Member of the Surbana Jurong Group

Preparation of Detailed Project Report (DPR) and providing Pre-Construction activities in respect of the Approach Roads with Avalanche Protection Works in between Z-morh Tunnel East portal to Zojila Tunnel West Portal and Access Road at Zojila East Portal

Package III- Construction of approach roads (Approach road 1 (Length 8.05 Km) from Design Ch.9+760 to Design Ch. 17+814 (Western Portal of proposed Zojila Tunnel) on Srinagar-Leh road (NH-1)& Approach road 2 (Length 0.66 Km)- Design Ch. 0+000 (Eastern Portal of proposed Zojila Tunnel) to Ch. 0+660 (Existing km 118.00 on NH-1)) to East and West Portal of Proposed Zojila Tunnel with Avalanche Protection Works (15nos.),01no. Major bridge (135.80 m) in the UT of Jammu & Kashmir and Ladakh

Draft Detailed Project Report
Main Report
March 2020






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SMEC (India) Private Limited			
1st Floor, West Wing, Novus Tower, Plot No. -18, Sector-18, Gurugram – 122015, Haryana, India			
Tel:	(91) 124 - 4501100	Fax:	(91) 124 - 4380043
Email:	Neeta.arora@smec.com	Website:	www.smec.com

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Abbreviations and Acronyms

Abbreviation/ Acronym	Description
BRO	Border Roads Organisation
DPR	Detailed Project Report
km	Kilometer
LA	Land Acquisition
SOI	Survey of India
NH	National Highway
NHIDCL	National Highways & Infrastructure Development Corporation Limited
QAP	Quality Assurance Plan
ROW	Right of Way
SASE	Snow Avalanche Study Establishment
TOR	Terms of Reference
NRSC	National Remote Sensing Centre
HAWS	High Altitude Warfare School

0 EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 GENERAL

The National Highways & Infrastructure Development Corporation Limited (NHIDCL) has been entrusted with the assignment of preparation of Detailed Project Report and providing Pre-Construction Activities:-

i) For construction of Approach Roads with Avalanche Protection Works to West and East portal of the proposed Zojila Tunnel (between Baltal and Minamarg) from Km 82.000 to Km 95.000 on Srinagar-Leh Road (NH-1) and

ii) For making the NH-1 from Z-Morh Tunnel to proposed Zojila Tunnel (approx. 20 km) all weather road in the State of Jammu & Kashmir.

M/s SMEC International Pty. Ltd has been appointed as Consultants vide **letter no NHIDCL/J&K/Zojila Tunnel- Approach Road/DPR/NH-1/2017/454 dated 28th March 2018** to carry out the Detailed Project Report (DPR) for all weather road with 2 lane with paved shoulder configuration from the Eastern Portal of the Z-Morth Tunnel at km 82.00 to the western portal of the Zojila Tunnel near Baltal Camp and approach road to eastern portal of the Zojila Tunnel with take off point at existing NH-1 at Km 118.00 in the State of Jammu & Kashmir. The contract with NHIDCL was signed on 1st May 2018.

This submission of DPR is for Construction of approach roads (Approach road 1 (Length 8.05 Km) from Design Ch.9+760 to Design Ch. 17+814 (Western Portal of proposed Zojila Tunnel) on Srinagar-Leh road (NH-1))& Approach road 2 (Length 0.66 Km)- Design Ch. 0+000 (Eastern Portal of proposed Zojila Tunnel) to Ch. 0+660 (Existing km 118.00 on NH-1)) to East and West Portal of Proposed Zojila Tunnel with Avalanche Protection Works (15nos.),01no. Major bridge (135.80 m) in the UT of Jammu & Kashmir and Ladakh.An index Map of the project corridor is shown in ***Figure 0-1Index Map***

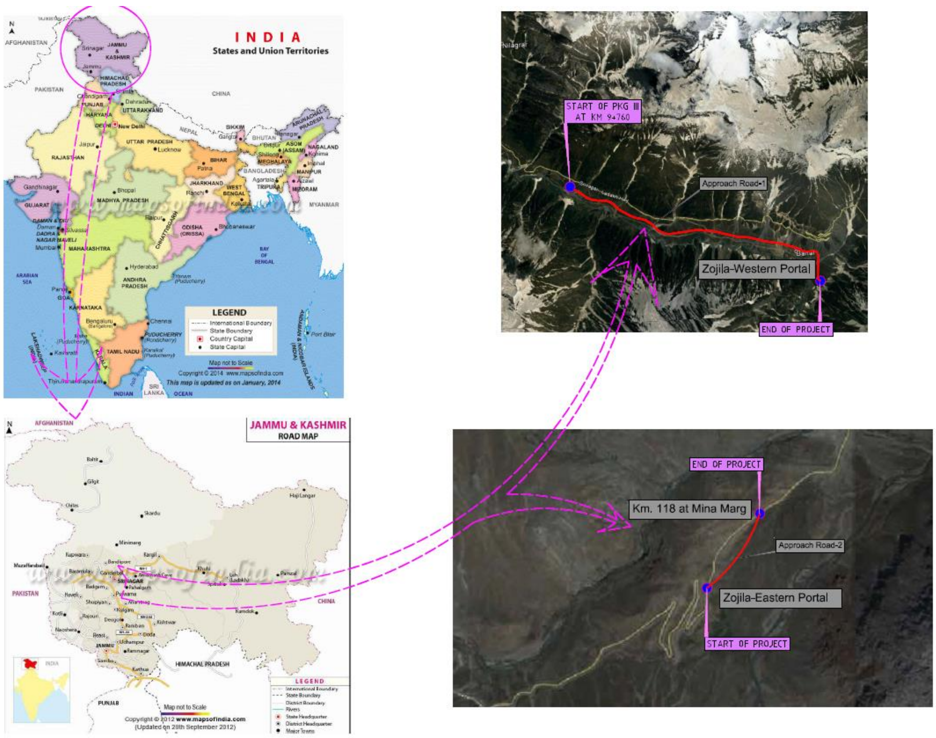

Fig. 0-1: Index Map

0.2 THE PROJECT ROAD

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0.2.1 EXISTING ALIGNMENT

The project road comprises of new construction of Approach Roads to the proposed portals of Zojila Tunnel

Table 0-1 Existing details

Carriageway Width (m)	Earthen Shoulder Width (m)	Embankment Height (m)
-	-	-

0.2.2 LAND USE PATTERN ALONG THE ALIGNMENT

The land use patterns along the project road are barren, agricultural and forest in which predominant land use pattern is forest.

0.2.3 EVALUATION OF PROPOSED ALIGNMENT

As per ToR, the scope of proposed project is Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the Approach Roads with Avalanche Protection Works to Zojila Tunnel.

Salient Features of the Alignment (Approach Road-1 to Proposed West Portal of Zojila Tunnel) are as follows:

- Total Length- 8.05 Km
- Cut & Cover Length- 2.35 km
- Snow Gallery Length- 0.45 km
- Bridges- 1 Nos.

Salient Features of the Alignment (Approach Road-2 to Proposed East Portal of Zojila Tunnel) are as follows:

- Total Length- 0.66 Km

0.3 DESIGN STANDARDS

The existing road is proposed to widen for Two lane with paved shoulder configuration based on the Traffic demand as indicated Chapter 3. Number of existing deficient geometry curves have been replaced with desired curves radius, as applicable for Mountainous and steep terrain.

In addition to IRC standards for Geometric Design, Drainage & Intersections (IRC:SP:23, IRC: 38, IRC:SP:41, IRC:SP: 42 etc.), following manuals are also followed:

- Manual of Two Laning issued by MORTH (IRC:SP:73-2018)
- Hill Road Manual (IRC:SP:48-1998)

Adopted Design Standards for the proposed road are presented in this chapter.

0.4 TRAFFIC SURVEYS AND ANALYSIS

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To capture traffic flow characteristics and travel pattern of users passing through the project road and other characteristics related to miscellaneous requirements as per the ToR, following primary traffic surveys have been conducted.

- Classified Traffic Volume Count (7 days) – 3 locations
- Origin-Destination Survey (OD) – 2 locations
- Axle Load Survey – 2 locations
- Truck Terminal Survey – 1 location
- Pedestrian and Animal Count Survey – 2 locations
- Speed and Delay Survey – Entire length

0.4.1 TRAFFIC ANALYSIS

The traffic surveys have been carried out at 3 locations. The Average Annual Daily Traffic volume (AADT) and Average daily traffic volume (ADT) on the project road for all 3 locations as given in Table 0.2 below:

Table 0-2: Traffic Sections of Project Highway

S. No	Section	ADT		AADT	
		In No.'s	In PCU	In No.'s	In PCU
1	Km 81+600	5446	6806	3376	4219
2	Km 85+900	4088	6081	2534	3770
3	Km 94+800	2731	4345	1779	2737

Maximum AADT of 4219 PCUs was observed at location Km 81.600 followed by 3770 at Km 85.900. Minimum traffic was observed at Km 94.800 which is 2737 PCUs.

0.4.2 TRAFFIC FORECAST

The future traffic demand assessment is made based on the past available data. Traffic forecasts are made for the horizon year 2048 which will form the basis for further work on pavement design, wayside amenities, intersection/ interchange design and developing capacity augmentation proposals.

0.4.3 ENGINEERING SURVEYS AND INVESTIGATIONS

The various surveys and investigations which have been carried out are as follows:

- Inventory and condition survey of Road and Pavement.
- Topographic Survey (cartosat Imagery)-Detailed topographic survey will be carried out.
- Inventory and condition survey of Bridges, Cross Drainage & other structures.
- Classified Traffic Volume Count (7 days)
- Origin-Destination Survey (OD)
- Axle Load Survey
- Intersection Turning Movement Count Survey
- Truck Terminal Survey
- Pedestrian and Animal Count Survey
- Speed and Delay Survey
- Hydraulic study and Hydrological Investigations
- Pavement Investigations
- Material Investigations
- Geo Technical investigation for bridges and structures

0.5 PAVEMENT DESIGN

0.5.1 NEW CONSTRUCTION

Pavement was designed on the basis of cumulative number of standard axles expected on the pavement for the design life of 15 years for Flexible Pavement and design life of 30 years for Rigid pavement. Proposed pavement composition based upon the design is given in Table 0.3 and Table 0.4.

Table 0-3: Recommended Pavement Crust Details for New Construction (Flexible Pavement)

Chainages		MSA	Effective CBR %	BC (mm)	Aggregate Inter Layer (mm)	CTB (mm)	CTSB (mm)	Subgrade	Extruded Polystyrene Sheet (EPS)	Bitumen
From	To									
9+760	17+814	20	8	50	100	115	235	500	50 mm	VG-10
0+000	0+660 (Approach Road 2)	20	8	50	100	115	235	500	50 mm	VG-10

0.6 GEOLOGICAL ASSESSMENT AND AVALANCHE PROTECTION MEASURES

The existing Srinagar-Leh highway between Z-Morh and the proposed Zojila tunnel portal at Baltal road remains closed for almost six months due to severe winter conditions that entail heavy snow falls and snow avalanches. As per detailed investigations by SASE (Snow Avalanche Study Establishment), as many as twenty-four avalanche routes have been identified in this project area. The preliminary geological studies in the area reveal that the area may be prone to other geo-hazards like debris flows along nallas and gulleys. This chapter presents detailed geological assessment along the project corridor.

The proposed road is affected by 15 number of registered avalanches sites.

Various Avalanche Protection Structures proposed along the project road such as Catch Dams, Deflector Dams, Cut & Cover Sections and Snow Galleries. After detailed Technical Discussions and Site visits with SASE, a conceptual layout of avalanche protection structures is prepared.

Various Protection Measures taken to mitigate Avalanches are presented under this chapter.

0.7 ENVIRONMENT IMPACT ASSESSMENT (EIA) AND MANAGEMENT PLAN (EMP)

The proposed project alignment takes off at Chainage 0+000 (Existing Km 82.000) which connects to proposed Zojila Tunnel portal.
Salient Features of the Alignment of Approach Road-1 are as follows:

- Total Length- 8.05 km
- Cut & Cover Length- 2.35 Km
- Snow Gallery Length- 0.45 Km
- Bridges- 1 Nos.

Salient Features of the Alignment of Approach Road-2 are as follows:

- Total Length- 0.66 km

The tract of the proposed project area is extremely mountainous with rugged terrain in Sindh and Mansbal ranges while the terrain in the Harran Sballabugh Range is flat.The land use patterns along the proposed project road in the existing alignment are built up, barren, agricultural and forest in which predominant land use pattern is forest.The proposed project road crosses various surface water bodies including rivers namely Sindh.The project falls under seismic intensity Zone V, which is classified as very high damage risk zone and Snow fall zone. The proposed project area falls in relatively clean environment. Pollution levels may be very low. The dominant plant families in the proposed project area are Rosaceae, Asteraceae, Ranunculaceae, Polygonaceae, Poaceae Fabaceae and Pinaceae. However, Pteridophytes and Bryophytes are also found in the proposed project area. Black Bear, Brown bear, Hangul, Fox, Leopard etc. are the main fauna of the proposed project area. Detailed study will be conducted during EIA and EMP.

As per the assessment, the proposed project does not trigger EC, as EIA notification 2006 and amendment thereafter. Moreover, Director (FC), MoEF&CC, vide letter dt. 19.05.2014 clarified Dte. of General Border Roads regarding the applicability of environmental clearance for similar project Z – Morh and Zozilla Tunnels in Jammu and Kashmir.

However, the proposed project will require clarification / consent from MoEF&CC, regrading applicability of EC, as EIA notification 2006 and amendment thereafter.

Approximately 35 plants are recorded within the proposed ROW. Thus, Tree Felling Permission will be taken as per requirement. Existing NH-1 is touching boundary of Thajwas- Baltal Wildlife Sanctuary at starting point of project road. Existing NH-1 is within ESZ of Thajwas- Baltal Wildlife Sanctuary at starting point of project road. Thus, Wildlife clearance may be required for the project, after joint site identification and clarification.

During EIA, environmental monitoring (air quality, noise level, surface & ground water quality, soil quality) will be conducted to establish baseline environmental condition of the project area. Impact of the proposed development activity on the surrounding environment will be assessed and mitigation measures would be proposed to minimize the adverse impacts & enhancement measures for positive impacts. The budgetary provision for environmental management activities will be taken as per GOI and GOJ&K Norms.

0.8 SOCIAL IMPACT ASSESSMENT (SIA) AND RESETTLEMENT PLAN (RP)

As a part of the project development process, concerted effort has been made to minimize the adverse social impact by integrating the social concerns in design and planning of the up-gradation proposals. There will be very few direct impact on Project Affected Households. The Road is passes through hilly terrain and no any major habitation has been impacted and land acquisition will be taken place.

This chapter presents the social surveys conducted and findings of the same.

0.9 COST ESTIMATION

The project cost includes construction cost, routine maintenance cost during construction period, social and environmental cost (land acquisition, structure acquisition, R&R, environmental cost), physical contingencies, price contingencies, supervision cost on base cost and cost for utility shifting and relocation. The abstract of cost estimates for the project corridor is given in Table 0.5 below.

Table 0-4: Summary of Cost

Bill No.	Description	Amount (Rs.)
1	Site Clearance & Dismantling	674,892
2	Earthwork	235,669,721
3	Sub-Base, Base Courses (Granular)	93,776,006
4	Bituminous Courses / Concrete Pavements	42,330,165
4 (a)	Reinforced Earth Embankment	568,114,052
5	Cross Drainage Structures	68,822,455
6	Major Bridges & Minor Bridges	223,486,418
6.1	Cut And Cover	3,251,436,941
6.2	Snow Gallery	450,369,654
7	Drainage & Protection Works	296,828,139
8	Traffic Signs, Road Markings & Appurtenances	36,937,037
9	Catch Dams and Deflection Structures	287,721,496
	Total Construction Cost --- (A)	**5,556,166,975**

	GST @ 12% of (A)	**666,740,037**
	Total Construction Cost --- (B)	**6,222,907,012**
10	Contingencies @ 2.8% of (A)	155,572,675
11	Supervision charges @ 3% of (A)	166,685,009
12	Agency Charges @ 3% of (A)	166,685,009
13	Escalation @ 5% of (B) per annum for 2nd & 3rd years' (Construction period 3 Year)	622,290,701
14	Snow Clearance (For 5 Year Defect Lability Period)	137,534,640
	Total Estimated Project Cost	**7,471,675,048**
15	Maintenance charges @ 0.5% for 2, 3 & 4th year & 1% for 5 years of (B)	155,572,675
	Total Project Cost	**7,627,247,723**
16	**Pre-Construction Activities**	
(i)	Shifting of utilities	136,711
(ii)	Environment Mitigation Cost	19,155,858
(iii)	Provision for LA and FC	64,094,921
	Total Capital Cost (INR)	**7,710,635,213**

0.10 ECONOMIC AND FINANCIAL ANALYSIS

Due to defence and national interest this project has critical importance though the project is not showing any economic viability but overall it is strategic in nature and therefore recommended for construction

0.11 WINTER ROAD MAINTENANCE

As a part of overall development of the region and to achieve all-weather connectivity, winter road maintenance is required. The chapter describes about the existing condition of project area and recommends a mechanism for a better snow clearance techniques. The chapter recommends the following techniques based on the intensity of snowfall:-

- Snow plowing
- Snow Blowing
- Graders
- Salt and sand spreaders
- Anti-skid Treatments

The chapter also suggests an intelligent winter management using Road Weather Information System (RWIS) and setting a Winter Road Quality Standard.

1 CHAPTER – 1 PROJECT PREPARATION

1.1 BACKGROUND OF THE PROJECT

The National Highways & Infrastructure Development Corporation Limited (NHIDCL) has been entrusted with the assignment of preparation of Detailed Project Report and providing Pre-Construction Activities:-

(i) For construction of Approach Roads with Avalanche Protection Works to West and East portal of the proposed Zojila Tunnel (between Baltal and Minamarg) from Km 82.000 to Km 95.000 on Srinagar-Leh Road (NH-1) and;

(ii) For making the NH-1 from Z-Morh Tunnel to proposed Zojila Tunnel (approx. 20 km) all weather road in the State of Jammu & Kashmir.

1.2 CONSULTANCY APPOINTMENT

M/s SMEC International Pty. Ltd has been appointed as Consultants vide **letter no NHIDCL/J&K/Zojila Tunnel- Approach Road/DPR/NH-1/2017/454 dated 28th March 2018** to carry out the Detailed Project Report (DPR) for all weather road with 2 lane with paved shoulder configuration from the Eastern Portal of the Z-Morh Tunnel at km 82.00 to the western portal of the Zojila Tunnel near Baltal Camp and approach road to eastern portal of the Zojila Tunnel with take off point at existing NH-1 at Km 118.00 in the State of Jammu & Kashmir. The contract with NHIDCL was signed on 1st May 2018.

This submission of DPR is for Construction of approach roads (Approach road 1 (Length 8.05 Km) from Design Ch.9+760 to Design Ch. 17+814 (Western Portal of proposed Zojila Tunnel) on Srinagar-Leh road (NH-1))& Approach road 2 (Length 0.66 Km)- Design Ch. 0+000 (Eastern Portal of proposed Zojila Tunnel) to Ch. 0+660 (Existing km 118.00 on NH-1)) to East and West Portal of Proposed Zojila Tunnel with Avalanche Protection Works (15nos.),01no. Major bridge (135.80 m) in the UT of Jammu & Kashmir and Ladakh.

An index Map of the project corridor is shown in **Figure 1-1 Index Map**

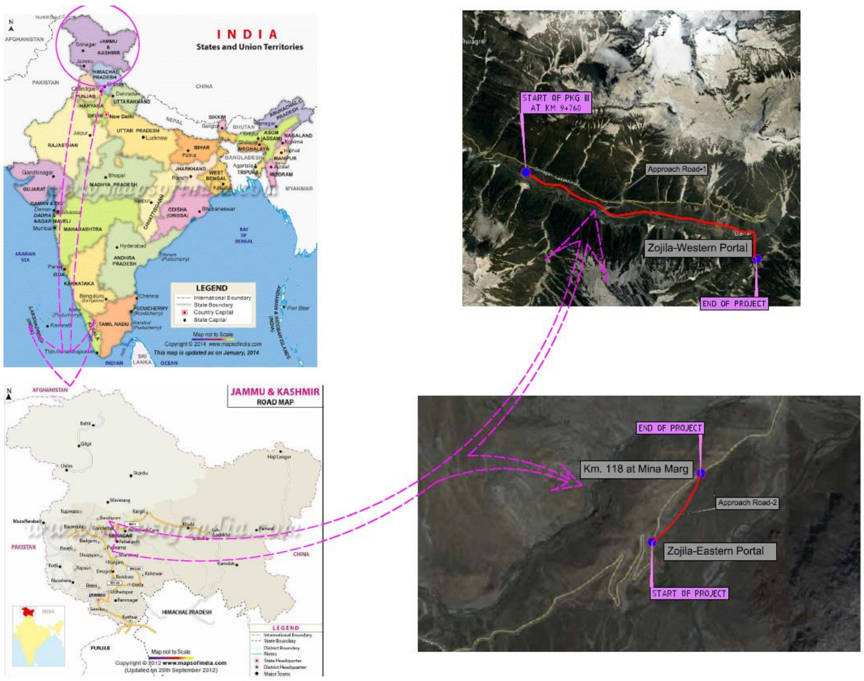


Figure 1-1 Index Map

2 CHAPTER–2: PROJECT ROAD DESCRIPTION

The project road length is around 8.71 km. It consists of 2 sections. First Section starts from km 82.000 of NH-1 after the bridge linking Eastern Portal of Z-Morh tunnel to NH-1 at km 82.000 and ends at Western Portal of the proposed Zojila Tunnel near Baltal Camp. This stretch of road lies in Ganderbal district. The road passes through Sonamarg Urban area and Baltal Base Camp. Second Section comprises of connecting the eastern portal of the Zojila Tunnel to NH-1 with take off point at existing Km 118. Generally, the existing road is of two lane configuration. A brief description of road project is as follows:

2.1 EXISITNG ROAD ALIGNMENT

The project road comprises of new construction of road and no existing road improvement is proposed.two sections. Project road length is 8.71 Km proposed for Two Lane with Paved Shoulder Configuration comprising of two sections.

Length of Approach Road-1 (Approach to Zojila Western Portal) is 8.054 Km. Approach Road-1 falls in the UT of Jammu & Kashmir in Ganderbal District. 8 nos. of Cut & Cover Sections, 2 nos. of Snow Galleries and 16 nos. of Avalanche Protection Dams are proposed to protect the proposed road from avalanches.

Approach Road-2 starts at proposed Eastern Portal of Zojila Tunnel and ends near km 118.000 at NH-1. Alignment is entirely new construction and length of the alignment is 660m. Approach Road-2 falls in UT of Ladakh in Kargil District.

This Proposed new alignment will act as an alternative to the existing NH-1 and will provide an all-weather connectivity to the proposed Zojila Tunnel. Also, there will be minimal traffic hassles during construction considering huge amount of traffic due to Military Convoy Movement and Amarnath Yatra during summers.

The proposed road is of 2-lane with paved shoulder configuration with additional snow storage lane.

a) Land use pattern along the alignment

The land use pattern along the project road is mainly forest with few patches of barren and agricultural land.

2.2 GEOLOGY, ROCK AND SOIL

The area of proposed project area comprises of lower reaches having a moderate physiography except that of north of Sindh river which has a rugged terrain. The Major portion of the area is covered by alluvium and karewa deposits cover the remaining area leaving very small portion occupied by Triassic limestone and other formations of the older age. The main litho units exposed are traps, states, quartzites, limestones and shales besides the alluvium and karewa clays.

2.3 CLIMATE

Given its high altitude and mountainous terrain, Sonamarg is a locality that experiences the regionally rare humid continental climate (Köppen: Dfb) with significant rainfall. The average temperature in Sonamarg is 6.5 °C, and nearly 932 mm of precipitation falls annually (not counting the heavy snowfall that occasionally falls on the valley floor during winter).

The existing Srinagar-Leh highway between Z-Morh and the proposed Zojila tunnel portal at Baltal road remains closed for almost six months due to severe winter conditions that entail heavy snow falls and snow avalanches.

2.4 ALTITUDE:

The altitude of the proposed project area ranges from 2800 to 3300 m.

2.5 PRECIPITATION:

The tract receives most its precipitation in the form of snow as early as November and the peaks remain snow-capped during most of the time of the year. The rainfall varies considerably depending upon the elevation and proximity to the hills. The maximum precipitation is received by the area during the winter and spring months in the form of snow and rain respectively. The Pir Panjal Mountan range acting as a lofty barrier, Scidom allows any monsoon from plains to cross in to the valley and therefore summer months are practically dry. The annual rainfall is approximately 676 mm.

2.6 WATER SUPPLY

The status of water supply is variable throughout the proposed project area and also with change in season. The high mountainous ranges remain usually bound for the major part of the year. The snow, which melt during summer release enough water for the perennial nallahs.

2.7 DEMOGRAPHY

Sonamarg has no permanent settlement and is inaccessible during winter due to heavy snowfall and avalanches. At the 2011 India census, Sonamarg had a population of 392, excluding tourists and those working in the tourism industry. Males constitute 51% and females constitute 49%. These are the permanent residents of Sonamarg though seasonally.

2.8 TOURISM

Sonamarg, which means 'meadow of gold' has, as its backdrop, snowy mountains against a cerulean sky. The Sindh meanders along here and abounds with trout and mahseer, snow trout can be caught in the main river. In late April when Sonamarg is open for road transport, the visitors can have access to snow which is furnished all over like a white carpet. Ponies can be hired for the trip up to Thajwas glacier a major attraction during the summer months.

The climate of Sonamarg is very bracing; but the rainfall is frequent though not heavy, except for two or three days at a time in July and August with fine spell in between. From Sonamarg, trekking routes lead to

the Himalayan lakes of Vishansar Lake, Krishansar Lake, Gangabal Lake and Gadsar Lake, stocked with Snowtrout and Brown trout and Satsar, glacier-fed and surrounded by banks of alpine flowers.

A close by excursion is to Baltal, 15 km east of Sonamarg. This little valley lies at the foot of the Zojila, only a day's journey away from the sacred cave of Amarnath is a base camp for Amarnath yatra. Trekkers can also reach the starkly splendid roof-top of the world Leh, by crossing over the Zoji La pass.

2.9 TERRAIN

The Project section is primarily lying in Steep/Mountainous terrain.

2.10 ECOLOGICAL ENVIRONMENT

a) Forest type: The Major Forest Types in the proposed project area are Montane Temperate Forests, Sub Alpine Forest and Alpine Forests groups.

b) Flora: The dominant families in the proposed project area are Rosaceae, Asteraceae, Ranunculaceae, Polygonaceae, Poaceae Fabaceae and Pinaceae. However, Pteridophytes and Bryophytes are also found in the Proposed project area.

c) Fauna: Black Bear, Brown bear, Hangul, Fox, Leopard etc. are the main fauna of the proposed project area.

2.11 SEISMICITY

According to 2014 seismic zoning map of India, the state of Jammu & Kashmir falls in Zone IV & V on the basis seismic hazard. The project falls under seismic intensity Zone IV, which is classified as high damage risk zone.

Fig 2-1: Seismic Zone Map of India

3 CHAPTER-3 DESIGN STANDARDS

3.1 GENERAL

The design of the road geometry for the assigned project will be cover the following main principles, which form the basis of desirable standard of highway design:

- All weather connectivity to commuters in the snow bound area will be of prime concern in the design by taking care of road safety and the smooth flow of traffic.
- Both horizontal and vertical geometry will be accorded due importance as per selected standards. It will not be compromised unless it becomes formidable to accept for the particular situation.
- Consistent Design will be adopted and abrupt changes in the design speed to be avoided.
- The proposed design will minimise the total transportation cost, including initial construction costs, costs for the maintenance of the facility and the costs borne by the road users.
- “Ruling” standards will be adopted and “Minimum” standards will be allowed only where serious restrictions are imposed by technical or economic considerations.

3.2 BASIS OF DESIGN

- Geometric Design
- Pavement Design
- Drainage
- Cross drainage Works and Structures
- Avalanche Protection Work and Protection works on Hill side and valley side

3.2.1 GEOMETRIC DESIGN

Geometric design standards have been laid down keeping the above in view. The project road lies in mountainous and steep terrain. The geometric design will be mainly prepared based on **IRC: SP:48-1998 “Hill Road”** and **IRC SP:73-2018** besides adopting relevant standards from IRC SP:23 - Vertical Curves for Highways, IRC:73-Geometric Design Standard of Rural (Non-Urban) Highway.

3.2.2 TERRAIN CLASSIFICATION

The project road lies in mountainous and steep terrain. However certain length of project road lies in rolling terrain. The geometric standards relevant to mountainous and steep terrain as contained in IRC: 73-1980 has been adopted and other relevant IRC standards and codes regarding bridges and other parameters has been adopted.

Table 3-1: Terrain classification for the roads based on per cent cross slope of the country

Terrain classification	Percent cross slope of the country
Plain	0-10
Rolling	>10-25
Mountainous	> 25-60
Steep	> 60

The Table below indicates the Terrain classification considered for existing road length which is being improved for Lane section as per proposed widening scheme for the project road.

Table 3-2: Terrain Classification

Stretch	Design Ch.		Length (in m)	Type of Terrain
	From	To		
Approach Road 1	0	17814	17814	Mountainous/Steep
Approach Road 2	0	660	660	Mountainous/Steep

3.2.3 DESIGN SPEED

It is the basic parameter, which determines all other geometric design features. The adopted design speed for this project is 50 km/hr to 80 km/hr. Where the site conditions or economic considerations do not permit the ruling design speed, same will be reviewed in consultation with the Client. The minimum design speed for National Highways in mountainous terrain is 40 km/hr and steep terrain 30 km/hr as stipulated in IRC:SP 48-1998.

Table 3-3: Design Speed

TABLE 1. NAME OF TERRAIN	TABLE 2. CROSS SLOPE OF THE COUNTRY (%)	TABLE 3. DESIGN SPEED (KM/HR)	
		TABLE 4. RULING	TABLE 5. MINIMUM
Mountainous	25-60	50	40
Steep	>60	40	30

3.2.4 SIGHT DISTANCE

i) The Project Highway is designed for stopping sight distance. Wherever feasible, intermediate sight distance in as much length of the road as possible, are attempted. Traffic signs depicting “Overtaking Prohibited” is recommended at all locations wherever stopping sight distance is provided.

ii) The recommended sight distances for various speeds are given in Table below.

Table 3-4: Sight Distances for Various Speeds

Speed(km/hr)	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

iii) Where horizontal and summit curves overlap, the design provides for the required sight distance, both in the vertical direction, along the pavement and in the horizontal direction on the inner side of curve.

3.2.5 WIDTH OF ROAD LAND (ROW), ROADWAY, CARRIAGEWAY AND SHOULDERS RIGHT OF WAY (ROW)

The desirable Right of Way for Non-urban & Urban areas is kept as given in table below, as prescribed in IRC:73& IRC:86 road are given in Table below.

Table 3-5: Desirable Road Land Widths (metres)/ROW)

NAME	CROSS SLOPE OF THE COUNTRY (%)	MOUNTAINOUS AND STEEP TERRAIN			
		OPEN AREAS		BUILT-UP AREA	
		NORMAL	EXCEPTIONAL	NORMAL	EXCEPTIONAL
1.	National and State Highways	24	18	20	18

Proposed right of way has been ascertained by the client based on cut/fill slopes in rural sections including landslide locations, portal locations and minimum formation width required. As the entire road is in new construction, PROW is 40m for Approach Road-1 and 24m for Approach Road-2.

Buffer Area: If the available right of way is sufficient, a buffer area between the curb and sidewalk is desirable. This area provides space for snow storage and allows for a greater separation between vehicle and pedestrian. The buffer area should be at least 5 ft wide to be effective and should desirably be wider. Although occasionally unavoidable, placing roadside appurtenances within the buffer area is undesirable. The proximity to the traveled way increases the likelihood of a vehicle/fixed-object crash. (Source: Adopted from Indiana Design Manual 2013, chapter 45 cross section elements).

Keeping above factors in consideration, the Proposed Right of Way (PROW) is kept 20-40m. Additional PROW is kept to accommodate avalanche protection measures.

Lane Width

The standard lane width of the Project Highway is 3.5 m

Extra Width of Carriageway

Existing geometry is poor at some locations with design speed even going as low as 20 Kmph and radius upto 30 m. Extra widening is proposed as per Table 10 of IRC 52 "Recommendations about the Alignment survey and Geometric design of Hill roads".

The additional width of paved carriageway is accommodated within formation width road width as per applicable Typical cross section, by reduction in Earthen shoulder width

Table 3-6: Widening of Pavement at curves

RADIUS OF CURVE IN M)	UPTO 20	**21 to 40**	**41 to 60**	**61 to 100**	**101 to 300**	**Above 300**
Extra width (m) Two lane	1.5	1.5	1.2	0.9	0.6	Nil

Shoulders
The shoulder width is as per IRC SP 73 2015 is given in table below, subjected to availability of land.

Table 3-7: Shoulder Width

TYPE OF SECTION	**Mountainous and Steep terrain (Hilly area)**			
		Paved	**Earthen**	**Total**
Open Country with Isolated Built up area	Hill Side	1.5 m	-	1.5m
	Valley side	1.5m	1.0m (in mild terrain)	2.5m
Built up area and approaches to grade separated structures/bridges	Hill Side	1.5m (Raised)	-	1.5m
	Valley side	1.5m (Raised)	-	1.5m

- A shoulder rumble strip is a raised or grooved pattern in the pavement surface of the shoulder. The raised rumble strip is not as desirable as the grooved type because of snow clearing operations. Grooved rumble strips are indented into the pavement of the shoulder of the roadway. In summer, grooved rumble strips are self-cleaned by highway traffic. In winter, even covered with snow the shoulder rumble strips still produce an effective humming noise when traversed by errant vehicles. (Source: Adopted from Geometric Design Guide for Canadian Roads 2011, chapter 2.2 cross section and roadside elements).
- Paved shoulders must be cleared of snow and ice during the winter months in order to function properly. Therefore, it is often practical for usable shoulders to be paved. (Source: Adopted from Mass Highway American Standard 2006, chapter 5 cross section and roadside elements).
- Apart from the paved shoulder, extra snow storage lane is provided of 1.5m as **per “IRC SP 48-1998”** Clause 6.5.2 Note-4.

3.2.6 ROADWAY WIDTH (FORMATION WIDTH)

Following typical cross sections have been developed for the proposed alignment.

- Type III - 2-Lane on mild slope terrain -13.4 (7.0m Carriageway + 2x 1.5m Paved shoulder + 1.5m Snow storage on valley side+ 1.0m Earthern Shoulder on valley side+0.9m Drain on Hill side).
- Type V - 2-Lane with hill side cut and valley side Metal Beam Crash Barrier -13.65 (7.0m Carriageway + 2x 1.5m Paved shoulder+ 1x1.5m Snow Storage on valley side+1.0m Earthen Shoulder with Metal Beam crash barrier on valley side +0.9m Drain on Hill side
- Type VI- 2-Lane New construction on high embankment -13.5 (7.0m Carriageway + 2x 1.5m Paved shoulder+ 2x0.75m Snow Storage + 2x1.0m Earthern Shoulder with Metal Beam Crash Barrier.
- Type VIII- 2-Lane New Construction with Both side cut -12.65 (7.0m Carriageway + 2x 1.5m Paved shoulder+1x1.5m snow storage with drain+0.9m Drain.
- Type IX- Cut& Cover
- Type X- Snow Gallery
- Type XI- Bridge

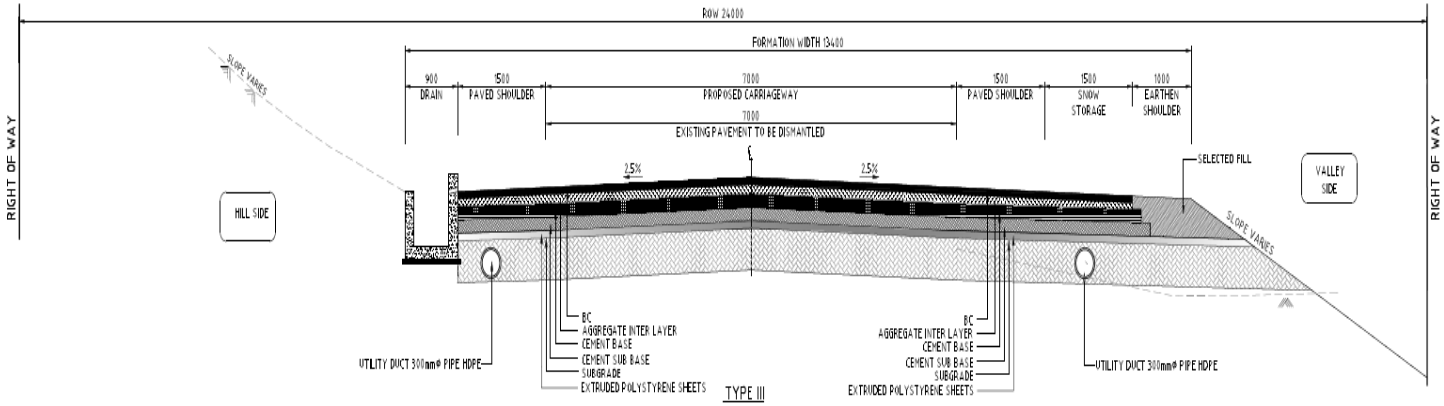
Table 3-8: Cross Section Schedule

S. No.	Design Chainage		Length (m)	Type of TCS	Description of TCS
	From (km)	To (km)			
Approach Road 1					
1	9760	9796	36	TCS VIII	Both Side Cut
2	9796	10106	310	TCS IX	Cut & Cover
3	10106	10146	40	TCS VIII	Both Side Cut
4	10146	10276	130	TCS VI	High Embankment Section
5	10276	10506	230	TCS IX	Cut & Cover
6	10506	10566	60	TCS VIII	Both Side Cut
7	10566	11066	500	TCS VI	High Embankment Section

S. No.	Design Chainage		Length (m)	Type of TCS	Description of TCS
	From (km)	To (km)			
8	11066	11256	190	TCS VIII	Both Side Cut
9	11256	11506	250	TCS IX	Cut & Cover
10	11506	11586	80	TCS VIII	Both Side Cut
11	11586	12626	1040	TCS VI	High Embankment Section
12	12626	12806	180	TCS III	Mild Slope Terrain
13	12806	13006	200	TCS VIII	Both Side Cut
14	13006	13406	400	TCS IX	Cut & Cover
15	13406	13486	80	TCS VIII	Both Side Cut
16	13486	13876	390	TCS VI	High Embankment Section
17	13876	13926	50	TCS V	Hill side gabion wall and valeey side Metal Beam Crash Barrier
18	13926	14006	80	TCS VIII	Both Side Cut
19	14006	14356	350	TCS IX	Cut & Cover
20	14356	14446	90	TCS VIII	Both Side Cut
21	14446	14586	140	TCS V	Hill side gabion wall and valeey side Metal Beam Crash Barrier
22	14586	14656	70	TCS VIII	Both Side Cut

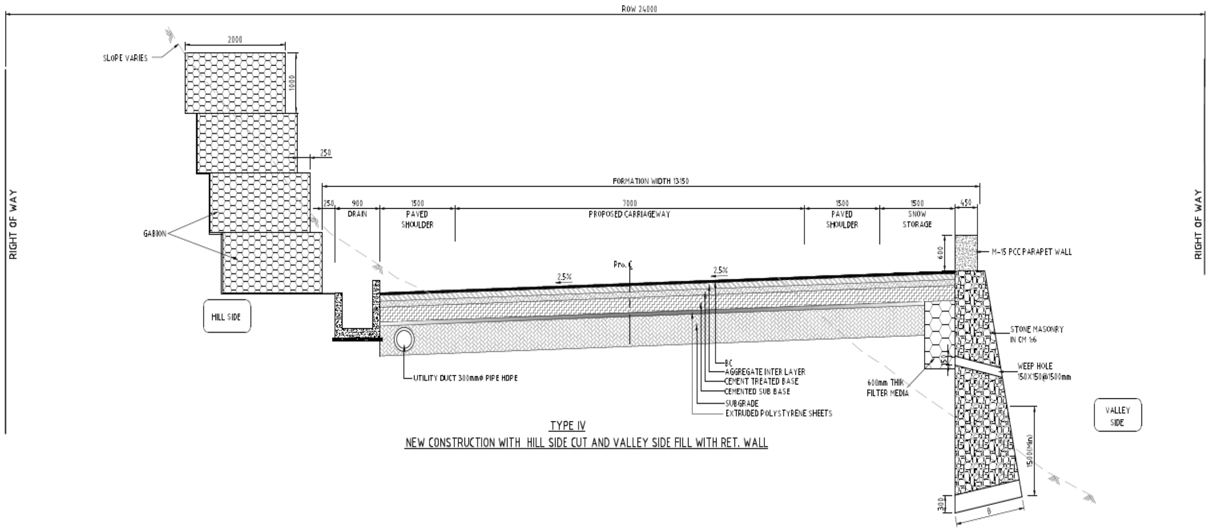
S. No.	Design Chainage		Length (m)	Type of TCS	Description of TCS
	From (km)	To (km)			
23	14656	14856	200	TCS IX	Cut & Cover
24	14856	14946	90	TCS VIII	Both Side Cut
25	14946	15036	90	TCS III	Mild Slope Terrain
26	15036	15156	120	TCS VI	High Embankment Section
27	15156	15206	50	TCS V	Hill side gabion wall and valeey side Metal Beam Crash Barrier
28	15206	15306	100	TCS VIII	Both Side Cut
29	15306	15766	460	TCS IX	Cut & Cover
30	15766	15906	140	TCS VIII	Both Side Cut
31	15906	16226	320	TCS III	Mild Slope Terrain
32	16226	16356	130	TCS V	Hill side gabion wall and valeey side Metal Beam Crash Barrier
33	16356	16656	300	TCS X	Snow Gallery
34	16656	16806	150	TCS IX	Cut & Cover
35	16806	16956	150	TCS X	Snow Gallery
36	16956	17172.5	216.5	TCS VI	High Embankment Section
37	17172.5	17307.5	135	TCS XI	Bridge

