	0.35
2026	0.88	3.32	2.49	1.56	4.17	0.35
2027	0.88	3.32	2.49	1.56	4.17	0.35
2028	0.88	3.32	2.49	1.56	4.17	0.35
2029	0.88	3.32	2.49	1.56	4.17	0.35
2030	0.88	3.32	2.49	1.56	4.17	0.35
2031	0.88	3.32	2.49	1.56	4.17	0.35
2032	0.88	3.32	2.49	1.56	4.17	0.35
2033	0.88	3.32	2.49	1.56	4.17	0.35
2034	0.88	3.32	2.49	1.56	4.17	0.35
2035	0.88	3.32	2.49	1.56	4.17	0.35
2036	0.88	3.32	2.49	1.56	4.17	0.35
2037	0.88	3.32	2.49	1.56	4.17	0.35
2038	0.88	3.32	2.49	1.56	4.17	0.35
2039	0.88	3.32	2.49	1.56	4.17	0.35
2040	0.88	3.32	2.49	1.56	4.17	0.35
2041	0.88	3.32	2.49	4.83	4.17	0.35
2042	2.85	6.98	2.49	6.78	4.17	0.35
2043	4.26	8.03	2.49	12.17	4.17	0.35

5 TOTAL VOC (DISTANCE AND TIME RELATED) (Rs/km)

Case-1						
Year	**NTC**	**LCV**	**HCV**	**BUS**	**MAV**	**TW**
2022	1.98	4.71	4.71	3.89	8.49	0.71
2023	1.98	4.71	4.71	3.89	8.49	0.71
2024	1.98	4.71	4.71	3.89	8.49	0.71
2025	1.98	4.71	4.71	3.89	8.49	0.71
2026	1.98	4.71	4.71	3.89	8.49	0.71
2027	1.98	4.71	4.71	3.89	8.49	0.71
2028	1.98	4.71	4.71	3.89	8.49	0.71
2029	1.98	4.71	4.71	3.89	8.49	0.71
2030	1.98	4.71	4.71	3.89	8.49	0.71
2031	1.98	4.71	4.71	3.89	8.49	0.71
2032	1.98	4.71	4.71	3.89	8.49	0.71
2033	1.98	4.71	4.71	3.89	8.49	0.71
2034	1.98	4.71	4.71	3.89	8.49	0.71
2035	1.98	4.71	4.71	3.89	8.49	0.71
2036	1.98	4.71	4.71	6.96	8.49	0.71
2037	3.29	11.89	4.71	7.37	8.49	0.71
2038	3.88	14.60	4.71	7.90	8.49	0.71
2039	5.04	19.84	4.71	5.45	8.49	0.71
2040	8.39	34.12	11.43	5.45	98.09	1.84
2041	113.80	221.51	13.69	5.45	8.49	2.20
2042	1.98	4.71	17.91	5.45	9.57	2.88
2043	1.98	4.71	28.61	5.45	9.72	4.61

Case-2

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.98	4.71	4.71	3.89	8.49	0.71
2023	1.98	4.71	4.71	3.89	8.49	0.71
2024	1.98	4.71	4.71	2.33	8.49	0.71
2025	1.98	4.71	4.71	3.89	8.49	0.71
2026	1.98	4.71	4.71	3.89	8.49	0.71
2027	1.98	4.71	4.71	3.89	8.49	0.71
2028	1.98	4.71	4.71	3.89	8.49	0.71
2029	1.98	4.71	4.71	3.89	8.49	0.71
2030	1.98	4.71	4.71	3.89	8.49	0.71
2031	1.98	4.71	4.71	3.89	8.49	0.71
2032	1.98	4.71	4.71	3.89	8.49	0.71
2033	1.98	4.71	4.71	3.89	8.49	0.71
2034	1.98	4.71	4.71	3.89	8.49	0.71
2035	1.98	4.71	4.71	3.89	8.49	0.71
2036	1.98	4.71	4.71	3.89	8.49	0.71
2037	1.98	4.71	4.71	3.89	8.49	0.71
2038	1.98	4.71	4.71	3.89	8.49	0.71
2039	1.98	4.71	4.71	3.89	8.49	0.71
2040	1.98	4.71	4.71	3.89	8.49	0.71
2041	1.98	4.71	4.71	3.89	8.49	0.71
2042	1.98	4.71	4.71	3.89	8.49	0.71
2043	1.98	4.71	4.71	3.89	8.49	0.71

