Client:

Executive Engineer,
Border Road Project Division-II,
CPWD, Chungthang, North Sikkim

Consultancy Services for Preparation of Detailed Project Report for Additional High Altitude Roads under Phase-II in the state of Sikkim using Satellite Imagery

DETAILED PROJECT REPORT (TOONG-PARLEM-PT4865-TAMZE)

JOB ORDER No.: SMC/Highway/2017/644

(MAIN REPORT)

Consultant:

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ABBREVIATIONS

CPWD	: Central Public Works Department
MORTH	: Ministry of Road Transport & Highway
AASHTO	: American Association of State Highway and Official
BRPC	: Border Road Project Circle
NRSC	: National Remote Sensing Centre
ITBP	: Indo-Tibetan Border Police
MoEF	: Ministry of Environment and Forest
IRC	: Indian Road Congress
BIS	: Bureau of Indian Standards
EPC	: Engineering Procurement Contract
PPP	: Public Private Partnership
DBFOT	: Design, Build Finance Operate & Transfer
ToR	: Term of Reference
QAP	: Quality Assurance Plan
GPS	: Global Positioning System
DEM	: Digital Elevation Map
TS	: Total Station
DTM	: Digital Terrain Model
BMS	: Bench Mark Stations
ESAL	: Equivalent Standard Axle Load
VDF	: Vehicle Damage Factor
MSA	: Million Standard Axle
AADT	: Average Annual Daily Traffic
ADT	: Annual Daily Traffic
TVC	: Total Vehicle Count
OD	: Origin-Destination
PCU	: Passenger Car Unit
GSDP	: Gross State Domestic Product
CBR	: California Bearing Ratio
OMC	: Optimum Moisture Content
DCPT	: Dynamic Cone Penetration Test
BOQ	: Bill of Quantities
SOR	: Schedule of Rates
GAD	: General Arrangement Drawing
ROW	: Right of Way
ROB	: Railway Over Bridge
RUB	: Railway Under Bridge
HFL	: High Flood Level
LWL	: Low water Level
LTL	: Low Tide Level
HTL	: High Tide Level
IRR	: Internal Rate of Return
COD	: Commercial Operations Date

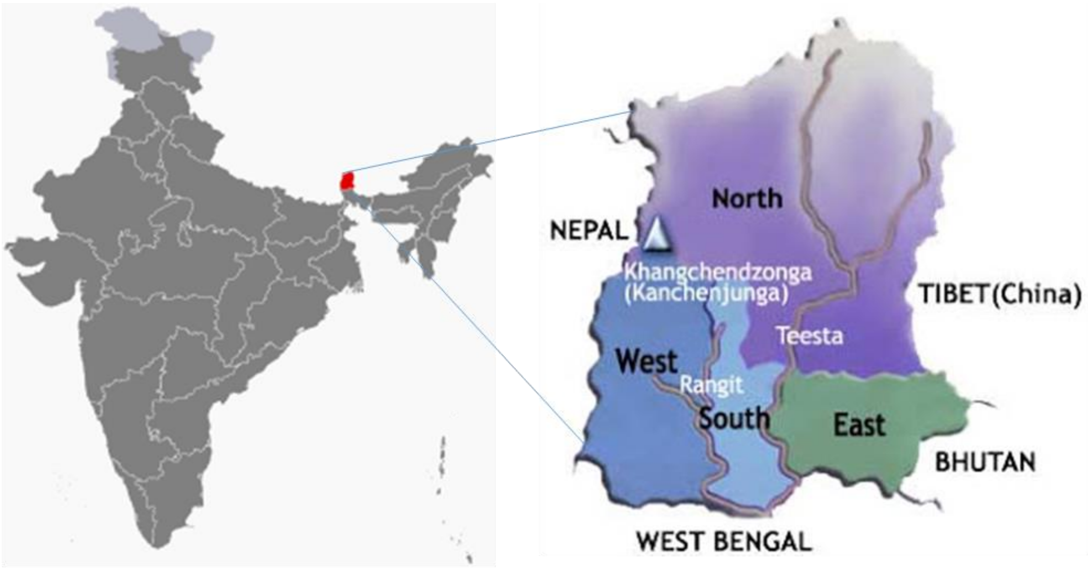

EXECUTIVE
SUMMARY

Executive Summary

0.1 Background

The work for preparation of Detailed Project Report of for additional high altitude roads under Phase-II in the state of Sikkim using satellite imagery for the following road has been awarded to M/s S.M. Consultants vide letter no Lr. No. 54(11)/EE/BRPD-II/2017/106 dated 13.06.2017: The project stretch under consideration is

- Toong-Partem-4865-Tamze in the state of Sikkim



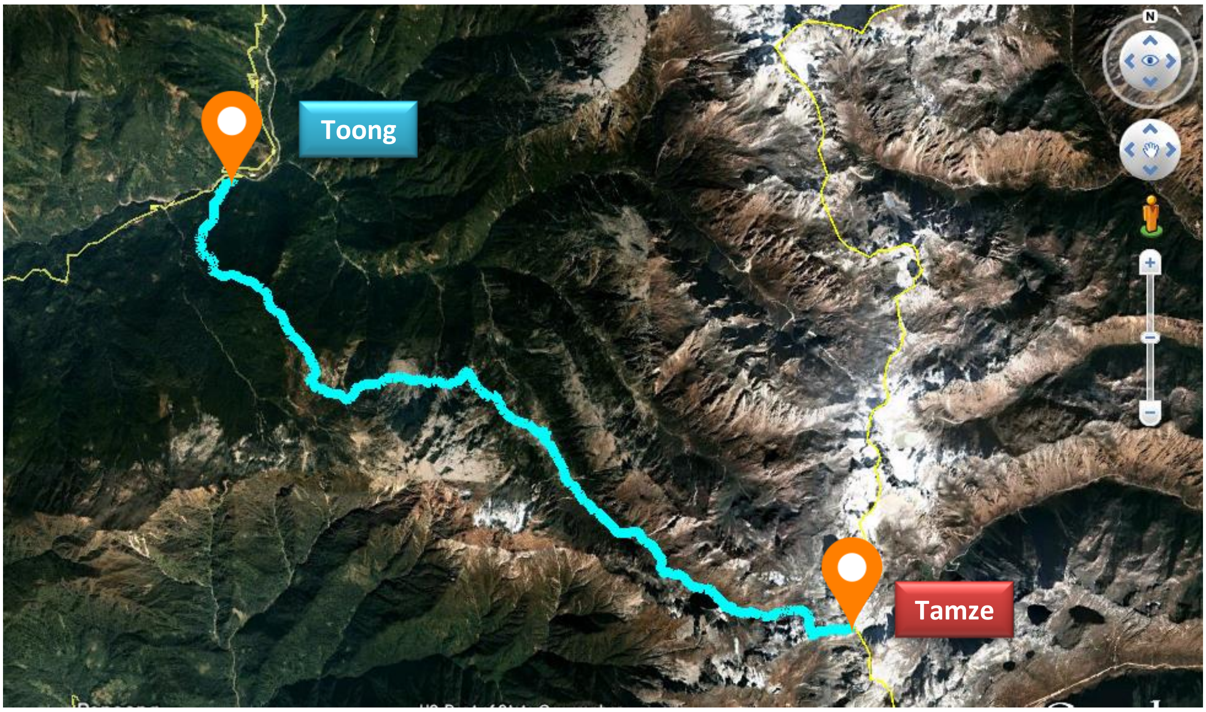


Figure 1: Index Map

The present submission is for Detailed Project Report in line with the terms of reference.