S. No.	Design Chainage		Length (m)	Type of TCS	Description of TCS
	From (km)	To (km)			
38	17307.5	17814.5	507	TCS VI	High Embankment Section
Approach Road 2					
39	0	660	660	TCS VI	High Embankment Section



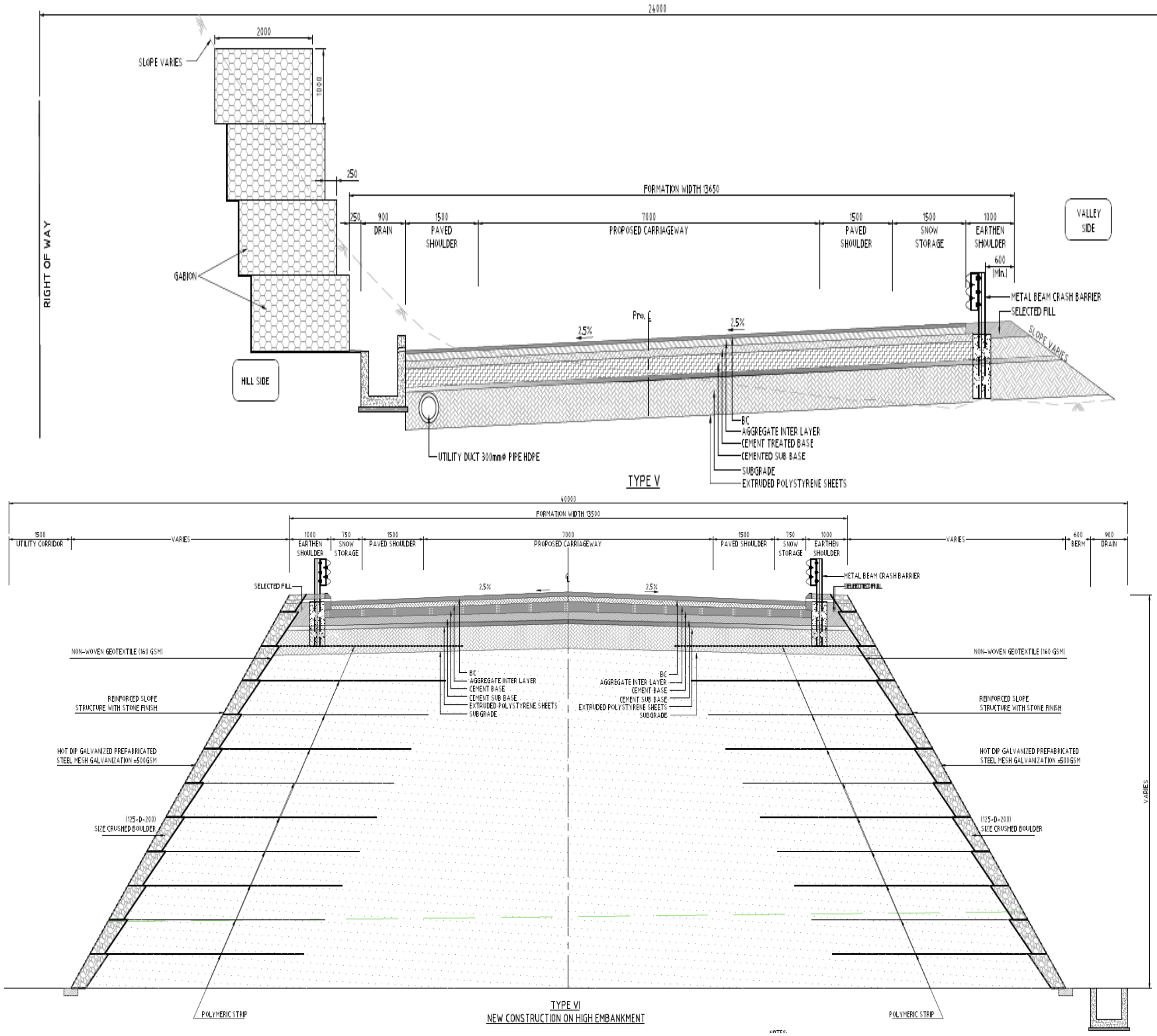
TYPE III

CONCENTRIC WIDENING IN RURAL AREA ON MILD SLOPE TERRAIN)



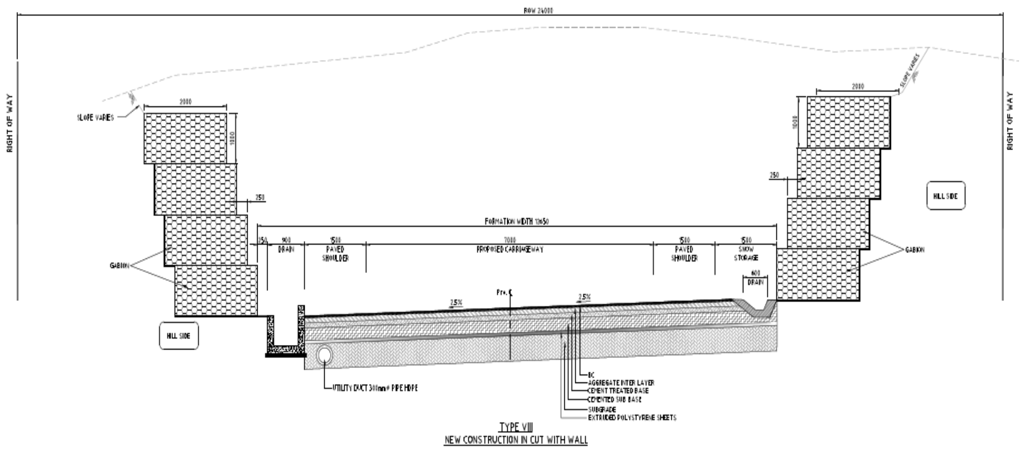
TYPE IV

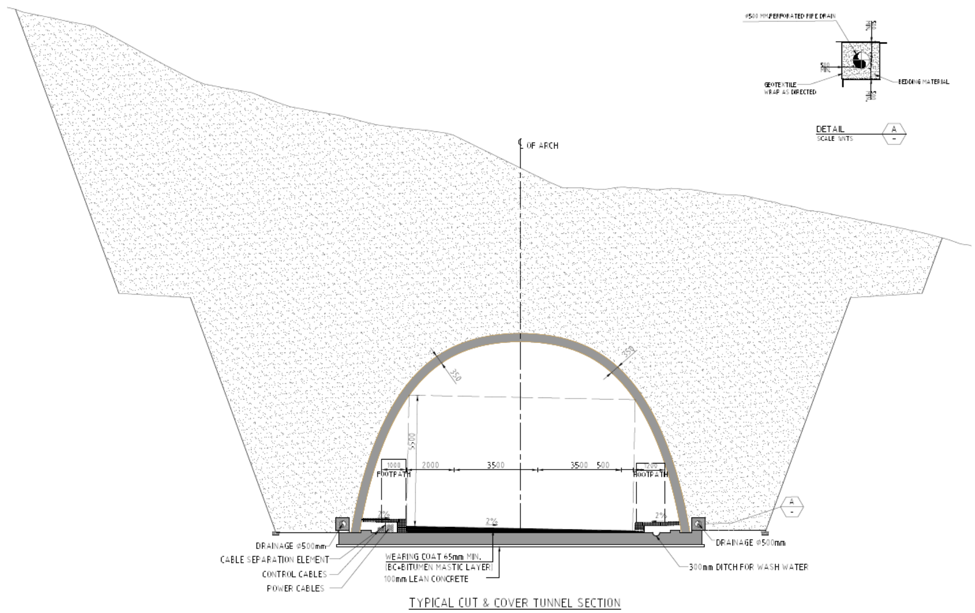
NEW CONSTRUCTION WITH HILL SIDE CUT AND VALLEY SIDE FILL WITH RET. WALL



SMEC

Member of the Surbana Jurong Group





Type IX Cut & Cover Section

SMEC
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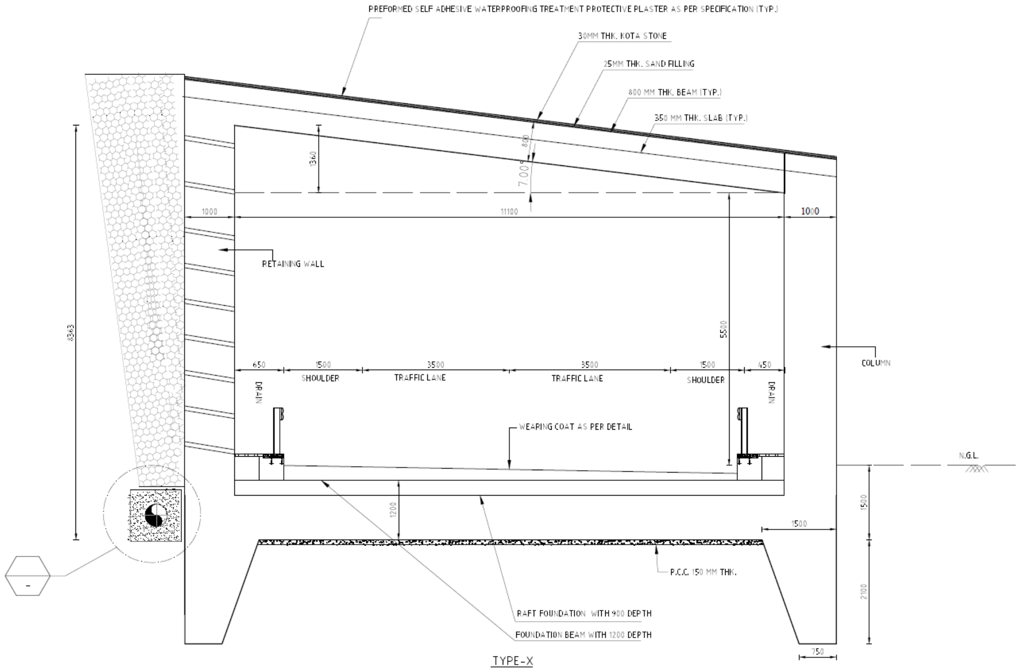
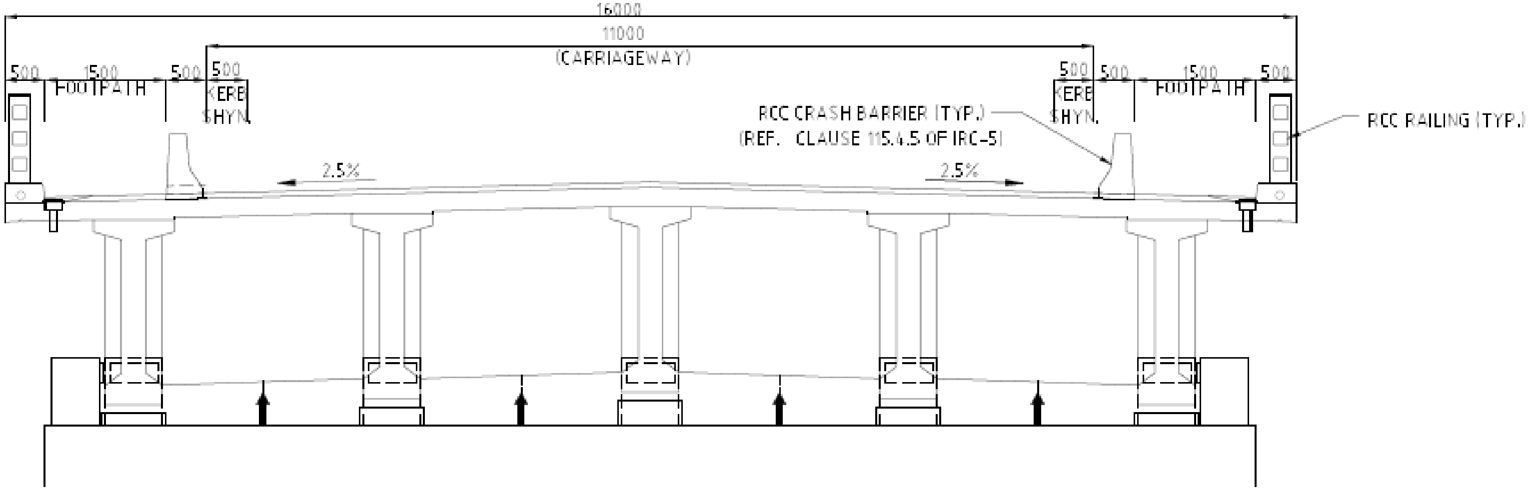


TYPE-X
TYPICAL CROSS SECTION FOR SNOW GALLERY



TYPICAL CROSS-SECTION OF BRIDGE WITH PROTECTED FOOTPATH
AS PER IRC-SP-73-2015

Type XI Typical Section of Bridge

3.2.7 CAMBER / CROSS FALL

i) The camber or crossfall on straight sections of road carriageway and shoulders is be as per Table below:

Table 3-9: Camber/Crossfall in percentage for different Surface Types

TABLE 6. CATEGORY OF SURFACE	Annual Low Rainfall (Less than 1500 mm)	Annual High Rainfall (More than 1500 mm)
Bituminous	2.5%	2.5%
Cement Concrete	2.0%	2.0%

ii) The camber for earthen shoulders on straight portion is at least 0.5 per cent steeper than the slope of the pavement and paved shoulder subject to a minimum of 3.0 per cent. On super elevated sections, the shoulders have the same crossfall as the carriageway.

Desirably, a shoulder cross slope should not be less than 4 percent to minimize ponding on the roadway. The shoulder cross slope on the outside of the curve may be constructed in the same direction as the adjacent lane. However, consideration should be given to snow storage in border area (snow melting in border area then draining and refreezing on roadway surface) by sloping the border away from roadway or by providing slotted drainage along shoulder. (Source: Adopted from New Jersey Roadway Design Manual 2015, Section 5 Major cross section elements).

3.2.8 HORIZONTAL ALIGNMENT

The Detailed Horizontal alignment has to be fluent and blend well with the topography. We are following here the designs a line, which conforms to natural contours, is aesthetically preferable to one with long tangents slashing through the terrain. The horizontal alignment should be coordinate carefully with the longitudinal profile.

Under IRC guidelines, the ruling design speed is 50 Kmph with a minimum design speed of 40 Kmph in mountainous terrain. In rolling terrain it varies from 80 Kmph to 65 Kmph.

Short curves give appearances of kinks, particularly for small deflection angles, and should be avoided. The curves should be sufficiently long and have suitable transitions to provide pleasing appearances. Curve length should be 150 meters for a deflection angle of 5 degree and some areas it has been increased by 30 meters for each degree decrease in the deflection angle.

The curves in the same direction separated by short tangents known as broken back curves should be avoided as far as possible in the interest of aesthetics and safety replaced by single curve.

In general horizontal curves consist of circular portion of the curve followed by spiral transitions on both sides. Design speed, super-elevation and coefficient of friction affect the design of curve.

3.2.9 GENERAL GUIDELINES

i) The alignment should be as directional, fluent and matching well with the surrounding topography as possible and also to avoid abrupt changes

ii) On new roads the curves should be designed to have the largest practical radius generally not less than the ruling value corresponding to ruling design speed given in Table 2.

iii) Absolute minimum values based on Minimum Design Speed may be used where economics of construction and site condition so dictates. The radii below the absolute minimum should not be provided.

iv) Straight section exceeding 3 km length should be avoided. A curvilinear alignment with long curve is better from point of safety and aesthetic.

v) Sharp curves should not be introduced at the end of long tangents, since these can be extremely hazardous.

vi) Curve should be sufficiently long and have suitable transition curves at either end to eliminate the shock due to application of centrifugal force. For deflection angle less than 1 degree no curve is required to be designed.

vii) Reverse curves may be needed in difficult terrain. Sufficient length between two curves shall be provided for introduction of requisite transition curve

viii) To avoid distortion in appearance, the alignment should co-ordinate with the longitudinal profile.

3.2.9.1 Horizontal Curves

The radius required for horizontal curves shall be calculated from the following formulae

R = $V^2 / 127(e + f)$

Where,

R = Radius in meters

V = Vehicle speed in km/hour

e = Super-elevation ratio in meter/meter

f = Coefficient of side friction between vehicle tyres and the pavement (taken as 0.15)

The desirable minimum and absolute minimum radii of horizontal curves for various classes of terrain as per Hill Road Manual (IRC: SP:48-1998) are given in Table below.

Table 3-10:Minimum Radii of Horizontal Curves

DESIGN SPEED KM/H	MINIMUM RADIUS (METRE) WHEN SUPERELEVATION IS LIMITED TO	
	7 Percent	4 Percent
30	30	40
50	90	105
60	130	150
80	230	265

Table 3-11 : Adopted Minimum Radii of Horizontal Curves

Nature of Terrain	Desirable Minimum	Absolute Minimum
Mountainous Terrain	80 m	50 m

3.2.9.2 Transition (spiral) Curves

A transition curve, transition spiral, or spiral easement, is a mathematically calculated Euler spiral fitted between a straight and a circular curve on a section of highway. In plan (i.e., the horizontal curve) the start of the transition is at infinite radius and at the end of the transition it has the same radius of curvature as the adjoining circular curve, thus forming a very broad spiral. At the same time in the vertical plane, the outside of the curve is gradually raised until the full super elevation is reached.

A spiral easement is used to smooth the change in centripetal acceleration experienced by a road vehicle and the users approaching the horizontal circular curve and to prevent abrupt forces and discomfort. Without such an easement, the centripetal force would change abruptly, with very undesirable results, at the tangent point where the straight track meets the curve.

Minimum length of the transition curve will be determined from the following considerations and the largest of the following values will be adopted for design.

Rate of change of centrifugal acceleration, the length of transition curve is given by:

$$Ls = 0.0215V^3 / CR$$

Where,

Ls = Length of transition in meters

V = Speed in Km/hr

R = Radius of circular curve in meters

C = 80/(75+V) (Subject to a maximum of 0.8 and minimum of 0.5)

Based on Rate of change of super-elevation, the minimum length of transition is given by:

$$Ls_1 = e\,N\,W$$

Where,

Ls_1 = Length of transition in meters

V = Speed in Km/hr

W = width of carriageway

N = Rate of change of super elevation (Should not be steeper than 1 in 150)

e = rate of change of super elevation

Based on Empirical formula

$$Ls_2 = 0.0635\,Ls_1\,V^2 / R$$

Ls_2 = Length of transition in meters

Ls_1 = Length of transition from formula 2

V = Speed in Km/hr

R = Radius of circular curve in meters

3.2.10 SUPERELEVATION

Superelevation to be provided on curve is calculated from the following formula:

$$e = V^2 / 225R$$

Where, e = Superelevation in meter per meter

V = Design speed in km/hr

R = Radius of the curve in meters

Super elevation obtained from the above expression should, however, be kept limited to 7%. Super elevation on all curves is provided as per IRC guidelines to a maximum of 7% in rural sections However, on urban sections with frequent intersections, it will be desirable to limit the superelevation to 4 % for convenience in construction and for facilitating easy and safe turning movement of vehicles.

The radii of curves which do not require super-elevation are as under:

Table 3-12: Radii beyond which Superelevation is not required

Design Speed Km/h	Radius (metre) for camber of			
	3 percent	2.5 percent	2 percent	1.7 percent
20	60	70	90	100
30	130	160	200	240
40	240	280	350	420
50	370	450	550	650

3.2.11 VERTICAL ALIGNMENT GENERAL

1. Broken-back grade lines, i.e. two vertical curves in the same direction separated by a short tangent, should be avoided due to poor appearance, and preferably replaced by a single curve.

2. Decks of small-drainage structures (i.e. culverts and minor bridges) should follow the same profile as the flanking road section, with no break in the grade line.

3. Gradient up to the 'ruling gradient' may be used as a matter of course in design.

4. 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 grades steeper than the ruling gradient should be as short as possible.

5. 'Exceptional gradients' are meant to be adopted only in very difficult situations and for short lengths not exceeding 100m at a stretch. Successive stretches of exceptional gradients must be separated by a minimum length of 100m having gentler/ flatter gradient.

6. The cumulative rise/fall in elevation over 2 Km length shall not exceed 100 m in mountainous terrain and 120m in steep terrain.

The following approach has been taken in designing the vertical alignment geometry.

- From field studies, low-lying areas where possible embankment construction would enhance pavement durability were identified.
- The minimum thickness of design overlay (includes base and sub-base thicknesses) consistent with pavement design and minimum cross fall have been provided as required along the road centre line under the up-gradation options.
- Summit curves have been designed to satisfy the criteria for Stop Sighting Distance (SSD). Intermediate Sight Distance (ISD) was also met in some straight stretches. Designing summit curves for ISD necessitates major changes in the vertical grade, which considerably increases the construction costs due to substantial increase in the volume of cutting and filling.
- A minimum gradient of 0.3% was used to fix grade lines and to limit the heights of embankments.
- The minimum curve lengths for suitable design speed and criteria for maximum grade changes, as per the IRC guidelines, have been followed when designing the vertical curves.
- “Broken-back” grade lines or two vertical curves lying in the same direction and separated by a short tangent have been replaced by single long curves wherever applicable.
- Sharp horizontal curves have been avoided at or near the apex of summit/sag vertical curves for safety considerations.
- As per the IRC guidelines, the vertical and horizontal curves have been phased.
- At bridges with spans □□ 30m, flanking sections of bridges have been combined into a single vertical curve.
- The vertical alignment has been designed to allow for adequate cover to culverts.
- In village and urban areas, the vertical gradients are designed to follow the existing profiles with allowance for required overlay thickness and efficient drainage needs but to keep the effective rise in finished road level to a maximum of 300 mm.
- All the valley curves are checked for the minimum required length to satisfy as per IRC 73 – 1980 for Head light sight distances at design speed of 80 Kmph or 100 Kmph. In some critical locations such as bridge approaches (where existing bridge is retained) or village limits etc., these vertical curves
- These vertical curves were designed for reduced design speed say at 50 or 65 Kmph, keeping the quantity of filling to minimum or to match the existing profile. In these situations, suitable speed regulatory measures were proposed to warn the drivers against possible hazard.
- Minimum length of summit curve adopted is 73.6A and for valley curves it is 41.5A considering SSD criteria for 100Kmph design speed, where ‘A’ being the algebraic difference in grades (expressed in percentage).
- The top levels of the culverts, minor bridges were considered as control points in design of vertical profile of the alignment.

3.2.11.1 Vertical Curve

Vertical curves are introduced for smooth transition at grade changes. Both summit curves and valley curves should be designed as parabola. The length of the vertical curve is controlled by sight distance requirements, but curves with greater length are aesthetically better. Curves should be provided at all grade changes exceeding those given in Table below. For satisfactory appearance, the minimum length should be as given in the Table below.

Table 3-13: Minimum Length of Vertical Curve

Design Speed km/h	Minimum Length of Vertical Curve (meter)
Upto 35	15
40	20
50	30
65	40
80	50

3.2.11.2 Vertical Gradient

The ruling and limiting gradients are given in Table below.

Table 3-14: Recommended Gradients

Nature of Terrain	Ruling Gradient	Limiting Gradient	Exceptional Gradient
Mountainous	5.0%	6.0%	7.0%
Steep	6%	7%	8%

i) Gradients up to the value corresponding to ruling & limiting gradient have been adopted, as far as possible. Exceptional gradients have been adopted only in very difficult situations and for short lengths.

ii) Attempts have been made to provide long sweeping vertical curves at all grade changes. These are designed as square parabolas.

iii) Vertical curves and its coordination with horizontal curves has been considered as per IRC:SP:23.

3.2.12 COORDINATION OF HORIZONTAL & VERTICAL ALIGNMENTS

Vertical curvature superimposed upon horizontal curvature gives a pleasing effect. As such the vertical and horizontal curves should coincide as far as possible and their length should be more or less equal. If this is difficult for any reason, then horizontal curve should be somewhat longer than the vertical curve. Shape horizontal curves should be avoided at or near the apex of pronounced summit/ sag vertical curves from safety point of view.

3.2.13 CROSS FALL AND LONGITUDINAL GRADIENT

The following cross fall is proposed in the project roads for quick dispersal of precipitation on the road surface.

Table 3-15: Cross fall Standards

Particulars	Cross fall %
Carriageway	2.5

Paved Shoulder	2.5
Gravel Shoulder	3.0

3.3 ROAD INTERSECTIONS

3.3.1 INTRODUCTION

The efficiency, safety, speed, cost of operation and capacity of all highways are influenced by the design of the intersections. Each intersection involves through or cross traffic movements on one or more of the roads concerned and turning movements between these roads may also be involved. These movements may be handled by various means depending on the type of intersections. Only at-grade junctions are required for this project.

The philosophy which will be adopted for the intersection designs is intended to reduce the severity of potential conflicts between cars, buses, trucks, bicycles and pedestrians while facilitating the convenience, ease and comfort of the road users traversing the intersections. The designs will therefore be fitted to the natural transitional paths and operating characteristics of the user.

3.3.2 AT GRADE INTERSECTIONS

The following factors will be considered in the design of the at-grade intersections:

- human factors
  - driving habits
  - ability to make decisions
  - driver expectancy
  - decision and reaction time
  - conformance to natural paths of movement
  - pedestrian use and habits
  - bicycle use and habits
- traffic considerations
  - design and actual capacities
  - design hour turning movements
  - size and operating characteristics of vehicle
  - variety of movements (diverging, merging, weaving and crossing)
  - vehicle speeds
  - transit involvement
  - accident statistics
  - bicycle movements
- physical elements

  - character and use of abutting property
  - vertical alignments
  - sight distance
  - angle of the intersection
  - conflict area
  - speed change lanes
  - geometric features
  - traffic control devices
  - lighting
  - safety features
  - bicycle traffic
  - environmental factors,
- economic factors
  - cost of improvements
  - effects of controlling or limiting rights-of-way on abutting residential or commercial properties where channelization restricts or prohibits vehicular movements.

3.3.3 DESIGN TRAFFIC

The traffic volume in terms of AADT and PCUs will be at one year's intervals for total period of 15 years for flexible pavement and 30 years for rigid pavement. Peak hour traffic will also be considered.

3.3.4 DESIGN VEHICLE

The designs will be suitable for single unit trucks/ bus chassis and for articulated/ semi-articulated vehicles with wheel base up to 12m.

The design speed for auxiliary lanes will be 60% of the ruling design speed for the highway in open areas. The turning speed for right angle turns will how-ever be restricted to 20 km/ hr and to a maximum of 30 km/ hr for left turns.

3.3.5 TURNING RADIUS

A minimum turning radius of 15m will be adopted for right turns to permit a turning speed of 20 km/hr. Maximum radius for left turns will be 30 m which will permit a turning speed of 30 km/hr. For village and other lower category roads including any permitted access connections to adjacent properties, a turning radius of 15 m will be adopted.

Where high proportions of left turning vehicles are anticipated, three-centred compound curves will be used to reduce the risk of vehicles leaving their designated lane and to minimise the paved area of the junction.

3.3.6 WIDTH AND NUMBER OF LANES

The number of lanes will be governed by peak hour traffic volume in each direction of travel. The provisions stipulated in IRC:64-1990 (Guidelines on Capacity of 'Roads in Rural Areas') and the relevant circulars issued by MOST will be observed when determining the number of lanes.

Carriageway widening will be achieved by a taper of not less than 1 in 15.

3.3.7 ROAD MARKING AND SIGNAGE

Road signing will comply with the provisions stipulated in IRC:67-2012 and the road markings provided will satisfy the requirements of IRC:35-1970. Signalization will be considered when the warrants given in IRC:93-1986 apply.

3.3.8 JUNCTION PROPOSAL

Junction proposal for following 02 no of Intersections along the project stretch are under consideration.

Table 3-16: Junction Details

S. No.	Existing Location (km)	Proposed Location (km)	Type	Major/Minor	Cross Road	
					LHS	RHS
1	-	12+520	T Type	Minor	-	Amarnath Pilgrim Road
Approach Road-2						
2	118+000	0+660	Y Type	Major	NH 1	-

3.4 PAVEMENT DESIGN

3.4.1 INTRODUCTION

The design of pavements in high altitude snow bound region tends to thick in order to sustain frost heave and particularly uneven settlements at spring thaw. Typically most roads in cold region only carry limited amounts of traffic. Keeping in view the distress potential of climate as also the relatively low volume of vehicular traffic on the roads in high altitude snow bound regions, the performance of pavements will essentially be affected more by the changing thermal regime of the ground than by the axle loads. This calls for a paradigm shift in the approach generally followed for designing pavements. Instead of designing for axle loads, the road pavements in high altitude snow bound regions should be designed primarily on the consideration of extremely varying climatic and geotechnical conditions of the ground. Such designs will invariably be found adequate for the vehicle axle loads, which the pavement is expected to carry during its design life. This basically aims at determining the total thickness of the pavement structure as well as the thickness of the individual structural components.

The effects of frost action introduce many challenges in the design and construction of roadways in cold regions. The penetration of frost into pavement structures can lead to differential frost heave during winter and thaw weakening during spring. Both of these damage mechanisms lead to premature pavement distress, structural deterioration, and poor ride quality.

The thickness of a pavement structure can play an important role in the performance of a roadway, especially in cold regions. If the frost penetration depth exceeds the thickness of the pavement structure in areas with frost-susceptible soils, frost heave, thaw weakening, and freeze-thaw cycling can cause substantial damage to the roadway.

In high altitude areas which are subjected to heavy snowfall, sub-zero temperature, frost action, snow drifts and avalanche activities, design and construction of pavement require special consideration. The performance of conventional type of flexible pavements, comprising viz GSB, WMM etc, may not be found satisfactory due to factors like:-

(a) Frost heaving and thawing action

(b) Intensive snow and avalanche activity

(c) Icing problems

(d) Damage by movement of tracked vehicles during snow clearance operations.

(e) Loss of ductility of bitumen due to sub-zero temperatures

(f) Blocking of drainage system

(g) Glacier and avalanche movement on the road

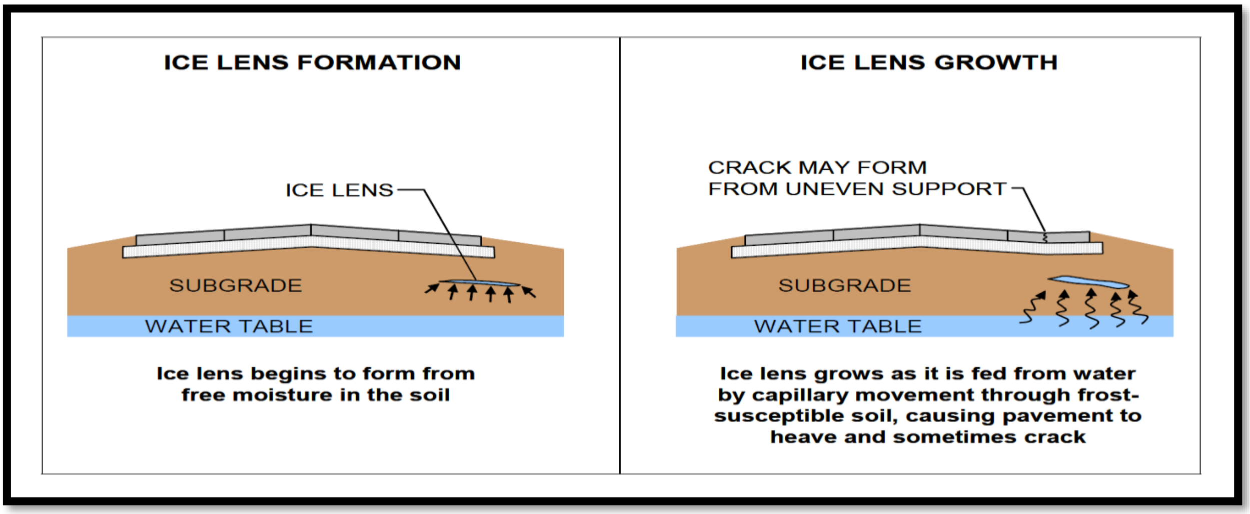


Fig 3-1: Formation of ice lens and frost heave in frost susceptible soil

The above result in excessive maintenance requirement and even destruction of pavement and allied structures. Roads in high altitude areas should be designed to retain their stability and serviceability inspite of yearly relentless cycle of freezing and thawing.

3.4.2 FROST SUSCEPTIBILITY OF SOIL

From the point of view of pavement design and construction, the need will for a simple set of criteria to distinguish whether a given soil will frost susceptible or not. Such criteria, in empirical form, incorporating the principles of freezing of soils and formation of ice lenses been evolved by Casagrande essentially based on grain size to serve as a useful guide. Soil have been divided in to 4 groups F1 to F4 (By US Corps of Engineers).

Table 3-17 : Grouping of Soil Based on Frost Susceptibility

Group	Description	Characteristics
F1	Gravelly soils containing between 3 to 20 percent finer than 0.02 mm. by weight.	Least frost susceptible and least thaw weakening.
F2	Sands containing between 3 and 15 percent finer than 0.02 mm. by weight.	Increased frost-susceptibility and thaw weakening.
F3	(a) Gravelly soils containing more than 20 percent finer than 0.02 mm. by weight. (b) Sands, except very fine silty sands, containing more than 15 percent finer than 0.02 mm. by weight. (c) Clays with plasticity indexes of more than 12. (d) Varved clays existing with uniform subgrade conditions.	Frost susceptible and high thaw weakening.
F4	(a) All silts including sandy silts. (b) Very fine silty sands containing more than 15 percent finer than 0.02 mm. by weight. (c) Clays with plasticity indexes of less than 12. (d) Varved clays existing with non-uniform subgrade conditions.	Frost susceptible and high thaw weakening.

3.4.3 DESIGN OF FLEXIBLE PAVEMENT FOR MAIN CARRIAGEWAY AS PER IRC: 37-2012 GUIDELINES

The design exercise is carried out as per the Annexure-1 of in IRC: 37-2012. The proposed pavement composition comprises of granular sub base, WMM base and bituminous layers.

Materials, Assumptions and Inputs BT layers

VG 10 grade bitumen is considered for bituminous layers (BC and DBM @35 C) with a stiffness value of 2300 Mpa as per table 7.1 of IRC 37-2012.

WMM & GSB

A granular base of WMM is considered. The GSB acts as drainage layer and shall be extended over the full formation width. WMM of 250 mm thick is considered for pavement design. Elastic modulus of granular layers is been calculated using the following formula.

MR_Granular = $0.2 \times h^{0.45} \times$ MR(SG) .... Para 7.3.1 of IRC 37-2012

h = Thickness of granular sub base (GSB) and base (WMM), mm.

Poisson’s ratio 0.35 and 0.35 are considered for bituminous and granular layers respectively.

Failure Criteria

The fatigue cracking at the bottom of the BT layer and rutting on the top of subgrade will considered as failures which govern the design

Fatigue life of Pavement

The fatigue life in terms of MSA will worked out using the following equations.

N_f= 2.021 x 10-4 x (1/€$_t$) ^3.89 x (1/M_R)^0.854
N_f = fatigue life in number of standard axles.
€$_t$ = Maximum tensile strain at the bottom of the bituminous layer
M_R = Resilient modulus of the bituminous layer

Rutting life of Pavement
The rutting life in terms of MSA will worked out using the following equation

N = 4.1656 x 10^{-8} x $(1/€v)^{4.5337}$
N = Number of cumulative standard axles
€v = Vertical strain in sub grade

3.4.4 DESIGN OF RIGID PAVEMENT

The main factors governing design of concrete pavements are design period, commercial traffic volume, composition of commercial traffic in terms of single, tandem, tridem, and multi axle, axle load spectrum, tyre pressure of commercial vehicles, lateral placement characteristic of commercial vehicles, directional distribution of commercial vehicles, composition and strength of foundation and climatic condition.

The design will carried out by calculating the following:-

Design Wheel Load, Temperature Differential, k- Value, Concrete Strength, Modulus of Elasticity, Poisson's ratio & Coefficient of thermal expansion, Design parameters, Percentage of Axle loads, expected repetitions, Load Safety factor, Fatigue Life Consumed, Cumulative fatigue life consumed <1, Check for Temperature Stress: Edge Warping Stress: Check for Corner Stress, Design of Dowel Bars, Check for bearing stress, Design of Tie bars, Spacing and length of the Deformed Tie bars.

Results thus obtained will tabulated in the format as shown below:-

Table 3-18: Rigid Pavement Design Option

S. No.	Description	Proposed thickness /Spacing
1	Granular sub base	
2	DLC of M - 10 grade	
3	PQC of M - 40 grade	
	Spacing of Reinforcement	
3-I	Dowel bars	
Ii	Plain Tie bars	
iii	Deformed Tie bars	

3.4.4.1 Road Capacity and Lane Width

According to two lane manual IRC:SP-73:2015 the recommended design services volume are tabulated below:

Table 3-19: Design Service Volume in PCU / day

S. No.	Nature of Terrain	Design Service Volume in PCU / day
1	Plain	18,000
2	Rolling	13,000
3	Mountainous and Steep	9,000

3.4.5 LEVEL OF SERVICE

Level of Service is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by drivers / passengers.

Level of Service definition generally describes these conditions in terms of factors such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, convenience and safety. Six levels of service are recognized commonly, designated from A to F, with Level of Service A representing the best operating condition (i.e. free flow) and level of service F the worst (i.e. forced or break-down flow)

Level of Service A: Represents a condition of free flow. Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is high. The general level of comfort and convenience provided to the road users is excellent.

Level of Service B: Represents a zone of stable flow, with the drivers still having reasonable freedom to select their desired speed and manoeuvre within the traffic stream. Level of comfort and convenience provided is somewhat less than level of service A, because the presence of other vehicles in the traffic stream begins to affect individual behavior.

Level of Service C: This also is a zone of stable flow, but marks the beginning of the range of flow in which the operation for individual users becomes significantly affected by interactions with other in the traffic stream. The selection of speed is now affected by the presence of their, and maneuvering within the traffic stream requires substantial vigilance of the part of the user. The general level of comfort and convenience declines noticeably at this level.

Level of Service D: Represents the limit of stable flow, with conditions approaching close to unstable flow. Due to high density, the drivers are severely restricted in their freedom to select desired speed and maneuver within the traffic stream. The general level of comfort and convenience is poor. Small increase in traffic flow will usually cause operational problems at this level.

Level of Service E: Represents operating conditions when traffic volumes are at or close to the capacity level. The speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and is generally accomplished by forcing a vehicle to give way to accommodate such maneuvers. Comfort and convenience are extremely poor, and driver frustration is generally high. Operations at this level are usually unstable, because small increase in flow or minor disturbance within the traffic stream will cause breakdowns

Level of Service F: Represents zone of forced or breakdown flow. This condition occurs when the amount of traffic approaching a point exceeds the amount which can pass it. Queues from behind such locations.

Operation within the queues are characterized by stop and go waves, which are extremely unstable. Vehicle may progress at a reasonable speed for several hundred meters and may then be required to stop in cyclic fashion. Due to high volumes break down occurs, and long queues and delay results.

3.4.6 CAPACITY AND DESIGN SERVICE VOLUME

From the viewpoint of smooth traffic flow, it is not advisable to design the width of road pavement for a traffic volume equal to its capacity which is available at LOS E. At this level, the speeds are low (typically half the free speed) and freedom to maneuver within the traffic stream is extremely restricted. Besides, at this level, even a small increase in volume would lead to forced flow situation and breakdowns within the traffic stream. Even the flow conditions at LOS C and D involve significant vehicle interaction leading to lower level of comfort and convenience. In contrast, level of Service B represents a stable flow zone which affords reasonable freedom to drivers in terms of speed selection and man oeuvres within the traffic stream. Under normal circumstances, use of LOS B is considered adequate for the design of rural highways. At this level, volume of traffic will be around 0.5 times the maximum capacity and this is taken as the “design service volume” for the purpose of adopting design values.

It is recommended that on major arterial routes LOS B should be adopted for design purposes. On other roads under exceptional circumstances, LOS C could also be adopted for design. Under these conditions, traffic will experience congestion and inconvenience during some of the peak hours which may be acceptable. This is a planning decision which should be taken in each case specifically after carefully weighing all the related factors. For LOS C, design service volumes can be taken as 40 per cent higher than those for LOS B given in subsequent paragraphs.

The design service volume that should be considered for design / improvement of a road facility should be the expected volume at the end of the design life. This can be computed by projecting the present volume at an appropriate traffic growth rate. The traffic growth rate should be established after careful study of past trends and potential for future growth of the traffic.

3.5 DRAINAGE

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

3.5.1 DESIGN PARAMETERS FOR DRAINS LONGITUDINAL GRADIENT

Gradients are provided on roads according to the road profile designed on the basis of design speed and to match the surrounding terrain. In any case, a slight longitudinal gradient in the road alignment helps improve internal drainage of pavement layers. A minimum longitudinal gradient of 0.3% is provided in most conditions except at few sections where flatter gradients have been adopted to match with the outfall inverts. A minimum longitudinal gradient of 0.3% is considered adequate in most conditions to secure satisfactory drainage. It is also required in cut sections and medians to facilitate the removal of water. A minimum longitudinal gradient of 0.3% is also preferable to facilitate flow of water in roadside drains, with outlets provided at required interval to restrict the depth of drains. But in flat terrain in the project area where 0.3% gradient is not possible, it can be varied to 0.1% or more flatter as per requirement.

Kerb drains on high embankments at approaches to bridges follow the general road gradient. Drainage for the project road has been designed as per

IRC-SP: 42 - Guide lines on Road

Drainage & IRC-SP: 50 - Guide lines on Urban Drainage.

3.5.2 CROSS SLOPE AND CAMBER

If a steep cross slope is provided, it helps in quick dispersal of water from the pavement surface, but it may be objectionable from considerations of comfort to the traffic. Therefore cross slope is often a compromise between the requirements of drainage and those of vehicular traffic. But from drainage point of view a reasonably steep cross slope will be helpful in minimizing ponding of water on flat grades. Flat slopes are major contributors to the condition which produces the phenomena of hydroplaning and accidents on roads.

IRC: 73-1980 "Geometric Design Standards for Rural (non-urban) Highways" recommends camber or cross slope on straight section of roads. In keeping With the IRC recommendations, the Consultants have adopted a crossfall and camber of 2.5% for main carriageway. This is considered enough to drain out the water from top of the pavement surface as even for steepest adopted longitudinal gradient of 3.33%.

The following cross fall is proposed in the project roads for quick dispersal of precipitation on the road surface.