Case-3

Year	NTC	LCV	HCV	BUS	MAV	TW
2022	1.98	4.71	4.71	3.89	8.49	0.71
2023	1.98	4.71	4.71	3.89	8.49	0.71
2024	1.98	4.71	4.71	3.89	8.49	0.71
2025	1.98	4.71	4.71	3.89	8.49	0.71
2026	1.98	4.71	4.71	3.89	8.49	0.71
2027	1.98	4.71	4.71	3.89	8.49	0.71
2028	1.98	4.71	4.71	3.89	8.49	0.71
2029	1.98	4.71	4.71	3.89	8.49	0.71
2030	1.98	4.71	4.71	3.89	8.49	0.71
2031	1.98	4.71	4.71	3.89	8.49	0.71
2032	1.98	4.71	4.71	3.89	8.49	0.71
2033	1.98	4.71	4.71	3.89	8.49	0.71
2034	1.98	4.71	4.71	3.89	8.49	0.71
2035	1.98	4.71	4.71	3.89	8.49	0.71
2036	1.98	4.71	4.71	3.89	8.49	0.71
2037	1.98	4.71	4.71	3.89	8.49	0.71
2038	1.98	4.71	4.71	3.89	8.49	0.71
2039	1.98	4.71	4.71	3.89	8.49	0.71
2040	1.98	4.71	4.71	3.89	8.49	0.71
2041	1.98	4.71	4.71	7.16	8.49	0.71
2042	3.95207662	8.37	4.71	9.11	8.49	0.71
2043	5.36	9.42	4.71	14.50	8.49	0.71

6 Vehicle operation cost for one year

Data on Vehicular Traffic on Alternative Proposals

vehicle type	Case-1	Case-2	Case-3
NTC	1881	695.97	1185.03
LCV	834	134	700
HCV	384	0	384
BUS	111	31	80
MAV	141	41	100
TW	3381	1691	1690

Increase in Price rate factor from base year 2022 = 5.00

Number of days = 365

Number of days during constrcution & Maintenance = 1095

Case-1

Length of road = 56.4 km

Year	NTC	LCV	HCV	BUS	MAV	TW	Total
2022	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2023	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2024	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2025	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2026	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2027	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2028	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2029	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2030	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2031	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2032	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2033	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2034	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2035	383350433	404323450.2	186163315.2	44444145	123216474	247084494	1388582312
2036	383350433	404323450.2	186163315.2	79504737	123216474	247084494	1423642904
2037	637255725	1020676975	186163315.2	84151629	123216474	247084494	2298548612
2038	750912094	1253376395	186163315.2	90307353	123216474	247084494	2651060124
2039	975646469	1703159123	186163315.2	62267504	123216474	247084494	3297537379
2040	1624144367	2928920739	451921785.4	62267504	1.424E+09	640656944	7131475016
2041	2.2032E+10	19015154095	541062841.6	62267504	123216474	766893371	42540834148
2042	383350433	404323450.2	708092512.6	62267504	138907412	1.004E+09	2700463386
2043	383350433	404323450.2	1130883774	62267504	141103473	1.603E+09	3724943804

Case-2

Length of road = 56.4 km

Year	NTC	LCV	HCV	BUS	MAV	TW	Total
2022	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2023	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2024	141839660	64963240.2	0	7434633.9	35828904	123578787	373645225.5
2025	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2026	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2027	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2028	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2029	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2030	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2031	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2032	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2033	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2034	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2035	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2036	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2037	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2038	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2039	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2040	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2041	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2042	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3
2043	141839660	64963240.2	0	12412329	35828904	123578787	378622920.3