0.2 Investigations and Evaluations

Feasibility Study was carried out and the report evaluates technical viability of alignment options and recommending the best alternate. The above evaluation has been based on various surveys and investigations carried out during the course of the study and these include traffic, topography. Maximum effort has been made to minimise the length of the road keeping the geometrical parameters as required.

0.3 Project Development Description:

0.3.1. General

The project road starts from Toong (0.00 km) and ends on Tamze (84.425 km). The road lies completely in the district of North Sikkim, Sikkim. The length of the road is 84.425 km. The road passes through no settlements. The project stretch has no existing road throughout the stretch only foot tracks are found at few locations.

0.3.2. Need for the road:

The awarded project stretch has no economic lining within the project corridor but has tracks of ITBP Army Troops As of now the ITBP relies on sport-utility vehicle, also known as SUV, and foot patrolling to scale mountainous tracks of the 3488 km-long India-China border that runs along Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh. This urges the necessity of roads for proper communication to the border area for regular patrolling.

0.3.3 Traffic Volume

The traffic on the project corridor is nil. After the development of the project road it is expected to provide a very good communication for the army vehicles to pass on the project stretch. The design consideration is based on taking into the light utility vehicles, fast track vehicles, medium truck, high mobility truck, artillery tractors, armoured vehicle and all-terrain transport vehicles. The project road has been designed with expected 5 msa traffic.

0.3.4 Traffic Projected

5% traffic growth rate has been considered for the project stretch. It is expected that the development of the road will benefit in their mobility during the patrolling and to reach their camps.

0.3.5. Proposed Development plan

- The commencement point and ending point as per ITBP is Toong (27°32’45’’N, 88°38’51’’E), Partem (27°30’12’’N, 88°42’57’’E), PT 4865 (27°27’31’’N, 88°46’15’’E) and Chhu Junction(27°38’11’’N and 88°46’15’’E) respectively. After trying all alternatives alignments the best alignment of length 84.425 km has been recommended.
- The development scheme is as follows:

Table 1: DEVELOPMENT SCHEME

Sl. No.	Design Chainage		Length	Typical Cross-section
	From	To		
1	0.000	84.425	84.425	Single Carriageway (3.75 m), with 1.25 m earthen shoulder on both sides, provision of drain on hill side and required protection works on both hill side and valley side.

- The pavement crust designed for widening with 5 msa and 10% CBR is as follows

Table 2: DETAIL OF PAVEMENT DEVELOPMENT

Chainage	Design traffic (MSA)	CBR of subgrade (%)	Viscosity grade of bitumen	Proposed pavement thickness
0/00-84/425 km	5 msa	10 %	VG 10, PMB	975 mm

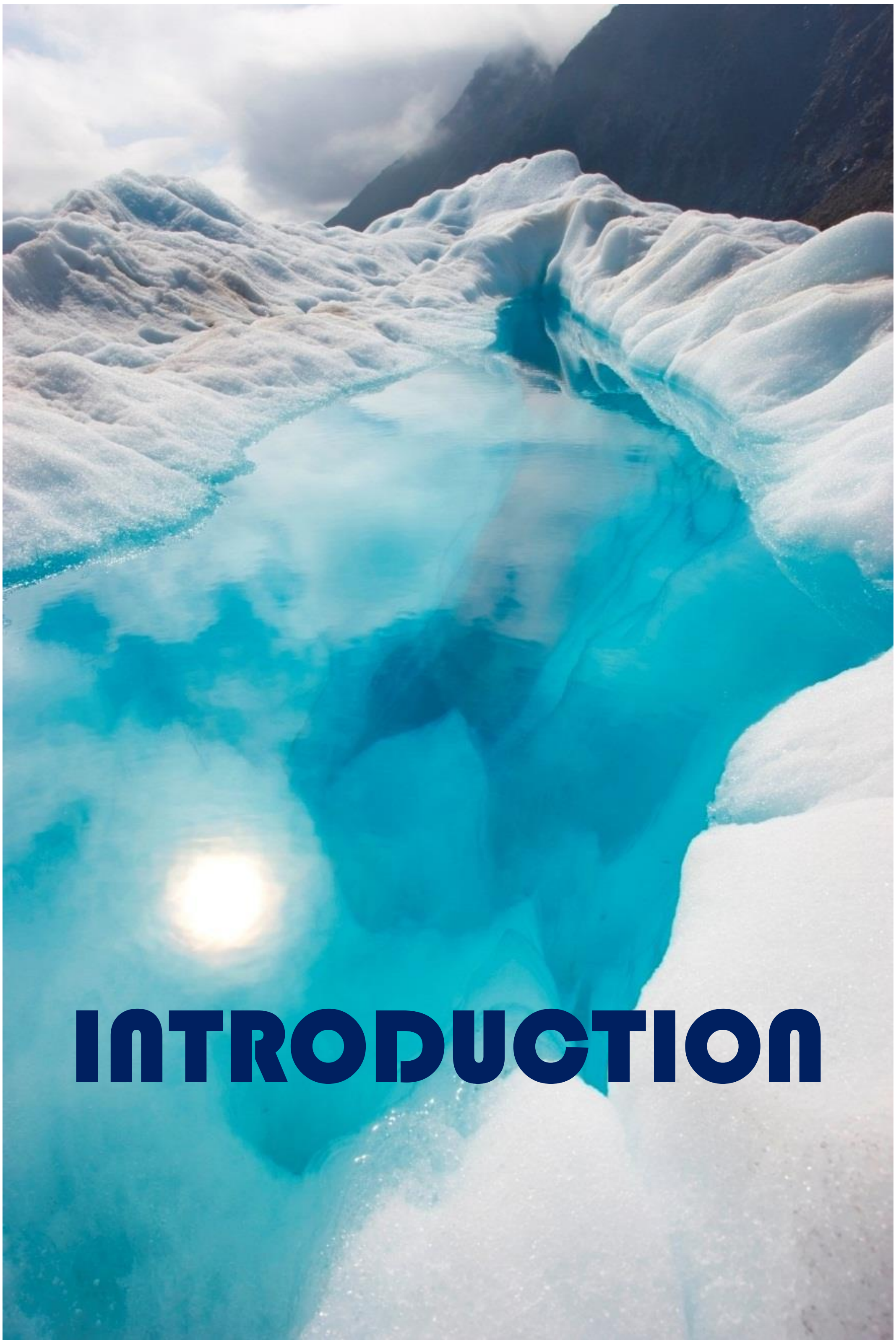
- The project corridor starts from the North Sikkim Highway road connecting Mangan on right and Chungthang on left with an intersection.
- The project road is in high altitude Himalayan Ranges for which the terrain is totally hilly and steep type. The new construction of roads in these sections require safety measures as well as heavy slope protection works. Efficient and enough protection as well as safety measures are provided in the project stretch.
- The development proposal for the bridge and culverts are as follows:

Table 3: ABSTACT OF PROPOSAL FOR CROSS-DRAINAGE STRUCTURE

Sl. No	Type	Nos.
1	RCC Box	394
2	Minor Bridge	10

0.4. Project cost

The project cost on above items has been worked out based on development proposal of the project corridor. Total Cost of the Project is estimated to be Rs. 1631.42 Crores.


INTRODUCTION

Chapter 1 Introduction

1.1 Background

Sikkim, a north-eastern state of India borders Tibet on its north and east, Bhutan in its east, Nepal in its west and Indian state of West Bengal on the south. It is located close to Siliguri corridor near Bangladesh. It is only connected by road to the remaining states of the country with the nearest airport in West Bengal. The state has 4 districts with major area and mountain ranges in North Sikkim. The district capital of North Sikkim is Mangan with sub division at Chungthang. The Indian Army has control over a large part of the state, as Sikkim forms part of a sensitive border area with China. Because of its hilly terrain and poor transport infrastructure, Sikkim lacks a large-scale industrial base. Brewing, distilling, tanning and watchmaking are the main industries, and are mainly located in the southern regions of the state, primarily in the towns of Melli and Jorethang. In addition, a small mining industry exists in Sikkim, extracting minerals such as copper, dolomite, talc, graphite, quartzite, coal, zinc and lead. Despite the state's minimal industrial infrastructure, Sikkim's economy has been among the fastest-growing in India since 2000; the state's GDP expanded by 89.93 per cent in 2010 alone. In 2003, Sikkim decided to convert fully to organic farming statewide, and achieved this goal in 2015, becoming India's first "organic state". Sikkim's roads are maintained by the Border Roads Organisation (BRO), an offshoot of the Indian Army. The roads in southern Sikkim are in relatively good condition, landslides being less frequent in this region. The state government maintains 1,857 kilometres (1,154 mi) of roadways that do not fall under the BRO's jurisdiction.

The Indo-Tibetan Border Police (ITBP) is one of the five Central Armed Police Forces of India, raised on 24 October 1962, under the CRPF Act, in the wake of the Sino-Indian War of 1962. The ITBP was intended for deployment along India's border with China's Tibet Autonomous Region. ITBP is a multi-dimensional force which primarily has 5 functions:

1. Vigil on the northern borders, detection and prevention of border violations, and promotion of the sense of security among the local populace.
2. Check illegal immigration and trans-border smuggling
3. Provide security to sensitive installations and threatened VIPs
4. Restore and preserve order in any area in the event of disturbance
5. to maintain the peace

Presently, battalions of ITBP are deployed on border guard duties from Karakoram Pass in Ladakh to Diphu La in Arunachal Pradesh, covering 3488 km of the India-China border. India is in a wake to construct roads connecting to the Indo China border intended to ease the movement of troops and military hardware in the event of a border conflict. The roads are being developed by BRO which has 73 roads under proposal and CPWD.

In this backdrop, CPWD has created a division for construction and maintenance of the border roads i.e. Border Road Project Division. The Executive Engineer, Border Road Project Division-II, CPWD, Chungthang, North Sikkim on behalf of the President of India the National Highways of the state has sought consultancy services for preparation of Detailed Project Report for construction of High Altitude Roads in the state of Sikkim. As a part of this endeavour, the Authority i.e., Executive Engineer, BRPD-II, CPWD, Chungthang has taken initiative to guide and supervise the consultancy service as well as the construction process.

The road under consideration for the present submission is Toong-Partem-4865-Tamze in the state of Sikkim under the Chungthang BRPD-II, CPWD. The total length of the road is 84.425 kms.

In the above backdrop, BRPD-II, CPWD, Chungthang has appointed M/s S. M. Consultants as consultant for carrying out the feasibility study and preparation of detailed project report of the project highway.

1.2 Project Description

The locations of Toong and Tamze lies in the borders of China and India, in the North Sikkim district and under sub division of Chungtang. The locations are at an altitude of 1325.0 - 4571.0 m and is steep in terrain. The project road commences from Toong (27°32'57.46"N, 88°38'41.35"E) and ends at PT 4865 (27°27'30.66"N, 88°46'15.01"E). The project road totally comes in the North Sikkim District. The locations are snow cladded for most part of the year. The locations of the origin and destination is as shown below:

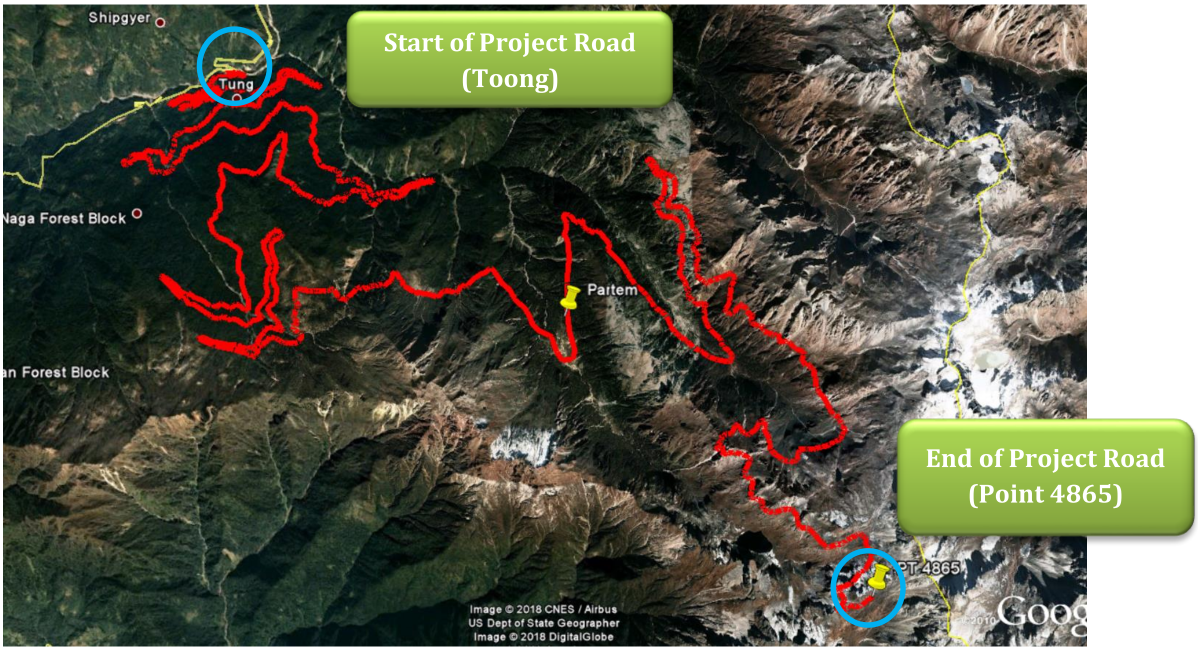


Figure 2: Proposed Project Road

The development of the road will provide scope to mobilise the army platoons and vehicles to the border.

1.3 Commencement

The work for Consultancy services for preparation of detailed project report for additional high altitude roads connecting Toong to Tamze has been awarded to consultants vide letter no.: 54(11)/EE/BRPD-II/2017/106 dated 13.06.2017.

The consultancy service has various systematic steps to prepare the detailed project report of Project Highway. In the first step, the Inception Report with Quality Assurance Plan is submitted to provide an overview of the project site, the mobilisation process to take up the work and the assurance of the work to be carried out for the consultancy service. The second phase includes the feasibility report and the last phase requires submitting the detailed project report.

The following reports have been submitted till date:

1. Inception Report and Quality Assurance Plan
2. Alignment Report

Based on the alignment report satellite imagery of the area was ordered for procurement from NRSC based on the availability.

1.4 Project Objective

The main objectives of the consultancy service will focus on establishing technical, economic and financial viability of the project and prepare detailed project reports for construction of the roads under consideration in high altitudes for the communication of paramilitary forces with the following points to be ensured.

- Check the coordinates of the proposed roads on ground in concurrence of ITBP posts at the particular stations by GPS
- Conduct exercise on Google Earth Pro and provide alternate alignments
- Ground checking of the alignment with respect to its feasibility at site.
- Identify geology of the area and potential landslide prone areas
- Identification of land requirement and the affected properties requiring resettlement and rehabilitation and acquisition of land from forest and private land owners.
- Generate the DEM alignment on the satellite image by internationally accepted and time tested software
- Superimpose the data of Stereo satellite imageries to prepare the ortho-rectified satellite imagery and Dem model including 3D modelling for interpretation of the images
- 3-D model generation in Digital Elevation Model (DEM) at every 15 metre interval and every sharp curve and hairpin bends

- Contour generation at an interval of 2.5 m will be done by the consultant and the spot height at every 1.25 m.
- Conduct aerial Triangulation in the satellite imageries to refine the Exterior Orientation parameters (X, Y, Z.....) computed through direct geo-referencing for each imagery to help in achieving the desired accuracy while generating DTM.
- Submit Geotechnical sustainable solution by appropriate analysis of the engineering parameters
- Preparation of detail L-section sheets for final alignment with 1:2500 horizontal scale and 1:250 vertical scale
- Carrying out Material Investigation
- Carrying out geometric design of the road and structural design of the structures.
- Estimation of quantities and computation of project cost

1.5 Scope of Work

The study includes field works and detailed engineering studies for the construction of the high altitude road to single lane with earthen shoulders. The scope of services as detailed in TOR is as follows:

- Review of all available reports and published information about the project road and the project influence area.
- Authentication of final alignment as fixed by satellite imageries or along available road/existing track by Total Station/DGPS/GPS.
- Alignment has been fixed by using coloured, high resolution, satellite imageries. DPR will be based on satellite imagery alignment authenticated by few ground control points by total station/DGPS.
- Complete route survey and planning including
    - Ground Control and reference stations information.
    - Authenticate the data obtained by satellite imageries with total station and DGPS. 100% satellite imagery data along proposed alignment has to be verified by total station and DGPS at site.
    - Compiling and processing of data electronically, conversion of data to user editable 2D scale maps showing on CAD system that show in detail the route superimposed upon local topography and any other natural or man-made structure and length measurements of proposed route and of other objects may be made by user.
    - Identification of most feasible route with currently gathered data.
    - Preparing scaled accurate construction route drawings

- Delivering final construction drawings along with DPR with accuracy and terms and condition compiled as per subject tender.

- Detailed design of black topping on existing operational track after collecting the available data of vehicular traffic from accounting agency and according to the existing subgrade characteristic and strength against scope of services.
- Detailed design of the structures with detail hydraulic calculation of the bridges.

Carrying out detailed rate analysis, estimate of the quantities and preparation of bill of quantities for tendering purpose.

1.6 Project Appreciation

The Project Road under consideration is Toong-Tamze. The road from Singtam to Chungtang passes on the starting point of the project road near Toong. The Lachung River also flows on valley parallel to the project road but does not cross the road at any point. The project road has negligible human interference but comes under the influence of Toong Village, Kokhir Forest Village, Terse Village, Narem Partem Village and Salera Village. The coordinates of the Toong village as provided by the Client is 27° 32' 45" N, 88° 38' 51" E, Partem (27° 30' 12" N, 88° 46' 36" E), PT 4856 (27° 27' 31" N, 88° 46' 15" E) and the coordinates of the Tamze is 27° 25' 16" N, 88° 46' 36" E.