Table 3-20: Cross fall Standards

Particulars	Cross fall (%)
Carriageway	2.5
Paved Shoulder	2.5
Earthen Shoulder	3.0

3.5.3 MINIMUM SECTION OF DRAINS

Section is chosen in such a way that the drain would be able to be cleared periodically using a spade. Accordingly, it is recommended that minimum width of a drain would be 600 mm. In case where drains are required to pass the existing cross roads, provision of buried pipe of minimum dia 900mm is made for drain to cross from one side to other. For drain in urban area, 1.0m internal width of drain is proposed under footpath of 1.5m.

3.5.3.1 Channel Shapes

The usual channel shapes are:

- ✓ Parabolic
- ✓ Trapezoidal
- ✓ Rectangular
- ✓ Triangular or V shaped

The parabolic section is the best from hydraulic consideration but it is very difficult to construct and subsequently maintain. The V-shaped drains are also very difficult to maintain as its desilting is difficult. The trapezoidal and rectangular sections are easier to construct and maintain, thus is considered the most suitable. Trapezoidal and Rectangular section is recommended to adopt for the project road.

3.5.3.2 Side Slopes

The economical sections can be obtained by adopting drain section based on the following relation between bed width and depth:

- Rectangular drain b = 2d
- Trapezoidal b = 0.82d (1 :1 side slope)
  B = 1.24d (1.5:1 side slope)

Side slope of 1.5 (H):1(V) is recommended for earthen drain considering angle of repose of available material. For lined drain with brick or stone or concrete paving, side slope of 1 (H): 1 (V) is preferred for trapezoidal section.

3.5.4 PAVEMENT INTERNAL DRAINAGE

Drainage of pavement layers across the earth shoulders has an important bearing on the performance of the pavement. In case of new carriageway and reconstruction of existing road, bottom most granular sub-base layer is to be extended upto to the edge of embankment slope. In case of widening with existing road on one-side, continuous drainage layer is not possible and extension is to be limited till existing crust.

The sub-base layer is to have following capacity to carry the design discharge. Flow through subbase layer is considered as saturated laminar flow and calculated using Darcy's Law as under;

$$Q=KiA$$

Where,

Q = discharge in cumlsec

K = Coefficient of permeability in mlsec i =

Hydraulic gradient

A = cross section area in sqm perpendicular to the direction

3.5.4.1 Pavement Internal Drainage

Two main objectives of subsurface drains are to lower the level of water table and to intercept or drain out underground water. The subsurface drains in cut slope are useful as these carry away underground water which otherwise responsible for sloughing of the slope.

3.6 DESIGN STANDARDS OF STRUCTURES

3.6.1 DESIGN STANDARDS

Summary of various Design Standards finalized and adopted for designing different structural components are:

Table 3-21: Summary of various Design Standards

(a)	**Width of Carriageway** (i) For Minor & Major Bridges	For all bridges with footpath – 16 meter overall width (0.5m Handrail, 1.5m Footpath & 0.5m Crash barrier on either edge with 11m carriageway including shyness in between) as per IRC

	(for New/ Reconstruction) • 2Lane Structures (ii) For Minor & Major Bridges (for Retain / Widening) • 2Lane Structures (iii) Culverts & other Structures	SP 73:2018 If structure is in sound condition & carriageway is ≥ 7.5m, the bridge is retained as it is, otherwise, widened to width as for new bridges considering structural condition. Width equal to the roadway width of the approaches
(b)	**Design Loading** Dead Loads, Footpath Live Loads, Live Loads, Snow load, other Forces/ Loads, Temp Variation etc.	As per IRC 6-2017.
(c)	**Seismic Loading** Project Road : Zone V	As per IRC 6-2017.
(d)	**Wearing Coat**	65mm thick wearing coat
(e)	**Expansion Joints**	Filler Type/ Strip seal Type depending upon span length of structure
(f)	**Drainage** Cross Fall, Drainage Spouts	As per design requirements
(g)	**Approach Slabs**	RCC approach slabs of 3.50 meter length over the full width of the bridge
(h)	**Bearings**	Tar paper or Elastomeric or POT-PTFE bearings for Bridges
(i)	**Superstructure**	Minor & Major Bridges: Span up to 10.0m - RCC Box/RCC Solid Slab; Span from 10.0m to 20.0m - RCC T-Beam/Portal Structure; Span from 20.0m to 40.0m - PSC T-Beam; Span from 40.0m to 60.0m - Composite Steel Plate Girders with Cast-in situ deck; Span > 60.0m - Steel Truss Type Superstructure / Pre-stressed Balanced Cantilever Box Girder Bridge Culverts:

		Solid Slab/ Pipe/ RCC Box (as the case may be)
(j)	**Substructure** Piers Abutments Wing walls	RCC Wall/ Circular Type. RCC Cantilever Type. RCC Cantilever Type Retaining Wall
(k)	**Foundations:**	Pile/Raft/ Strip/ Open Foundation for bridges
(l)	**Materials Specifications:** **Steel:** Un-tensioned steel Prestressing steel Structural Steel **Concrete** Piers/ Abutments, Open/ Pile foundation RCC/PSC Superstructure	Fe-500D Grade shall be used with reference to IS: 1786. Class II 7 wire stress relieved, low relaxation type strands confirming to IRC:112, with the following properties:- Nominal size 15.2mm Guaranteed nominal breaking load 260.7 kN Modulus of elasticity 195 kN/mm^2 Friction coefficient in ducts 0.17 (Corrugated HDPE) Wobble 0.002 rad/m (steel ducts) Wedge pull-in 6mm Jacking force shall be restricted to 78.3% breaking load (max) High tensile steel (Grade E350 B0) to IS: 2062-2011. Tensile Strength = 490 Mpa Yield Stress (t <= 20mm) = 350 Mpa (20 < t <= 40mm) = 330 Mpa (t > 40mm) = 320 Mpa Young Modulus of elasticity = 200,000 Mpa As per IRC: 78-2014 and IRC 112

3.6.2 CODES OF PRACTICES AND STANDARDS

The structural design will conform to the latest revision of codes and recommendation of MOST specifications and sound engineering practice.

For manufactured items the recommendations of manufacturer regarding the use, design criteria, installation instructions and properties will be considered for the design of structures.

The following are the various design codes that shall be followed for the structural design of various components of the project road. These shall be supplemented, wherever required, by guidelines from various international codes:

IRC: 5 – 1998	Standard Specifications and Code of Practice for Road Bridges. Section I - General Features of Design
IRC: 6 – 2017	Standard Specifications and Code of Practice for Road Bridges. Section II – Loads and Stresses
IRC: 22– 2008	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design)
IRC: 24– 2010	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)
IRC: 45 – 1972	Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges.
IRC: 78 – 2014	Standard Specifications and Code of Practice for Road Bridges. Section VII – Foundation and Substructure
IRC: 83	Standard Specifications and Code of Practice for Road Bridges. Section XI – Bearings (Part I to Part III)
IRC: 89 – 1997	Guidelines for Design and Construction of River Training and Control Works for Road Bridges.
IRC: 112 – 2014	Code of Practice for Concrete Road Bridges.

Other IRC Special Publications for Bridges:

IRC: SP – 13	Guidelines for the Design of Small Bridges and Culverts
IRC: SP – 33	Guidelines on Supplemental Measures for Design, Detailing and Durability of Important Bridge Structures.
IRC: SP – 35	Guidelines on Inspection and Maintenance of Bridges
IRC: SP – 40	Guidelines on Techniques for Strengthening and Rehabilitation of Bridges
IRC: SP – 69	Guidelines and Specifications for Expansion Joints
IRC: SP – 73	Manual of Standards & Specifications for Two-Laning of State Highways on BOT Basis

The specifications of latest MOST, IS, BS, AASHTO codes, in that order, will be followed for items outside the purview of the foregoing standards.

3.6.3 PROPOSAL OF BRIDGES AND CROSS DRAINAGE STRUCTURES

There are 5 new bridges out of which four are major bridges and one is a minor bridge. There are total 41 culverts proposed, 10 are in reconstruction and 31 are in new construction. Out of 41 total culverts, 30 are box culverts and 11 are pipe culverts.

Table 3-22: Details Proposed Improvements for the Culverts

Type of Structure	Existing Culverts	Culvert Improvements Proposals						Total Culverts proposed
						Additional Culverts		
		Retained & Widen	Reconstruction	New Construction due to Realingment or Earth fill\cut	Abandoned	Due to Hydrology	Suggested	
Box Culverts	0	0	0	10	-	0	0	10
Pipe Culverts	-	-	0	10	-	-		10

Table 3-23: Details of Proposed Improvements for Bridges

S. No.	Description	Number of Existing Structures	Proposal of Bridges			
			Number of retained bridge	Number of structures to be reconstructed as bridge	Number of bridges that are New Construction	Remark
1	Major bridge	-	-	-	1	-
2	Minor bridge	-	-	-	-	-
Total Existing Bridges		-	Total Proposed Bridges		1	

The Summary of proposed cross drainage structures is shown below:

Table 3-24: Cross Drainage Structures / Culvert in Reconstruction

S. No.	Existing Chainage (km)	Design Chainage (km)	Existing Structure Type	Final Structure Proposal				
				Structure Type	Span/ Opening / Pipe Dia.	Re - commendation	Remarks	Type of construction
Nil								

Table 3-25: Cross Drainage Structures / Culvert in New Construction

S. No.	Existing Chainage (km)	Design Chainage (km)	Final Structure Proposal				
			Structure Type	Span/ Opening/ Pipe Dia.	Re - commendation	Remarks	Type of construction
Approach Road-1							
1	-	10+196 10+586	Pipe Box	3x1.2 ⌀ 1x3x3	New construction	-	-
2	-	10+656 10+735	Pipe Box	1x1.2 ⌀ 1x5x6.5	New construction	-	-
3	-	11+906 12+216	Box Pipe	1x5x6.5 2x1.2 ⌀	New construction	-	-
4	-	12+481 12+676	Box Box	2x3x6 1x2x2	New construction	-	-
5	-	13+584 13+694	Pipe Pipe	3x1.2 ⌀ 2x1.2 ⌀	New construction	-	-
6	-	13+886 14+996	Box Box	1x2x2 1x2x2	New construction	-	-
7	-	15+076 15+186 15+986	Pipe Box Box	2x1.2 ⌀ 1x2x2 1x2x2	New construction	-	-
8	-	16+196 17+106	Box Box	1x2x2 1x2x2	New construction	-	-
9	-	17+746 10+196	Pipe Pipe	3x1.2 ⌀ 3x1.2 ⌀	New construction	-	-
10	-	10+586 10+656	Box Pipe	1x3x3 1x1.2 ⌀	New construction	-	-
11	-	10+735 11+906	Box Box	1x5x6.5 1x5x6.5	New construction	-	-
12	-	12+216 12+481	Pipe Box	2x1.2 ⌀ 2x3x6	New construction	-	-
13	-	12+676	Box	1x2x2	New	-	-

		13+584	Pipe	3x1.2 ⌀	construction		
14	-	13+694 13+886	Pipe Box	2x1.2 ⌀ 1x2x2	New construction	-	-
15	-	14+996 15+076	Box Pipe	1x2x2 2x1.2 ⌀	New construction	-	-
16	-	15+186 15+986	Box Box	1x2x2 1x2x2	New construction	-	-
17		16+196 17+106	Box Box	1x2x2 1x2x2	New construction	-	-
18	-	17+746	Pipe	3x1.2 ⌀	New construction	-	-
Approach Road 2							
19	-	0+110	Pipe	3x1.2 ⌀	New construction	-	-
20	-	0+400	Pipe	2x1.2 ⌀	New construction	-	-

The Summary of bridges is shown below:

Table 3-26: Bridges Proposed for New Construction as Major Bridge

S. No.	Existing Chainage (Km)	Design Chainage (Km)	Proposed Arrangements/ Details				
			Type of Bridge	Improvement Proposal	Load Classifi-cation	Total Span (CL of Exp) (m)	Type of Super-structure
1	-	17+242	Major bridge	New Construction	As per IRC-6	1x135.87 (total)	Steel Composite

Table 3-27: Bridges Proposed for New Construction as Minor Bridge

S. No.	Existing Chainage (Km)	Design Chainage (Km)	Proposed Arrangements/ Details				
			Type of Bridge	Improvement Proposal	Load Classifi-cation	Total Span (CL of Exp) (m)	Type of Super-structure
Nil							

3.7 PROVISION OF RETAINING WALLS/BREAST WALL AND OTHER PROTECTION WORKS

Based on provisions for slope protection works given in “IRC:SP: 48- Hill Road Manual”, IS 14458 (Part 1): 1998 “Retaining wall for Hill Area – Guidelines, Part 1 Selection of Type of wall”, Literature Studies and

Member of the Surbana Jurong Group

multiple site visits of consultant's Highway Engineer and Geologist summary of recommendations for Hill and Valley slope protection work are mentioned in the following Table.

Table 3-28: Provision of Retaining Wall/Breast Wall and other protection work

Sl. No.	Type of Protection Wall	Avg. Ht (m)	LHS Length (m)	RHS Length (m)	Total Length (m)
1	Retaining Wall in Stone Masonry	2.5-6	-	-	-
	GRAND TOTAL =		**-**	-	-
2	Breast Wall in Stone Masonry	2.5	-	-	-
3	Gabion Wall	4-8	1626	1256	2882

3.8 EMBANKMENT DESIGN

3.8.1 REINFORCED EARTH WALL STRUCTURE FOR EMBANKMENT & SLOPES

This work shall consist of reinforced earth steep slopes comprising of construction of internally stabilized soil mass, built in layers, duly compacted with specific fill requirements in combination with minimum 50 mm wide Geosynthetic strap, minimum 70 mm wide geosynthetic strap and 50 mm wide high friction geosynthetic strap coated with Linear Low-Density Polyethylene (LLDPE) or similar as soil reinforcing structural elements of designated grades and design strengths connected directly with flexible galvanized steel mesh facing through mechanical connection system.

Design and construction of reinforced earth steep slope shall include all dead and live loads and combinations including snow loads with adequate factor of safety , seismic loads, drainage provision for dissipation of pore water pressure and flexible galvanized steel mesh facing system with erosion protection measure for long term performance with a minimum design life of 100 Years. The contractor shall assess and substantiate the availability and design adequacy of foundation soil for overall stability under the location of the reinforced earth steep slope before execution of the works.

The work shall generally be done in conformity to the MORTH "Specification for Road and Bridge Works: Latest Revision, Section 3100 and specifically as per this document. The detailed design and drawings of the work done in accordance with the MORTH specifications and in accordance to FHWA Guide line "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes". Reference can also be made to BS: 8006:2010 "Strengthened/Reinforced Soils and Other Fills" for general detailing or wherever relevant.

In reinforced earth steep slope structures, the facing units are galvanized steel welded mesh units. The steel mesh shall be of 'L' shape. Special compressible type galvanized steel mesh panels and secondary reinforcement may be used for total wall slope height more than 10.0m to allow enhanced flexibility in the wall slope, as per recommendation and design of specialized system or technology provider.

The steel mesh facing shall be hot-dip galvanized with minimum thickness of 86 microns. The steel elements shall be of diameter not less than 8 mm, Hot-dip Galvanizing shall be done in accordance with BS 729: 1971 (1994), bending of bars shall be as per BS: 4466.

Since the reinforced earth structures are located in high seismic zone, the connection system between the soil reinforcing geosynthetic strap and the reinforced earth facing shall be direct and mechanical in nature, frictional connections shall not be used or approved for works in high seismic zones. The connection shall consist of galvanized steel mid steel loops and horse shoe plate or similar arrangement. The weight of galvanization shall not be less than 500 grams per sqm (Zinc thickness not less than 70 micron). The surface finished shall consist of flat, dressed boulders/stones of more than 125 mm in size and shall be appropriately packed for achieving a complacent surface finish.

Principal fill material for Reinforced Earth Walls / Slopes

The properties of structure fill, subsoil and the retained fill and their interface media shall be based on assumed representative soil data at the design stage, but the values shall be verified at the time of the construction.

Fill in the structure or slope shall either be wholly frictional or cohesive-frictional. Stratified layers of combined frictional and cohesive-frictional fill shall not be used without specific design check. The use of soft chalk, un-burnt colliery shale and unsuitable material shall not be permitted and got removed from site.

Fill for Reinforced Earth structures shall be well graded selected material as specified and available within reasonable lead distance. The fill must allow dissipation of pore pressure by designing the same with free draining characteristics or by providing vertical and horizontal drainage provisions with geosynthetic drains in the reinforced soil volume. The association of drainage bay or interface drains shall be connected properly to the gradient required and shall be maintained during compaction in layers.

Backfill materials used in the reinforced earth volume shall be reasonably free from organic or otherwise deleterious materials and shall conform to the following mechanical and physico-chemical requirements.

Mechanical requirements

Sieve size	***Percent passing***
80 mm (gravel)	100%
4.75 mm (coarse sand)	more than 75%
75 micron (silt)	less than 15%

Acceptance limits for materials with more than 15% passing 75micron are related to the percentage of particles smaller than 15 microns as follows:

- Materials with more than 15% passing 75micron sieve but less than 10% of particles smaller than 15 microns are acceptable.
- Materials with more than 15% passing 75micron sieve and more then 20% of particles smaller than 15 microns are inadequate and shall not be used except as specified in (e) below.
- The plasticity index (PI) shall be less than 6 and co-efficient of uniformity (C_u) shall be greater than 2.
- Materials with more than 15% passing 75micron sieve and 10 to 20 % of particles smaller than 15 microns are acceptable provided that the internal friction angle is not smaller than 30°.

Initially at approval of source and subsequent at each change of source, backfill is to be checked for sieve analysis, pH and angle of internal friction. The results will indicate what further tests are needed, if any. Materials not conforming to the above requirements may be used with the written consent of engineer in charge after carrying out test. Such materials shall be tested for their functional properties to assure that they are consistent with the parameters used in the design calculations.

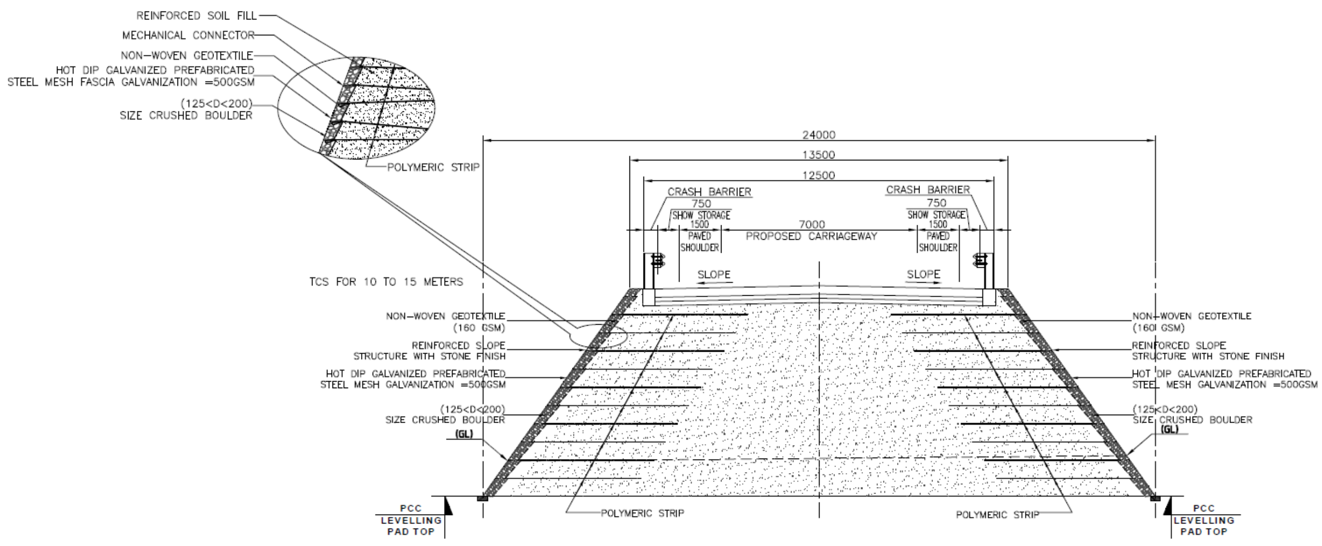
3.8.2 DRAINAGE LAYER

Horizontal drainage gallery and chimney drain gallery shall be minimum 600 mm wide. The drainage gallery shall be constructed using aggregate or gravel (size: 19.5mm passing and 9.1mm retained). Non-woven geotextile shall be used to restrict the files enter the drainage gallery. The drainage gallery shall be constructed as shown in the construction drawings. Alternatively, geo-composite drains as per section 700 of MoRT&H guidelines may be used as chimney drain and drainage board wrapped with non-woven geotextiles on both sides may also be used as horizontal drainage layers.

Criteria used for Design of Reinforced Earth Slopes

Description	Cohesion	Φ	Seismic Zone	SBC	Fascia	Connection
Fill Material	Nil	30^0	V	10 T/m^3	Galvanized Welded Wire Mesh	Mechanical

Typical Section used for High Embankment Sections is given under:



TYPICAL CROSS SECTION WITH GeoTrel Wall

4 CHAPTER-4 TRAFFIC SURVEY AND ANALYSIS

4.1 GENERAL

This chapter is intended to give the present traffic scenario and studies which are very much important to design the pavement, so that pavement is able to perform well for the designed traffic and service life.

4.2 IDENTIFICATION SECTION FOR TRAFFIC SURVEYS

Detailed traffic surveys are conducted along the project road based on the observations and discussion with client at following mutually agreed locations.

- *7- days Continuous Classified Traffic Volume Count at 3 locations*
- *1 day - Origin – Destination Surveys at 2 Locations*
- *2 day Axle load Surveys at 2 Locations*
- *24 hours Turning Movement Count Surveys at 2 locations*
- *12 hour Truck Terminal Survey at 1 location*

- *12 hour Pedestrian and Animal count Survey at 2 location*
- *Speed & Delay Survey throughout the Road Alignment*

Traffic Survey schedule is shown in table 4.1 below and Traffic Survey location is shown in Figure below:

Table 4-1: Traffic Survey Schedule

ID	Survey Location/section	Date	Duration
Classified Traffic Volume Count Surveys			
C1	Km 81+600	13.06.2018 to 20.06.2018	7 days
C2	Km 85+900	13.06.2018 to 20.06.2018	7 days
C3	Km 94+800	14.06.2018 to 21.06.2018	7 days
Origin-Destination Surveys			
O1	Km 81+500	17.06.2018	1 day
O2	Km 85+800	19.06.2018	1 day
Axle load Surveys			
A1	Km 81+500	17.06.2018 to 18.06.2018	2 day
A2	Km 85+800	19.06.2018 to 20.06.2018	2 day
Turning Movement Count Surveys			
T1	Km 89+000	14.06.2018	1 day
T2	Km 95+000	15.06.2018	1 day
Truck Terminal Survey			
T1	Km 85+300	20.06.2018	12 hours
Pedestrian and Animal Count Survey			
P1	Km 82+400	15.06.2018	12 hours
P2	Km 84+700	16.06.2018	12 hours
Speed and Delay Survey			
S1	Sonamarg to Baltal	14.06.2018	-
S2	Baltal to Sonamarg	14.06.2018	-

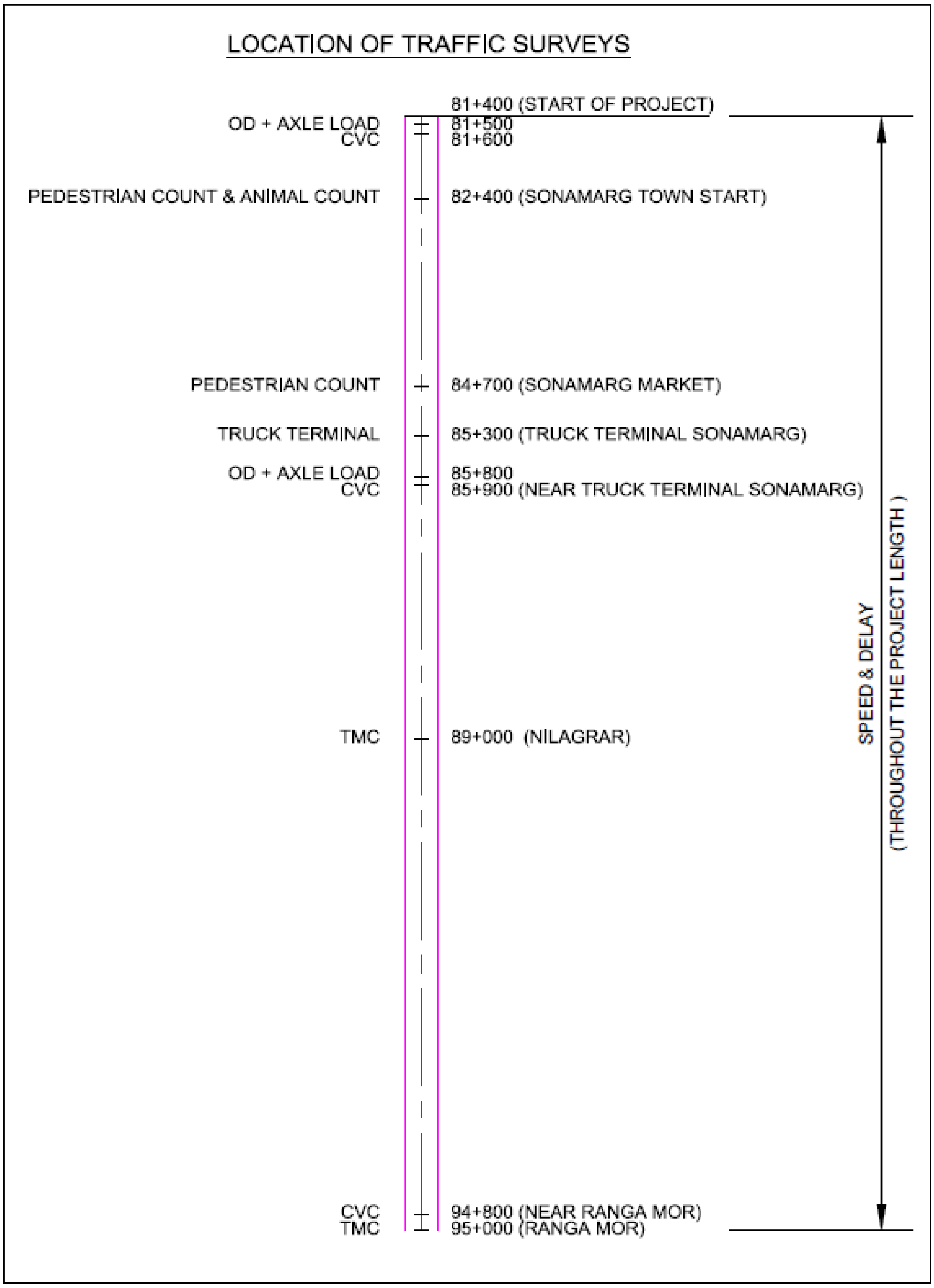


Fig. 4-1: Map showing location of Traffic Surveys

Traffic surveys have been carried out on the project corridor in order to identify present and likely future scenarios and to device suitable remedial measures and to evolve appropriate design method.

The primary objectives of these traffic surveys are to determine the characteristics of traffic movement on the project corridor, determine the travel pattern as well as type and weight of commodity carried by trucks, determine the spectrum of axle loads and vehicle damage factors for different types of commercial vehicles, determine the turning movement pattern of traffic at road intersections and determine traffic bottlenecks.

4.3 TRAFFIC SURVEY DATA

4.3.1 CLASSIFIED TRAFFIC VOLUME COUNT

All the survey locations were determined in consultation with client and carried out using ATCC systems under the supervision of experienced technical site staff and traffic engineers of SMEC. The locations were selected based on the following considerations:

- *Traffic homogeneity based on major traffic generation and dispersal locations along the project road; and*
- *Suitability of proposed locations for traffic surveys*

Traffic surveys were conducted in both directions for seven consecutive days using ATCC systems.

The field staffs having been made aware of their responsibilities and field safety before the start of field surveys was continuously monitored by their supervisor and an on-site traffic engineer.

For recording vehicle classification information mode-wise, vehicles were grouped under the categories as shown **Error! Reference source not found.** in **Table 4-2** below:-

Table 4-2: Classification of Vehicles

<table>
<tr><th></th><th colspan="2">Motorized Vehicles</th><th>Non-motorized Vehicles/ Slow moving</th></tr>
<tr><td rowspan="6">Fast passenger vehicles</td><td colspan="2">Two wheelers</td><td>Cycle</td></tr>
<tr><td colspan="2">Three wheelers</td><td>Cycle Rickshaw</td></tr>
<tr><td colspan="2">Car/Jeep/Van Taxi</td><td>Animal Drawn Vehicle (ADV)</td></tr>
<tr><td colspan="2">LMV (pickups and other less than 3T)</td><td rowspan="11"></td></tr>
<tr><td rowspan="2">Bus</td><td>Mini Bus</td></tr>
<tr><td>Standard Bus</td></tr>
<tr><td rowspan="8">Goods vehicle</td><td colspan="2">LCV</td></tr>
<tr><td rowspan="2">Truck</td><td>2 – Axle Truck</td></tr>
<tr><td>3 – Axle Truck</td></tr>
<tr><td rowspan="2">MAV</td><td>4-6 Axles</td></tr>
<tr><td>7 and more than 7 Axles</td></tr>
<tr><td></td><td>Tractor</td></tr>
<tr><td>Tractor</td><td>Tractor + Trailer</td></tr>
<tr><td></td><td></td></tr>
</table>

4.3.2 ORIGIN-DESTINATION SURVEY (OD SURVEY)

The Origin – Destination survey was carried out with the primary objective of studying the travel pattern of passenger and goods traffic along the project corridor. The O-D survey was conducted as mentioned in Origin and Destination chapter as per the guidelines given in IRC: 102-1988. Roadside Interview Method was adopted for conducting the survey. The vehicles were stopped at random sample basis with the help of police and the drivers were interviewed by trained enumerators to collect the needed information/data. The pertinent information in respect of travel characteristics including the following were collected during these interviews:

- Origin and Destination of the trip
- Trip length
- Trip purpose
- Commodity type
- Loading pattern

4.3.3 AXLE LOAD SURVEY

The axle load survey has been carried out at 2 locations to work out the Vehicle Damage Factor (VDF) and the axle load spectrum for design of pavement.

4.3.4 INTERSECTION TURNING MOVEMENT SURVEY

The Turning Movement Count survey has been carried out at 2 locations for 24 hours. This survey was conducted to obtain information on directional movement of traffic at four major intersections along the project road for a continuous 24 hour period. Trained enumerators to record all individual turning movements were stationed at each intersection. The data for peak hour directional movements and ADT on cross road at the junction will help in prioritizing junctions and improving junction if warranted.

4.3.5 TRUCK TERMINAL SURVEY

The Truck Terminal survey has been carried out at 1 locations for 12 hours. The entry and exit Truck count survey at existing Truck Terminal (Sonamarg – 85+300) was carried out. The data derived from O-D, Speed-Delay, and other Surveys and Opinion Surveys be analyzed to assess requirements for present and future development of truck terminals at suitable locations enroute.

4.3.6 PEDESTRIAN COUNT AND ANIMAL COUNT SURVEY

The Pedestrian and Animal Count survey has been carried out at 2 locations for 12 hours. Pedestrian count data is used frequently in planning applications to evaluate sidewalk and crosswalk needs. Pedestrian count survey was carried out at mid-block locations where pedestrian movement is high. Pedestrian movements across the road and along the road will be recorded during peak hours. The pedestrian count data will be analyzed to identify the requirements of pedestrian facilities across and along the roads. Also, the animals crossing the road was collected to provide the safety of both vehicles and animals.

4.3.7 SPEED AND DELAY SURVEYS.

This survey was carried out along the project road corridor to know the average speed and amount of delay if any. The survey was performed by Moving Car Method.

4.3.8 WAY SIDE AMENITIES

There are no way side amenities along the project except Major towns like Sonamarg having hotels and eating place.

4.3.9 DATA ANALYSIS - CLASSIFIED TRAFFIC VOLUME COUNT

The analysis of the classified traffic volume counts at all 3 count stations was done to determine following traffic characteristics:

- *Average Daily Traffic*
- *Daily Variation of Traffic*
- *Maximum, Minimum and Average Traffic*
- *Percentage Variation of Traffic*
- *Hourly Distribution and Directional Distribution of Traffic*
- *Traffic composition*
- *Annual Average Daily Traffic (AADT)*

Data collected at the site was computerized for further analysis. The traffic values obtained in terms of ADT have been converted to PCU values to study the existing traffic volume Vis-à-vis the existing highway capacity and for future projections. The PCU factors have been adopted as per IRC guidelines and are provided in Table below.

Table 4-3: PCU factors adopted for the project highway

Vehicle Type	PCU Factor
MOTORIZED	
Two wheelers	0.5
Three wheelers	1
Car/Jeep/Taxi	1
Bus	3
LCV	1.5
Truck	3
Truck-Trailer (MAV)	4.5
Tractor+ Trailer	4.5
Tractor (without Trailer)	1.5
NON MOTORIZED	
Cycle	0.5
Cycle-Rickshaw	0.5
Animal Drawn	8

4.3.9.1 Average Daily Traffic (ADT)

The counting of each traffic and its recording shall be continued without break for the full week over seven consecutive days & 24 hours of each day. The survey and count sheets will be spot checked and data registered in the field office. The results shall be presented in tabular and graphical form. The survey data shall be analyzed to bring out hourly and daily variations. The traffic volume count per day will be averaged to show a Weekly Averaged Daily Traffic (ADT) for vehicle type and ADT PCU. The compiled survey data as average of the week are presented in Tables below.

Table 4-4: Average Daily Traffic (Vehicles)

Vehicle	Km 81+600_NH01		Km 85+900_NH01		Km 94+800_NH01	
	ADT	PCU	ADT	PCU	ADT	PCU
Cars, passenger vans, jeep	2,846	2,846	2,233	2,233	1,289	1,289
Auto Rick.	0	0	0	0	0	0
Two-Wheeler	1,179	590	448	224	319	159
LCV's	435	652	328	492	257	386
Mini Buses	169	254	68	102	59	89
Buses	24	72	35	106	29	86
Trucks of 2 Axle	752	2255	968	2,903	772	2,316
Trucks of 3 Axle	30	89	7	20	5	15
Multi-Axle Trucks	10	46	0	0	1	5
Tractor	1	2	1	1	1	1
Tractor trailer	0	0	0	0	0	0
Cycle	0	0	0	0	0	0
Animal Drawn	0	0	0	0	0	0
Total Vehicles	**5,446**	**6,806**	**4,088**	**6,081**	**2,731**	**4,345**

Daily Variation of Traffic

The distribution of traffic by vehicle type was also studied for the three traffic volume count station. A study of the daily variations in volume count at all count stations are provided in Table below.

Table 4-5: Daily Traffic Variation at Km – 81+600

Vehicle type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	ADT
Cars, passenger vans,	3897	3732	2896	2370	2541	2579	1906	2,846
Auto Rick.	0	0	0	0	0	0	0	0
Two Wheeler	947	1101	1024	759	1449	1491	1482	1,179
LCV's	491	463	395	535	299	369	490	435
Mini Buses	198	215	183	161	170	156	102	169
Buses	27	24	24	24	24	24	22	24
Trucks of 2 Axle	689	584	941	1093	544	636	775	752
Trucks of 3 Axle	13	12	12	56	35	46	34	30
Multi-Axle Trucks	1	1	1	8	22	22	17	10
Tractor	1	1	1	1	1	1	1	1
Tractor trailer	0	0	0	0	0	0	0	0
Cycle	0	0	0	0	0	0	0	0
Animal Drawn	0	0	0	0	0	0	0	0
Total Vehicles	6264	6133	5477	5007	5085	5324	4829	5446
Percentage Variation with ADT	15.02	12.61	0.57	8.76	7.09	2.29	12.77	

Table 4-6: Daily Traffic Variation at Km – 85+900

Vehicle type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	ADT
Cars, passenger vans, jeep	2990	1769	1771	3049	2169	2008	1876	2,233
Auto Rick.	0	0	0	0	0	0	0	0
Two Wheeler	645	330	318	711	319	304	511	448
Mini LCV's	0	0	0	0	0	0	0	0
LCV's	314	380	277	231	398	451	244	328
Mini Buses	72	48	60	83	63	80	68	68
Buses	66	13	11	68	13	15	61	35
Trucks of 2 Axle	652	640	739	748	906	897	594	739
Trucks of 3 Axle	2	4	4	18	4	14	1	7
Multi-Axle Trucks	0	0	0	0	0	0	0	0
Tractor	2	0	0	2	0	0	2	1
Tractor trailer	0	0	0	0	0	0	0	0
Cycle	0	0	0	0	0	0	0	0
Animal Drawn	0	0	0	0	0	0	0	0
Total Vehicles	4743	3184	3180	4910	3872	3769	3357	3859
Percentage Variation with ADT	17.24	22.02	18.59	20.1	9.83	3.34	11.48	

Table 4-7: Daily Traffic Variation at Km – 94+800.