Case-3

Length of road = 34.5 km

Year	NTC	LCV	HCV	BUS	MAV	TW	Total
2022	443197961	622762087.5	341629488	58781790	160365488	226646111	1853382925
2023	443197961	622762087.5	341629488	58781790	160365488	226646111	1853382925
2024	443197961	622762087.5	341629488	58781790	160365488	226646111	1853382925
2025	443197961	622762087.5	341629488	58781790	160365488	226646111	1853382925
2026	443197961	622762087.5	341629488	58781790	160365488	226646111	1853382925
2027	443197961	622762087.5	341629488	58781790	160365488	226646111	1853382925
2028	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2029	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2030	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2031	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2032	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2033	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2034	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2035	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2036	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2037	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2038	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2039	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2040	147732654	207587362.5	113876496	19593930	53455163	75548704	617794308.47
2041	147732654	207587362.5	113876496	36075439	53455163	75548704	634275817.40
2042	294874124	368688672.7	113876496	45881510	53455163	75548704	952324669.93
2043	399942841	415383351.3	113876496	73058269	53455163	75548704	1131264823.61

COST BENEFIT ANALYSIS

IRR	**Sum Co=$(B_t-C_t)/(1+i)^t$**	Length of Existing Road	=	56.4	km
1. Do Nothing and Flexible Pavement		Length of Bypass Road	=	34.50	km
Case-1 =	Do Nothing	Construction cost of Bypass (Rs.)	=	25740612774	
Case-2 =	Existing Road after Bypass is constructed	The Internal Rate of Return (IRR) (%)	=	**12.00**	
Case-3 =	**Bypass Road (with flexible pavement)**	Rs in Lakhs			

Year (t)	t	Road User Cost/VOC			Maintenance cost + construction cost			Cost (6-7-8)	Benefit (3-4-5)	Discounted Costs and Benefits	
		Case-1	Case-2	Case-3	Case-1	Case-2	Case-3				
1	2	3	4	5	6	7	8	9	10	11	12
2022	0	13885.82	3786.23	18533.83	1129253.76	1129253.76	60480.00	-60480.00	0.00	-60480.00	
2023	1	13885.82	3786.23	18533.83	1129253.76	1129253.76	120960.00	-120960.00	0.00	-108000.00	
2024	2	13885.82	3736.45	18533.83	1072791.08	1072791.08	120960.00	-120960.00	0.00	-96428.57	96428.57
2025	3	13885.82	3786.23	18533.83	1072791.08	1072791.08	10727.91	-10727.91	-8434.24		1632.59
2026	4	13885.82	3786.23	18533.83	1072791.08	1072791.08	10727.91	-10727.91	-8434.24		1457.67
2027	5	13885.82	3786.23	18533.83	1072791.08	1072791.08	10727.91	-10727.91	-8434.24		1301.49
2028	6	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		7421.92
2029	7	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		6626.72
2030	8	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		5916.71
2031	9	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		5282.78
2032	10	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		4716.77
2033	11	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		4211.40
2034	12	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		3760.18
2035	13	13885.82	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	3921.65		3357.30
2036	14	14236.43	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	4272.26		3069.33
2037	15	22985.49	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	13021.31		4338.89
2038	16	26510.60	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	16546.43		4449.04
2039	17	32975.37	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	23011.20		4913.91
2040	18	71314.75	3786.23	6177.94	1072791.08	1072791.08	10727.91	-10727.91	61350.58		9373.06
2041	19	425408.34	3786.23	6342.76	1072791.08	1072791.08	10727.91	-10727.91	415279.35		49462.33
2042	20	27004.63	3786.23	9523.25	1072791.08	1072791.08	10727.91	-10727.91	13695.16		2531.86
								-495502.39	**553246.79**	**-264908.57**	**220252.53**
								B/C =	**1.12**		