1.7 Structure of the Report

Volume I: Main Report

Executive Summary

Chapter 1: Introduction

Chapter 2: Satellite Imagery Interpretation

Chapter 2: Project Description and Possible Alignments

Chapter 3: Indicative Design Standards, methodologies and specifications

Chapter 4: Improvement & Engineering Proposals

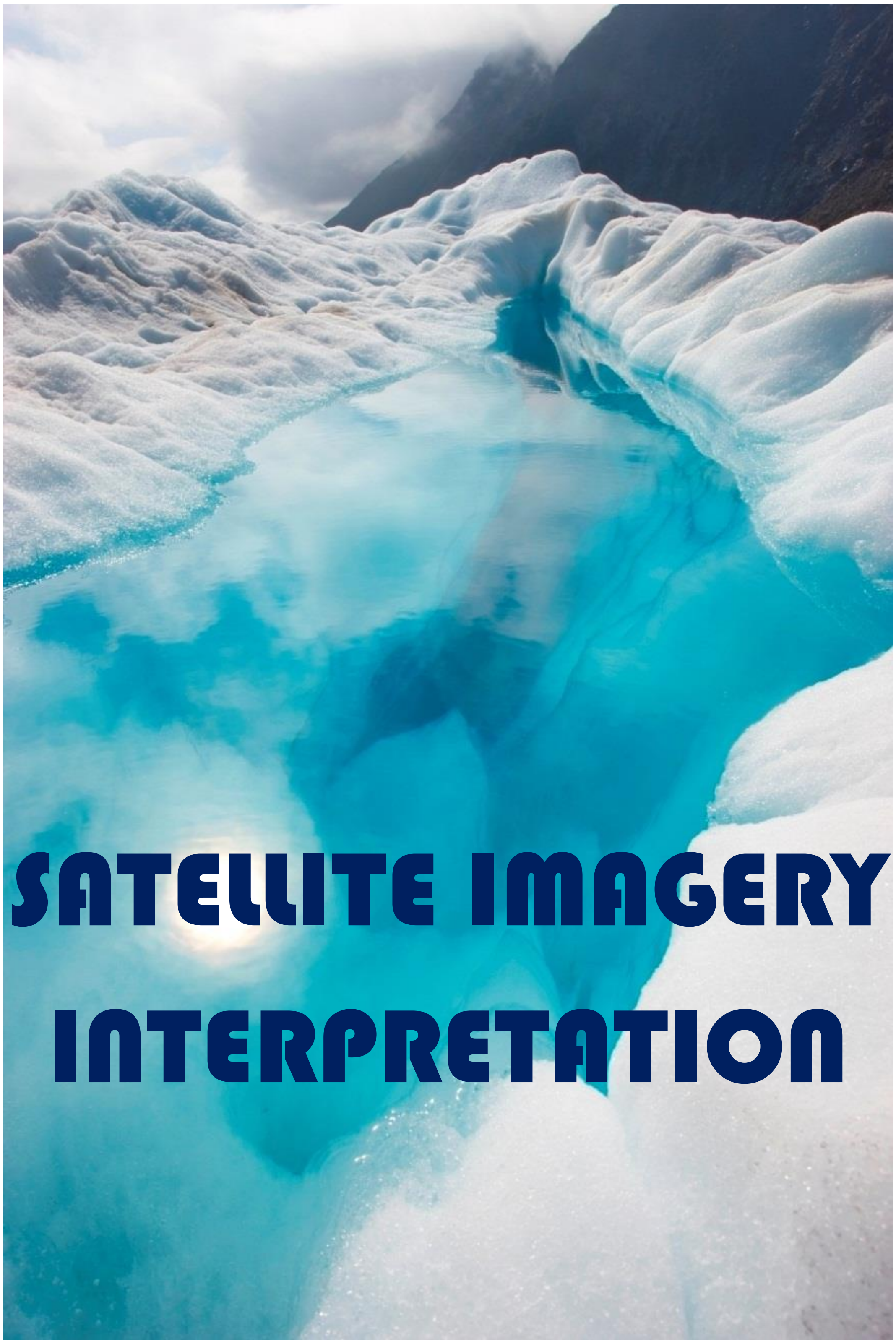
Chapter 5: Protective Measures

Chapter 6: Cost Estimates

Chapter 7: Conclusion

Estimates

Volume II: Drawings


SATELLITE IMAGERY
INTERPRETATION

Chapter 2 Satellite Imagery Interpretation

2.1 General

The Project Road which is Toong-Tamze passes through hilly and steep terrain in the state of Sikkim at high altitude where topographical survey using DGPS and Total Station is quite difficult. To get through with the project road, the only possible way for topographical survey is space images/ satellite images.

2.2 Satellite Image Details

Satellite(s):	GE01,WV02,WV03	**Area of interest**:	Toong-Tamze
Order type:	**Tasking Only**	Image Library	
Product type:		Ortho Ready Standard Stereo	
Product option(s):		Pan+MS1	
Projection:		UTM WGS84 (M)	
DRA:		Off	
Ground sample distance:		0.50 m	
Tiling:		16,384 X 16,384	
Bit depth:		16	
Resampling method:		4 X 4 Cubic Convolution	
Customer framing:		Area	
License type:		Base	
ACOMP:		False	
Polygon (Longitudes-Latitudes):		88.75166997700006,27.41516917300004, 88.82264886800004,27.48890860100005, 88.66790711500005,27.57431475800007, 88.58121373700004,27.529435874000058	

2.2.1 WorldView-2

WorldView-2, launched October 2009, is the first high-resolution 8-band multispectral commercial satellite. Operating at an altitude of 770 km, WorldView-2 provides 46 cm panchromatic resolution and 1.85 m multispectral resolution. WorldView-2 has an average revisit time of 1.1 days and is capable of collecting up to 1 million sq. km of 8-band imagery per day, greatly enhancing Digital Globe's multispectral collection capacity for more rapid and reliable collection. WorldView-2 substantially expands imagery product offerings to all Digital Globe customers.

2.2.1.1 Features

- Very high resolution
- The most spectral diversity commercially available - 4 standard colours: blue, green, red, near-IR1 - 4 new colours: coastal, yellow, red edge, and near-IR2
- Industry-leading geolocation accuracy
- High capacity over a broad range of collection types
- Bi-directional scanning
- Rapid retargeting using Control Moment Gyros (>2x faster than any competitor)
- Direct downlink to customer sites available
- Frequent revisits at high resolution

2.2.1.2 Benefits

- Provides highly detailed imagery for precise map creation, change detection, and in-depth image analysis » Geolocate features to less than 5 m to create maps in remote areas, maximizing the utility of available resources.
- Collects, stores, and downlinks a greater supply of frequently updated global imagery products than competitive systems
- Stereoscopic collection on a single pass, ensures image continuity and consistency of quality
- Provides the ability to perform precise change detection, mapping and analysis at unprecedented resolutions in 8-band multispectral imagery

2.2.2 WorldView-3

WorldView-3 is the industry's first multi-payload, super-spectral, highresolution commercial satellite. Operating at an altitude of 617 km, WorldView-3 provides 31 cm panchromatic resolution, 1.24 m multispectral resolution, 3.7 m short-wave infrared resolution, and 30 m CAVIS resolution. WorldView-3 has an average revisit time of <1 day and is capable of collecting up to 680,000 sq km per day, further enhancing the Digital Globe collection capacity for more rapid and reliable collection.