Vehicle type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	ADT
Cars, passenger vans, jeep	971	1045	783	1031	1652	1725	1817	1,289
Auto Rick.	0	0	0	0	0	0	0	0
Two Wheeler	383	257	293	326	251	366	356	319
LCV's	240	296	260	144	325	248	288	257
Mini Buses	50	65	59	66	58	57	58	59
Buses	57	11	11	34	13	8	66	29
Trucks of 2 Axle	186	586	911	973	1160	795	792	772
Trucks of 3 Axle	0	4	4	4	4	17	1	5
Multi-Axle Trucks	0	0	0	0	0	7	0	1
Tractor	0	0	0	2	0	0	2	1
Tractor trailer	0	0	0	0	0	0	0	0
Cycle	0	0	0	0	0	0	0	0
Animal Drawn	0	0	0	0	0	0	0	0
Total Vehicles	1887	2264	2321	2580	3463	3223	3380	2731
Percentage Variation with ADT	44.72	20.62	17.66	5.85	26.8	18.01	23.76	

The graphical representation of daily variation of Traffic for the four traffic count locations is shown below in Figures 4.2 to 4.4

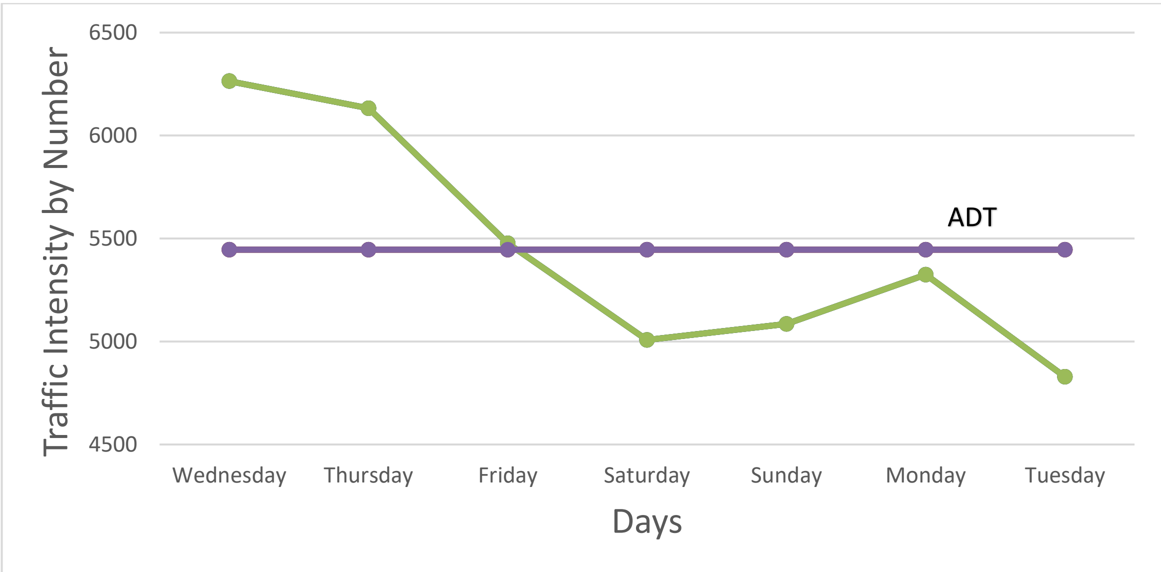


Fig. 4-2 : Daily Variation Traffic at Km- 81+600

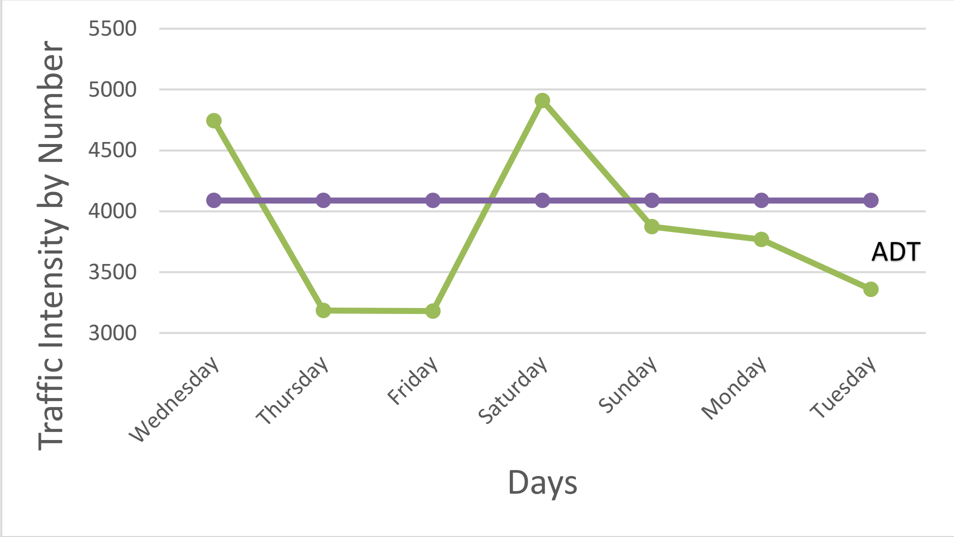


Fig. 4-3: Daily Variation Traffic at Km- 85+900

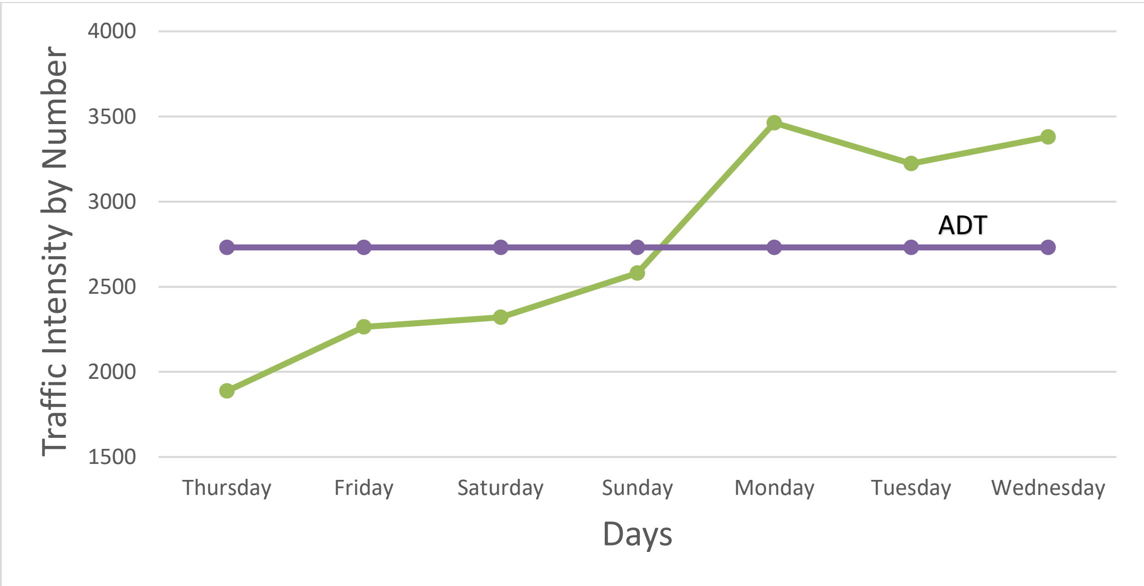


Fig. 4-4: Daily Variation Traffic at Km- 94+800

4.3.9.2 Hourly Distribution and Directional Distribution of Traffic

The hourly variation of traffic illustrates the distribution of traffic over the day with respect to time and vehicles. The Peak Hour Factor (PHF) (defined as the ratio between the numbers of vehicles counted during the peak hour to the total vehicles counted in a day) is the maximum percentage of total traffic that uses the project road in one single hour of the day. The 7-days hourly variation of traffic all locations have been presented in figures below:

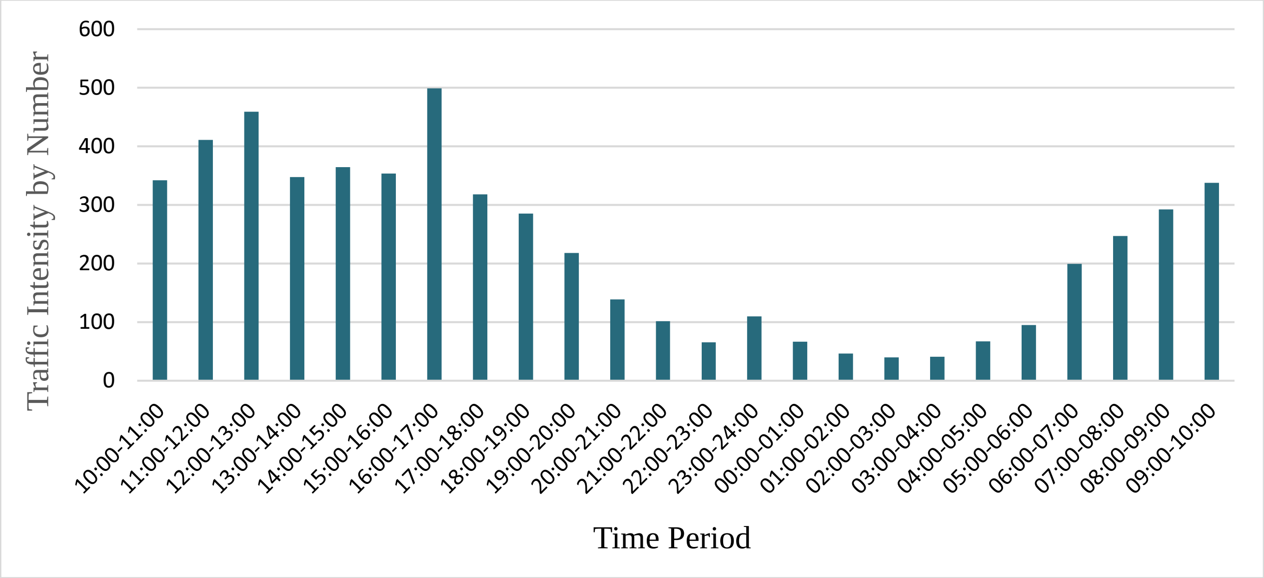


Fig. 4-5: Hourly Variation Traffic at Km- 81+600

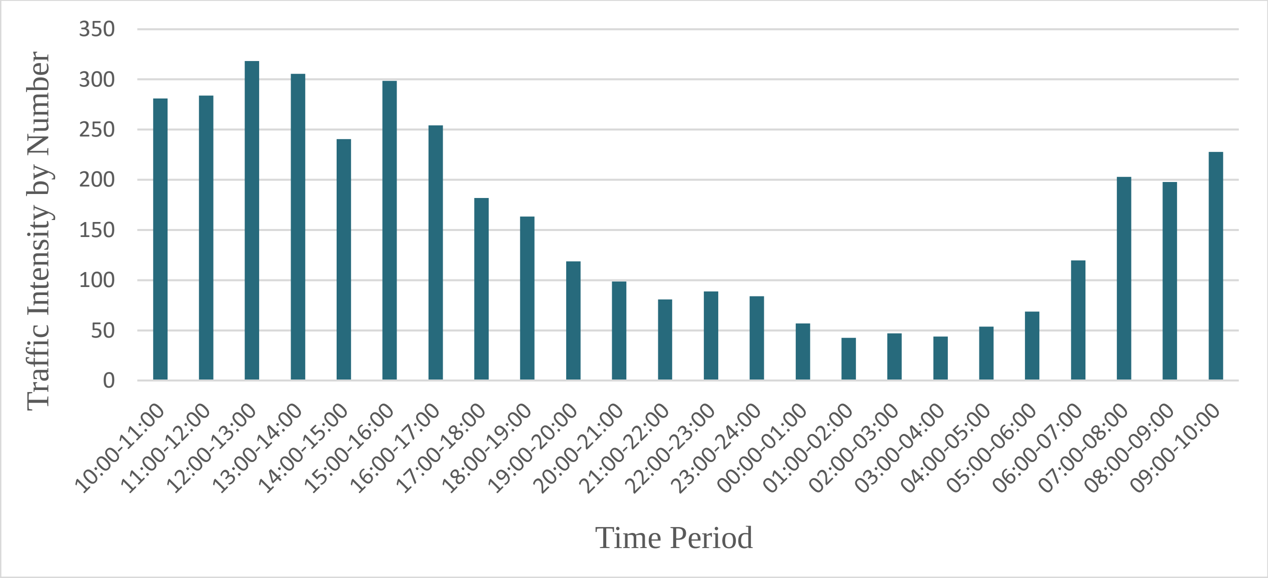


Fig. 4-6: Hourly Variation Traffic at Km- 85+900

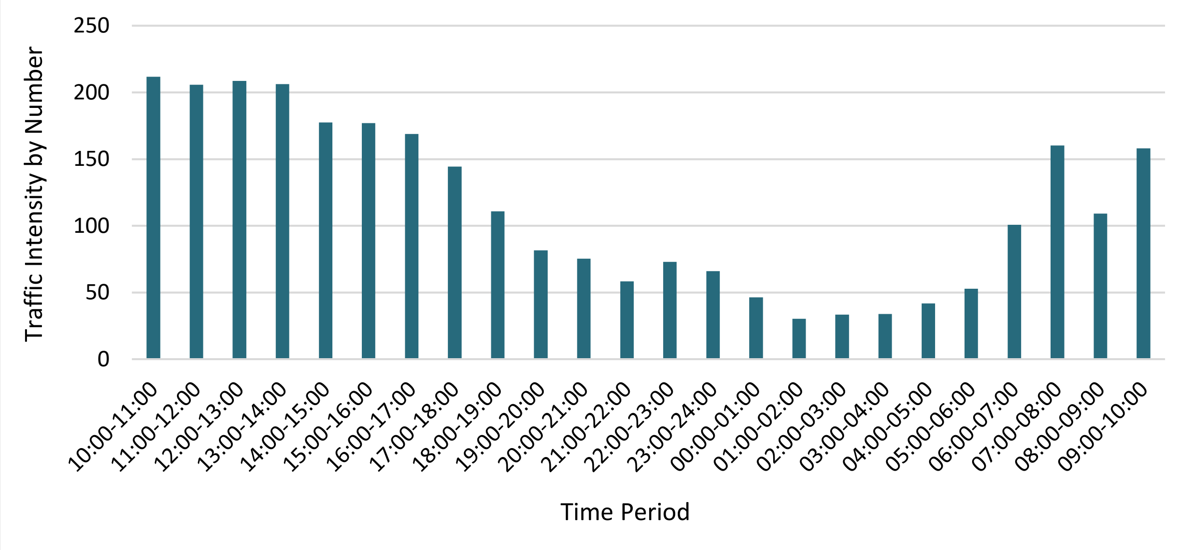


Fig. 4-7: Hourly Variation Traffic at Km- 94+800

4.3.9.3 Directional Distribution

Directional distribution along the project road is shown section wise graphically in the figures 6.9 to 6.10 below. Findings along the project corridor is as under.

- At Km-81+600, Average Traffic share is 48.70 % for Sonamarg to Baltal (Up) direction and 51.30 % for Baltal to Sonamarg (Down) direction.
- At Km-85+900, Average Traffic share is 49.86 % for Sonamarg to Baltal (Up) direction and 50.14 % for Baltal to Sonamarg (Down) direction.

At Km-94+800, Average Traffic share is 50.84 % for Sonamarg to Baltal (Up) direction and 49.16 % for Baltal to Sonamarg (Down) direction.

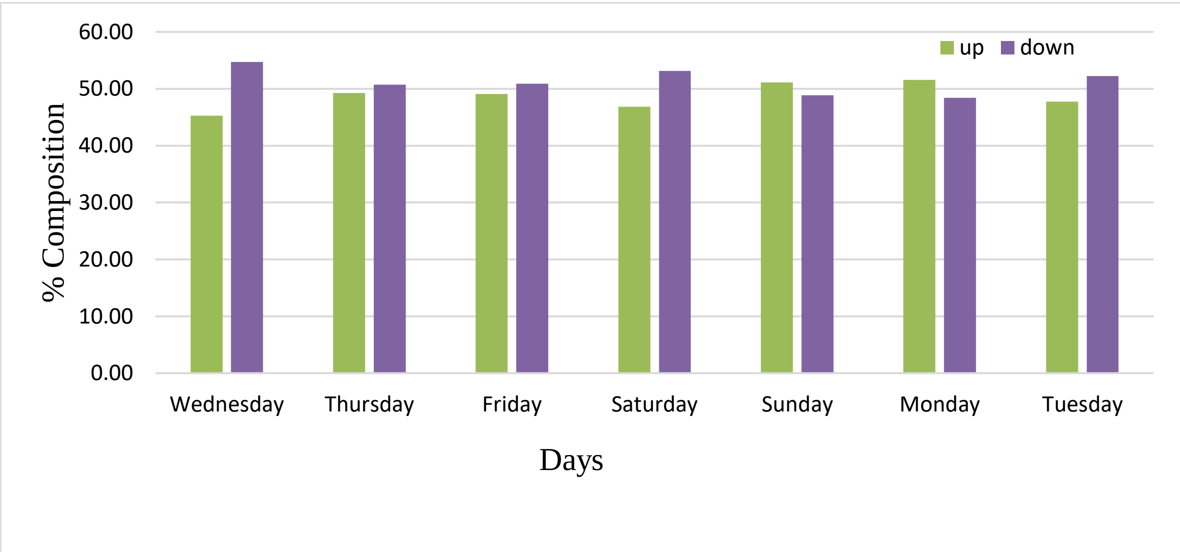


Fig. 4-8: Directional Distribution at Km – 81+600

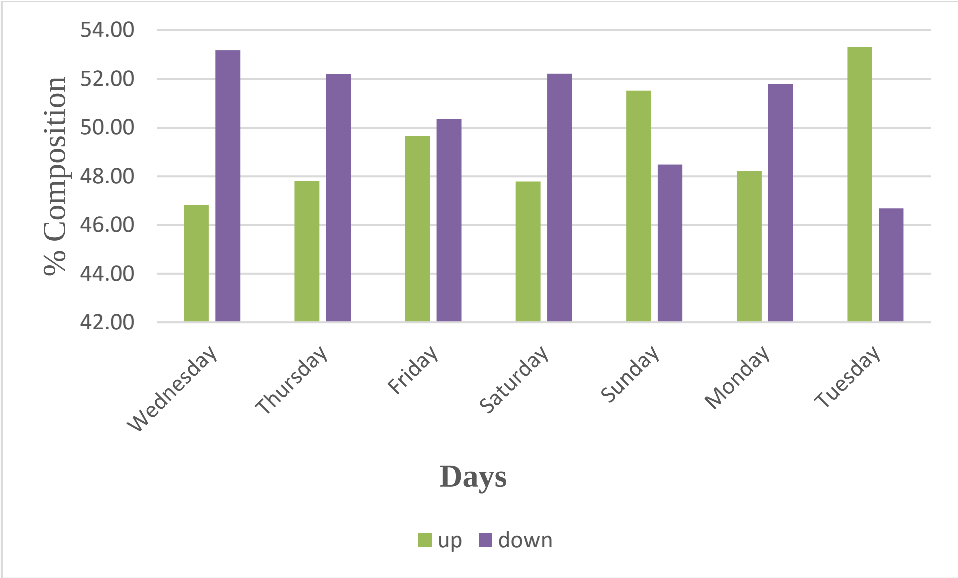


Fig. 4-9: Directional Distribution at Km – 85+900

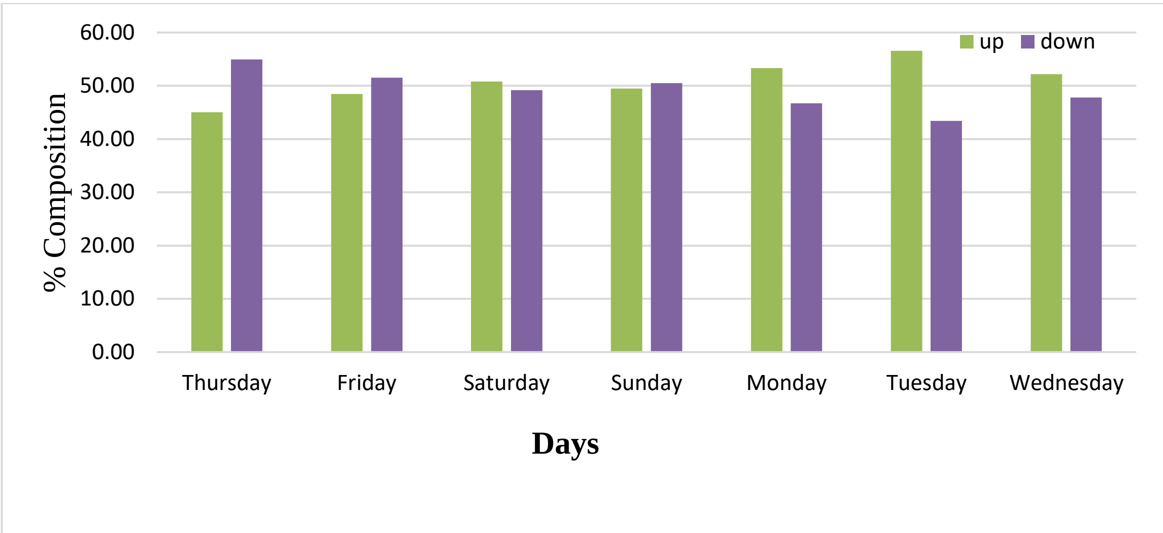


Fig. 4-10 : Directional Distribution at Km – 94+800

4.3.9.4 Traffic Composition

Overall composition of vehicles has been analyzed for traffic homogeneous sections. The salient findings are presented below:-

Table 4-8: Composition of traffic on an average day

Vehicle type	Km–81+600 (%)	Km – 85+900 (%)	Km – 94+800 (%)
Car	52.26%	63%	47.20%
Multi Axle Trucks	0.19%	0.00%	0.04%
Tractor	0.02%	0.02%	0.02%
Tractor Trailer	0.00%	0.00%	0.00%
3-A Truck	0.55%	0.16%	0.18%
2-A Truck	13.80%	14%	28.26%
LCV	7.98%	7%	9.42%
Toll Exempted	0.00%	0.00%	0.00%
Mini Bus	3.11%	1%	2.16%
Two Wheeler	21.65%	14%	11.67%
Bus	0.44%	1%	1.05%

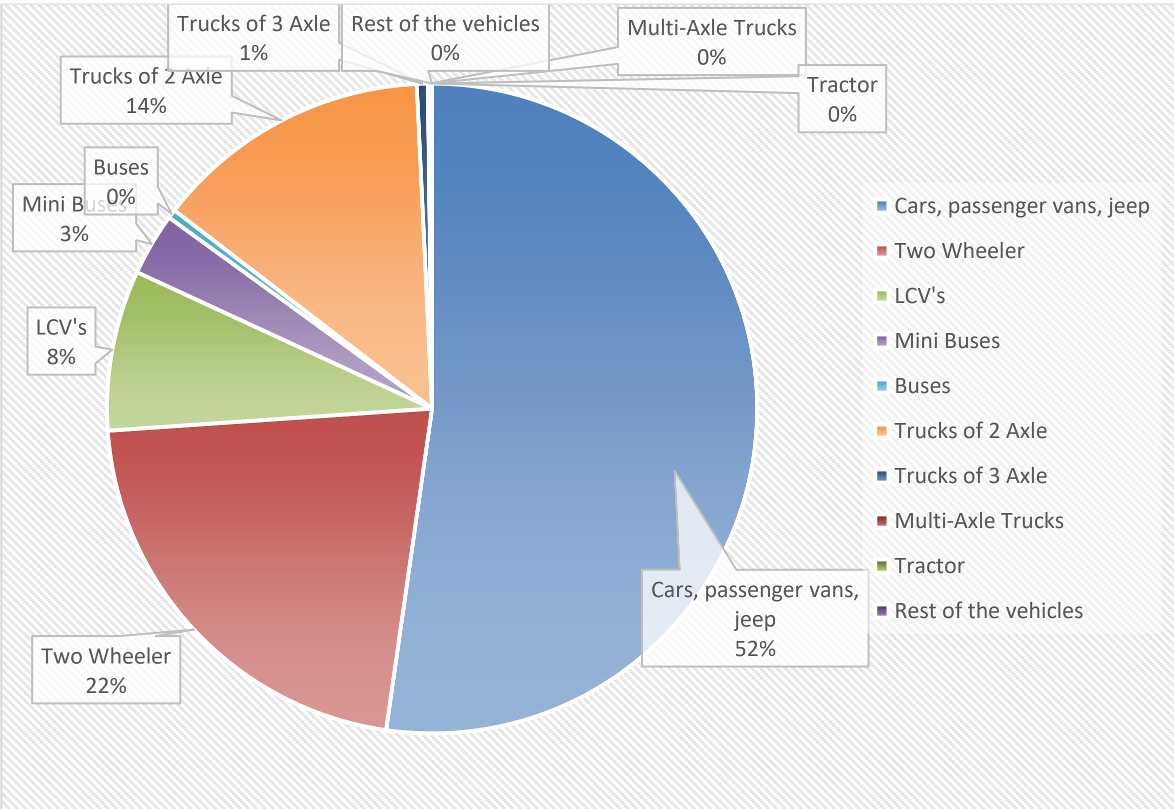


Fig. 4-11: Vehicle Composition at Km – 81+600

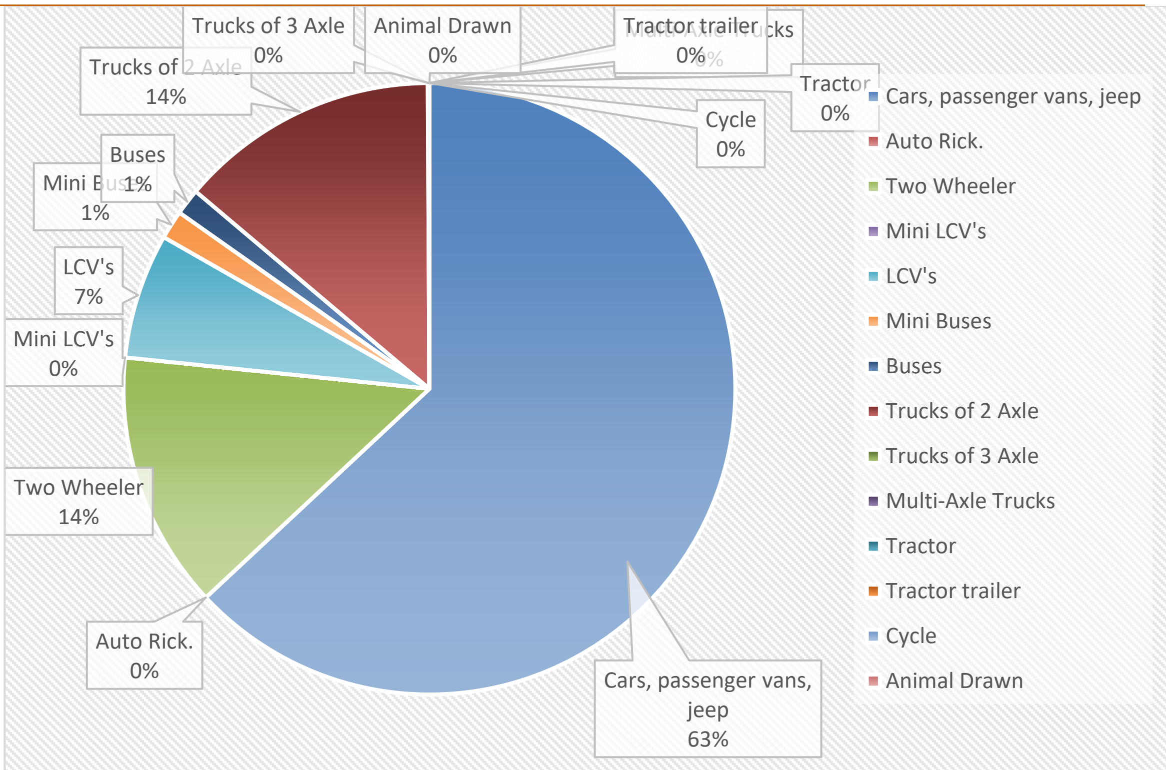


Fig. 4-12: Vehicle Composition at Km – 85+900

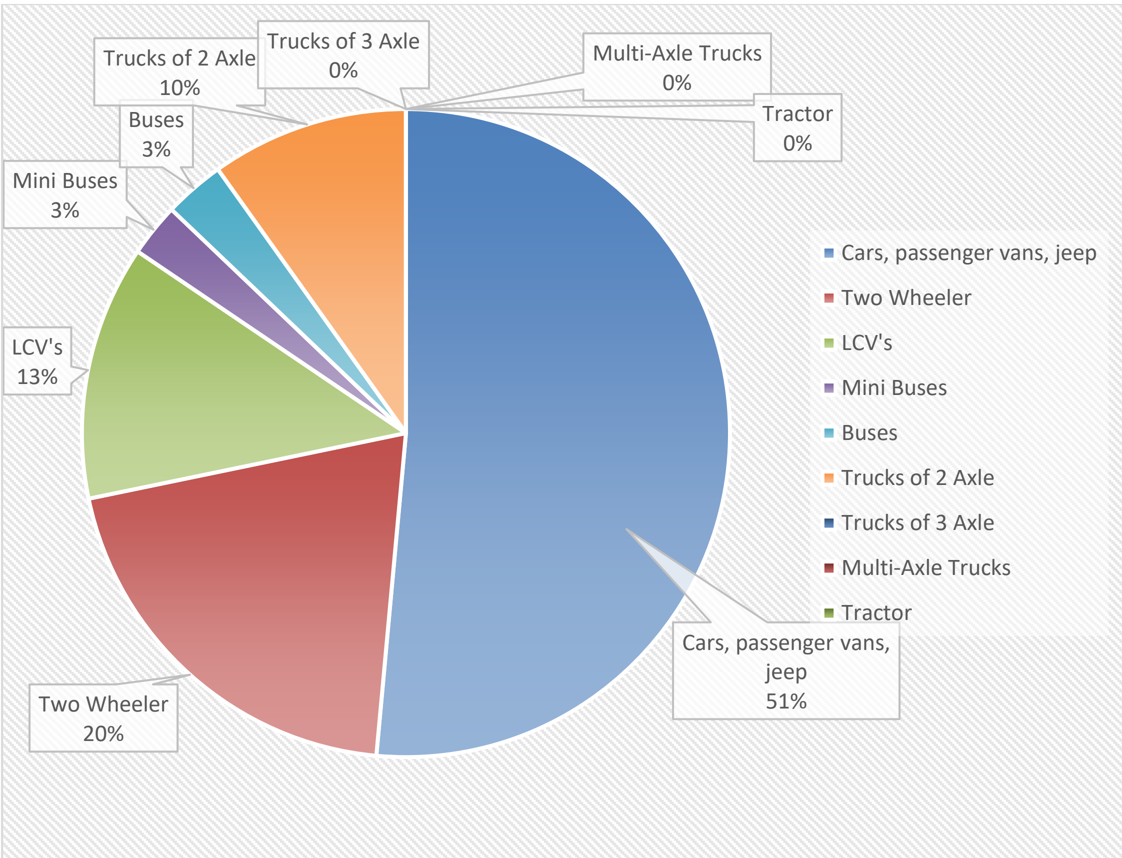


Fig. 4-13: Vehicle Composition at Km – 94+800

4.3.9.5 Average Annual Daily Traffic

For the Base year (2018), Annual Average Daily Traffic (AADT) is computed by multiplying ADT with respective seasonal factor. The traffic survey along the corridor was carried out during June month in the year 2018. Seasonal Variation Factors have been calculated after analyzing the data from fuel sales (petrol and diesel) from the petrol pump outlets located along /near the project highway and the seasonal fluctuations in fuel consumption. The Table below indicates the total monthly sales for High Speed Diesel (HSD) and petrol for two years from the various petrol pump outlets along the highway.

The computed AADT values for all the locations are given below in Table

Table 4-9: Calculation for Seasonal Correction factor

Paristan filling station, Gagangeer						
Month	Daily Petrol Consumption (KL)	Daily Diesel Consumption (KL)	Both	SCF(Petrol)	SCF(Diesel)	SCF (Both)
2017-18						
May	24	144	168	0.80	0.75	0.76
June	34	170	204	0.57	0.63	0.62
July	32	220	252	0.60	0.49	0.50
August	24	108	132	0.80	1.00	0.96
September	24	96	120	0.80	1.12	1.06
October	25	131	156	0.77	0.82	0.81
November	8	100	108	2.40	1.08	1.18
December	4	32	36	4.81	3.37	3.53
2018-19						
Janu	4	20	2	4.81	5.39	5.2

ary			4			9
February	4	8	12	4.81	13.47	10.58
March	8	40	48	2.40	2.69	2.65
April	21	111	132	0.92	0.97	0.96
May	38	221	259	0.51	0.49	0.49
Average	19.2	108	127			

Table 4-10 : Seasonal Correction factor for Different Locations

Vehicle	Km 81+600_NH01	Km 85+900_NH01	Km 94+800_NH01
Cars, passenger vans, jeep	0.62	0.62	0.62
Auto Rick.	0.62	0.62	0.62
Two Wheeler	0.62	0.62	0.62
LCV's	0.62	0.62	0.62
Mini Buses	0.62	0.62	0.62
Buses	0.62	0.62	0.62
Trucks of 2 Axle	0.62	0.62	0.62
Trucks of 3 Axle	0.62	0.62	0.62
Multi-Axle Trucks	0.62	0.62	0.62
Tractor	0.62	0.62	0.62
Tractor trailer	0.62	0.62	0.62
Cycle	0.62	0.62	0.62
Animal Drawn	0.62	0.62	0.62

4.3.9.6 Annual Average Daily Traffic (AADT)

To convert ADT into AADT, SCF are used in order to obtain an estimate of the variations in the traffic from average. Annual Average Daily Traffic (AADT). AADT is calculated by multiplying SCF (Seasonal Correction Factor) with ADT (Average Daily Traffic). Results are shown in table 4.11 below:

Table 4-11: AADT Variation along the Stretch

Vehicle	Km 81+600_NH01		Km 85+900_NH01		Km 94+800_NH01	
	ADT	AADT	ADT	AADT	ADT	AADT
Cars, passenger vans, jeep	2,846	1764	2,233	1385	1,289	799
Auto Rick.	0	0	0	0	0	0
Two Wheeler	1,179	731	448	278	319	284
LCV's	435	269	328	203	257	160
Mini Buses	169	105	68	42	59	37
Buses	24	15	35	22	29	18
Trucks of 2 Axle	752	466	968	458	772	479
Trucks of 3 Axle	30	18	7	3	5	3
Multi-Axle Trucks	10	6	0	0	1	1
Tractor	1	1	1	1	1	0
Tractor trailer	0	0	0	0	0	0
Cycle	0	0	0	0	0	0
Animal Drawn	0	0	0	0	0	0
Vehicles	**5446**	**3376**	**4088**	**2393**	**2731**	**1779**
PCU	**6806**	**4219**	**6081**	**3346**	**4345**	**2737**

4.3.9.7 Traffic Forecast and Growth Rates

Investment priorities are typically driven by the traffic demand, assessed benefits and cost of the project and the strategic importance of road. Demand and importance plays the important role, governing which type of facility / infrastructure needs to be created. This in turn determines likely benefits and costs to develop the same. A highway project of this size requires significant investment. Traffic Forecasting becomes very important and critical and has to be assessed as accurate as possible. Estimation of traffic will determine viability of the project. Efforts are made to carefully assess all the parameters that help in predicting the traffic demand in future, which necessitates realistic estimation of traffic growth rates. Traffic growth on a road facility is generally estimated on the basis of historical trends. In the present case, traffic growth rates have been estimated using elasticity method as per IRC: 108 – 2015. Demand changes are usually because of shifts in the pattern of economic activities in the surrounding regions. Hence, future traffic estimation necessitates assumption however imprecise, of the probable pattern of future growth of the economy.

4.3.9.8 Past Trend in Growth of Registered Vehicles

Project stretch is influenced by one state, Jammu & Kashmir as clearly evident from OD Analysis. For establishing growth rates, data of Jammu & Kashmir State have been considered from Source Transport Research Wing, Ministry of Surface Transport for which results are shown in table 4.12

Table 4-12: Past Trend Vehicle Growth Rate of Registered Vehicles

YEAR	(Car/Delivery Van / Taxi)	LMV (passengers)	(2W)	(Bus)	Trucks / Trailers
2005-06	96,590	15,054	273,265	20,735	45,464
2006-07	109,367	15,919	297,656	21,435	50,017
2007-08	123,357	16,562	320,754	22,161	55,701
2008-09	139,693	18,440	341,834	23,149	61,651
2009-10	164,031	19,673	363,029	24,051	66,464
2010-11	188,010	20,853	407,928	23,480	78,347
2011-12	219,545	22,105	446,791	25,858	82,206
2012-13	255,905	13,759	480,815	25,765	89,894
2013-14	321,310	16,407	530,594	26,888	96,981
Growth rate (%age)	**16.21**	**1.08**	**8.65**	**3.30**	**9.93**

**Source: - Transport Research Wing, Ministry of Surface Transport*

4.3.9.9 Past Trend in Growth in Economy & Population

Consultants have collected past economic data from website of Reserve Bank of India (RBI), Planning Commission, Directorate of Economics and Statistics. The time series data of state income NSDP at constant (2004-05) prices, state population, per-capita income of PIA states and GDP as published by them have been collected and studied to assess the past performance of the influencing state economies.

The analysis of country and Jammu & Kashmir statistics shows that the average growth rate of GDP of country between 2005-06 and 2013-14 is 7.36 % while the NSDP growth rate of Jammu & Kashmir for the same period is 5.56%. The per capita income growth rate in this period is 4.16%. The population growth in this period was 2.18% per annum. The details are presented in Table 4-13.

Table 4-13: Year wise Economic Parameters growth

S. No.	Year	GDP (in crores)	PCI (Rs)	NSDP	*Population
1	2005-6	3253073	22406	24371	11044866
2	2006-7	3564364	23375	25794	11282400
3	2007-8	3896636	24470	27387	11525041
4	2008-9	4158676	25641	29102	11772901
5	2009-10	4516071	26518	30512	12026092
6	2010-11	4918533	27666	32256	12284728
7	2011-12	5247530	28833	34040	12548926
8	2012-13	5482111	29754	35562	12837551
9	2013-14	5741791	31054	37563	13125956
Growth Rate		**7.36**	**4.16**	**5.56**	**2.18**

Traffic Demand Forecasting

Elasticity approach has been used for determining growth rates of future traffic. Since time series traffic data on project road is available for only one count location, traffic growth rates and elasticity values are established by using registered vehicles as the dependent variable and moderated as per the general trends of traffic observed.

4.3.9.10 Description of Regression Analysis

Regression Analysis tool performs linear regression analysis by using the "least squares" method to fit a line through a set of observations. We can find out how a single dependent variable is affected by the values of one or more independent variables. In this case, registered vehicles by type are the dependent variables whereas the economic parameters are independent variables. Once the relation is established by regression, the measures explained below are used to accept or reject the same.

4.3.9.11 R Square

R Square is another measure of the advisory power of the model. In theory, R square compares the amount of error explained by the model as compared to the amount of error explained by averages. The higher the R-Square, the better it is.

A regression analysis was carried out on the database to arrive at the transport demand elasticity and growth rates using each category of vehicle with various combinations of economic parameters and population of the respective states. The resultant elasticity values, growth rates, R2 values and t-statistic are presented in Table 4.14. The highlighted parameters are selected for traffic forecast in each case, based on best fit.

Table 4-14: Observed transport demand elasticity values and traffic growth

Vehicle Type	Economic Parameter	Elasticity	R-Square	CAGR(GR)	CAGR (REG)
CAR	PCI	3.60	0.99	15.01	14.92
2W	PCI	2.38	0.99	9.91	9.85
LMV	PCI	0.29	0.99	1.22	1.22
BUS	POPULATION	1.48	0.96	3.23	3.22
TRUCK	NSDP	1.80	0.99	9.99	9.95

4.3.9.12 Projected transport demand elasticity

In order to arrive at realistic future elasticity for the project road, various factors relating to vehicle technology changes, in addition to character of traffic and travel pattern on the project road, have been considered. Also, Elasticity values derived from regression analysis gives higher value as registered vehicle data include vehicles which are registered new but do not take into account vehicles which are going off the road due to old age.

High elasticity of cars being witnessed now is because of large demand facilitated by financing schemes and loans. Factors like growth of household incomes (particularly in urban areas), reduction in the prices of entry-level cars, growth of the used car market, changes in life-style, growing personal incomes, desire to own a vehicle, facilitated by availability of loans/financing schemes on easy terms etc. have all contributed to the rapid growth in ownership of cars. However, such trend would slow down and elasticity can be expected to decline.

Over the years, there has been a change in passenger movement with more and more people shifting towards personalized modes. Moreover, buses are usually plying on fixed pre-decided routes and thus elasticity values for buses have been considered accordingly.

With the changing freight vehicle mix in favour of LCVs for short distance traffic and 3-axle/MAVs for long-distance traffic, higher elasticity values for these have been considered as compared to 2-axle trucks. Considering the ongoing technical advancements in automobile industry, some of the standard two axle trucks would gradually be replaced by three axle truck and MAVs, leading to reduction in number of trucks. This shift has already been observed in various parts of the country.

Transport demand elasticity by vehicle type, over a period of time, tends to decline and approach unity or even less. As the economy and its various sectors grow, every region tends to become self-sufficient. Moreover, much of the past growth has been associated with the country's transition from a largely rural subsistence economy to cash-based urban economy, dominated by regional and national linkages. As the transition proceeds, its impact on transport pattern can be expected to become less dominant. Therefore, the demand for different type of vehicles falls over time, despite greater economic development. In other words, the values of elasticity tend to decrease with economic development in future years due to changes in the structure of economy, with higher contribution from service sector and higher value of industrial outputs. The same is also clear from the relationships of the economy and transport demand elasticity over time, both nationally and internationally. The elasticity values have therefore been moderated for the future years as given in Table 4-15.

Table 4-15: Projected transport demand elasticity values

Vehicle Type	Indicator	2018-22	2023-27	2028-32	Beyond 2032
Two Wheeler	PCI	2.03	1.83	1.65	1.48
Car	PCI	3.08	2.77	2.50	2.25
LMV (Passengers)	PCI	0.25	0.23	0.20	0.18
Bus	Population	1.27	1.14	1.03	0.92
Trucks	NSDP	1.54	1.38	1.24	1.12

4.3.9.13 Perspective Growth Rate

Future growth of the state economies and country has to take into account past trends, future prospects, and the emerging challenges for economy. The growth prospects for the state have been developed taking into consideration the past performance of the state economies and the economic growth envisaged for the future. The pace with which the regional economies grow with the envisaged growth of the state is a major contributing factor in growth of traffic.

The growth of NSDP of Jammu & Kashmir from 2005-2006 to 2013-14 is 5.56 percent. Considering the present GDP growth and its future targets, a realistic growth rate of 5.0 % to 6 % has been assumed. The perspective economy growth rates considered are presented in Table 4.16.

Table 4-16: Projected growth rates of indicators

Indicator	2014-17	2018-22	2023-27	2028-32
Population (J&K)	2.07	1.86	1.67	1.51
NSDP (J&K)	5.26	4.73	4.26	3.83

4.3.9.14 Projected Traffic Growth Rate

It is felt that the future growth rates should neither be under nor over targeted. The complexities involved and sensitive dimensions of economy are many, so it is important that its larger issues are to be addressed by constructing different scenarios. Thus, an effort has been made to develop three different scenarios of varying growth rates of economic indicators as under.

- **Optimistic Scenario**
- **Most likely Scenario**
- **Pessimistic Scenario**

Considering all the above discussed points, the growth rates were conceived using methods discussed earlier and have been modified accordingly. The basic growth factors are considered to be realistic rates. In the calculation, the growth rate of economic indicators was treated with ±0.5 sensitivity and the pessimistic and optimistic values were arrived at. The final recommended growth rates are given in Table 4-17.

Table **4-17**: Estimated and recommended traffic growth rates

Vehicle type	2018-22	2023-27	2028-32	Beyond 2032
Most likely				
Car	10.9	8.8	7.2	5.8
Two Wheeler	7.2	5.8	4.7	3.8
Bus	2.4	1.9	1.5	1.3
Mini Bus	2.4	1.9	1.5	1.3
LCV	7.2	5.9	4.8	3.9
2-Axle Truck	6.4	5.4	4.4	3.6
3-Axle Truck	13.1	7.9	6.1	4.8
MAV	14.3	9.7	7.3	5.8
Optimistic				
Car	11.4	9.3	7.7	6.3
Two Wheeler	7.7	6.3	5.2	4.3
Bus	2.9	2.4	2	1.8
LCV	2.9	2.4	2	1.8
2 Axle Truck	7.7	6.4	5.3	4.4
3 Axle Truck	6.9	5.9	4.9	4.1
Multi Axle	13.6	8.4	6.6	5.3
MAV	14.8	10.2	7.8	6.3
Pessimistic				

Vehicle type	2018-22	2023-27	2028-32	Beyond 2032
Car	10.4	8.3	6.7	5.3
Two Wheeler	6.7	5.3	4.2	3.3
Bus	1.9	1.4	1	0.8
LCV	1.9	1.4	1	0.8
2 Axle Truck	6.7	5.4	4.3	3.4
3 Axle Truck	5.9	4.9	3.9	3.1
Multi Axle	12.6	7.4	5.6	4.3
MAV	13.8	9.2	6.8	5.3

4.3.9.15 Traffic forecast for non–motorized traffic

The slow moving vehicles essentially cater to short haul traffic, meeting localized demand for transportation of individual passenger and goods to market centers and urban centers. Non–motorized traffic, especially pedal cycles, will be gradually being replaced by motorized vehicles. Therefore, it is assumed that animal drawn vehicles and pedal cycles volume are expected to decline by a negative growth of 3 per annum because of economic improvement. The growth rates of tractors have been however considered as 3 per annum.

4.3.9.16 Diverted Induced and Generated Traffic

There will be diverted and induced traffic after the road is constructed and open for full year i.e. 365 days as the Sonamarg – Baltal route is a very popular tourist and religious spot for Indians and Foreigners. This route is very important for military purposes and for trade purposes. This road provides link to Leh and Ladakh.