2.2.2.1 Features & Benefits

- Very high-resolution
- Panchromatic 31 cm
- Visible & near-infrared 1.24 m
- Short-wave infrared 3.7 m ° CAVIS 30 m
- The most spectral diversity commercially available:
  - Panchromatic band
  - 4 standard VNIR colours: blue, green, red, near-IR1

- 4 added VNIR colours: coastal, yellow, red edge, and near-IR2
- 8 SWIR bands: Penetrates haze, fog, smog, dust, and smoke
- 12 CAVIS bands: Maps clouds, ice and snow, corrects for aerosol and water vapour

- Industry-leading geolocation accuracy
- High capacity in various collection modes
- Bi-directional scanning
- Rapid retargeting using Control Moment Gyros (two times faster than any competitor)
- Direct Access tasking from and image transmission to customer sites
- Daily revisits
- Simultaneous, high resolution,
- Super-spectral imagery
- Large area mono and stereoscopic collection eliminates temporal variations
- Precision geolocation possible without ground control points
- Global capacity of 680,000 km sq per day
- New and enhanced applications, including:
  - Mapping
  - Land Classifications
  - Disaster Preparedness/Response
  - Feature Extraction/Change Detection
  - Soil/Vegetative Analysis
  - Geology: Oil & Gas, Mining
  - Environmental Monitoring
  - Bathymetry/Coastal Applications
- Superior haze

2.2.3 GeoEye-1

The GeoEye-1 satellite is equipped with some of the most advanced technology ever used in a commercial remote sensing system. The satellite collects images at .41-meter panchromatic (black-and-white) and 1.65meter multispectral resolution. The satellite can collect up to 350,000 square kilometers of pan-sharpened multispectral imagery per day. This capability is ideal for large-scale mapping projects. GeoEye-1 can revisit any point on Earth once every three days or sooner.

2.2.3.1 Features

- Very high resolution
- Industry-leading geolocation accuracy
- High capacity over a broad range of collection types

- Direct downlink to customer sites available
- Frequent visits at high resolution

2.2.3.2 Benefits

- Provides highly detailed imagery for precise map creation, change detection, and in-depth image analysis
- (Note: imagery must be re-sampled to 50 cm for non-US government customers)
- Geolocate features to less than 5 m to create maps in remote areas, maximizing the utility of available resources
- Collects, stores, and downlinks a greater supply of frequently updated global imagery products than competitive systems
- Stereoscopic collection on a single pass ensure image continuity and consistency

2.3 Approach & Methodology

2.3.1 Stage-1

Finalizing the alternative alignment route

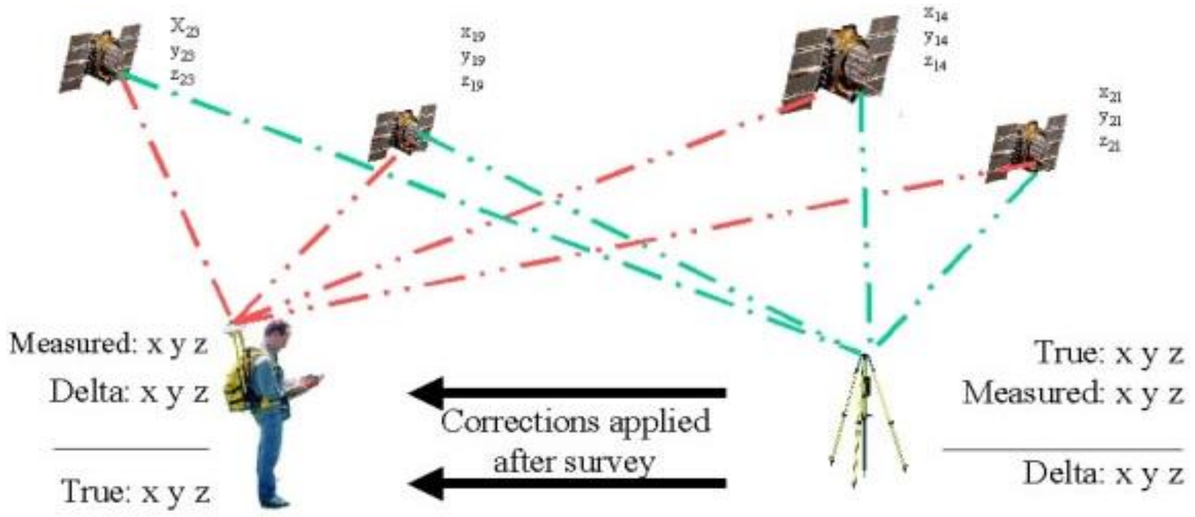
Following methodology has been adopted while finalizing the alignment route:

- Corridor marking in Google Pro.
- Available Elevation database such as SRTM\Google elevation has been used for analysis.
- With the help of imagery from Google and Elevation model, best fit alignment has been marked and further fine-tuned for fitting and analysis in 0.5m resolution coloured satellite imagery.
- After satisfying horizontal specification requirements of appropriate IRC guidelines, vertical design of the same alignment has been finalized on the basis of IRC codes. Three tentative alignment of the road were marked initially.
- Best suited alignment finalized / suggested. Geometric design has been done for best suited alignment.

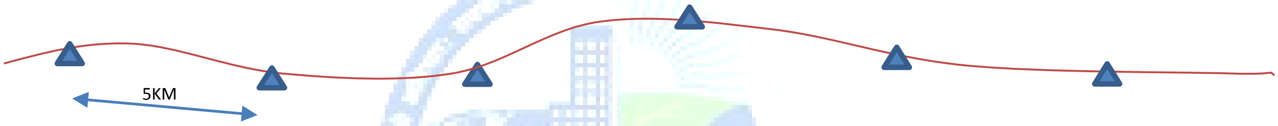
2.3.2 Stage -2

DGPS survey

The Control points planning was done on 0.5 m resolution coloured satellite imagery by indentifying the permanent structure like Bridge location, major culverts or any topographic features which is visible on the imagery and aero-triangulation process. The control points were established on approx. 5 KM distance along the selected alignment using Differential GPS instrument (compatible with L1/L2 & Glonass to achieve “Sub-meter accuracy” of the ground control points).



Control Point Survey Pattern along the alignment:



2.3.3 Stage-3

DEM Generation from High Resolution Data

The original scenes have been resampled according to Epipolar Geometry. The resampled scenes exhibit two main properties. First, conjugate points are located along the same rows. Second, the x-parallax between conjugate points is proportional to the height of the corresponding object point. The following sub-sections briefly discuss the utilization of the normalized imagery for DEM generation. The generation process involves four steps: Primitive extraction, Primitive, matching, Space intersection, and Interpolation.

Primitive Extraction

At this stage, a decision has to be made regarding the primitives to be matched in the normalized scenes. Possible matching primitives include distinct points, linear features, and/or homogeneous regions. Then point features are chosen to extract distinct points from the imagery. The operator identifies points with unique grey value distribution at their vicinity (e.g., corner points and blob centres), thus reducing possible matching ambiguities.

Primitive Matching

The outcome from the interest operator is a list of distinct points in the left and right scenes. The solution to this problem can be realized through defining the location and the size of search space as well as establishing matching criteria for evaluating the degree of similarity between conjugate points.