4.3.9.17 Adopted Traffic Growth Rate

As per the provision of IRC:73, the minimum annual growth rate of the commercial vehicle shall not be less than 5 msa. Thus, minimum growth rate adopted for commercial traffic has been taken as 5% and for other category vehicle the growth rate has been adopted as calculated above. The table below indicate the adopted growth rate of vehicle for traffic analysis:

Table 4-18: Traffic Growth Rates

Period	Two-Wheelers	Auto Rickshaw	Cars	Mini Bus	Bus	Mini LCV	LCV	2-Axle Trucks	3-Axle Trucks	MAV(4-6 Axle)	MAV(=>7 Axle)	HCM	Tractor	Tractor with Trailer
2018-22	7.20	5.00	10.90	5.00	5.00	7.20	7.20	6.40	13.10	14.30	14.30	5.00	3.00	3.00
2023-27	5.80	5.00	8.80	5.00	5.00	5.90	5.90	5.40	7.90	9.70	9.70	5.00	3.00	3.00
2028-32	4.70	5.00	7.20	5.00	5.00	5.00	5.00	5.00	6.10	7.30	7.30	5.00	3.00	3.00
2033-37	5.00	5.00	5.80	5.00	5.00	5.00	5.00	5.00	5.00	5.80	5.00	5.00	3.00	3.00
2038-42	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.00	3.00
2043-51	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.00	3.00

Table 4-19: AADT comparison at all locations

Sl. No.	YEAR	AADT km 81+600	Km 84+800	Km 94+800
1	2018	2645*	2393	1779
2	2019	2896	2611	1932
3	2020	3172	2851	2099
4	2021	3476	3114	2281
5	2022	3810	3402	2480
6	2023	2561	3660	2658
7	2024	2751	3938	2849
8	2025	2957	4238	3054
9	2026	3178	4562	3275
10	2027	3417	4911	3512
11	2028	3634	5225	3727
12	2029	3864	5561	3955
13	2030	4110	5918	4198
14	2031	4371	6299	4456
15	2032	4650	6705	4731
16	2033	4906	7076	4988
17	2034	5176	7468	5260
18	2035	5461	7882	5546
19	2036	5761	8319	5848
20	2037	6078	8780	6167
21	2038	6413	9219	6475
22	2039	6766	9680	6799
23	2040	7139	10164	7139
24	2041	7532	10672	7496
25	2042	7948	11206	7871
26	2043	8386	11766	8264
27	2044	8848	12354	8677
28	2045	9336	12972	9111
29	2046	9852	13621	9567
30	2047	10395	14302	10045
31	2048	10969	15017	10547
32	2049	11575	15768	11075
33	2050	12214	16556	11628
34	2051	12889	17384	12210
35	2052	13601	18253	12820

* The bypass for Sonamrg town which is under construction by BRO is assumed to cater certain traffic which eases traffic on project stretch. The percentage reduction of traffic is based on OD analysis which is assumed as follows – for up direction % reduction has been assumed as about 48%, 21%, 80%, 17.65%, 32.43% for car, mini bus, bus, LCV and 2AT respectively and for down

direction the % reduction has been assumed as 51%, 43% 70%, 7.8% and 3.8% respectively for car, mini bus, bus, LCV and 2AT respectively.

Table 4-20: AADT PCU comparison at all locations

Sl. No.	YEAR	km 81+600*	Km 84+800	Km 94+800
1	2018	3854	3346	2737
2	2019	4186	3625	2950
3	2020	4550	3929	3182
4	2021	4947	4260	3432
5	2022	5381	4621	3704
6	2023	4166	4944	3948
7	2024	4447	5291	4208
8	2025	4748	5664	4487
9	2026	5072	6065	4785
10	2027	5418	6496	5104
11	2028	5737	6890	5399
12	2029	6075	7310	5712
13	2030	6434	7756	6044
14	2031	6815	8229	6396
15	2032	7219	8733	6769
16	2033	7604	9206	7128
17	2034	8009	9704	7507
18	2035	8436	10230	7906
19	2036	8886	10784	8326
20	2037	9361	11369	8768
21	2038	9860	11937	9207
22	2039	10387	12534	9667
23	2040	10942	13161	10150
24	2041	11526	13819	10658
25	2042	12142	14510	11190
26	2043	12792	15235	11750
27	2044	13476	15997	12337
28	2045	14196	16797	12954
29	2046	14956	17637	13602
30	2047	15756	18518	14282
31	2048	16600	19444	14996
32	2049	17489	20416	15746
33	2050	18426	21437	16533
34	2051	19413	22509	17360
35	2052	20453	23634	18227

4.3.10 DATA ANALYSIS- OD SURVEYS

4.3.10.1 General

In order to understand the travel pattern on the corridor, Origin and Destination (O-D) Surveys were carried out at 2 locations on the project road. The O-D surveys were carried out on a weekday, over a full 24 hours, by the roadside interview method as described in IRC: 102-1988. Police assistance was arranged for carrying out this survey. Vehicles were stopped on a random sampling basis and interviewed.

Trained enumerators under the supervision of traffic engineer collected the trip characteristics using the survey forms designed for this purpose. The information collected during roadside interviews was analysed to obtain the trip length, trip distribution, commodity movement based on a zoning system suitably designed for the study. Sample sizes collected at these locations are in table 4.21 below:

Table 4-21: Mode Wise Sample Size Achieved

Mode	Km – 81+500	Km – 85+800
Car	40%	38%
Mini Bus	78%	44%
Bus	100%	64%
LCV	11%	1%
2-Axle Truck	33%	64%
3-Axle Truck / MAV	0%	0%

** Sample is small, resulting in high percentages.*

4.3.10.2 Zoning System

For analysis of O-D data and preparation of trip tables for studying the regional interaction, a zoning system was developed. The zoning system took into consideration the project influence area and trip generating and attraction points. In all, 6 zones were identified. The list of traffic zones is presented below in Table 4.22 below:

Table 4-22: List of Zones

Zone	Place/Region	State
1	Ganderbal	Jammu and Kashmir
2	Leh, Kargil, Drass, Zojila	Jammu and Kashmir
3	Rest of Kashmir	Jammu and Kashmir
4	Himachal Pradesh	Himachal Pradesh
5	Haryana, Delhi, UP, Uttarakhand, Punjab	Haryana, Delhi, UP, Uttarakhand, Punjab
6	Rest of India	Rest of India

4.3.10.3 Passenger Vehicles- lead and Occupancy

Analysis of passenger vehicles along the project corridor is enclosed. At Km – 81+500, Average lead for car is 246 Km, for Mini Bus is 235 Km and for Bus is 164 Km. At Km – 85+800, Average Lead for car is 346 Km, for Mini Bus is 329 Km, for Bus is 60 Km.

Occupancy analysis for Km-81+500 and Km-85+800 are enclosed in the table 4.23 & 4.24 below:

Table 4-23: Occupancy analysis for (Km-81+500)

Vehicle Type	Total Vehicles	0 – 2	2 – 5	5 – 8	8 – 20	20 – 50	> 50
Car	763	10%	35%	24%	3%	0%	0%
Mini Bus	80	0%	5%	20%	68%	5%	0%
Bus	25	0%	12%	8%	40%	44%	0%

Table 4-24: Occupancy analysis for (Km-85+800)

Vehicle Type	Total Vehicles	0 – 2	2 – 5	5 – 8	8 – 20	20 – 50	> 50
Car	645	15%	60%	23%	2%	0%	0%
Mini Bus	18	0%	6%	44%	33%	17%	0%
Bus	7	0%	0%	14%	43%	43%	0%

4.3.10.4 Goods Vehicle - Lead and Load Analysis

It is observed from the analysis that:-

AT Km – 81+500, Average Lead for LCV is 160Km, for 2-Axle is 453 Km. AT Km – 85+800, Average Lead for LCV is 65 Km, for 2-Axle is 438 Km.

Load analysis are enclosed in the table 4-25 & 4-26 below.

Table 4-25: Load Distribution for Commercial vehicles at Km – 81+500

Vehicle Type	Total Vehicles	0 – 3	3 – 5	5 – 10	10 – 15	15 – 20	% Empty
LCV	43	37%	21%	14%	9%	2%	16%
2 Axle	179	14%	7%	59%	6%	3%	11%
3 Axle	0	0%	0%	0%	0%	0%	0%
M Axle	0	0%	0%	0%	0%	0%	0%

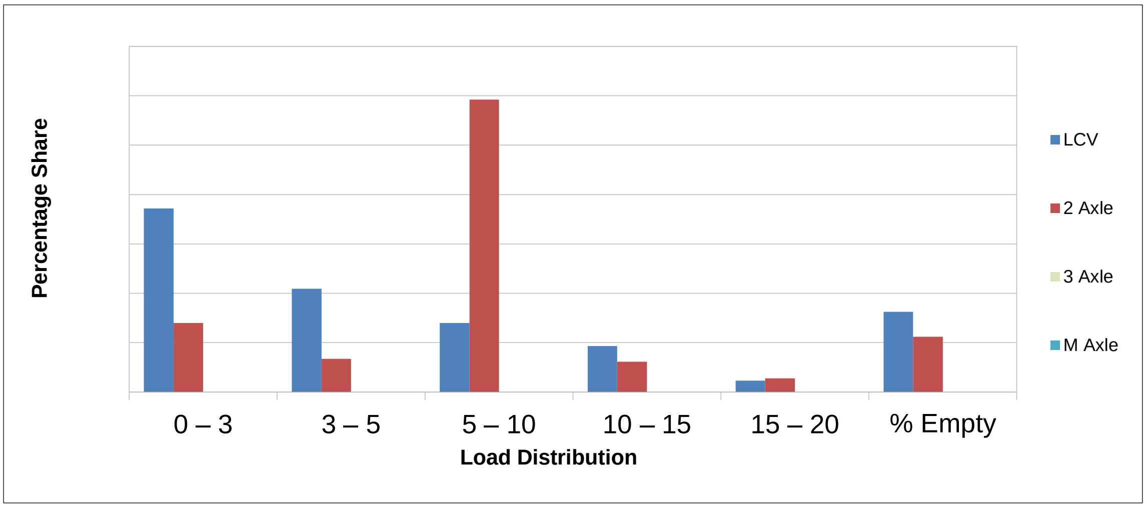


Fig. 4-14 : Load Distribution for Commercial vehicles at Km – 81+500

Table 4-26: Load Distribution for Commercial vehicles at Km – 85+800

Vehicle Type	Total Vehicles	0 – 3	3 – 5	5 – 10	% Empty
LCV	3	67%	33%	0%	0%
2 Axle	440	1%	0%	47%	52%
3 Axle	0	0%	0%	0%	0%
M Axle	0	0%	0%	0%	0%

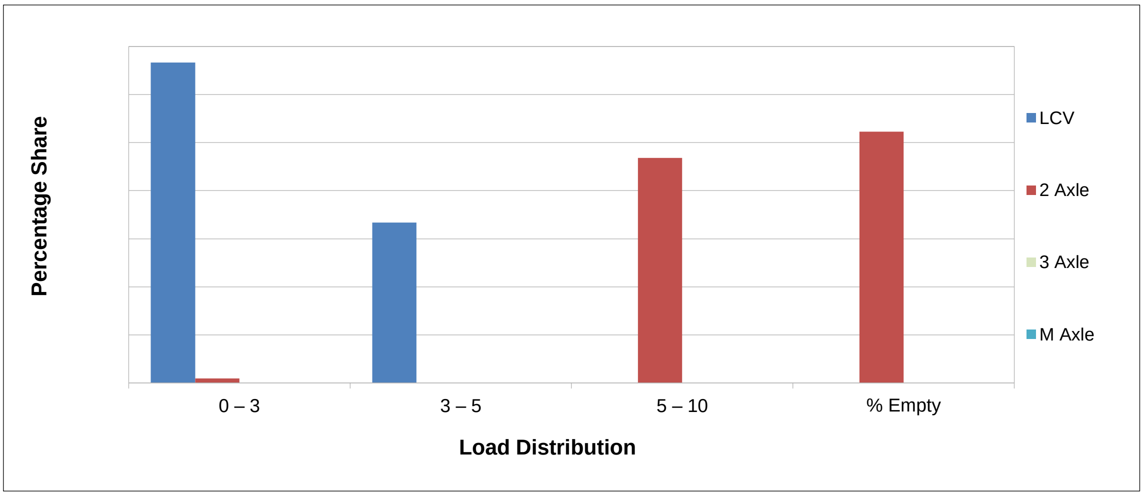


Fig. 4-15: Load Distribution for Commercial vehicles at Km – 85+800

4.3.10.5 Development of Origin-Destination Matrices

Vehicle wise O-D matrices were developed using the expansion factors. O-D matrices for different vehicle types for the project road.

4.3.10.6 Travel Pattern and Major Trip Generators

It is observed that at Km – 81+500, the passenger vehicles are travelling from Delhi, Chandigarh, Jammu, Hisar, Moradabad, Meerut, Ghaziabad, Indore, Jaipur and Gurgaon to Sonamarg, Baltal, Drass, Leh, Kargil, Zero Point, Zojila and Ladakh.

Goods traffic is travelling from Delhi, Gujrat, Bihar, Srinagar, Rajasthan, Kangan to Sonamarg, Baltal, Drass, Leh, Kargil, Zero Point, Zojila and Ladakh.

At Km-85+800, it is observed that the passenger are travelling from Delhi, Chandigarh, Jammu, Hisar, Moradabad, Meerut, Ghaziabad, Indore, Jaipur and Gurgaon to Sonamarg, Baltal, Drass, Leh, Kargil, Zero Point, Zojila and Ladakh.

Goods traffic is travelling from Delhi, Gujrat, Bihar, Srinagar, Rajasthan, Kangan to Sonamarg, Baltal, Drass, Leh, Kargil, Zero Point, Zojila and Ladakh.

4.3.10.7 Trip Characteristics Distribution

From the O-D analysis, Trip distribution of goods and passenger vehicles has been observed and the results are shown in table 4-27,4-28,4-29 & 4-30.

Table 4-27: Trip Distribution of Passenger Vehicles at Km – 81+500

Vehicle Type	I-I	I-E	E-I	E-E
Car	14%	17%	43%	26%
Mini Bus	10%	13%	58%	20%
Bus	8%	16%	32%	44%

Note: I-I: Internal to Internal, I-E: Internal to External, E-I: External to Internal, E-E: External to External.

Table 4-28: Trip Distribution of Goods Vehicles at Km – 81+500

Vehicle Type	I-I	I-E	E-I	E-E
LCV	28%	28%	31%	13%
2 Axle	6%	14%	6%	75%

Note: I-I: Internal to Internal, I-E: Internal to External, E-I: External to Internal, E-E: External to External

Table 4-29: Trip Distribution of Passenger Vehicles at Km – 85+800

Vehicle Type	I-I	I-E	E-I	E-E
Car	20%	16%	24%	40%
Mini Bus	0%	0%	33%	67%
Bus	0%	0%	100%	0%

Note: I-I: Internal to Internal, I-E: Internal to External, E-I: External to Internal, E-E: External to External

Table 4-30: Trip Distribution of Goods Vehicles at Km – 85+500

Vehicle Type	I-I	I-E	E-I	E-E
LCV	0%	33%	33%	33%
2 Axle	4%	13%	2%	82%

Note: I-I: Internal to Internal, I-E: Internal to External, E-I: External to Internal, E-E: External to External

4.3.10.8 Travel Characteristics

The travel characteristics of passengers and goods has been observed and the results are shown in table 4-31,4-32, 4-33 & 4-34.

4.3.10.9 Travel characteristics for passengers

For Passenger trips, the travel characteristics involve the travel frequency, travel purpose and the trip length distribution.

Table 4-31: Travel frequency of Passenger Vehicles at Km – 81+500

Travel Frequency (In Percentage) - Km 81+500													
Vehicle Type	Total No of Vehicles	Daily Once	Daily Twice	> Daily Twice	Weekly Once	Weekly Twice	> Weekly Twice	Monthly Once	Monthly Twice	> Monthly Twice	Yearly Once	>Yearly Once	Total
Car	763	35%	5%	1%	11%	4%	1%	18%	3%	1%	21%	1%	100%
Mini Bus	80	31%	0%	0%	31%	3%	0%	29%	0%	0%	5%	1%	100%
Bus	25	20%	8%	0%	20%	4%	0%	24%	0%	0%	20%	4%	100%

Fig. 4-16: Travel Frequency for Passenger vehicles at Km – 81+500

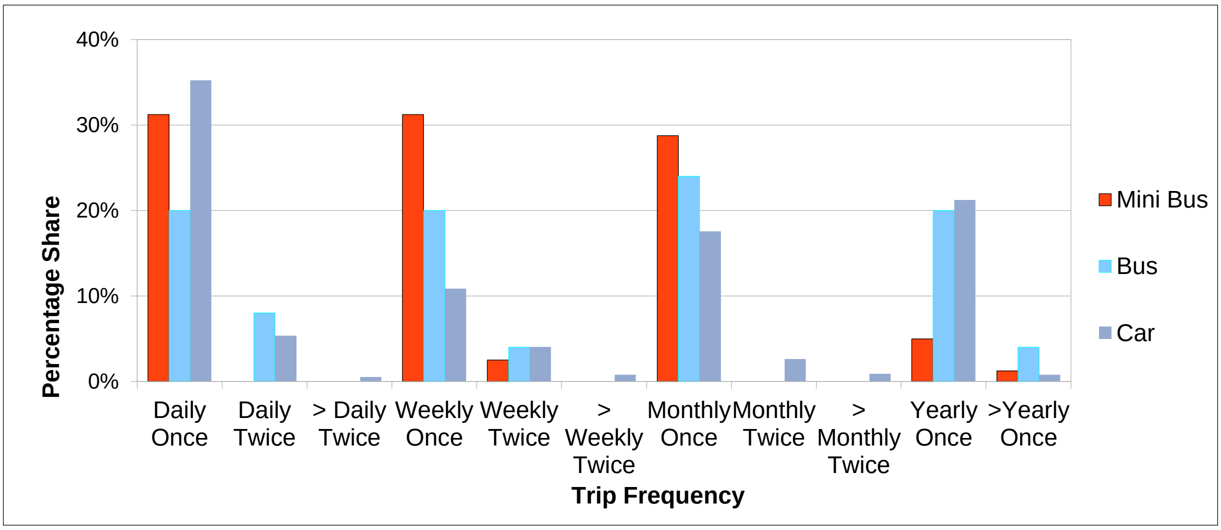


Table 4-32: Trip length distribution of Passenger Vehicles at Km – 81+500

Vehicle Type	Total Vehicles / Km Range	0 – 20	21 - 50	51 - 100	101 - 250	251 - 500	501 - 1000	> 1000	Average Trip Length (Km)
Car	763	108	189	197	53	136	38	42	308
Mini Bus	80	0	4	34	12	22	4	4	144
Bus	25	2	2	4	9	6	2	0	324

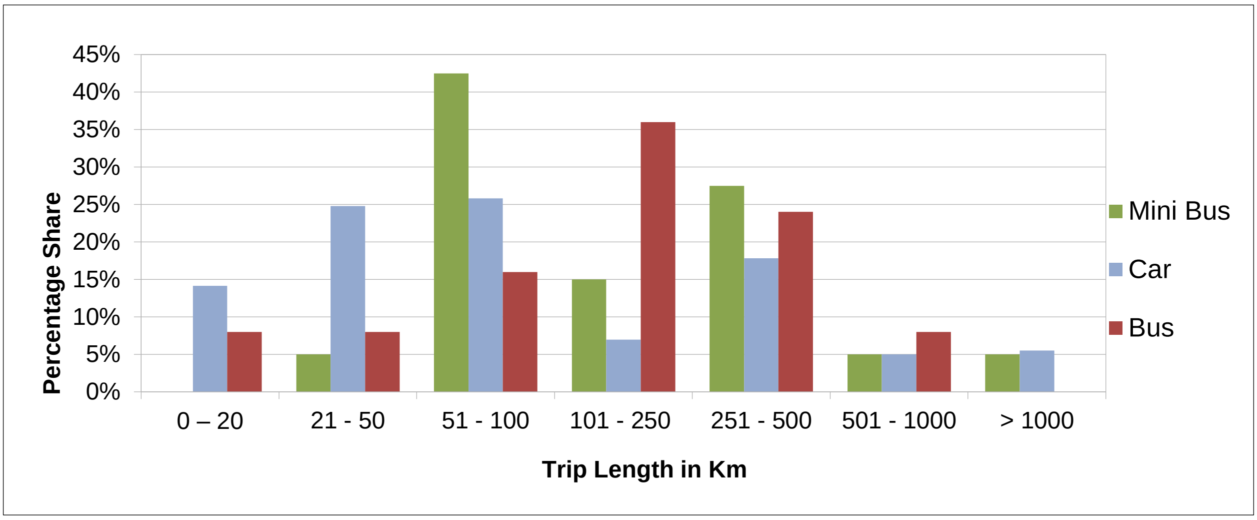


Fig. 4-17: Trip length distribution of Passenger Vehicles at Km – 81+500

Table 4-33: Composition of passenger vehicle with their purpose (Km-81+500)

Purpose	Car	Mini Bus	Bus
	1	2	3
Work	41%	14%	20%
Business	2%	0%	4%
Education	3%	10%	16%
Social	0%	0%	0%
Shopping	1%	5%	0%
Religious/Tourism	52%	76%	44%
Others	0%	5%	8%
Total	100%	100%	100.0%

Table 4-34: Travel frequency of Passenger Vehicles at Km – 85+800

Travel frequency (In Percentage) - Km 85+800													
Vehicle Type	Total No of Vehicles	Daily Once	Daily Twice	> Daily Twice	Weekly Once	Weekly Twice	> Weekly Twice	Monthly Once	Monthly Twice	> Monthly Twice	Yearly Once	>Yearly Once	Total
Car	645	17%	10%	3%	18%	5%	1%	15%	1%	0%	29%	0%	100%
Mini Bus	18	33%	0%	0%	17%	0%	11%	22%	0%	0%	17%	0%	100%
Bus	7	0%	0%	0%	0%	0%	0%	57%	0%	0%	43%	0%	100%

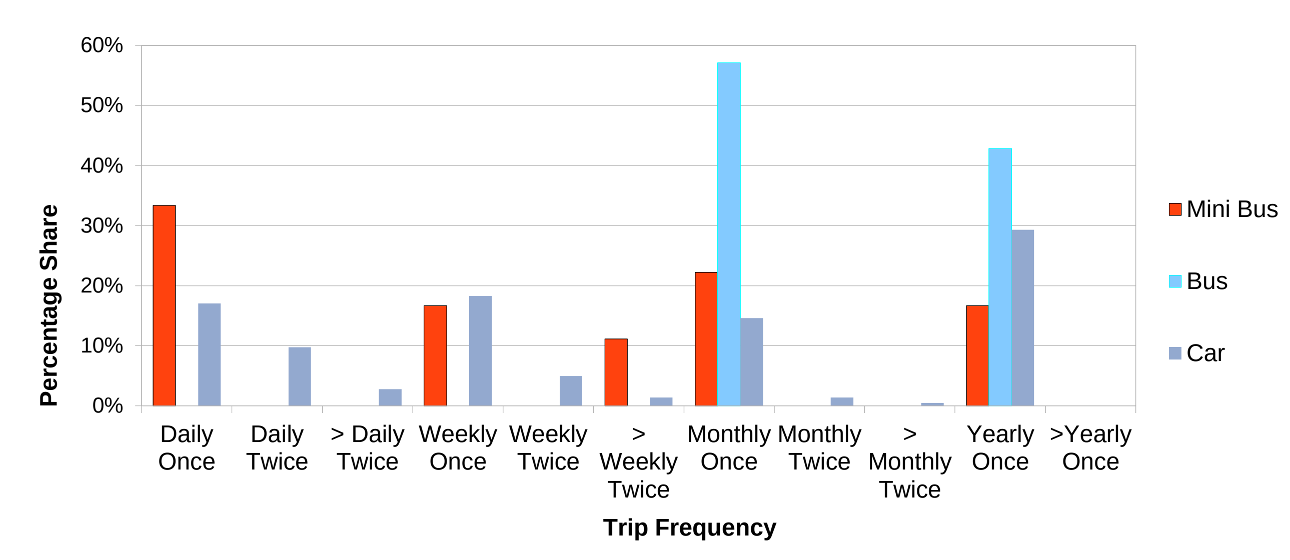


Fig. 4-18 : Travel Frequency for Passenger vehicles at Km – 85+800

Table 4-35: Trip length distribution of Commercial Vehicles at Km – 85+800

Vehicle Type	Total Vehicles / Km Range	0 – 20	21 - 50	51 - 100	101 - 250	251 - 500	501 - 1000	> 1000	Average Trip Length (Km)
Car	645	135	69	132	118	60	38	93	346
Mini Bus	18	3	0	3	3	9	0	0	329
Bus	7	0	3	4	0	0	0	0	60

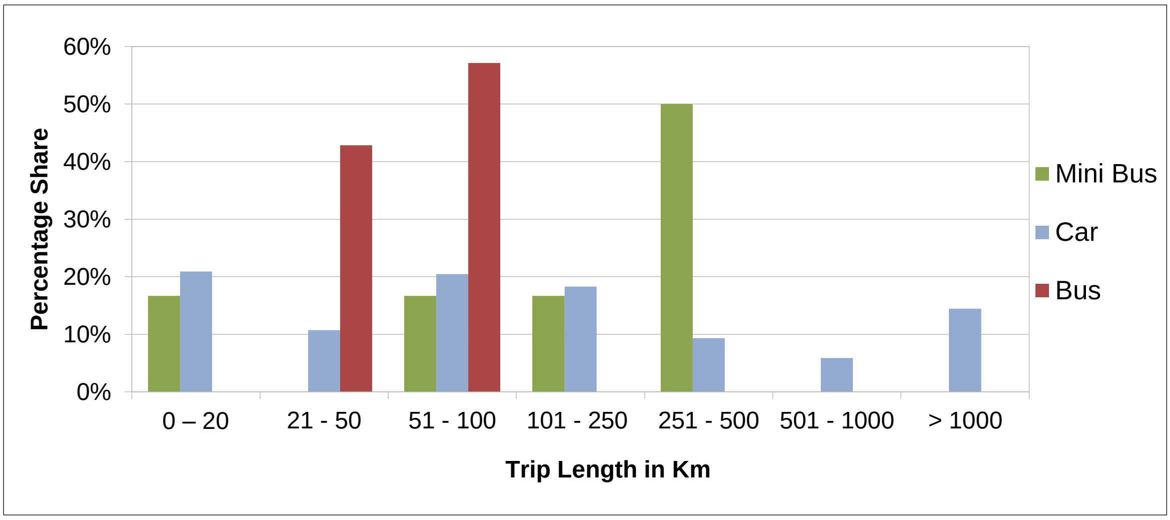


Fig. 4-19: Trip length distribution of Commercial Vehicles at Km – 85+800

Table 4-36: Composition of passenger vehicle with their purpose (Km-85+800)

Purpose	Car	Mini Bus	Bus
	1	2	3
Work	26%	6%	0%
Business	5%	0%	0%
Education	8%	28%	43%
Social	0%	0%	0%
Shopping	1%	0%	0%
Religious/Tourism	58%	67%	57%
Others	2%	0%	0%
Total	**100%**	**100%**	**100.0%**

4.3.10.10 Travel Characteristics for Commercial Vehicles

For Goods trip, the travel characteristics involve the travel frequency, commodity carried and the trip length distribution.

Table 4-37: Travel frequency of Commercial Vehicles at Km – 81+500

Travel Frequency (In Percentage) - Km 81+500													
Vehicle Type	Total No of Vehicles	Daily Once	Daily Twice	> Daily Twice	Weekly Once	Weekly Twice	> Weekly Twice	Monthly Once	Monthly Twice	> Monthly Twice	Yearly Once	>Yearly Once	Total
LCV	43	33 %	0%	0%	42%	5%	12%	7%	2%	0%	0%	0%	100 %
2 Axle	179	2%	6%	2%	58%	18%	5%	2%	2%	4%	2%	0%	100 %
3 Axle	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
M Axle	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

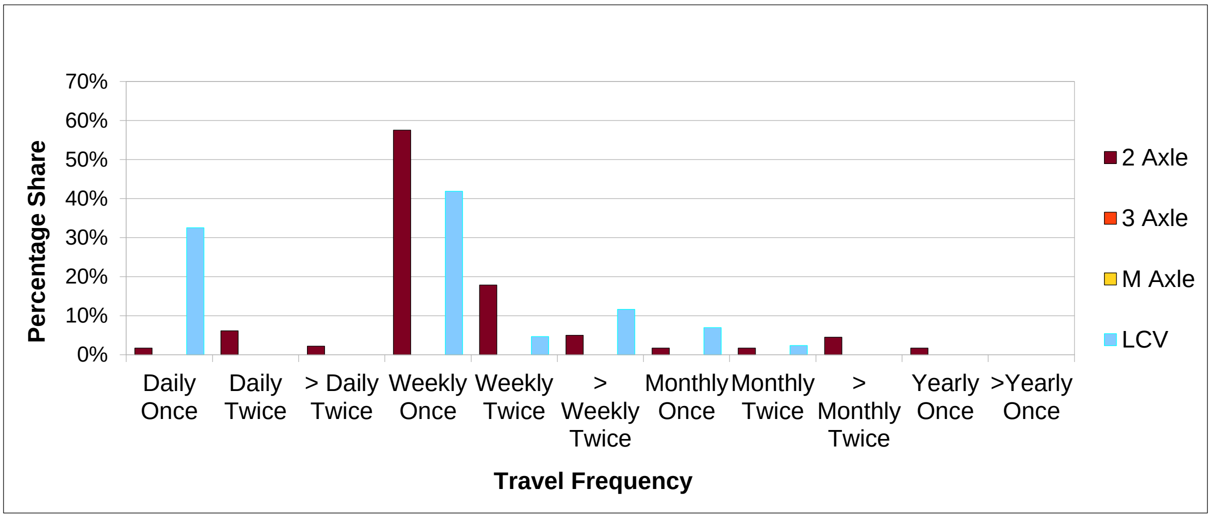


Fig.4-20: Travel Frequency for Commercial vehicles at Km – 81+500

Table 4-38: Trip length distribution of Commercial Vehicles at Km – 81+500

Vehicle Type	Total Vehicles / Km Range	0 – 20	21 - 50	51 - 100	101 - 250	251 - 500	501 - 1000	> 1000	Average Trip Length (Km)
LCV	32	3	13	17	4	4	2	0	293
2 Axle	179	3	17	13	15	68	60	3	336
3 Axle	0	0	0	0	0	0	0	0	0
M Axle	0	0	0	0	0	0	0	0	0

Fig. 4-21: Trip length distribution of Commercial Vehicles at Km – 81+500

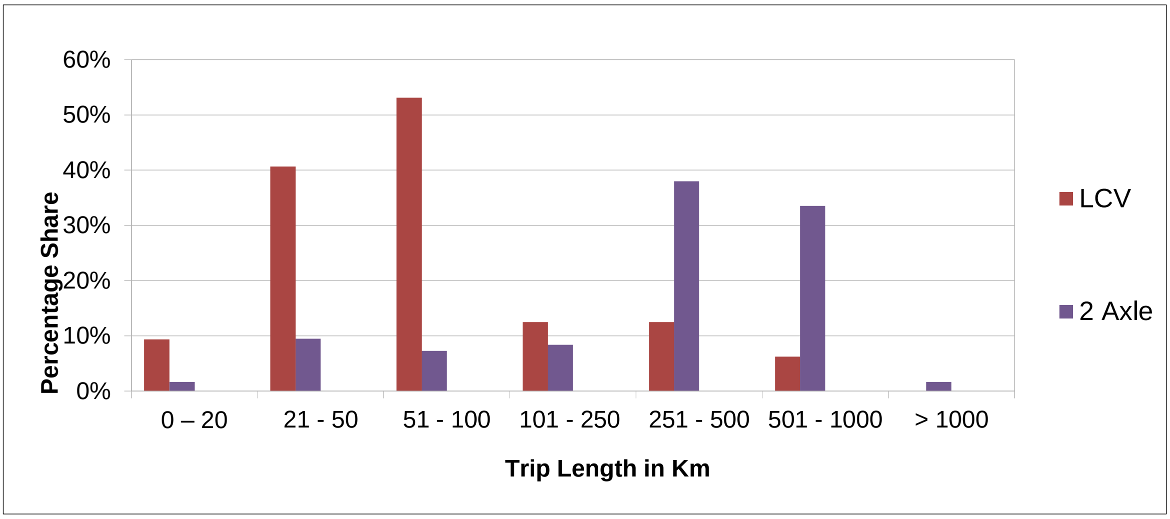


Table 4-39: Vehicle wise Commodity Composition (%) (Km-81+500)

Code	Commodity	LCV		2 Axle		3 Axle		M Axle	
		Sample	Percent	Sample	Percent	Sample	Percent	Sample	Percent
1	Food grains and pulses	1	2%	4	2%	0	0%	0	0%
2	Cash crops	0	0%	0	0%	0	0%	0	0%
3	Vegetables and Fruits	3	7%	1	1%	0	0%	0	0%
4	Processed Food Items	2	5%	2	1%	0	0%	0	0%
5	Packed Food Items	0	0%	2	1%	0	0%	0	0%
6	Fishery, Poultry and Animal feed	1	2%	0	0%	0	0%	0	0%
7	Building Materials, Iron , sheet, Aluminium products, Iron coil and Iron Pipe	1	2%	35	20%	0	0%	0	0%
8	Industrial Raw Materials	0	0%	1	1%	0	0%	0	0%
9	Consumer Goods	15	35%	2	1%	0	0%	0	0%
10	Fertilizers, Chemicals and Pharmaceuticals	0	0%	0	0%	0	0%	0	0%
11	Machinery and Automobiles	1	2%	0	0%	0	0%	0	0%
12	Petroleum Products	0	0%	25	14%	0	0%	0	0%
13	Parcel Goods	0	0%	0	0%	0	0%	0	0%
14	Empty	19	44%	107	60%	0	0%	0	0%
15	Industrial Outputs	0	0%	0	0%	0	0%	0	0%
16	Liquor and Cool Drinks	0	0%	0	0%	0	0%	0	0%
Total		**43**	**100%**	**179**	**100%**	**0**	**0%**	**0**	**0%**

Table 4-40: Travel frequency of Commercial Vehicles at Km – 85+800

Travel frequency (In Percentage) - Km 85+800													
Vehicle Type	Total No of Vehicles	Daily Once	Daily Twice	> Daily Twice	Weekly Once	Weekly Twice	> Weekly Twice	Monthly Once	Monthly Twice	> Monthly Twice	Yearly Once	>Yearly Once	Total
LCV	3	67 %	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100 %
2 Axle	440	100 %	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100 %
3 Axle	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
M Axle	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

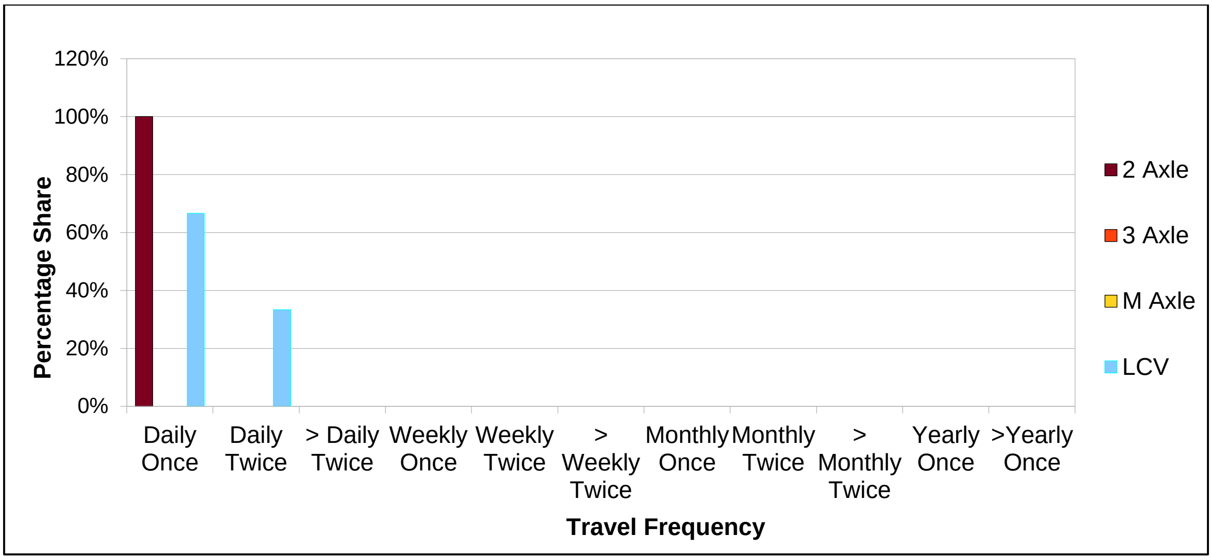


Fig. 4-22: Travel Frequency for Commercial vehicles at Km – 85+800

Table 4-41: Trip length distribution of Commercial Vehicles at Km – 85+800

Vehicle Type	Total Vehicles / Km Range	0 – 20	21 - 50	51 - 100	101 - 250	251 - 500	501 - 1000	> 1000	Average Trip Length (Km)
LCV	3	1	0	2	0	0	0	0	65
2 Axle	440	16	8	20	39	228	129	0	438
3 Axle	0	0	0	0	0	0	0	0	0
M Axle	0	0	0	0	0	0	0	0	0

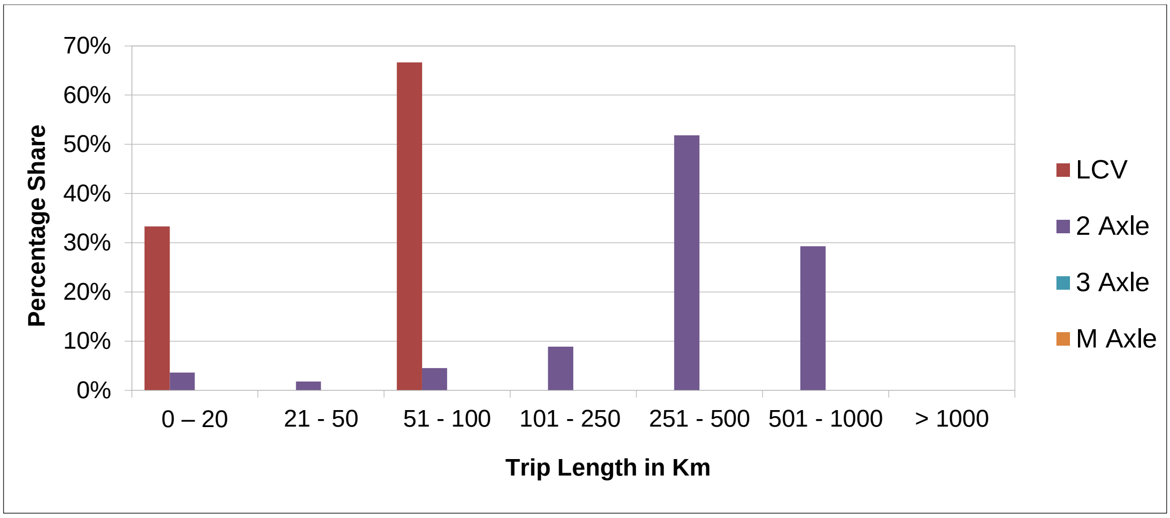


Fig. 4-23: Trip length distribution of Commercial Vehicles at Km – 85+800

Table 4-42: Vehicle wise Commodity Composition (%) for Km – 85+800

Code	Commodity	LCV		2 Axle		3 Axle		M Axle	
		Sample	Percent	Sample	Percent	Sample	Percent	Sample	Percent
1	Food grains and pulses	0	0%	0	0%	0	0%	0	0%
2	Cash crops	0	0%	0	0%	0	0%	0	0%
3	Vegetables and Fruits	0	0%	108	25%	0	0%	0	0%
4	Processed Food Items	0	0%	0	0%	0	0%	0	0%
5	Packed Food Items	0	0%	0	0%	0	0%	0	0%
6	Fishery, Poultry and Animal feed	0	0%	0	0%	0	0%	0	0%
7	Building Materials, Iron sheet, Aluminium products, Iron coil and Iron Pipe	2	29%	53	12%	0	0%	0	0%
8	Industrial Raw Materials	0	0%	10	2%	0	0%	0	0%
9	Consumer Goods	2	29%	0	0%	0	0%	0	0%
10	Fertilizers, Chemicals and Pharmaceuticals	0	0%	0	0%	0	0%	0	0%
11	Machinery and Automobiles	0	0%	0	0%	0	0%	0	0%
12	Petroleum Products	0	0%	42	10%	0	0%	0	0%
13	Parcel Goods	0	0%	0	0%	0	0%	0	0%
14	Empty	3	43%	227	52%	0	0%	0	0%
15	Industrial Outputs	0	0%	0	0%	0	0%	0	0%
16	Liquor and Cool Drinks	0	0%	0	0%	0	0%	0	0%
Total		**7**	**100%**	**440**	**100%**	**0**	**0%**	**0**	**0%**

4.4 CAPACITY ANALYSIS

4.4.1 CAPACITY AND LEVEL OF SERVICE GUIDELINES

Capacity Analysis of the project road has been carried out in order to define the level of service offered by the project road sections under prevailing roadway and traffic conditions during the study period. Capacities for various lane configuration as specified by IRC – SP: - 73-2015.

Capacity analysis is fundamental to planning, design and operation of roads. Among other things it provides the basis for determining the number of traffic lanes to be provided for different road sections having regard to volume, composition and other traffic parameters.

It is assumed that 2019-2022 will be the construction period. In the above table comparison for 10 years (2027) and 15 years (2032) capacity is shown. From the table, it is seen that the cells highlighted in red colour needs up gradation after 10 and 15 years as the projected capacity exceeds the design capacity.

Table 4-43: Capacity Analysis for different sections

Section	LOS (Level of Service) as per IRC SP 73 :2015			
	Year	Traffic (PCU)	LOS B	LOS C
Section - 1 (Km-81+600)*	2018	3854	9000	12600
	2027	5418	9000	12600
	2032	7219	9000	12600
	2037	9361	9000	12600
Section - 2 (Km-85+900)	2018	3346	9000	12600
	2027	6496	9000	12600
	2033	9206	9000	12600
	2037	11369	9000	12600
Section - 3 (Km-94+800)	2018	2737	9000	12600
	2027	5104	9000	12600
	2032	6769	9000	12600
	2038	9207	9000	12600

*The construction of Sonamarg bypass is under progress and it is assumed that it will cater certain traffic and the distribution is considered based on O&D analysis.

Table 4-44: Design Service Volumes at Different Level of Services

Level of Service	2 lane	4 lane with paved shoulder	6 lane with paved shoulder
A	10350	24000	36000
B	17250	40000	60000
C	24150	56000	84000
D	29325	68000	102000
E	34500	80000	120000

4.4.2 TRAFFIC AT INTERSECTION

As per IRC: 92-1985

The criterion for grade separation at intersection is based on IRC: 92-1985 "Guidelines for the Design of Interchanges". The guidelines suggest that a grade separated intersection besides other warrants is justified when the total traffic on the intersection is in excess of 10000 PCUs per hour. To assess the requirement of grade separation at intersections, peak hour traffic was projected and type of improvement presented in Table 4-45 and 4-46.

Table 4-45: Projected Peak Hour Traffic at Intersections and Improvement Proposals

Sl. No	Name of Intersection	Chainage (km)	Peak Hour PCUs	Year in which 9000PCUs Exceeds	Improvement Proposal
1	Nilagrar	Km 89	416	2042	No Improvement is required.
2	Ranga Mor	Km 95	181	2056	No Improvement is required.