Space Intersection

Following the matching process, conjugate points undergo an intersection procedure to derive the ground coordinates of the corresponding object points. The parallel projection formulas are used for such computation. For a conjugate pair in the left and right scenes, one can formulate four equations with three unknowns (X, Y, Z - the ground coordinates of the corresponding object point). These coordinates are derived through a least-squares adjustment procedure.

Interpolation

The ground coordinates of matched interest points, which passed the consistency check, are derived through space intersection. These points are irregularly distributed and are not dense enough to represent the object space. Therefore, they need to be interpolated.

2.3.4 Methodology and Flow chart

Once the proper selection is made the stereo pair has to be oriented/ triangulated using sensor parameters and Ground control points to generate orientations In this research work digital photogrammetric techniques has proposed to use for generation of DEM and Contour. A flowchart of methodology for generation of DEM and Contours is shown below.

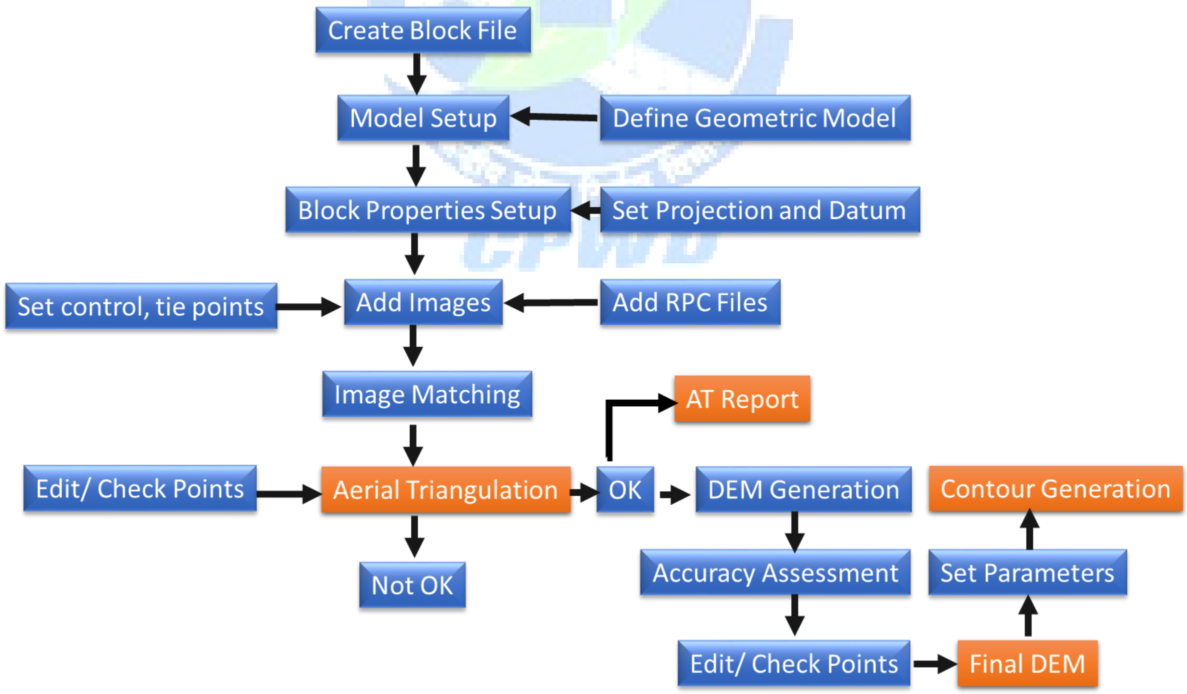


Figure 3: Flow Chart of the Methodology

Figure 4: Flow Chart Generation of DEM and Contour

The Digital Elevation Model is extracted by considering all the stages as shown in the above flow chart. The generated contour and DEM (3D View) is shown in figure below.

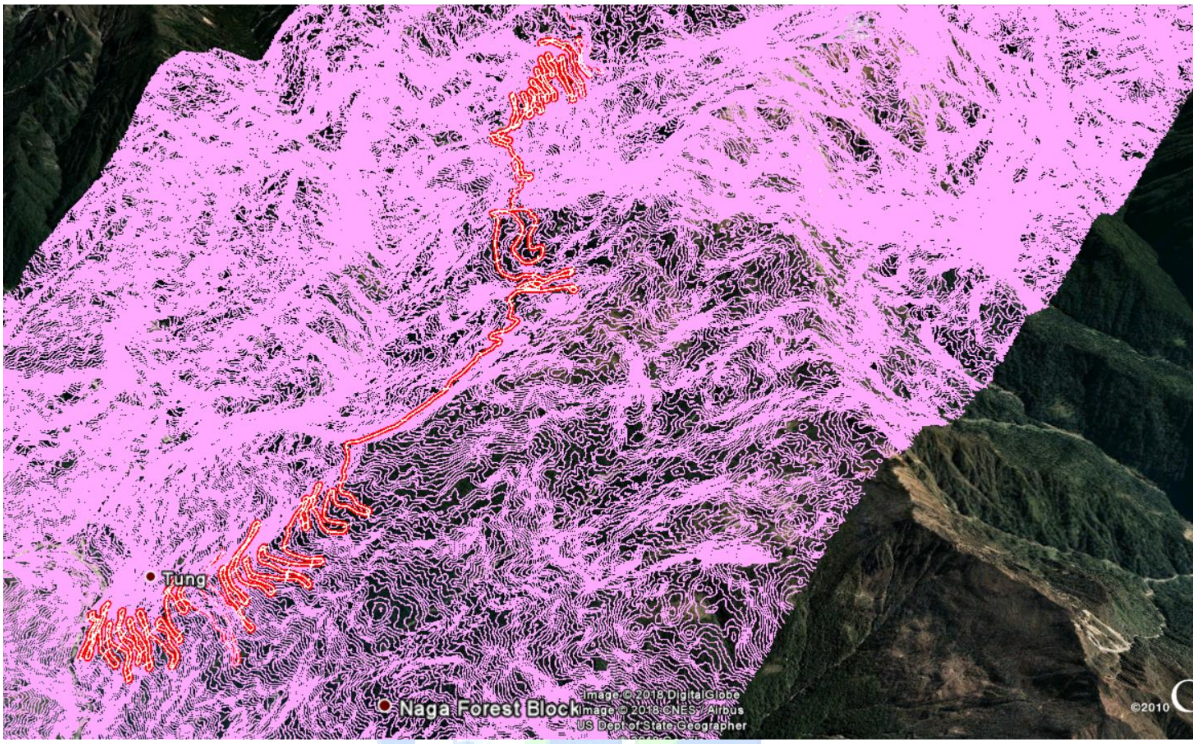


Figure 5: Contour generated for the project road

PROJECT DESCRIPTION AND POSSIBLE ALIGNMENTS

Chapter 3 Project Description and Possible Alignments

3.1 Project Corridor

The Project Roads under consideration starts from Toong and ends at PT 4865 passing hilly and steep terrain in the state of Sikkim. The project highway starts at design chainage of 0/000 km and ends at design chainage 84/425 km in the state of Sikkim. This project road falls in the district of North Sikkim. The project road is of 84.425 km.