Table 4-46: Interchange proposal at Intersection

Sl. No	Name of Intersection	Chainage (km)	Cross road ADT (Fast Vehicles Only)	After 5 years	Proposal of Interchange
1	Nilagrar	Km 89	3149	3827	No Interchange is required.
2	Ranga Mor	Km 95	1629	1980	No Interchange is required

IRC:62-1976 gives the Guidelines for control of access on Highways, Grade Separation should be provided at intersection if the ADT (fast vehicles only) on the cross road within next 5 years exceeds 5000. So, from the analysis, it can be stated that grade separated facility is not required, only Geometric improvement is required.

Growth rates for various modes at the junctions have been taken on the basis of growth rates arrived at for the homogenous sections. As in case of the homogeneous section, traffic at the junctions has also been considered to be contributed from various influence zones identified earlier. This has been done considering the fact that the traffic at the junction and the section will have similar characteristics. The projection of traffic has been done for the peak hour.

4.4.3 IMPROVEMENT PROPOSALS

Capacity analysis for different sections is done for 10 years and 15 years. Capacity analysis is done for LOS B & LOS C. Improvement proposals considered are shown in table 4.47 below:

Table 4-47: Improvement Proposal

Sections	Proposed Configuration	Based on 2 Lane with paved shoulder Capacity Guidelines	
		LOS B	LOS C
Section - 1 (Km-81+600)	Two Lane with paved shoulder	2037	2043
Section - 2 (Km-85+900)	Two Lane with paved shoulder	2033	2040
Section - 3 (Km-94+800)	Two Lane with paved shoulder	2038	2045

From Table 4-47traffic on Sections 1, 2 & 3 will exceed the capacity of 2-lane with LOS C in 2043, 2040 and 2045 respectively and after that widening will be required.

5 CHAPTER-5 PAVEMENT DESIGN

5.1 INTRODUCTION

The design of pavements in high altitude snow bound region tends to thick in order to sustain frost heave and particularly uneven settlements at spring thaw. Typically most roads in cold region only carry limited amounts of traffic. Keeping in view the distress potential of climate as also the relatively low volume of vehicular traffic on the roads in high altitude snow bound regions, the performance of pavements will essentially be affected more by the changing thermal regime of the ground than by the axle loads. This calls for a paradigm shift in the approach generally followed for designing pavements. Instead of designing for axle loads, the road pavements in high altitude snow bound regions should be designed primarily on the consideration of extremely varying climatic and geotechnical conditions of the ground. Such designs will invariably be found adequate for the vehicle axle loads, which the pavement is expected to carry during its design life. This basically aims at determining the total thickness of the pavement structure as well as the thickness of the individual structural components.

The effects of frost action introduce many challenges in the design and construction of roadways in cold regions. The penetration of frost into pavement structures can lead to differential frost heave during winter and thaw weakening during spring. Both of these damage mechanisms lead to premature pavement distress, structural deterioration, and poor ride quality.

The thickness of a pavement structure can play an important role in the performance of a roadway, especially in cold regions. If the frost penetration depth exceeds the thickness of the pavement structure in areas with frost-susceptible soils, frost heave, thaw weakening, and freeze-thaw cycling can cause substantial damage to the roadway.

In high altitude areas which are subjected to heavy snowfall, sub-zero temperature, frost action, snow drifts and avalanche activities, design and construction of pavement require special consideration. The performance of conventional type of flexible pavements, comprising viz GSB, WMM etc, may not be found satisfactory due to factors like:-

(a) Frost heaving and thawing action

(b) Intensive snow and avalanche activity

(c) Icing problems

(d) Damage by movement of tracked vehicles during snow clearance operations.

(e) Loss of ductility of bitumen due to sub-zero temperatures

(f) Blocking of drainage system

(g) Glacier and avalanche movement on the road

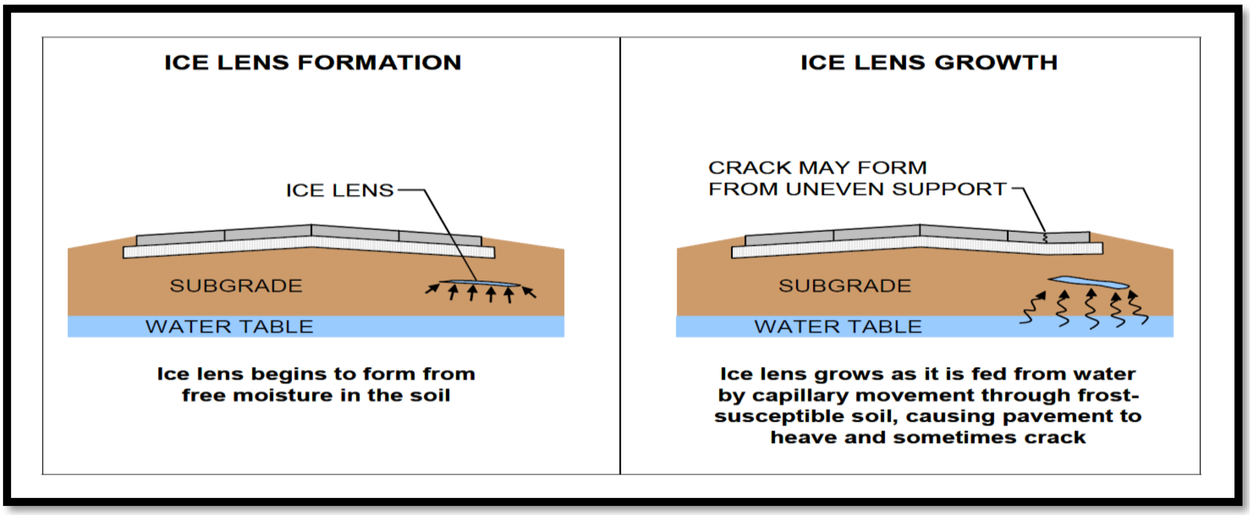


Fig. 5-1: Formation of ice lens and frost heave in frost-susceptible soil

The above result in excessive maintenance requirement and even destruction of pavement and allied structures. Roads in high altitude areas should be designed to retain their stability and serviceability inspite of yearly relentless cycle of freezing and thawing and occurrence of avalanches.

As per IRC:SP:48-1998, The various alternate specifications that may be adopted for heavy snow accumulation/avalanches sites requiring clearance by heavy mechanical equipment are as under:

(a) Flexible Pavement:

(i) This may consist of a layer of Dense Bituminous Carpet, over Bituminous Macadam/Dense Bituminous Macadam on a crushed stone base Laid on Non-frost susceptible sub base.

(ii) If conditions warrant only lesser thickness, the thickness may be restricted to not less than 450mm by reducing sub base thickness.

(b) Stone set pavement:

This is a semi rigid type of pavement. The stone is set over a layer of lean cement concrete (1:4:8) and crushed stone base. The sub base should be non-frost susceptible material.

(c) Precast concrete block pavement:

Where construction time is limited and road is to be kept open during the construction stage, small size high density precast concrete blocks laid on sand over crushed stone base and non-frost susceptible sub-base is suitable.

(d) Rigid Pavement:

Rigid pavements should be used only where favourable subgrade conditions exist, such as over non-frost susceptible subgrades and possibly uniform subgrade soils from groups F1 and F2.

Concrete pavements must be protected from freezing during the placement and curing period and must be permitted to gain substantial tensile strength before exposure to very low temperatures to minimize cracking. High early-strength cement with air entrainment is recommended. Joints should be at much smaller spacing than usual because of exceptional expansion and contraction.

5.2 FROST SUSCEPTIBILITY OF SOILS

From the point of view of pavement design and construction, the need will for a simple set of criteria to distinguish whether a given soil will frost susceptible or not. Such criteria, in empirical form, incorporating the principles of freezing of soils and formation of ice lenses been evolved by Casagrande essentially based on grain size to serve as a useful guide. Soil have been divided in to 4 groups F1 to F4 (By US Corps of Engineers).

Table 5-1:Grouping of Soils Based on Frost Susceptibility

Group	Description	Characteristics
F1	Gravelly soils containing between 3 to 20 percent finer than 0.02 mm. by weight.	Least frost susceptible and least thaw weakening.
F2	Sands containing between 3 and 15 percent finer than 0.02 mm. by weight.	Increased frost-susceptibility and thaw weakening.
F3	(a) Gravelly soils containing more than 20 percent finer than 0.02 mm. by weight. (b) Sands, except very fine silty sands, containing more than 15 percent finer than 0.02 mm. by weight. (c) Clays with plasticity indexes of more than 12. (d) Varved clays existing with uniform subgrade conditions.	Frost susceptible and high thaw weakening.
F4	(a) All silts including sandy silts. (b) Very fine silty sands containing more than 15 percent finer than 0.02 mm. by weight. (c) Clays with plasticity indexes of less than 12. (d) Varved clays existing with non-uniform subgrade conditions.	Frost susceptible and high thaw weakening.

5.3 EXTRUDED POLYSTRENE SHEET

Soil insulation is a means of protecting in ground construction from the ravages of frost action. The concept itself is borne of the insulating principles common to the design of building above ground.

Insulation in the upper level of the soil, its unique combination of properties will effectively prevent harmful sub soil frost action. EPS sheets has been used in engineering construction in Canada, U.S.A., Japan and throughout Europe. On roadways, rail lines, airport pavement, buildings and transmission tower foundations, drainage works in ground utilities. EPS insulation sheets has proven to be an economical, long term solution to ground frost problems. It conserves the natural heat in the subgrade, retarding frost penetration during winter and, in turn, eliminating frost heave and spring break-up.

It performs the inverse task of retaining the frozen state of the subgrade during summer months to prevent a warming influence in the subgrade which would result in thaw weakening.

It is an ideal defence against the damage brought by frost heave and spring break-up on projects including roadways, airports runways and rail lines.

5.4 DATA COLLECTION AND CALCULATIONS

As per IRC: 37-2012, to estimate the cumulative number of standard axles to be carried by the pavement during the design life. To do this the following calculations need to be done:-

- Traffic intensity in terms of commercial vehicles per day;
- Traffic growth rate;
- Design life;
- Vehicle damage factor (VDF);
- CBR % for subgrade soil; and
- Cumulative MSA (CMSA) for the design period

5.5 DESIGN LIFE

The design life of a pavement depends on a lot of factors including rainfall, traffic loading, construction quality and material quality. The design life is considered as 15 years for Flexible pavements as per IRC 37: 2012 and 30 years for Rigid Pavement Design as per IRC:58:2015.

5.6 VEHICLE DAMAGE FACTOR

The following IRC guidelines are used in calculation of Vehicle Damage Factor (VDF) for estimation of cumulative MSA and design thickness of proposed pavement.

The Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicle of different axle loads and axle configuration into the number of repetitions of standard axle load of magnitude 80 KN. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration and axle loading.

The equations for computing equivalency factors for single, tandem and tri-dem axles given below should be used for converting different axle load repetitions into equivalent standard axle load repetitions. Since the VDF values in AASTHO Road Test for flexible and rigid pavement are not much different, for heavy duty pavements, the computed VDF values are assumed to be same for bituminous pavements with cemented and granular bases.

Single axle with single wheel on either side = $(\frac{axle\ load\ in\ kN}{65})^4$

Single axle with dual wheels on either side = $(\frac{axle\ load\ in\ kN}{80})^4$

Tandem axle with dual wheels on either side = $(\frac{axle\ load\ in\ kN}{148})^4$

Tridem axles with dual wheels on either side = $(\frac{axle\ load\ in\ kN}{224})^4$

VDF is arrived at carefully by carrying out specific axle load surveys on the existing roads. Axle load survey has been carried out without any bias for loaded or unloaded vehicle. It is observed there is significant difference in axle loading in two directions of traffic. The VDF is evaluated direction wise. Higher VDF is taken into account for design since it is difficult to provide different thickness for two lane roadThe Axle Load survey was carried out at Km. 81+500 and

Km. 85+800 to appreciate the loading characteristics of goods vehicles and the damage potential of these vehicles have been estimated using a metric called Vehicle Damage Factor (VDF). The sample were taken randomly for goods vehicles (LCV, Truck and MAV). Detailed calculation sheet of vehicle damage factor has been represented in design report chapters. Adopted VDF value for computation of design traffic are as follows:

Table 5-2:Vehicle Damage Factor

Vehicle Damage Factor (VDF)			
Vehicle Type	AT CH. 81+500	AT CH. 85+800	Final Adopted VDF
	Maximum VDF	Maximum VDF	
LCV	1.41	0.14	**1.41**
BUS	0.99	2.85	**2.85**
2 AXLE TRUCK	3.45	2.95	**3.45**
3 AXLE TRUCK/ARMY VEHICLE	4.03	4.03	**4.03**

5.7 CUMULATIVE MSA FOR THE DESIGN PERIOD

Traffic Survey were conducted at two locations along the project road. Following equation is used for calculation of Cumulative number of standard axles.

$$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$$

Where,

N = Cumulative number of standard axles to be carried during the design in terms of MSA,

A = Commercial Vehicles per Day (CVPD),

D = Lane distribution factor,

F = Vehicle damage factor,

n = Design life of road,

r = Annual growth.

Table 5-3:CMSA for project road

Chainage	MSA	
	Calculated	Adopted for Design
Km 81+600	11.81	20 msa
Km 85+900	11.20	
Km 94+800	11.07	

Since, the computed design traffic is less than 20 msa, as per the provision of IRC:SP-73-2015, minimum design traffic of 20 msa has been adopted.

5.8 SOIL CBR

Test pit investigations were done and Soil samples were taken along the project stretch and the samples were tested to evaluate 4 days soaked CBR value. Summary of CBR test results are represented below:

Table 5-4:CBR Test Results

SL. No.	Chainage	CBR
1	10+300	5.5
2	11+000	5.0
3	11+900	4.7
4	16+700	5.4
5	17+100	4.6

Based on the CBR test results and soil characteristics, the project stretch could be divided into two homogeneous sections. The 90th percentile CBR was computed for each homogeneous section, which is represented below

Table 5-5: CBR

Sl. No.	Chainage	90th Percentile CBR	Adopted Effective CBR for Design
1	Km 9+760 to km 10+100	11.9	8%
2	Km 10+100 to 17+814	4.5	8%

Further from the soil characteristics, it is noted that soil strata in section 1 and 3 mostly consist of clay and silt. Clayey and silty soils are susceptible to frost and thaw. Thus, the soil in these strata shall be excavated and replaced with non-frost susceptible soil or stabilized by mechanical or chemical means to achieve effective CBR greater than 8%. Stabilization may be done by using borrow area material or using cement or lime stabilization. For design purpose, the effective CBR of 8% has been adopted.

5.9 PROPOSED PAVEMENT COMPOSITION

For the subjected project package, Flexible Pavement with bituminous surface course with Cement Treated Sub - Base, Cement Treated Base and granular crack relief layer and with Expanded Extruded Polystyrene have been proposed.

Table 5-6: Proposed Crust Composition

Chainages		MSA	Effective CBR %	BC	Aggregate Inter Layer	CTB	CTSB	Subgrade	Extruded Polystyrene Sheet (EPS)
From	To								
9+760	17+814	20	8	50 mm	100 mm	115 mm	225 mm	500 mm	50 mm
0+000	0+660	20	8	50 mm	100 mm	115 mm	225 mm	500 mm	50 mm

**Expanded Extruded Polystyrene shall be used for insulation in the upper level of the soil and shall be placed at top of subgrade layer.*

Bitumen of VG-10 grade has been proposed

5.10 DESIGN CHECK

The above pavement crust composition was checked using IITPAVE and it was found that stains at critical locations was less than the allowable strains. Thus, the adopted pavement crust composition is safe.

6 CHAPTER-6 GEOLOGICAL ASSESSMENT AND AVALANCHE PROTECTION WORK

6.1 INTRODUCTION

The highway between East Portal of Z-Morh tunnel west of Sonamarg Township, and West Portal of Zojila tunnel close to Shrine Board camping site at Baltal, remains closed for almost six months due to severe winter conditions that entail heavy snow falls and snow avalanches. This segment of the highway assumes great importance in the all-weather connectivity of Kargil-Leh to Srinagar of which the 6.6km long Z-Morh tunnel is already under construction and the 14km long Zojila tunnel is in pre-construction stage. As per detailed investigations by SASE (Snow Avalanche Study Establishment), as many as fifteen avalanche routes have been identified in this project area.

All-weather connectivity of the road must ensure availability of the highway on all the 365 days of the year considering its strategic importance.

6.1.1 OBJECTIVE

Given the difficult geo-hazard prone condition of the highway, techno-economic selection of the alignment is indeed a complex problem to say the least. Ideally, the search for an alignment must focus on finding the most techno-economic solutions circumventing the known and suspected geo-hazards. However, the strategic importance of this route in the context of the Kargil War of 1999, and uncompromised all-weather connectivity of the selected alignment, add other dimensions to the task in hand. The geological and engineering analysis of the highway area, undertaken and discussed in this report, has helped achieve these objectives. Prima facie, the philosophy of the alignment selection is based on the premise that the more the alignment stays over-ground the more it would be prone to the uncertainties of geo-hazards. Yet, at the same time, also considering the overall cost of the project and tourism quotient of the pristine Sindh Valley, efforts have been made to keep the alignment over-ground as much as possible, particularly in the most picturesque segments around Sonamarg and Sarbal-Baltal area.

The preliminary geological studies in the area reveal that the area may be prone to other geo-hazards like debris flows along nallas and gulleys.

From the point of view of alignment selection, the configuration of the Sindh Valley in the project area can be divided into three distinct segments. Two of these include the open valley segments from Z-Morh East Portal to HAWS and from around Sarbal village to Baltal. The third segment comprises a rather narrow valley between Sonamarg and Sarbal. In general, therefore, the highway structures would be basically governed by the openness or narrowness of the valley. While, over-ground structures like at-grade road and avalanche galleries, and shallow sub-surface structures like cut & cover and box, are envisaged in the open valley segments, the narrow valley segments may need negotiations through tunnels in combination with over-ground structures. The proposed alignment, therefore, have the open valley segments from Z-Morh to HAWS and from Sarbal to

Baltal. The connecting highway stretch between these two segments negotiates the narrow valley, and hence, has been negotiated through two tunnels.

The geology and the geo-hazards are shown in the geological and geo-hazard map of the project area appended in drawings as 7061520-GEO-008 and 7061520-GEO-009 in the drawing volume. The snow avalanche sites are listed in Table 6.1.

6.1.2 SALIENT FEATURES

The salient features of the proposed alignment are as follows:

Salient Features of the Alignment of Approach Road-1 are as follows:

- Total Length- 8.05 Km
- Cut & Cover Length- 2.35 Km
- Snow Gallery Length- 0.45 Km
- Bridges - 1 Nos

Salient Features of the Alignment of Approach Road-2 are as follows:

- Total Length- 0.66 Km

6.1.3 METHODOLOGY

To achieve the objective, preliminary studies on Google Images were carried out to assess the overall condition of the area followed by multiple field visits and data collection. Geological work comprised fairly detailed examination of the highway alignment on the Srinagar-Leh road and Baltal road. Geological traverses were taken all along the existing road between Sonamarg and Baltal, and along foot tracks and accessible mountain slopes adjoining the proposed alignment. Special attention has been paid to lithological variation, suspected major geological weakness zones like faults and shears, and groundwater conditions. Also, delineation of geomorphological features, different material types, slope assessment and categorization of ground types has been done. Studies emphasized on identification of avalanche sites other than the identified by SASE on the left bank of Sindh River and also close to the Baltal area (Table6.1).

Discontinuity survey was also conducted to collect the discontinuity data for rocky stretches.

A detailed first stage investigation plan was formulated followed by geological mapping of the area. Further, in second stage after the finalization of highway alignment and selection of structures in light of the identified geo-hazards, second stage investigation plan was formulated and is in progress.

A geological map of the area and geological section along the alignment have been developed and are appended with this report.

Table 6-1: List of Identified Avalanche Sites

Avalanche ID	Location	Frequency
SL-32	Right Bank, Just Upstream of Kokaran Nar	Frequent

SL-33	Right Bank, In between Kokaran Nala and Sarbal Village	Frequent
SL-34		Frequent
SL-35	Right Bank, Opposite Sarbal Village	Occasional
SL-36	Right Bank, In between Sarbal Village and Ranga Morh	Frequent
SL-37		Occasional
SL-38		Occasional
SL-39	Right Bank, At Ranga Morh	Occasional
SL-40	Right Bank, In between Ranga Morh and Bajri Nala	Occasional
SL-41		Frequent
SL-42		Frequent
SL-43		Frequent
SL-44	Right Bank, At Bajri Morh	Frequent
SL-45	Right Bank, Upstream of Bajri Morh	Frequent
SL-46		Frequent
SL-47		Frequent
SL-48		Frequent

6.2 REGIONAL GEOLOGY

A geological section across the Panjal Volcanics by Wadia (1919) illustrates a folded sequence of Cambro-Silurian (Phyllitic/Schsistose rocks, Slates, Arenaceous/Calcareous beds; greywackes) rocks at the basement followed by Devonian (Muth Quartzites), Panjal Traps overlain by Triaasic (Shales and Limestone) (Fig6.1). The Panjal Volcanics are found to occur in the core of an anticline with overlying upper Triassics towards west and in the core of a syncline overlying Muth Quartzites and conglomerate.

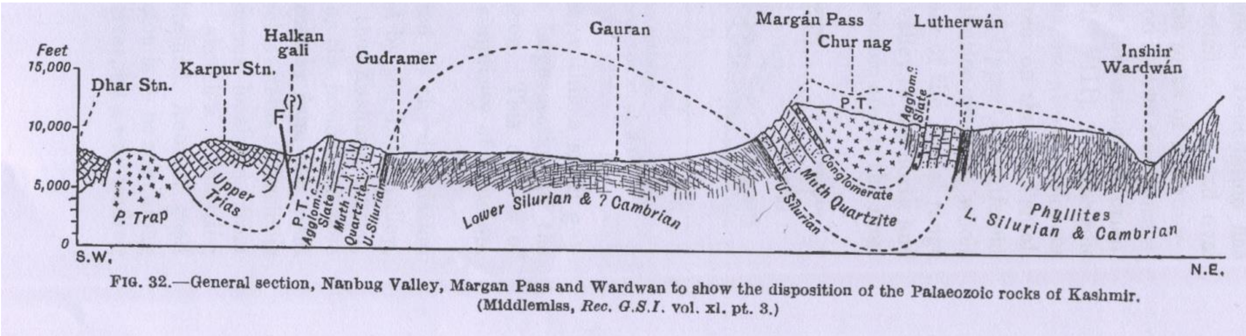


Fig. 6-1 : Geological Section by Wadia (1919) illustrating disposition of Panjal Volcanics with reference to adjoining rock formations.

Fuchs (1987) describes the base of the Panjal Traps to be formed by 8-10m thick band of darker and hardened quartzites with partings of black silty argillite. It has been considered as the influence of the magmatic contact. Fuchs has also reported conglomerate and breccia layers in the very hard white, green or grey quartzites. The Traps overlie the older formations with an undisturbed angular unconformity. The stratigraphic sequence in a part of Kashmir valley based on works of Wadia and Fuchs with Special Reference to Panjal Volcanics is given in Table6.2.

Table 6-2: Stratigraphic Sequence in Part of Kashmir Valley with Special Reference to Panjal Volcanics (Based on Geology of India, D N Wadia, 1919)

Age	Litho Types
Recent	Colluvium, Debris Fans, River Terraces/RBM
Triassic	Shales/Limestone
Permian	Shale/Black Shale, Limestone (Zewan Series)
Permo-Carboniferous	Limestone, Shale, Sandstone
Upper Carboniferous	Panjal Volcanics and Conglomerates-Slates
Middle Carboniferous	Shales, Quartzites, Snadstone and Limestone
Devonian	Quartzites (Muth)
Silurian	Shale, Sandstone with Yellow Limestone
Cambrian? and Ordovician	Slates and Arenaceous/Calcareous Beds (Grewackes), Phyllites/ Schistose Rock

In general, therefore, the lithostratigraphic sequence along the proposed alignment from east portal of Z-Morh Tunnel to West Portal of Zojila Tunnel comprises about 15 km combined length of recent deposits, followed by hard limestone with occasional bands of phyllites belonging to Triassics for a length of about 2.5 km. The general stratigraphic sequence along the proposed tunnel is given in Table6.3. The lithostratigraphic sequence established at the site is in general aggrement with the geological models of Panjal Volcanics by Wadia (1919) and Fuchs (1987).

Table 6-3: Stratigraphic Sequence along Sindh River from Sonamarg to Baltal

Age	Litho Types
Recent	Colluvium, Debris Fans, River Terraces/RBM
Triassic	Shales/Limestone with occasional bands of phyllites

The proposed alignment is aligned through wide valley along the River Sindh. Alignment starts near to the village Sarbal on the right bank of the River Sindh and ends at El. 2900m at West Portal of Zojila Tunnel close to Baltal.

The existing Srinagar-Leh road is located close to the river on its left bank in Sonamarg area and crosses the River Sindh close to Signal Dett. Predominance of foothill colluvium with a prominent debris fans at the base of major gulleys/streams/avalanche sites is noticed.

The site is located within Tethyan zone and is dominated by Panjal Volcanics that are flanked by Cambro-Devonian metasediments towards Srinagar and by Triassic metasediments towards Sonamarg. Further eastwards, in Sonamarg area, the Triassics are folded in to a major antiformal structure and the River Sindh follows the axial plane making itself an antiformal valley. Proposed alignment lies completely in recent deposits.

Seismicity

As per the seismic zoning map of India (IS 1893 (Part-1), 2002), the proposed alignment falls in Zone-IV, and hence, the seismic parameters are taken accordingly (Fig6.2). The list of major earthquake is given in Table6.4 and locations are given in Fig6. 3.

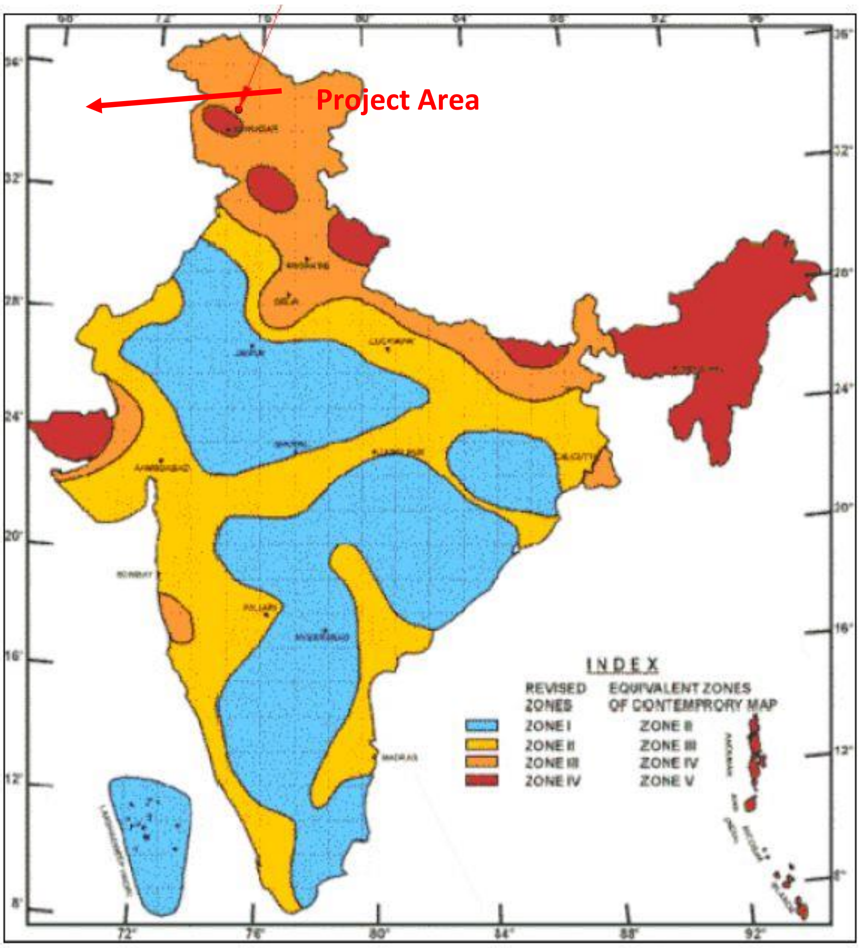


Fig. 6-2: Project located in Zone-IV as per seismic zoning map of India.

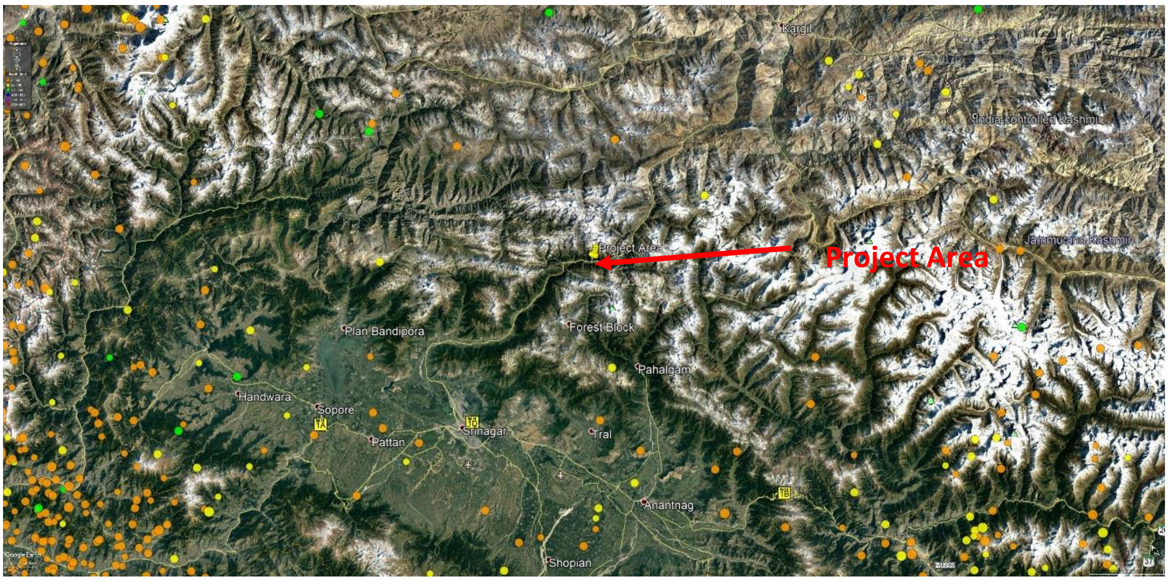


Fig6. 6-3: Major earthquake in the vicinity of the project area.

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Table 6-4 : List of major earthquake in the area in last 100 years.

5/9/2018	6.2	mww	17	36km NW of Ishkashim, Tajikistan
1/31/2018	6.2	mww	17	37km S of Jarm, Afghanistan
4/10/2016	6.6	mww	17	42km WSW of Ashkasham, Afghanistan
12/25/2015	6.3	mww	17	42km WSW of Ashkasham, Afghanistan
9/17/2010	6.3	mwb	30	Hindu Kush region, Afghanistan
10/22/2009	6.2	mwb	16.2	Hindu Kush region, Afghanistan
3/20/2008	7.2	mwc	25.9	Xinjiang-Xizang border region
12/12/2005	6.5	mwb	20.5	Hindu Kush region, Afghanistan
10/8/2005	6.4	mwc	21.4	Pakistan
10/8/2005	7.6	mwc	21.1	Pakistan
8/10/2004	6	mwb	46.1	Hindu Kush region, Afghanistan
4/5/2004	6.6	mwb	18.3	Hindu Kush region, Afghanistan
11/20/2002	6.3	mwc		northwestern Kashmir
11/23/2001	6.1	mwc		Hindu Kush region, Afghanistan
2/25/2001	6.2	mwb		Hindu Kush region, Afghanistan
7/17/2000	6.3	mwc		Hindu Kush region, Afghanistan
11/8/1999	6.5	mwc		Hindu Kush region, Afghanistan
2/20/1998	6.4	mwb		Hindu Kush region, Afghanistan
12/17/1997	6.3	mwc		Hindu Kush region, Afghanistan
5/13/1997	6.5	mwb		Hindu Kush region, Afghanistan
11/19/1996	6.9	mwc		Kashmir-Xinjiang border region
10/25/1994	6	mwb		Hindu Kush region, Afghanistan
6/30/1994	6.3	mwb		Hindu Kush region, Afghanistan
9/18/1993	6.3	mwb		Hindu Kush region, Afghanistan
9/4/1993	6	mw		Hindu Kush region, Afghanistan
8/9/1993	7	mwb		Hindu Kush region, Afghanistan
5/20/1992	6.3	mwb		Pakistan
7/14/1991	6.7	mw		Hindu Kush region, Afghanistan

7/13/1990	6.4	mw		Hindu Kush region, Afghanistan
3/25/1990	6.3	ms		Hindu Kush region, Afghanistan
3/5/1990	6.2	mw		Hindu Kush region, Afghanistan
2/5/1990	6.3	mw		Hindu Kush region, Afghanistan
7/24/1989	6	mw		Hindu Kush region, Afghanistan
8/6/1988	6.3	mw		Hindu Kush region, Afghanistan
10/3/1987	6.1	mw		Hindu Kush region, Afghanistan
7/6/1986	6	mw		western Xizang
8/2/1985	6.4	mw		Hindu Kush region, Afghanistan
7/29/1985	7.4	mw		Hindu Kush region, Afghanistan
2/16/1984	6.4	mw		Hindu Kush region, Afghanistan
1/27/1984	6.1	mw		Hindu Kush region, Afghanistan
9/12/1983	6.2	mw		Hindu Kush region, Afghanistan
9/12/1981	6.2	mb		northwestern Kashmir
5/2/1981	6.3	mb		Hindu Kush region, Afghanistan
2/13/1980	6.1	mb		Kashmir-Xinjiang border region
11/27/1976	6.1	mb		Hindu Kush region, Afghanistan
4/28/1975	6.3	ms		Kashmir-Xinjiang border region
1/19/1975	6.8	ms		Kashmir-Xizang border region
12/28/1974	6.2	ms		Pakistan
7/30/1974	6.5	mb		Hindu Kush region, Afghanistan
9/4/1972	6	mw		northwestern Kashmir
9/3/1972	6.2	mw		northwestern Kashmir
1/20/1972	6.2	mw		Hindu Kush region, Afghanistan
11/24/1969	6.1	mw		Tajikistan
1/25/1967	6	mw		Tajikistan
6/6/1966	6.6	mw		Hindu Kush region, Afghanistan
1/28/1964	6.6	mw		Hindu Kush region, Afghanistan

6/26/1963	6	mw		Kashmir-Xinjiang border region
9/2/1957	6.1	mw		Hindu Kush region, Afghanistan
6/27/1955	6.2	mw		Kashmir-Xizang border region
2/13/1948	6.3	mw		Xinjiang-Xizang border region
11/6/1946	6.4	mw		western Xizang
6/22/1945	6.5	mw		Himachal Pradesh, India
11/15/1937	6.4	mw		Kashmir-Xinjiang border region
8/6/1926	6.3	mw		Kashmir-Xinjiang border region
10/12/1920	6.7	mw		Xinjiang-Xizang border region
10/9/1914	6.3	mw		Himachal Pradesh, India
4/4/1905	7.9	mw		Himachal Pradesh, India

6.3 GEOLOGY OF THE PROJECT AREA

6.3.1 GEOMORPHOLOGY

The valley of the SE-NW flowing Sindh River is generally U-shaped flanked by precipitous mountain ranges (Fig 6.4) that reach elevations of 6000m above msl, i.e. a relief of over 3000m above the River. The mountain ranges are dissected by deeply entrenched perennial and seasonal drainages. In the project area, while the left bank of the River is drained by one major perennial drainage joining it at Sarbal village (Fig 6.5), the right bank is drained by two main perennial tributaries that join the River at Ranga Morh (Fig 6.7) and Baltal (Fig 6.8). The one at Baltal drains the Zojila area and forms a major confluence with expansive river terraces hosting the Amarnath Shrine Board pilgrimage settlement with helipads. Apparently, the River Sindh has been pushed to the left bank for which while the right bank valley slopes are comparatively gentler to the right bank slopes that are mostly steep (Fig 6.9).

Fig. 6-4: Steep difficult slopes on left bank (U/s of Sarbal Village)

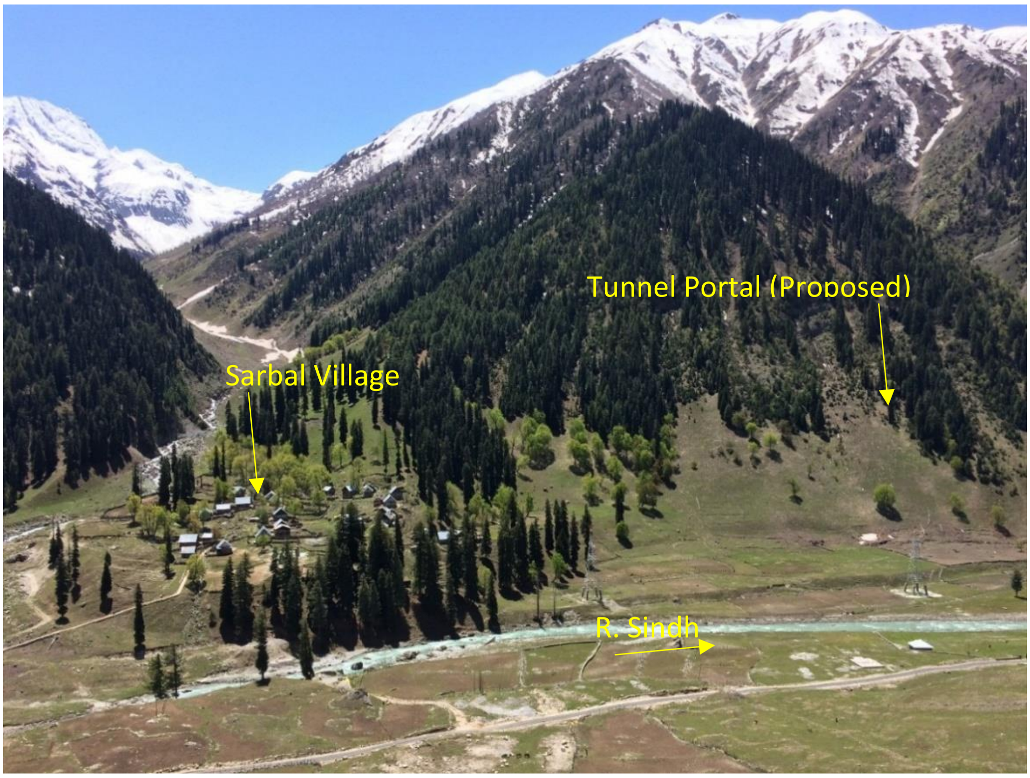


Fig. 6-5: Major drainage at Sarbal Village

Fig. 6-6: SL-39

Fig. 6-7: Baltal bridge site and right bank terrace

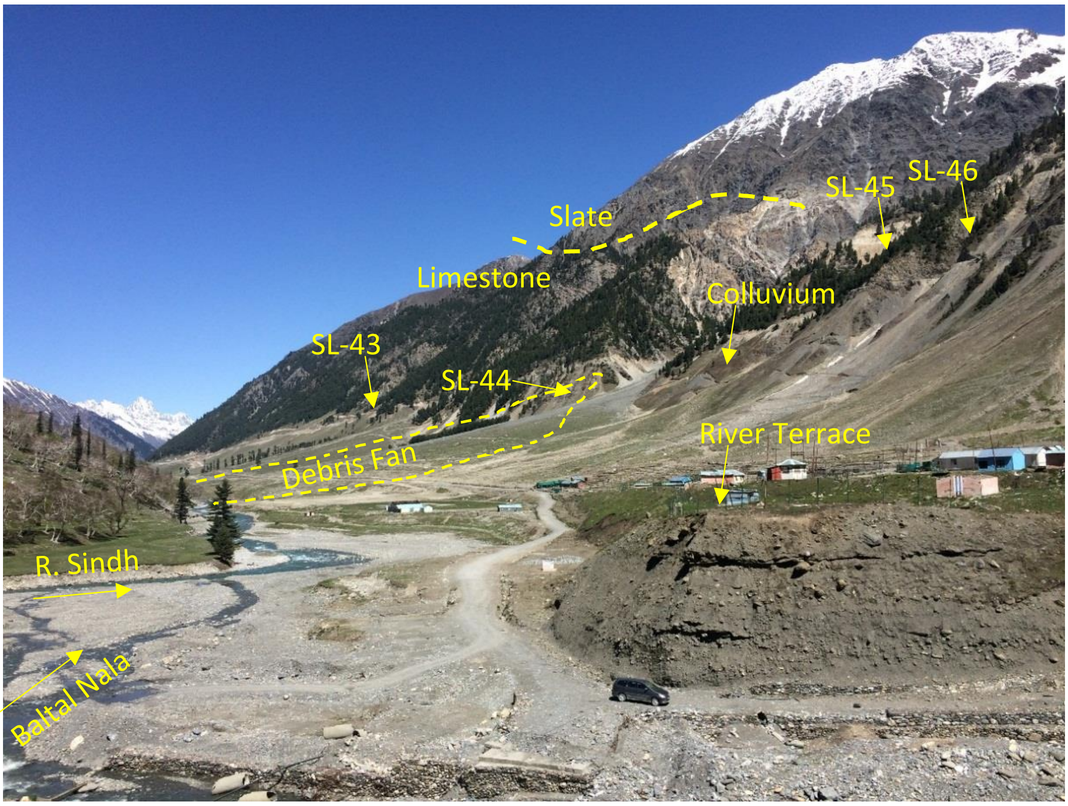


Fig. 6-8: Sindh River low terraces and debris fans (SL-44 in main)

In general, the valley bottom is filled up with overburden material contributed mainly by the drainages from both sides of the River (Fig 6.10). The rock line lies considerably above the valley floor and runs erratically depending upon the disposition of the overburden deposits. While the river bed of the Sindh is occupied by river borne material (RBM) comprising rounded to sub-rounded material embedded in gravelly and sandy matrix, the deposits on the flanks comprise mainly the river terraces, debris fans and colluvium. Almost all the drainages have their debris fans with the magnitude depending upon the discharges they carry. Significantly, debris fans of SL-29 to SL-31 appear to have overshot to the other bank and later cut through by the River Sindh (Fig 6.11). The debris fan of SL-31 even exhibits an Oxbow channel. In general, the debris fans on the right bank tend to be enormous compared to those on left bank (Fig 6.12). that tend to drop down in to smaller heaps due to steeper valley slopes. Significantly, large debris fans include those of Ranga Morh (SL-39) (Fig 6.13), Bajri Morh (SL-44) (Fig 6.14), SL-43 (Fig 6.15), SL-34 (opposite Sarbal Village), etc.

Fig . 6-9 : Steep difficult slopes on left bank

Fig . 6-10 : SL-32 to 34 and 39

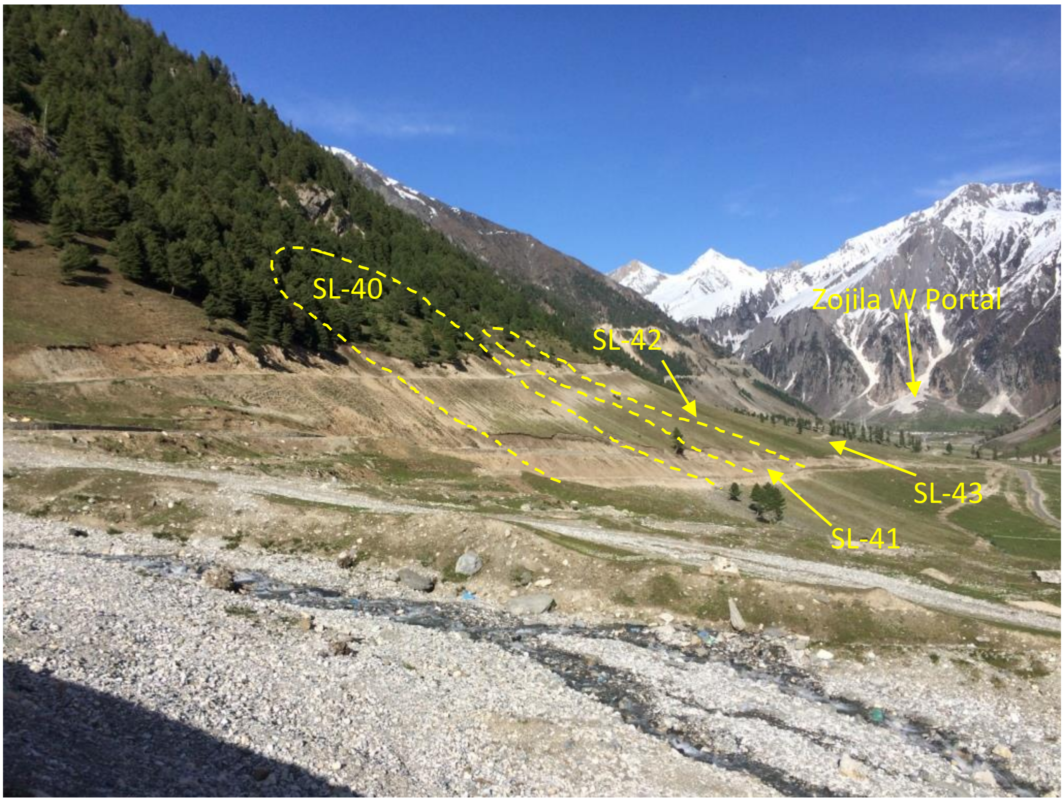


Fig. 6-11: SL-40 to 432/ Zojila West portal/ Ranga Morh N. in foreground

Fig. 6-12: SL-44 (Bajri Morh***)***

Fig. 6-13: SL-43

Invariably, the snow in such deposits consists of sugary and fluffy snow and, characteristically, is devoid of any debris material (Fig 6.17 & 6.18).

Fig. 6-14: Sugary snow at SL-43

Fig. 6-15: Typical snow deposit at SL-43

6.3.2 LITHOLOGY

Lithologically, Palaeozoic limestone represents the bulk of the rock formations having gentle to steep dips into the right bank. The limestone is hard, blocky, slightly to moderately weathered at surface, thickly bedded and jointed. The limestone is the underlying unit for which it occupies the lower portions of the valley with the overlying slates occurring in the upper slopes on the right bank. Intercalations of other rock types like phyllites, quartzites, etc. are found associated with the main lithological unit. In general, the rocks have steep north easterly dips, i.e. into the right bank. With such a disposition, the limestone beds are sub-parallel to the river flow, thereby, making a rather small angle with the direction of the river flow.

6.3.3 GEO-HAZARDS

6.3.3.1 Debris Flows

The overall mode of occurrence of overburden deposits strongly suggests that off-winter mass wasting processes like debris flows, sliding, seasonal runoff with bed material, etc. are more likely to have contributed to the formation of the bulk of valley fill in the form of conspicuous and long-lasting land forms. There are reports of one major recent debris flows in the project area that include one from SL-45/46 engulfing a part of Baltal Camp area in peak season. The snow avalanches, on the other hand, are believed to be generating moving masses of dry snow along the drainage paths culminating in to vast deposits at valley floors. These are short lived as they melt away with rising temperatures at the end of the winter and, consequently, not expected to leave significant landforms once they are gone.

6.3.3.2 Snow Avalanches

The SASE team has identified 15 snow avalanche sites in the project area and have named them as SL-32 to SL-48. The runout zones of the snow avalanches are expected to be along those of the debris flows, viz. along the drainage routes.

It may be noted that the effect of snow avalanches is reported from inhabitated areas across known snow avalanche sites and such effect across other sites may not have come to notice for lack of inhabitation. Hence, air blast effect from hitherto benign avalanches on the left bank cannot be ruled out.

SASE have defined all snow avalanches as “Direct” meaning thereby that the avalanches trigger during the snowfall or within few hours after the cessation of snowstorm. Further, the snow avalanches have been categorised as “Occasional” and “Frequent” where occasional avalanches are those which trigger once in four to six years and frequent avalanches are those that trigger every or alternate year (Table 6.6).

6.3.3.3 Ground Creep

Ground creep forms another geo-hazard and has been interpreted in the sprawling debris fan deposit of the nalla at Ranga Morh. The cluster of trees in the fan deposit on the left bank of the nalla is in conspicuously tilted state suggesting creep movement (Fig 6.21).

Fig. 6-16: SL-39, creep in debris material (tilted trees)

Table 6-5: Damage and Human Fatalities Caused by Natural Hazards

Sr. No.	Hazard	Hazard ID	Year	Damage Causing Factor	Damage to Property	Human Fatality
1	Snow Avalanche	SL-32 to 38	No Info.			
2	Snow Avalanche	SL-39	1987	Debris Flow	BRO Det.	NIL
3	Snow Avalanche	SL-40 to 44	No Info.			
4	Debris Flow/Cloud Burst	SL-45/46	-	Debris Flow/Cloud Burst	Highway, Baltal Road, Pilgrimage Camp (Parking Area)	No Info
5	Snow Avalanche	SL-47 to 48	No info.			

6.4 SUB-SURFACE INVESTIGATIONS, FIELD AND LABORATORY TESTS

The proposed alignment has been extensively investigated through exploratory bore holes and exploratory pits. During the alignment optimization stage, investigations included 21 bore holes, 42 exploratory pits for pavement composition and soil properties, laboratory tests on material suitability and 03 plate load tests for bearing capacity. After the finalization of alignment, 30 exploratory bore holes, 20 pits for soil testing and 08 soil gradation tests have been proposed. Moreover, geophysical surveys in tunnel portal locations have also been proposed. Investigation for assessment of creep in debris fan soil 03 inclinometers have also been proposed. The soil and rock samples from exploratory pits and exploratory bore holes have been collected and tested in laboratory for their engineering properties.

Out of the 13 completed exploratory bore holes during stage-1, 02 holes have been bored at bridge locations, 09 holes at cut & cover and snow gallery locations and 02 holes behind HAWS for tunnel.

6.5 ENGINEERING GEOLOGICAL ASSESSMENT

In general, the proposed alignment passes through the wide Sindh valley and partially through Triassic rocks. The debris fan area have been negotiated by cut & cover tunnels of less than 500m length and snow galleries.

As discussed earlier the River valley fill and debris fans due to mass wasting processes is very thick and bedrock appears to be exceptionally deep. Exploratory bore holes have intersected this material to about 40m depth.

6.5.1 GROUND TYPES AND ASSOCIATED RISKS

The project area can be divided into following ground types based on their geomorphic mode of occurrence and material content:

6.5.2 GT-1: LOW GROUNDS COMPRISING RIVER TERRACES/DEBRIS FANS COALESCING ZONES

These are nearly flat surfaces on river banks/Slopes comprising semi-consolidated to consolidated river borne material (RBM) (Fig 6.22).The shear strength and bearing capacity are expected to be moderate. Geo-hazard risks to the stability of the surface structures are very low. River Terraces/RBM, consolidated to semi-consolidated with good binding in matrix. Material is bouldery in silty to sandy matrix. Percentage of clay is very less. As most of this is confined to River bed area and is negotiated by bridges, investigations are in progress (Table6.7).

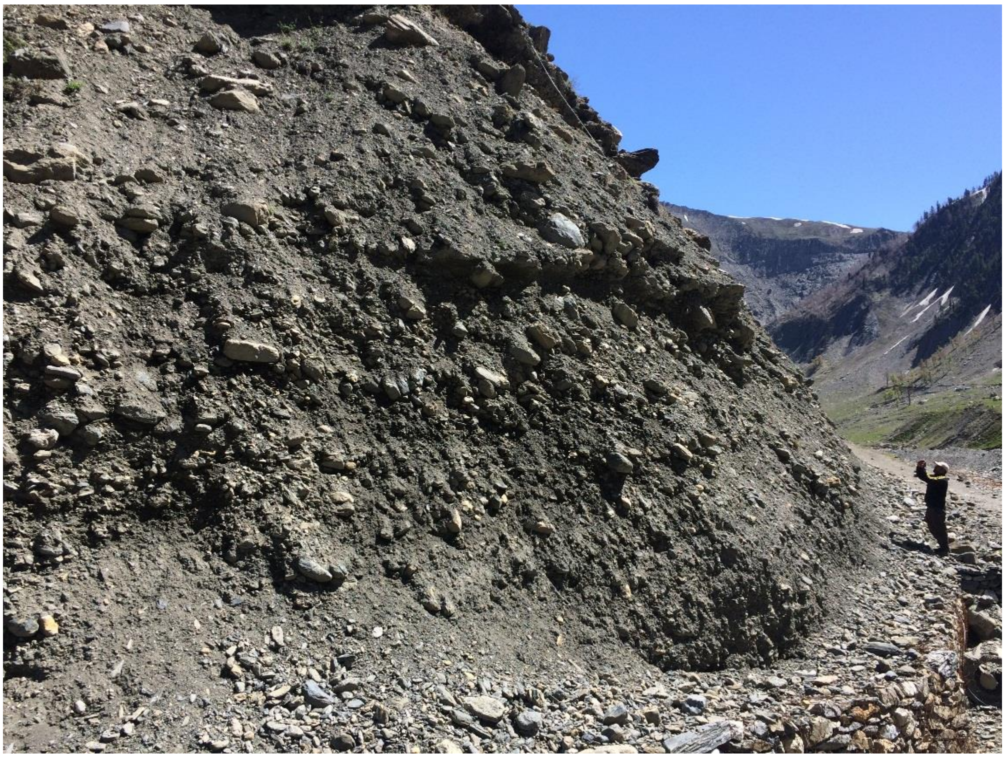


Fig . 6-17 : Sub-rounded boulders and pebbles in river terrace material

Table 6-6 : Engineering properties for GT-1

Ground Types	Geotechnical Parameter	Unit	
GT1	Unit Weight (Dry)	gm/cm^3	1.84
	C	KPa	0
	Phi	(°)	30
	Bearing Capacity	T/m^2	20

GT-2: Low grounds comprising debris fans

These are gently sloping grounds comprising unconsolidated heterogeneous deposits formed due to debris movement along the drainage Fig 6.23.The shear strength and bearing capacity are expected to be low to very low (Table6.8). Geo-hazard risks of moving debris to the stability of the surface structures are high.

Fig. 6-18: Unconsolidated heterogonous material in debris fans

Table 6-7: Engineering properties for GT-2

Ground Types	Geotechnical Parameter	Unit	
GT2	Unit Weight (Dry)	gm/cm^3	1.84
	C	KPa	0
	Phi	(°)	30
	Bearing Capacity	T/m^2	10

GT-3: Low to moderately sloping grounds comprising colluvium deposits

These are gently to moderately sloping grounds comprising semi-consolidated to unconsolidated heterogeneous deposits formed due to mass wasting of rocky slopes (Fig 6.24). The shear strength and bearing capacity are expected to be low (Table6.9). Geo-hazard risks to the stability of the surface structures are low to moderate.

Fig. 6-19: Semi-consolidated material in Colluvium

Table 6-8: Engineering properties for GT-3

Ground Types	Geotechnical Parameter	Unit	
GT3	Unit Weight (Dry)	gm/cm^3	1.85
	C	KPa	0
	Phi	(°)	30
	Bearing Capacity	T/m^2	10

6.5.3 SELECTION OF STRUCTURES

The identified ground types and associated risks as above are considered the primary governing factor in selecting the types of structures along the highway alignment. The proposed highway may involve construction of the following civil structures in different ground types:

- GT-1: Open Highway/Embankments with Avalanche Protection Structures
- GT-2: Cut & cover/ Box
- GT-3: Snow galleries
- Bridges/Viaducts across the River/ Nalas/ Depressions

Salient geotechnical features of surface and subsurface civil structures are discussed in brief below.

6.5.3.1 SURFACE STRUCTURES

First and foremost, the surface civil structures would be prone to the direct impact of the geo-hazards like snow avalanche, heavy snow fall and debris flows, etc. and consequently would have to be safeguarded against any such eventuality.

Further, in consideration of the site geology where the valley floor is predominantly overburden covered, most of the surface civil structures like the present highway would rest on the overburden deposits with varying foundation conditions. Slope cuts would be in overburden. As the maximum slope cut height is not more than 10m, these will be stabilized by breast walls with drainage holes.

6.5.3.2 SUB-SURFACE STRUCTURES

Cut & Cover (Pre-cast/Box)

These structures are proposed across active debris fans (GT-2) that are prone to moving mass of rolling blocks during debris flows. The open excavations involve un-consolidated material for which the depth of the excavations is being kept at a minimum and therefore, the maximum slope cut is about 20m from the foundation level. Temporary slope excavation will be in overburden and hence, has been proposed to be protected using suitable pile system. However, slope cuts of less than 10m height close to cut & cover portal location would be supported temporarily with gabions. Piles will be provided only in the stretches where slope excavation will be more than 10m.

In particular, the cut & cover/ box structure across ground creep affected debris fan at Ranga Morh may involve provision of shear keys. The structures have been designed for the assessed bearing capacity of 10 t/m^2.

The monitoring of the ground creep at Ranga Morh is proposed through inclinometers in the drill holes both on short and long term basis. Although, evidences for ground creep are not found in other fans. It is proposed to monitor this feature in major debris fans. At present, 03 nos. of self-recording type inclinometers have been proposed in debris fans of Ranga Morh (SL-39), SL-43, Bajri Morh (SL-44).

6.5.4 DISTRIBUTION OF THE GROUND TYPES ALONG ALIGNMENT

The alignment has been proposed considering the geo-hazards identified in the area.

The selection of structures for the road alignment has been carried out based on the ground conditions and associated geotechnical issues as discussed earlier. Geologically, area is occupied mainly by four ground types GT-1, GT-2, GT-3 which are composed of RBM/Coalescing debris fans zones, debris fans, colluvium, and bedrock (limestone) respectively. Major debris fans along the alignment are located in this segment include the debris fans at SL-34, SL-35, SL-36, SL-39 (Ranga Morh), SL-43, and SL-44 (Bajri Morh), SL-46 & SL-47. These debris fans comprise heterogeneous nala transported material with rock blocks ranging in size of 4-5m. Proportion of the large size blocks, however, is low, particularly in the SL-44 (Bajri Morh) debris fan where finer material predominates. Keeping surface structures in such zones is not safe for which sub-surface structures have been proposed. Since, the debris fans across the alignment are gently sloping, shallow cut & cover tunnels have been provided. As discussed earlier, underground structures are safe in view of the direct impact from big rolling blocks and debris flows particularly in the debris fan areas. Wherever, the risk from the identified geo-hazards is low, the alignment has been kept at-grade/embankments with the protection measures like snow galleries as and where required.

The distribution of various types of structures along the alignment along with identified geo-hazard and ground types are shown in Table 6.11.

Table 6-9 : Ground Types along Alignment

Chainage (m)		Component	Identified Ground Type	Remarks
From	To			
9760	9796	Open Highway	GT-1	
9796	10106	Cut & Cover	GT-2	Across Avalanche Sites SL-32
10106	10276	Open Highway	GT-1+GT-3	Across Avalanche Sites SL-33
10276	10506	Cut & Cover	GT-2	Across Avalanche Sites SL-34
10506	11256	Open Highway	GT-1+GT-3	
11256	11506	Cut & Cover	GT-2	Across Avalanche Sites SL-35
11506	13006	Open Highway	GT-2+GT-3	
13006	13406	Cut & Cover	GT-2	Across Avalanche Sites SL-39 (Ranga
13406	14006	Open Highway	GT-2+GT-3	
14006	14356	Cut & Cover	GT-2	Across Avalanche Sites SL-41
14356	14656	Open Highway	GT-2+GT-3	
14656	14856	Cut & Cover	GT-2	Across Avalanche Sites SL-43
14856	15306	Open Highway	GT-2+GT-3	
15306	15766	Cut & Cover	GT-2	Across Avalanche Sites SL-44
15766	16356	Open Highway	GT-2+GT-3	Across Avalanche Sites SL-45
16356	16656	Snow Gallery	GT-2	Across Avalanche Sites SL-46
16656	16806	Cut & Cover	GT-2	Across Avalanche Sites SL-47
16806	16956	Snow Gallery	GT-2	Across Avalanche Sites SL-47
16956	17172.5	Open Highway	GT-3	
17172.5	17307.5	Bridge	GT-1+GT-3	
17307.5	17814	Open Highway	GT-2+GT-3	

6.6 AVALANCHE PROTECTION MEASURES

In view of the identified geo-hazarads falling in open highways and embankments, avalanche protection measures are required. The major geo-hazards where protection measures would be required are as follows:

1. Avalanche/Debris Flow: Catch Dam/Deflection Dam of maximum 8m height as suggested by SASE.
2. Air Blast: Wall of maximum 4m height as recommended by SASE.
3. Avalanche Galleries

Draft Report on Conceptual Layout of Avalanche Protection Structures recommended by SASE is attached as Annexure-I to this report.

6.6.1 CATCH DAMS

Catch dams are in general provided in run out zones to catch the very slow moving avalanche debris. Five major catch dams are required along the alignment particularly in open road stretches. The locations of these dams are listed in below Table6.12.

Table 6-10: Chainages for catch dams

Chainage (km)	App. Catch Dam Length (m)	Avalanche Site ID
15.75 to 16.35	600	SL-45
17.3 to 17.55	250	N-14

Typical Section of Catch Dam is shown in Figure 6.26.

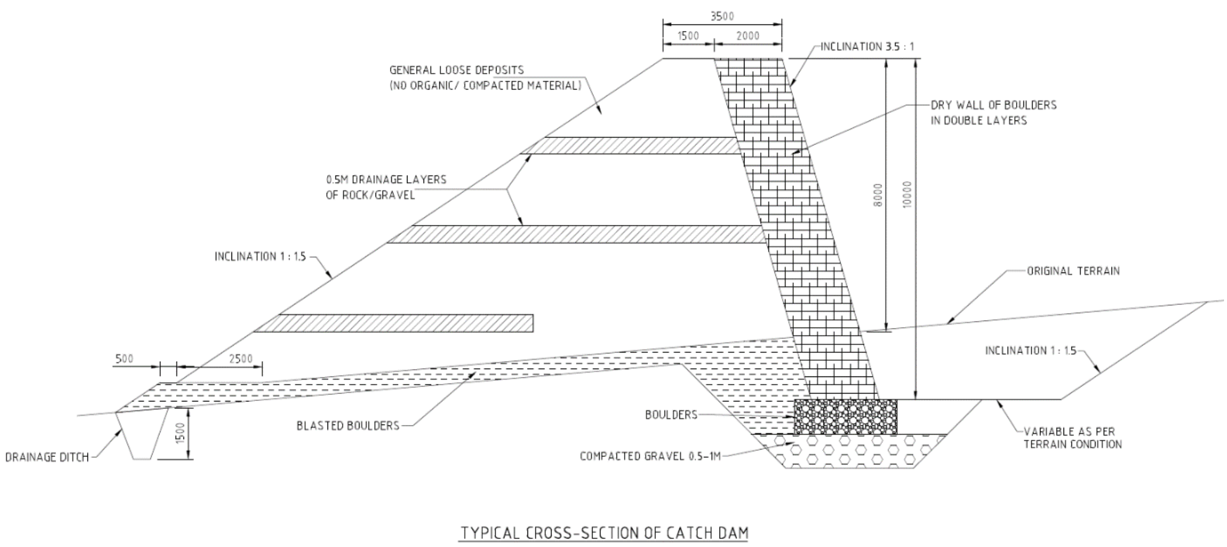


Fig. 6-20:- Typical Section of Catch Dam

6.6.2 DEFLECTION DAMS

Deflection dams are in general provided guide the moving avalanche debris in a particular direction. Along the alignment, these are required to deflect the debris from the cut & cover section portal locations, snow gallery's start and end point locations and protection of major bridges. Thirteen locations have been identified by SASE where deflection dams are required. The locations of these dams are listed in below Table6.13.

Table 6-11: Chainages for deflection dams

Chainage (km)	App. Dam Length (m)	Avalanche Site ID
9.8 to 10.05	Two Dams each of 50m length	Portals of Cut & cover at SL-33
10.5 to 10.6	100m	Portal of Cut & cover at SL-34
11.15 to 11.6	Two Dams each of 100m length	Portals of Cut & cover at SL-36
13 to 13.4	Two Dams each of 75m length	Portals of Cut & cover at SL-39
14 to 14.35	Two Dams each of 75m length	Portals of Cut & cover at SL-42
14.6 to 14.9	Two Dams each of 100m length	Portals of Cut & cover at SL-43
15.3 to 15.75	100m	Portal of Cut & cover at SL-44
16.9	150m	SL-47, Baltal Bridge Protection

Typical Section of Deflection Dam is shown in Figure 6.27.

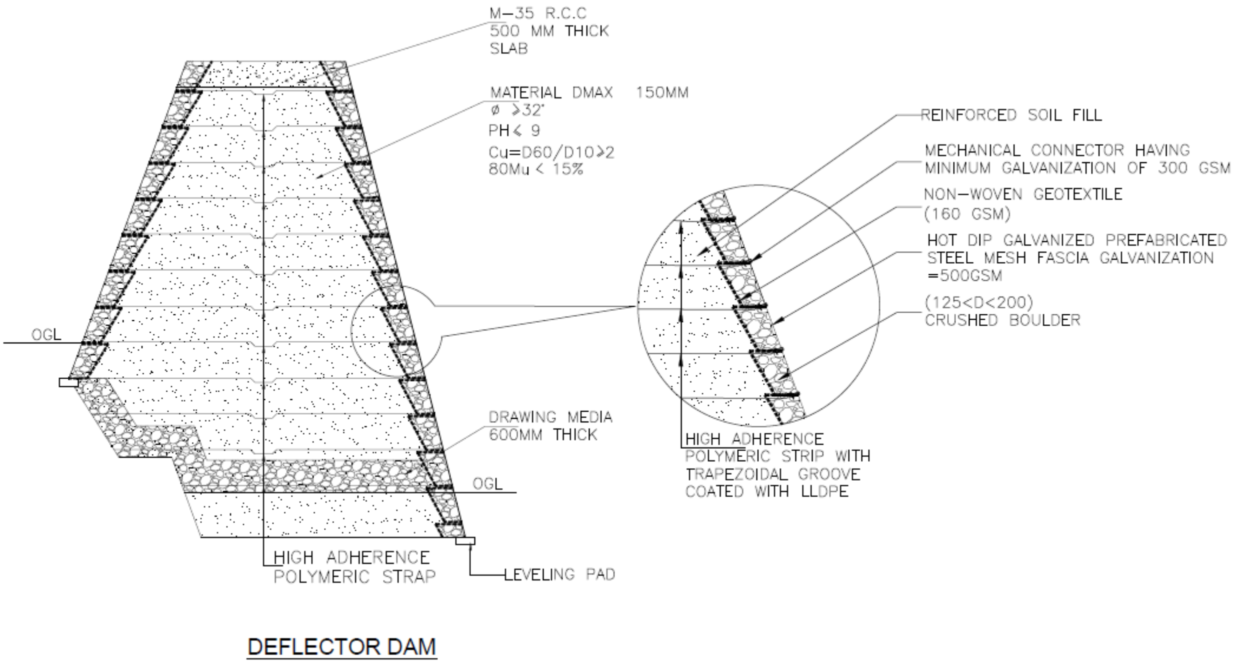


Fig. 6-21- Typical Section of Deflection Dams

6.6.3 AIR BLAST PROTECTION WALL

This is in general provided for protection from direct impact of air blast on moving vehicles. Along the alignment, these are required in the open highway stretches. Seven locations have been identified by SASE where these walls would be required. The locations are listed in below Table6.14.

Table 6-12: Chainages for Air Blast Deflection Wall

Chainage (km)	App. Wall Length (m)	Avalanche Site ID
4.02 to 4.2	175	SL-26
9.1 to 9.25	150	N4
10.05 to 10.3	250	N6
12.1 to 12.3	200	N7
12.5 to 13	475	N8
13.4 to 14	600	N9
14.35 to 14.65	300	N10
14.8 to 15.3	450	N11 and N12

6.7.2. Avalanche Gallery

Two numbers of Avalanche Galleries are proposed to protect from SL-46 (300m straight snow gallery) and SL-47 (150m curved snow gallery) as recommended by SASE.

Typical Section of Avalanche Gallery is shown in Figure 6.28.

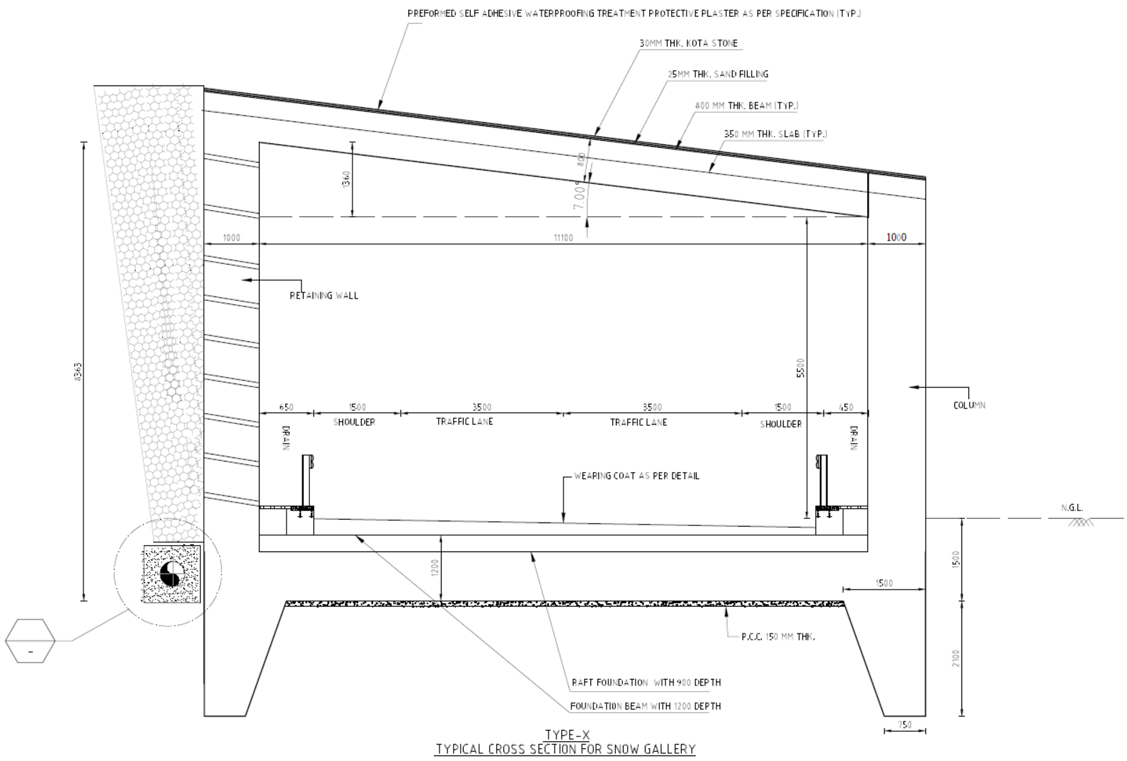


Fig. 6-22- Typical Section of Snow Gallery

Detailed Design of Avalanche Gallery is give in Volume II Design Report of   Avalanche Galleries.

6.7 CONCLUSIONS

Based on the geological mapping, investigations and assessment, following conclusions have been made:

1. Existing highway is passing through 15 identified avalanche sites (By SASE) in between Sonamarg and Baltal. Highway remains blocked during winter season due to heavy snow, avalanche triggering, debris flow along most of the drainages and debris slides during winter/monsoon.
2. All-weather connectivity of the road is to be ensured of the highway on all the 365 days of the year considering its strategic importance by ensuring snow shelter and avalanche protection.
3. Proposed Highway alignment is a composite structure comprising tunnels, cut & cover sections, high embankments, open highway, snow galleries, bridges and a viaduct.
4. Selection of structures is based on the identified ground types and geo-hazards. Underground structures are preferred in major geo-hazard prone area.
5. Open highway stretches are protected with suitable avalanche protection structures like catch/deflection dams against the avalanche flow, and air blast protection wall.
6. The cut & cover sections are proposed in debris flow identified stretches. The slope cuts would be in overburden, and hence, suitable protection measures for temporary slopes with piles have been proposed. The foundation of the section will be on overburden with a bearing capacity of 10 t/m^2, and hence, has been designed with raft foundation.
7. Snow galleries have been proposed in identified avalanche sites of SL-46 and SL-47, where its foundation will lie on overburden with a bearing capacity of 10 t/m^2, and hence, have been designed with raft foundation. The backslope cuts will also lie in overburden and suitable temporary measures will be provided.
8. The foundation of bridge will lie in RBM (River Borne Material), and hence, are designed accordingly.
9. High embankment zones founded either on RBM or debris fans are designed appropriately for low bearing capacity of 10 t/m^2.
10. The slope along the highway in open stretches will be cut mostly in overburden of colluvium and debris fans. The maximum height would be about 10m and stabilisation with breast/retaining walls is proposed.

7 CHAPTER-7 DESIGN OF TUNNEL

7.1 CUT & COVER TUNNELS

8 Nos. of Cut & Cover Sections are identified along the project road to protect from Avalanches. The details of the cut & cover sections are as follows:

Chainage (m)		Length (m)	Component	Remarks
From	To			
9796	10106	310	Cut & Cover	Across Avalanche Sites SL-32
10276	10506	230	Cut & Cover	Across Avalanche Sites SL-34
11256	11506	250	Cut & Cover	Across Avalanche Sites SL-35
13006	13406	400	Cut & Cover	Across Avalanche Sites SL-39 (Ranga Mor)
14006	14356	350	Cut & Cover	Across Avalanche Sites SL-41
14656	14856	200	Cut & Cover	Across Avalanche Sites SL-43
15306	15766	460	Cut & Cover	Across Avalanche Sites SL-44
16656	16806	150	Cut&Cover	Across Avalanche Sites SL-47

Typical Cut & Cover Section adopted is shown under:

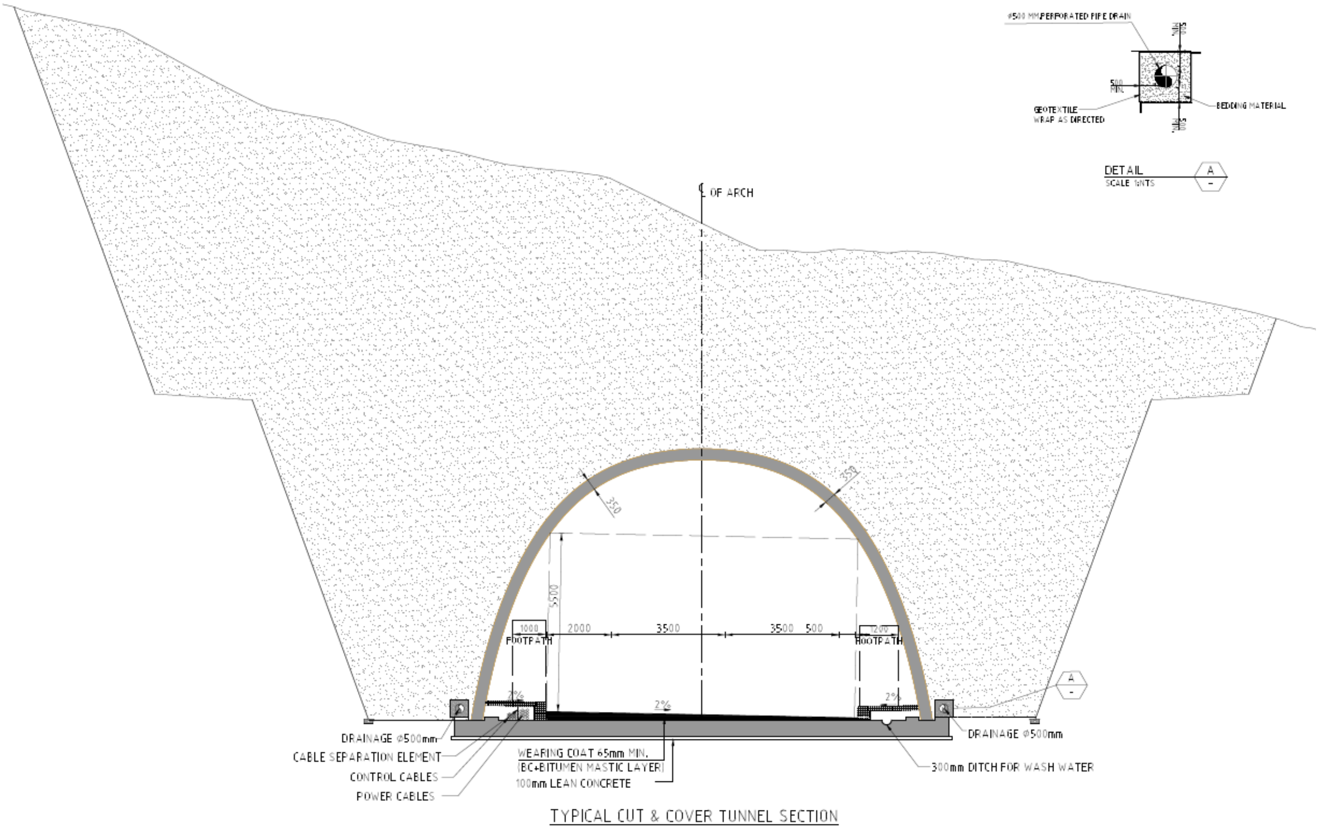


Fig. 7-1: Typical Cut & Cover Section

Detailed Design Aspects of Tunnels are covered under Volume II Design Report.

8 CHAPTER-8 ENVIRONMENTAL IMPACT ASSESSMENT

8.1 OBJECTIVES OF THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The main objective would be to alleviate the current unsafe and congested conditions of the identified road network connecting the villages and towns by providing better quality and safe roads to the users in a sustainable and environment friendly manner.

Environmental Impact Assessment (EIA) has been conceived as an integral part of developing the project road as Green Highway, so that the project can facilitate economic stimulation and improvement to community and cultural assets by integrating environmental enhancement measures along the project corridors through community partnering.

A detailed Environmental Impact Assessment (EIA) Report and Environmental Management Plan (EMP) is attached as a separate volume Vol IV.

CHAPTER-9 COST ESTIMATE

9.1 GENERAL

This Chapter deals the Cost Estimate for the preparation of Detailed Project Report and providing Pre-Construction Activities:- (i)For construction of Approach Roads with Avalanche Protection Works to West and East portal of the proposed Zojila Tunnel (between Baltal and Minamarg) from Km 82.000 to Km 95.000 on Srinagar-Leh Road (NH-1) and;(ii).For making the NH-1 from Z-Morh Tunnel to proposed Zojila Tunnel (approx. 20 km) all weather road in the State of Jammu & Kashmir.

As discussed in the previous chapters the project would construction of Approach Roads with Avalanche Protection Works, construction of cross-drainage and road appurtenances etc. This cost estimate has been worked out using TCS drawings, Gad Drawings, quantities for different items of works derived from the design and unit rates derived from the schedule of Rates/Market.

9.2 METHODOLOGY

The following procedure has been adopted for the estimation:

- The rates of various items of construction work have been analysed as per procedure laid down in the "MORT&H Standard Data Book"-2003 (Fourth Revision, Reprint 2006) and guidelines set there in.
- Machinery rates rentals of as per J&K Revised Schedule of Rates 2012 w.e.f 01.06.13 published by Public Works Department, Jammu and Kashmir year 2012 with escalation to arriver current rate.
- The unit rates of Labour is considered as per Schedule of Rates, Public Works Department, Jammu and Kashmir year 2012 with escalation to arriver current rate.
- The rates of cement, Steel and Bitumen which have been provided as per current market rates.
- Computation of quantities of earthwork and other components of road worked out from TCS drawings and computed.
- Computation of cost of bridges from their General Arrangement Drawings by working out the quantities.
- Estimation of cost of land acquisition, resettlement and rehabilitation costs, utility relocation and environment mitigation measures as per detailed assessment of their costs.
- Estimation of allowances for contingencies and supervision charges as percentage of civil cost.
- Estimation of total project cost.

9.3 UNIT RATES

The rates of various items of construction work have been analysed as per procedure laid down in the "MORT&H Standard Data Book"-2003 (Fourth Revision, Reprint 2006) and guidelines set therein. For road embankment borrow areas have been identified along the project road. For stone metal quarries have been identified along the road. Average lead has been worked out for earth and stone metal and cartage cost has been provided at State Schedule of Rates. The unit rates have been worked out by taking the cost of materials as provided in the State Schedule of Rates (except for cement steel and bitumen for which market rates have been provided). The component of labour, material and machinery has been provided as per Standard Data Book of the Ministry of Road Transport and Highways.

9.4 CONSTRUCTION QUANTITIES

For study the quantities of pavement have been worked out as per proposed TCS drawings. Detailed Cut and fill volumes are generated from MX Road software and taken into earthwork consideration.

Quantities of culverts and Minor/Snow Gallery/cut & cover Structures have been worked out from respective drawings. The cost of land acquisition, resettlement and rehabilitation costs, utility relocation costs and environmental mitigation measures have been provided as per preliminary assessment of their costs. Estimates for allowances for contingencies and supervision charges have been provided as percentage of total cost.

9.5 PAVEMENT DESIGN OPTIONS

Flexible pavement has been considered for main carriageway as per the recommended proposal and Pavement Composition. Rigid pavement has been considered for Tunnel portion.

9.6 COST COMPONENTS

The estimated cost has been worked out under the following sub heads: -

Site* clearance *and dismantling

Under this sub head provision has been made for removing the roots of trees of girth more than 300 mm and dismantling the structures, which are proposed to be reconstructed.

Earth Work

This sub head provides for items of earth work in excavation, embankment, sub grade and shoulders.

Sub Base* and *Base Courses

The items of cement sub base, cement base and Aggregate Inter Layer have been provided under this sub head for flexible pavement.(option-1)
The items of granular sub base, wet mix macadam have been provided under this sub head for flexible pavement.(option-2)

Bituminous *Courses/Cement Concrete pavement*

This sub head provides for items of bituminous courses for flexible pavement. Rigid Pavement for Tunnel portion.

Culverts

Additional new Culverts is provided based on hydrological investigation. The schedule of widening and providing new culverts are fixed up and accordingly the different types of culverts (box) quantities are worked out from the standard drawings or from the available drawings of the particular project.

Further the abstract of Quantities is prepared for all the culverts and the Abstract of cost is prepared by multiplying the rates.

Minor /Major Structures

The quantities for reconstruction/widening/rehabilitation of Minor / Major Structures are considered under this head.

Cut & Cover /Snow gallery

The quantities for Construction of Cut & Cover/snow Gallery are considered under this head.

Tunnel

The quantities for Construction of Tunnel are considered under this head.

Traffic signs, Markings & Road Appurtenances

The road traffic signs and road markings for the project are provided as per IRC standards. This includes the quantities of road markings, road signs (all kinds), crash barriers and street lightings required for main highway as well as service roads.

Drainage and Protective Works

All works relating to longitudinal drainage requirements, lined and unlined drains/ditches, embankment slope protection works are covered here.

Traffic management system

This section includes the items required for providing Traffic Management System.

Miscellaneous items

Under this sub head provision has been made for the following main items.

Routine Maintenance During Construction

Under this sub head provision has been made for the following main items.

Miscellaneous items (snow clearance, Maintenance etc)

Under this sub head provision has been made for the following main items.

9.7 CONTINGENCIES AND SUPERVISION COSTS

The following provision has been made for contingency and supervision cost:

- Contingencies - 2.8%
- Supervision Charges - 3%
- Agency charges - 3 %
- GST - 12%

9.8 PROJECT COST

The total cost includes Contingencies, Supervision charges, Agency charges. General Abstract of cost is enclosed as follows:

Table 0-1: Summary of Cost

Bill No.	Description	Amount (Rs.)
1	Site Clearance & Dismantling	

		674,892
2	Earthwork	235,669,721
3	Sub-Base, Base Courses (Granular)	93,776,006
4	Bituminous Courses / Concrete Pavements	42,330,165
4 (a)	Reinforced Earth Embankment	568,114,052
5	Cross Drainage Structures	68,822,455
6	Major Bridges & Minor Bridges	223,486,418
6.1	Cut And Cover	3,251,436,941
6.2	Snow Gallery	450,369,654
7	Drainage & Protection Works	296,828,139
8	Traffic Signs, Road Markings & Appurtenances	36,937,037
9	Catch Dams and Deflection Structures	287,721,496
	Total Construction Cost --- (A)	**5,556,166,975**
	GST @ 12% of (A)	**666,740,037**
	Total Construction Cost --- (B)	**6,222,907,012**
10	Contingencies @ 2.8% of (A)	155,572,675
11	Supervision charges @ 3% of (A)	166,685,009
12	Agency Charges @ 3% of (A)	166,685,009
13	Escalation @ 5% of (B) per annum for 2nd & 3rd years' (Construction period 3 Year)	622,290,701
14	Snow Clearance (For 5 Year Defect Lability Period)	137,534,640
	Total Estimated Project Cost	**7,471,675,048**

15	Maintenance charges @ 0.5% for 2, 3 & 4th year & 1% for 5 years of (B)	155,572,675
	Total Project Cost	**7,627,247,723**
16	**Pre-Construction Activities**	
(i)	Shifting of utilities	136,711
(ii)	Environment Mitigation Cost	19,155,858
(iii)	Provision for LA and FC	64,094,921
	Total Capital Cost (INR)	**7,710,635,213**

10 CHAPTER-10 ECONOMIC AND FINANCIAL ANALYSIS

10.1 ECONOMIC ANALYSIS

Any infrastructure project, which is in terms of improving the existing facility, is subjected to economic and financial analysis, to establish its viability and ensure that the investment proposed would yield appropriate return either to the national economy of the private/ public investor. The present study envisages the use of *Highway Development and Management model hereafter referred as HDM-4* for undertaking economic analysis of the implementation of improvement proposals on the said project Corridor.

10.2 METHODOLOGY FOR APPRAISAL

The appraisal has been carried out within the framework of 'with' and without' the project situations. 'Without' the project situation is the one in which the projected traffic would continue to move on the existing two-lane road which will require certain minimum routine and periodic maintenance for upkeep of the facility. In the case of 'with' project situation, the traffic would use the improved facility, which is two lane carriageways with paved shoulders facility.

The benefits due to improvements are the saving in vehicle operation cost, saving in time and other caused benefits. The cost of the project is subtracted from benefits accruing year wise and discounted to work out the Economic Internal Rate of Return with the help of HDM-4 software. In the economic appraisal, all the financial estimates of costs and benefits are converted to economic costs by applying necessary factors.

10.3 BASIC INPUT DATA

Implementation of the project road improvements is conceived to be carried out in three packages as follows:-

Table 10-1: Project Detail Package-wise

	Start Chainage	End Chainage	Length (km)
Approach Road-1	9+760	17+814	8.054
Approach Road-2	0+000	0+660	0.660

Economic Analysis has been exercised as a whole project.

10.4 GENERAL DATA

Physical characteristics data of each link pertains to altitude/rainfall, existing road geometry, pavement (structure, strength and condition) sub grade strength and construction/maintenance history and derived from field survey and investigations carried out for the project and presented in the earlier Chapter. The data reveals that the physical characteristics for entire project length are quite uniform and homogeneous.

10.5 PROJECT COST

Project costs based on engineering design have been worked out and given in earlier chapter. A conversion factor of 0.85 has been used to convert financial costs to economic costs. For economic evaluation, base costs have been taken as factor costs of civil works and other costs related to social, environmental and utility relocations. Link-wise economic and financial costs are given below:

Table 10-2: Package – wise Costing in Rupees

	Economic Cost	Financial Cost
Project	**7,710,635,213**	-

In addition to project cost routine and periodic maintenance cost has been worked out for the project road. A construction period of 5 years (2018, 19, 20, 21 and 22) has been envisaged with a phasing of 30%, 40%, 20%, 5% and 5% respectively. The proposed improved project road will have 2.8 Km of rigid pavement and 15.03 Km of flexible pavement. Based on the ratio following table gives the maintenance cost of the project.

Table 10-3: Maintenance Cost in Rupees

Sl No.	Maintenance	Cost
1	Reconstruction @ 10 IRI	20000/ Sq. m.
2	Drainage	1000/ Sq. m.
3	Routine Edge	5000/ Sq. m.
4	Potholes	4000/ Sq. m.
	Patching	4000/ Sq. m.
5	Crack Sealing	1000/ Sq. m.
6	Shoulder Repair	10000/ Sq. m.

10.6 EXISTING ROAD ROUGHNESS AND GEOMETRY

Prevailing road conditions have been provided in Appendix 7.2. Physical condition of project road used for economic analyses is derived from road condition survey. The inputs used for economic analyses are provided in table below:-

Table 10-4: Package-Wise Present Road Condition

	Project
End of Year	2017
IRI	3.0
All structural Cracks	2.0
Ravelled Area	2.0
Number of Potholes	1.00
Edge Break Area m^2/km	6.0
Mean Rut Depth	1.00
Texture Depth	0.30
Skid Resistance	0.40
Drainage	Very Poor

10.7 ECONOMIC COST OF VEHICLE PARAMETERS

Economic Costs of vehicle and tyre are derived from the online market data of Jammu and Kashmir. Representative retail price for each category of vehicle have been collected. Elements of taxes and duties applicable have been removed to arrive at the economic costs.

Details of derived economic costs for each vehicle category are presented in Table 12.8. Summary is given below:

Table 10-5: Details of Vehicle Category

Category	Two	Three	Medium	Bus	LCV	2 Axle	3 Axle	Multi Axle
	Wheeler	Wheeler	Car			Truck	Truck	Truck
Vehicle	40000	60000	250000	1050000	654000	1800000	2300000	2600000
Tyre	1000	328	3000	14000	6000	14000	18000	20000

10.7.1 MAINTENANCE LABOUR AND CREW COSTS

Based on the market survey and inquiries from the various organisations in Jammu and Kashmir, the maintenance labour cost/hr and wages/hour has been evaluated. Rates have been compared with that adopted for the recent studies before arriving at reasonable values.

Table 10-6: Maintenance Labour and Crew Costs Details

Category	Two	Medium	Bus	LCV	2 Axle	3 Axle	Multi Axle
	Wheeler	Car			Truck	Truck	Truck
Maint. Labour	40.61	60.92	126.93	101.54	101.54	101.54	101.54
Crew Wage	0	25.38	116.97	45.69	76.15	91.38	91.38

10.7.2 PASSENGER TIME-DELAY COSTS

Time value of passengers (Work trips and Non Work Trips) is arrived based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP:30-2009"). The Values of 2009 are upgraded by considering Whole Sale Price Index Ratio for the year 2009 and 2015. Non work time value of passenger is considered 15% and work time value of passenger is considered 85% of time value of passengers as suggested in IRC SP:30-2009". The adopted values are summarised as given in table below.

Adopted time delay cost for the project in year 2018 is given below.

Table 10-7: Maintenance Labour and Crew Costs Details

	Eq. Work- Time Value in 2009	Eq. Non-work Time Value in 2009	Eq. Work- *Time Value in 2019	Eq. Non-work *Time Value in 2019
Car/ Taxi	55.9	14.0	98.52	28.98
2 W/ 3W	28.0	8.0	27.20	8.00
Minibus	33.6	9.8	33.58	9.88
Bus	21.4	5.3	36.98	10.88
*Taking Consideration of WPI				

Interest

An economic interest rate of 12% has been adopted based on opportunity cost of capital

10.8 SENSITIVITY ANALYSIS

Two critical factors could affect the viability of the project and these are the Capital Cost and traffic level. The capital cost can increase or the expected traffic growth could not materialise or both factors could occur simultaneously sensitivity check using the following parameters has been carried out:

- Sensitivity Option S1 Base Scenario
- Sensitivity Option S2 New Scenario with increase in cost by 15%
- Sensitivity Option S3 New Scenario with reduction in base benefits by 15%
- Sensitivity Option S4 New Scenario with increase in cost by 15% and reduction in base benefits by 15%

10.9 ECONOMIC ANALYSIS RESULTS

The EIRR and NPV (at 12%) for each link and section along with sensitivity analysis was carried out and it was found that the project is considered as economically unviable. Though the factors like Tourism and Defence governs this project, hence the project is recommended in the national interest

10.10 CONCLUSIONS

Due to defence and national interest this project has critical importance though the project is not showing any economic viability but overall it is strategic in nature and therefore recommended for construction.

11 CHAPTER 11: WINTER ROAD MAINTENANCE

11.1 WINTER MAINTENANCE MECHANISM IN SNOW BOUND AREAS

Driving in snowy regions like Zojila is certainly affected by increased braking distance, reduced tire-traction, slow reaction of tires to the steering, poor visibility, less fuel efficiency, etc. Often, when it snows, traffic is often paralysed for about 4-5 months in this area. To ensure, a reliable and safe flow of road traffic during the winter season, the road should be maintained and cleared with a proper mechanism. A proper mechanism consists of collecting road and weather information, analysing the condition, taking necessary action and informing the respective authorities and users. Thus, an effective winter road maintenance with proper mechanism can save cost with other benefits like increased safety on the roads, increased flow of traffic and decreased environmental negative impacts in winter time. This chapter deals with an overview of winter maintenance mechanism being performed of snow bound areas in some of the cold countries.

11.2 WEATHER INFORMATION SYSTEM

Effective management of winter road maintenance is only possible on the basis of relevant information about current and future road weather and surface conditions on specific road sections. Along with this, the information about the real-time movements of maintenance vehicles create the basis for support of winter maintenance decision process and for efficient fleet management. For this purpose, a Road Weather Information System is proposed for such areas.

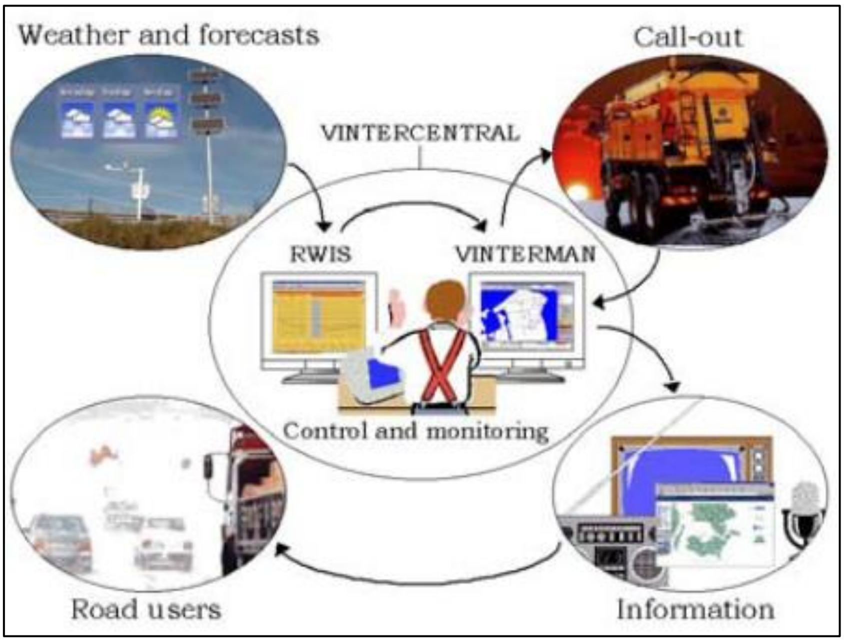


Fig. 11-1: RWIS – Road weather information system (Source: Snow and ice data book 2006)

A general working mechanism for Danish Road Weather System (Figure 12-1) clearly indicates the flow of maintenance system. It comprises of the following part:

A. **Weather forecasting and Control and Monitoring:** Parameters like air and surface temperature, wind direction and strength, weather effectiveness, precipitation, snowfall etc. are to be measured and forecasted. These parameters are measured with the help of recording stations and controlled with the help of servers. This information is needed to make decisions concerning the start, duration and end of winter maintenance action.

B. **Call-out/ Snow Clearance Mechanism:** Snow clearing of carriageway should begin, when the snowfall has reached to 3-5 cm snow and there is prospect for continuous snowfall. If the snowfall has already taken place or the weather forecast indicates snowfall, the duty engineer decides the priority of snow clearance. The responsibility of the officials is to take the decision depending on the field conditions and to ensure safe and smooth flow of traffic. The officials callout for the snow clearing mechanism and with respect to this the information is passed to road operators and users. The snow clearance mechanism is discussed in detail in section 12.2.3.

C. **Information and Road Users:** The data obtained from the automatic weather stations is processed and used for forecasting and to inform or warn the road weather condition to the road operators and users. This information is used by road operators for clearance and other maintenance call, while the users make the decision of travelling through the path.

The figure 11-2 shows the basic components of winter road maintenance management in Slovak conditions, which includes Current Data Module(CDM) and Maintenance Decision Support System (MDSS).

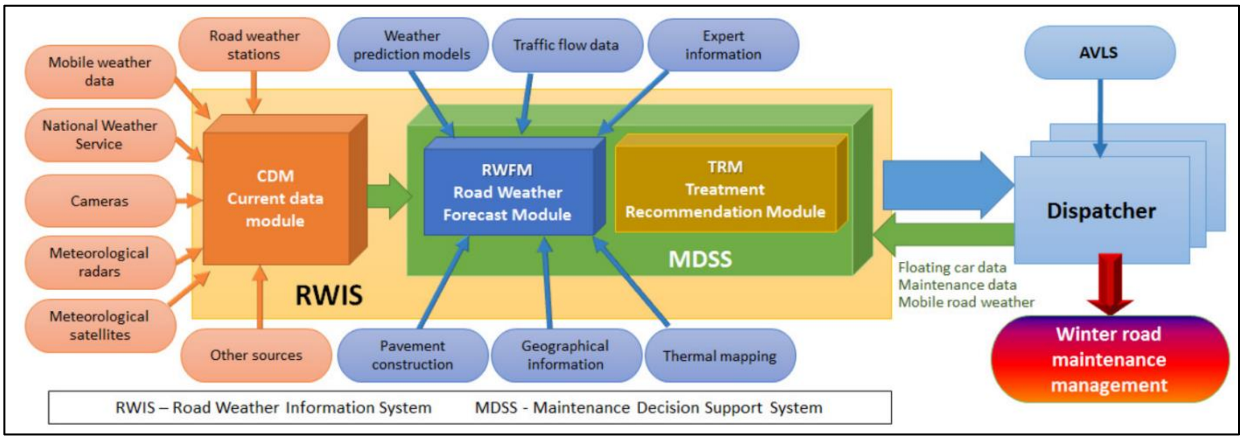


Fig. 11-2: The basic components and scheme of intelligent winter road maintenance management

The RWIS is a is a software tool which collects all relevant available data which can be used by dispatchers to support decision making in winter road maintenance management. The dispatchers continuously monitor the development of weather and road weather conditions, deciding on deploying maintenance crews in certain parts of given region and determining appropriate technology and intensity of maintenance (e.g. technology used, amount of spreading). The maintenance vehicles usually consist of spreaders, plow and graders, and the driver plays an important role for the actual performance of maintenance in the field.

The RWIS provide a comprehensive overview of historical data, current real-time data and predicted data about road weather and surface conditions. The RWIS also collects data from Automatic Vehicle Location System (AVLS) and thus can serve as a tool for registering and checking of maintenance performance. The RWIS integrates current data from road weather stations, meteorological radars and satellites, cameras, mobile road weather stations, the National Weather Service (NWS) and others. For data collection automatic weather stations, also known as Environmental Sensing Stations, are placed along the roadside at critical locations. These stations consist of three types of sensors, namely, atmospheric sensors, pavement/subsurface sensors and water level sensors. They measure real-time atmospheric parameters, pavement conditions, water level conditions, and visibility. The Environmental Sensing stations and its operation applicability are as shown in figure 11-3.

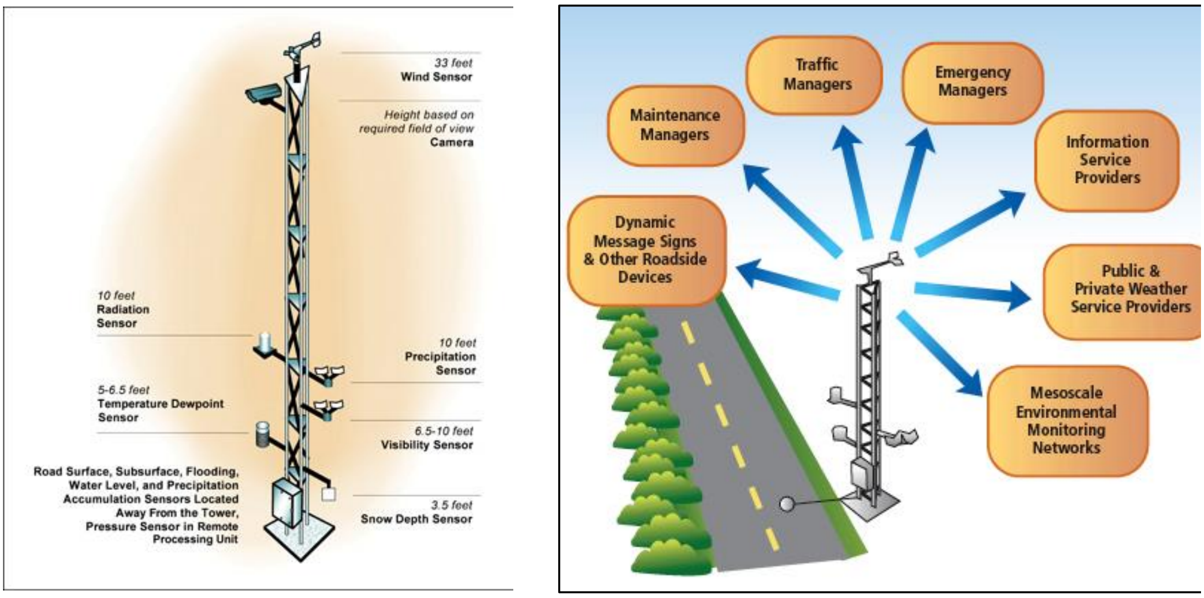
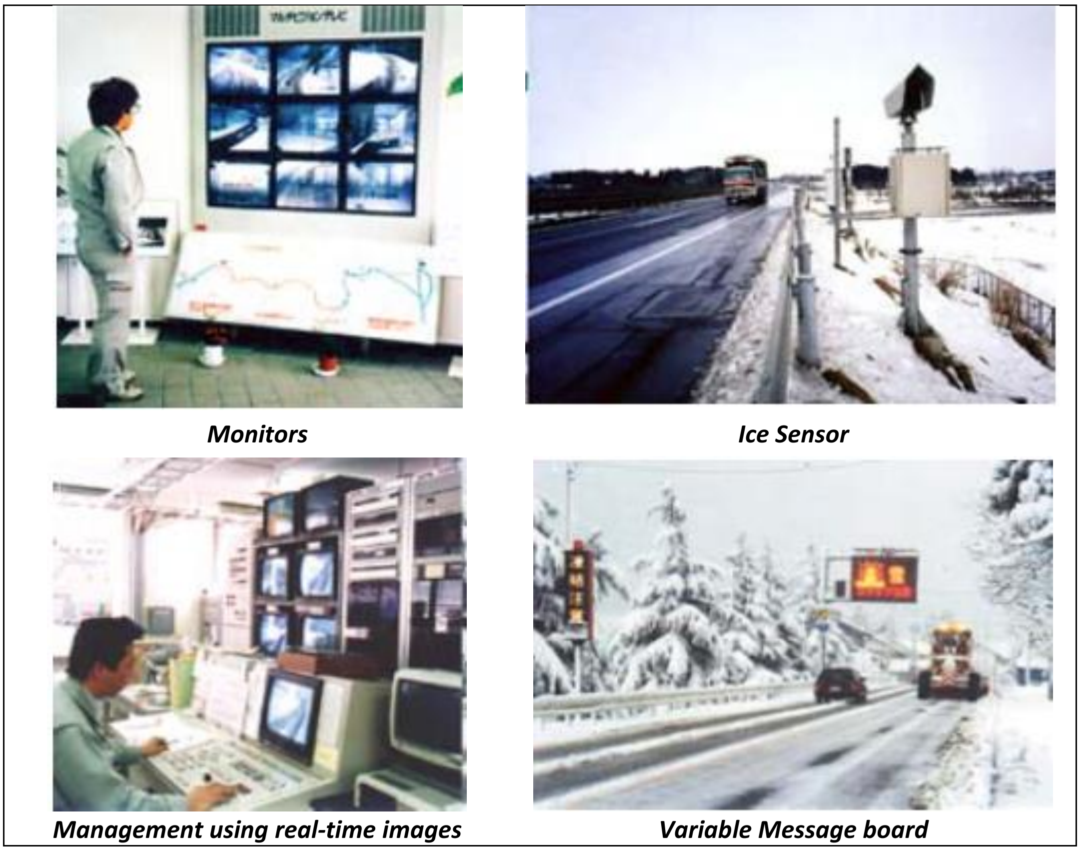


Fig. 11-3 : Environmental Sensing Stations



Monitors — ***Ice Sensor*** — ***Management using real-time images*** — ***Variable Message board***

Fig. 11-4: Road Weather Information System

(Source: https://www.fhwa.dot.gov/publications/publicroads/05nov/04.cfm)

Maintenance Decision Support System (MDSS) is a part of RWIS focused on special linear weather and road surface status forecast and recommendations on winter maintenance. These are computer systems which generate predictive outputs on the basis specific inputs. It is a useful assistant for dispatcher, which can specify the weather situation development. Road weather forecast (road condition, road surface temperature, freezing point temperature and snow amount) plays an important role in the timely intervention of winter maintenance. Road weather forecast (RWF) should be differentiated on the medium-term RWF (over the next two days) and short-term RWF (within the next 12 hours). Medium-term forecast is for the activation of capacities – preparation of maintenance vehicles, drivers or spreading materials. Short-term forecast is a basis for immediate decision-making in winter maintenance management.

In addition to the linear prediction the MDSS system can based on constantly ingesting data from road weather and atmospheric data, reviewing current treatment operations, and analysing the latest road weather forecasts produce treatment recommendations for winter maintenance operators. It is very useful tool for non-experienced operators, which can take get recommendations on what treatment strategies needed to be taken and they can take the right decision where and when road maintenance should be performed.

Thus, Winter Road Information systems can be divided into two categories: those that support road administrators in winter maintenance, including snow removal and friction management, and those that provide road users with information on weather and road-surface conditions.

Therefore, a system is to be developed so that one can create predefined action plans where the length of routes, methods and amount of salts etc. are decided. In addition to this, depending on the weather situation, a choice between dry salt, pre-wetted salt and brine can be made. After being called out, the resources are monitored with the system. The speed, dosage of salt/brine, spreading width, GPS location, etc of salt spreaders can be done. The centralised system is able to provide statistics on the number of activities, consumption of salt, duration and time of callout along with the cost of salt and payments to contractors. This provides the opportunity to monitor and control the work quality, and eventually to re-organise action-plans if needed. In short, the figure 11-4 can be a representation of some components of RWIS.

11.3 SNOW AND ICE-CONTROL MEASURES

A snow clearance mechanism is to be followed in order to optimise the resources within the least operation time. The snow clearance mechanism triggers after the callout made by the officials. Some of the common techniques are as discussed below:

11.3.1 SNOW PLOWING

A snowplow is a device intended for mounting on a vehicle, used for removing snow and ice from the roads. To maintain the trafficability of Highways and to promote interregional exchanges and living activities, snow removal on roadways is conducted around the clock in many of the cold countries.

Fig. 11-5 Snow Plowing

11.3.2 SNOW BLOWER

A snow blower or snow thrower is a machine for removing heavy snow from the roadway area.

Fig. 11-6 Snow Blowing

11.3.3 SNOW GRADER

In snow bound regions, graders are used for grading the snow in the snow storage areas and remove the snow from the carriageway.

Fig. 11-7: Snow Grader

11.3.4 SALT/BRINE SPRAY

Salt is spread along the carriageway as a de-icing agent and acts as an alternative for snow removal. The figure below shows the spraying of salt/brine along the roadway. The salt spraying device is generally added on the backside of the plow. However, the use of salt / brine has been restricted now a days due to its detrimental effect on the environment and also due to its corrosive effect on pavement and structures.

Fig. 11-8: Spreading technique

11.3.5 SAND / ABRASIVE SPRAY

The use of abrasives in winter maintenance is a well-established practice. Typically sand is placed on the road in amounts up to 1,200 lbs per lane mile (340 kg per lane km). The sand is intended to increase friction between vehicles and the (often snow or ice covered) pavement. The sand may be applied "straight" or by pre-wetting the abrasives at the spinner, as they are placed on the road or heating the abrasives to high temperatures (about 180º C seems to be effective) just prior to being placed on the road, or by mixing the abrasives with hot water (about 90º C) as they are placed on the road.

11.3.6 CALCIUM MAGNESIUM ACETATE (CMA)

Calcium magnesium acetate is an alternative to road salt. Calcium magnesium acetate works by interfering with the bond between snow particles and the road surface; in contrast, road salt chemically breaks down snow and ice as it moves downward from the surface. CMA, a solid, has a deicing range closer to that of salt.

Calcium magnesium acetate is generally used in its granular form and spread on the surface like other deicers. CMA looks like road salt, a rigid, angular particle that is more likely to stay where it is put. CMA works by preventing snow and ice particles from adhering to each other or to the road surface. It can be applied on top of snow and ice like other deicers or 30 minutes to two hours before precipitation begins. Often, CMA is used as a corrosion inhibitor, sometimes blended with road salt at rates greater than 20% CMA by weight. CMA costs $650-675 per ton as compared to about $50 Although direct costs are higher than that of salt, when indirect costs such as pollution and corrosion are factored in, CMA is much more economical.

Calcium magnesium acetate exhibits very low corrosion rates on metals found in bridges, roadways, parking garages, other steel and concrete systems and is commonly specified by design engineers for use on the previously mentioned structures. Commonly described as being about corrosive as tap water, CMA is often used as the corrosion standard by which other deicers are judged.

11.3.7 POTASSIUM ACETATE

Liquid potassium acetate (CH_3COOK) is an organic, biodegradable fluid that is used for de-icing and anti-icing roads. As opposed to rock salt or other alternative road deicers, such as urea-based or glycol-based products, potassium acetate has less of an environmental impact, while being more efficient at removing ice. On top of being a good deicer, it is more effective as an anti-icer, and can also be used as a "pre-wetter" with other solid deicers to enhance their performance.

11.3.8 ANTI-SKID TREATMENTS

It consists of spreading beforehand de-icing salts on roads and/or anti-icing mixtures (salts and aggregates) in order to prevent ice formation on pavements, on bridges and viaducts, near tunnels (entrance/exit portals). A brief of antiskid treatments is as shown in figure below:

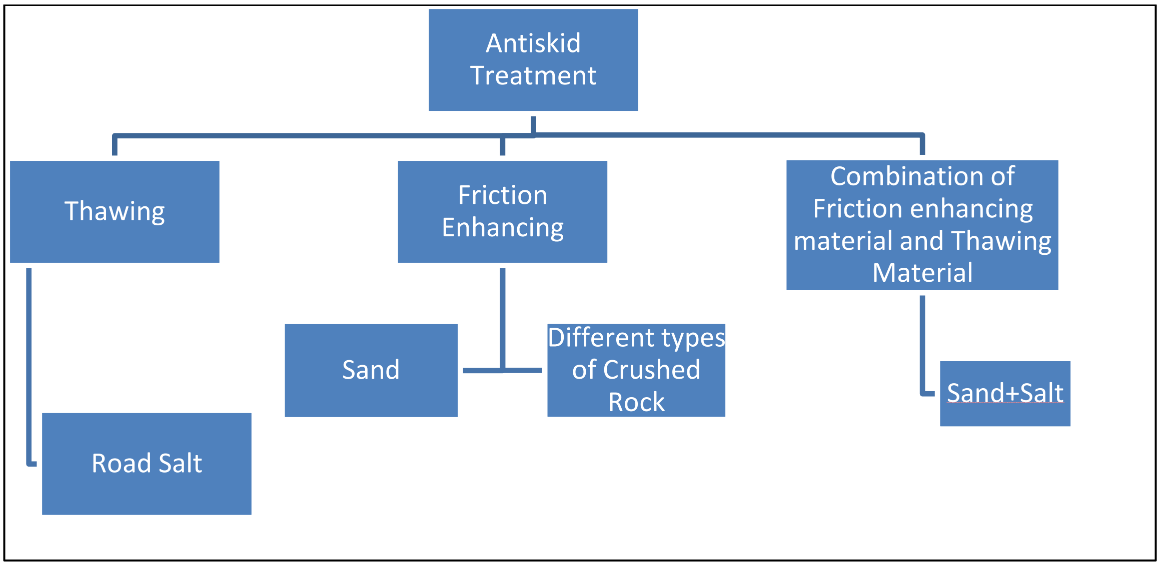


Fig. 11-9: Anti-skid treatments based on purpose

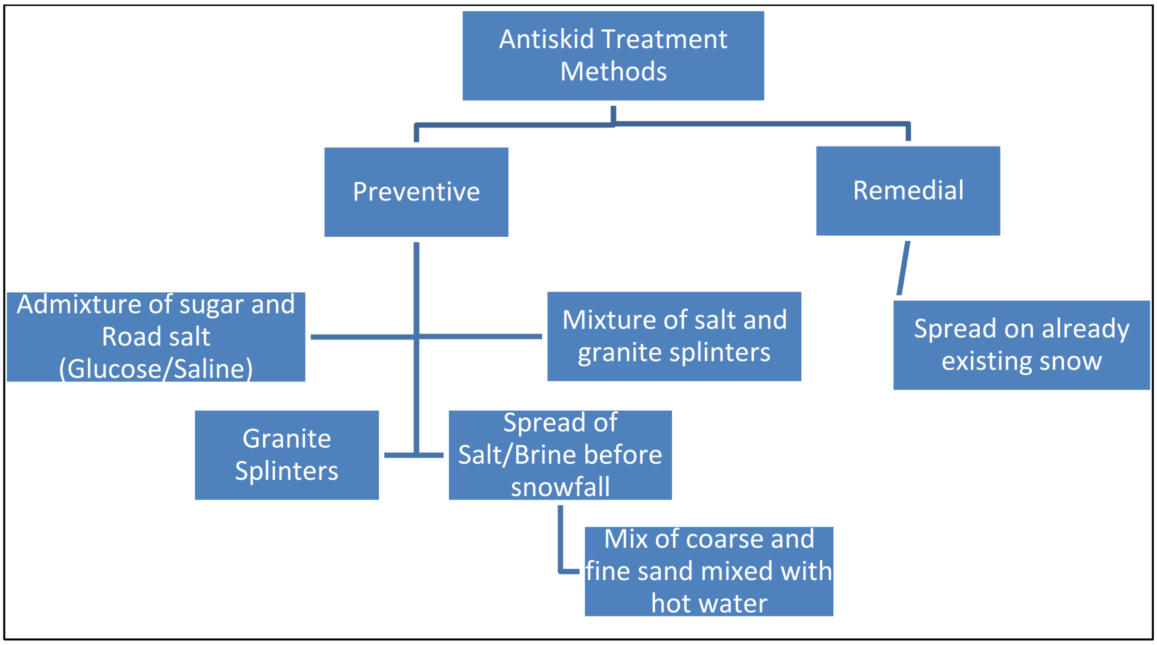


Fig. 11-10: Anti-skid treatment based on type of treatment

11.3.8.1 Promotion of measures for barrier-free winter mobility

Comprehensive snow removal measures have been formulated and implemented to remove barriers to wintertime mobility, such as the increased danger of pedestrian slip and fall accidents on frozen roads, reduction of walking space due to snowfall, and other inconveniences. Toward barrier-free mobility, thorough snow removal on sidewalks around railway stations has been promoted and road heating has been installed.

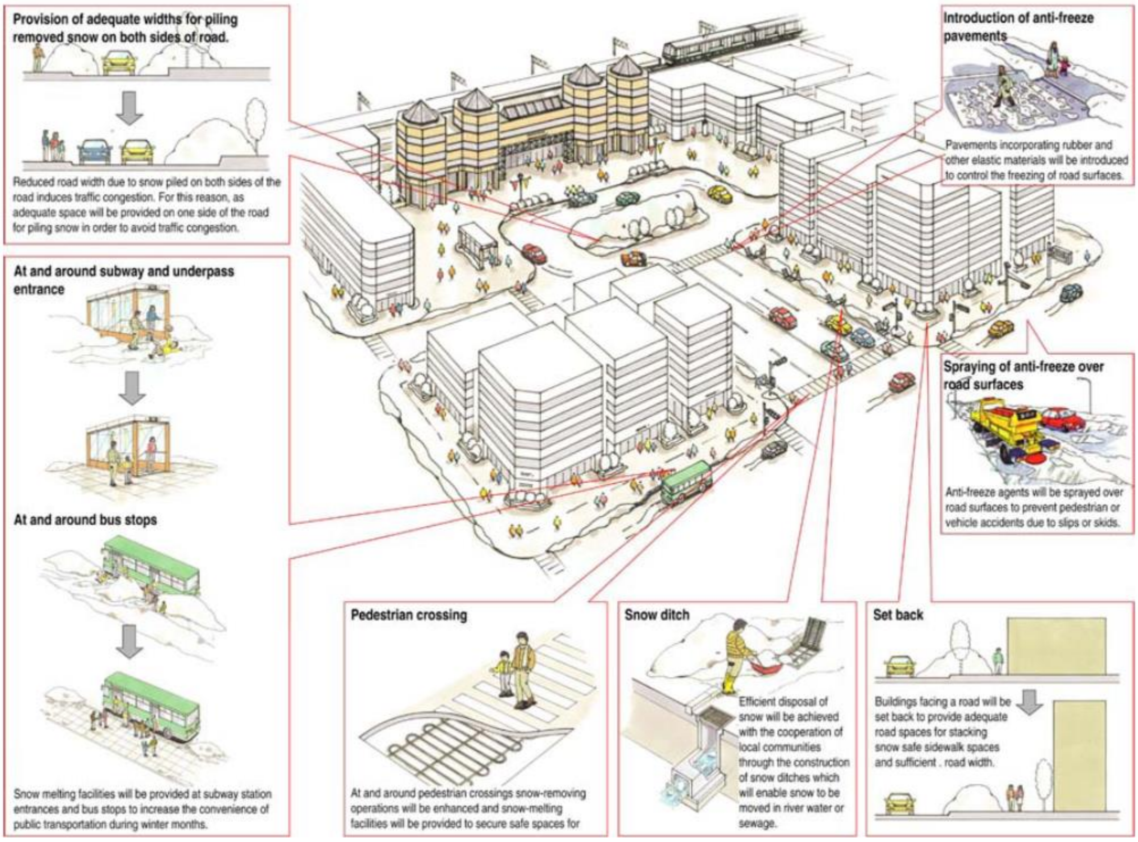


Fig. 11-11: Measures for barrier-free winter mobility taken in conjunction with various other projects for snow and ice-control

11.3.9 WORKING SCHEDULE FOR SHIFT WORKING

The service equipment fleet is mainly lorries with snow ploughs, pay loaders and graders. Rotary blowers are very important in winter service on mountain roads and exposed primary roads. Grader works, such as removal of hard snow and ice are increasingly overtaken by plough trucks with under body blades. Graders are however still important to level snow banks on the road shoulder in exposed areas.

The foreseen activities are normally carried out continuously for the winter period all day long and in working days and holidays. All such activities are carried out in such a way to give the least traffic congestion possible. Furthermore, they are all carried out by means of adhoc signals and barriers.

Snow and Ice Control Measures leading to additional cost reductions and environment preservation

Brine and pre-wetted salt is preferred instead of dry salt for most situations except under snowfall. The advantages of brine are that there is little salt in the solution and almost 100% of the quantity distributed remains on the road surface. The brine is usually made from a NaCl-solution but sometimes from a $CaCl_2$ solution, which is more effective and more expensive as well. Brine has proved favourable for preventive measures on thin ice or on rime.

The purpose of prewetting salt is to increase its weight, bind fine-grained salt, make the salt stick better and increase its moisture content to hasten its melting.

11.3.10 WINTER QUALITY STANDARD

A certain guideline/policy document is needed for the regular operation of winter maintenance of the road. A representative example of winter road quality standards from Iceland is as shown below:

Table 11-1: Summary of Winter Road Quality Standards

Zojila project road		Service Category	
		Approach Road 1 (Sonamarg to Baltal)	Approach Road 2 (km 118 at Minamarg)
Service hours	In town	24-hour service 7 days a week	06:00-22:30
	20 km from town		08:15-22:00
Critical Snow Depth for service start		2 cm	4 cm
After snowfall, snow removal is completed within		2 hours	3 hours
After road closure, snow removal is completed within		-	3 hours
Max. service cycle duration		2 hours	2 hours
Max. length of service route		10.8 km	0.6 km
Maximum snowdepth			
Min. Friction Coefficient	General	0.25	0.15
	Hazardous spots e.g. curves and slopes	0.25	0.25
Whenever road temperature is too low for effective salting (-10°C or lower), then sanding should occur within		2 hours	3 hours
Visual obstructions due to snow-banks at road junctions should be cleared within		24 hours	48 hours
Clearance of snow banks on the road shoulder within		24 hours	48 hours

Source: Snow and ice data book 2006

11.4 INFORMATION AND ROAD USER

11.4.1 INFORMATION PROVISION TO THE ROAD USER

The road and weather information can be collected from regional administrations by telephone, electronic transfer or through Road Weather Information System. This is to be processed and transferred to the road user. Information provided is; condition of road (slipperiness), weather (wind speed, gust and wind direction, temperature), road temperature, humidity and dew point, traffic (last 10 min, traffic from midnight), estimated time of opening if road is closed, maintenance works, axle-load restrictions, ferry schedules, on traffic accidents, their causes, traffic conditions etc.:

- Information on traffic accidents and their causes is given to news agencies, radio stations and television, the press, electronic mass media: on the situation during the day, week, month/s, year.
- Publications (brochures, leaflets, calendars etc.) are prepared, printed and distributed.
- Measures of safe traffic for children in winter time are taken: education on traffic peculiarities, skiing and other winter sports and their location etc.

To ensure traffic safety road user should have awareness about the system. It can be achieved by following measures:

- Education (information in mass media, publications on traffic safety, instructing pedestrians, cyclists and horse drivers how to use reflectors).
- Engineering measures (lighting road sections, fencing, reconstruction of intersections and some road sections, constructing cycle tracks and pedestrian walkways).
- Control of road users (administrative measures); more attention given to the control of tyres and lights.
- Special campaigns of traffic safety when education and control is coordinated.

11.4.2 USE OF WEATHER RELATED ROAD SENSOR AND VARIABLE ROAD SIGNS

Most of the weather stations have temperature sensors in the road surface, and some have road surface humidity sensors for management use only.

Frost depth sensors are used to determine weight restrictions on roads. Variable Message signs are used to show wind speed, wind direction, temperature and in extremely exposed areas wind gust. Variable road signs are also used if roads are closed.

Fig. 11-12: Variable Message Sign

The users may also have certain interface as shown in figure below, so that they are able to know about the road condition.

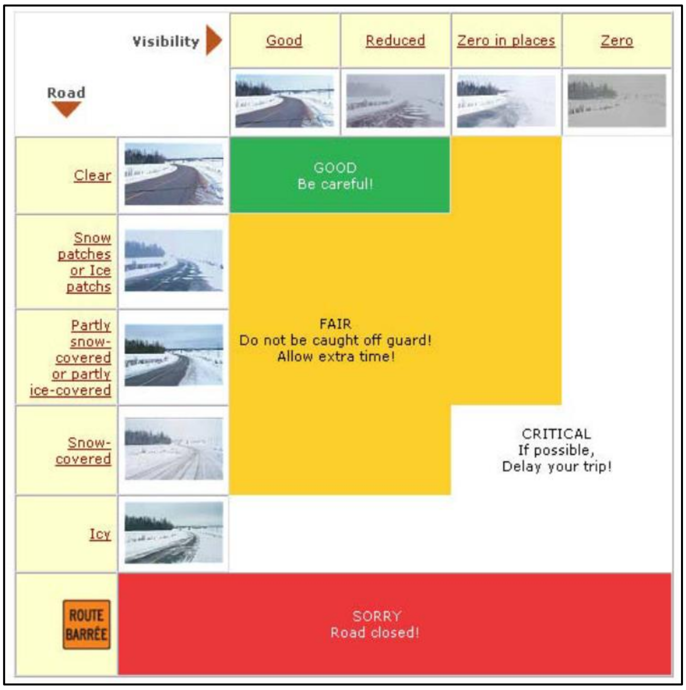


Fig. 11-13: Terminology of Road Conditions

11.5 COST PARAMETERS

11.5.1 EQUIPMENT COST

Cost plays a vital road in the successful operation of winter road mechanism. Certain cost parameters based on the market rates are as follows:

Table 11-2 Tentative Cost of Equipment

Sr. No.	Equipment	Representative image	Approximate cost
1	RWIS		Total installation costs = $85231/unit. Total site commissioning costs = $3,300 per site Mapping to Scan Web software = $180 per sit This cost included purchasing four power modules and the server costing $100,000 per module (approx.)

2	Snow Plow with salt spreader (In case of normal snowfall)		US $39,800-44,500 / Units (INR 27,86,000 – 31,15,000)
3	Snow Blower		US $39,800-44,500 / Units (INR 27,86,000 – 31,15,000)
4	Motor grader		US $60,000-80,000 / Units (INR 42,00,000 – 56,00,000)

11.6 RECOMMENDATIONS

Existing NH-1 is being developed to provide an all-weather connectivity between Srinagar and Leh. If winter maintenance mechanism can be extended from main road to cross roads, internal roads and area adjacent to house/hotels, then locals from this area will not leave their homes during winters. There are army camps, HAWS area which can be benefitted from this winter mechanism process. Continuous water supply and interrupted power distribution along with all-weather road will boost socio-economic profile of this area and they can earn more, as these areas will be made accessible/functional throughout the year. This mechanism will help in employment generation, increase revenue potential and provide better connectivity to town through cross roads/internal roads. One more objective of this road upgradation is to boost tourism in Sonamarg town. If villagers can stay back and hotels are functional then it will be an advantageous for tourists, who are going to visit Sonamarg to access winter sports etc. It will directly increase income of locals and every community will get benefitted. Local Municipal body in coordination with Sonamarg Development Authority (SDA) and NHIDCL can provide a winter working maintenance mechanism to this area during winters.

Local Municipal body in association with Sonamarg Development Authority (SDA) and NHIDCL can work together to make it possible.