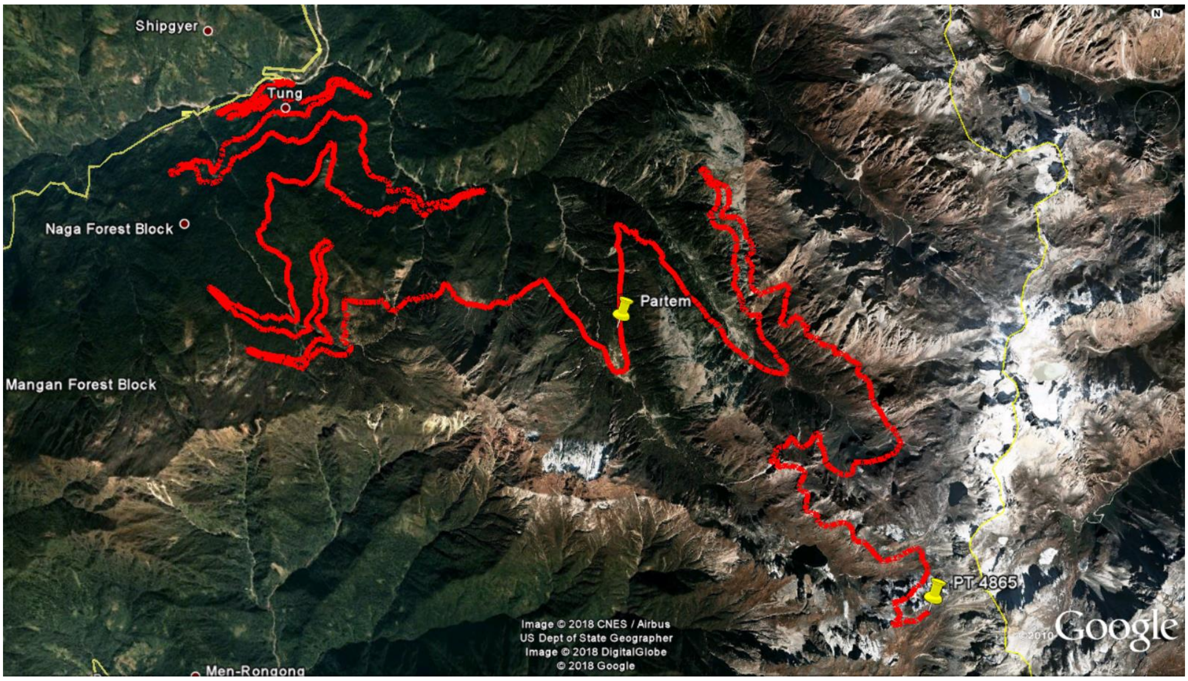


Figure 6: Project Stretch (Toong – PT 4865)

3.1.1 Sikkim

Clean, green and 'all organic' since 2016, Sikkim is mostly a maze of plunging, super-steep valleys thick with lush subtropical woodlands and rhododendron groves, rising in the north to the spectacular white-top peaks of the eastern Himalaya. When clouds clear, an ever-thrilling experience from many a ridge top perch is spotting the world's third-highest mountain, Khangchendzonga (8598m), on the north western dawn horizon. Sikkim is a land that is home to several unique cultures and pristine beauty. Sikkim sets it foot in new cultural believes, carrying forward its thriving traditions from thousands of years. When it comes to the tourist attraction, it lags behind because of boundary conflicts and the condition of the roads.

The project roads come under the influence of North Sikkim District of Sikkim. A brief view of the districts is presented below so that we can overview the effects that the various features of the district are likely to influence the project roads.

3.1.2 North Sikkim District

A land - where haven touches the earth, the ambiance creates mystery, landscape dominated by elements, silence can be heard, vision tends to travel beyond the horizon, soul starts meditating-unknowingly, mind gets rejuvenated; and a land that makes you bow.

North Sikkim is the northern district of Sikkim. Mongan is the district headquarter of the district. At an altitude of 3950 ft. the town is located at a distance of 65 km from Gangtok, the state capital. Tourists need special permits to visit North Sikkim beyond Mangan. The area can be visited only as part of an organized tour.

The road from Mangan goes straight to Chungthang, another major town of North Sikkim. At 5,600 ft. Chungthang is 95 km from Gangtok. From here the road bifurcates. The road to the left goes to Lachen and the road to the right reaches Lachung. Lachen is the base from where tours to Gurudongmar Lake and Chopta valley is organised. Lachung on the other hand is the base for your tours to Yumthang valley.

Landscape changes rapidly on every curve, as your road winds upwards. With thick smell of wild flowers, mossy trees, streams rushing down, mists coiling up from the deep gorges, sudden flashy flight of colourful birds, huge snow range embossed in the horizon, wide spread valley, deep blue sky, lonely prayer flag waving leisurely at the distant top - you are on your way to a different destination.

Tourism in the region is at a nascent stage and guests may not get the same level of service in North-Sikkim as they would in other parts of the region.

Table 4: DISTRICT PROFILE OF NORTH SIKKIM DISTRICT

Geographical area	:	**4,226 km^2 (1,632 sq mi)**
Population(Census 2011)	:	
Total		43,354
Density		10/km^2 (27/sq mi)
District Head quarter	:	Mongan
Latitude	:	27° 31’N
Longitude	:	88° 32’N
Altitude	:	610 m above MSL
Climate	:	Cold Deserts
Annual Rainfall	:	5000 mm
Temperature	:	25^o C to -40^o C (average)

- **Soil:**

The geography of Sikkim is characterized by a vast array of magniloquent knolls that extends from one nook of the state to the other. Amongst all the stupendous hammocks that span across the entire terrain of Sikkim, Kanchenjunga is recorded to be the highest. The terrain that forms an exceedingly important portion of geography in Sikkim is most obviously not as fertile as most would imagine it to be. The main reason that lies behind this abnormality is the fact that there is an abundance of extremely rocky and precipitous slopes which present a tough look to the landscape.

- **Climate & Rainfall:**

Temperature conditions vary from sub-tropical in the southern lower parts to cold deserts in the snowy north. It is also the most humid region in the whole range of the Himalayas, because of its proximity to the Bay of Bengal and direct exposure to Southern monsoon.

Rainfall is heavy and well distributed during the months from May to early October. July is the wettest month in most of the places. The intensity of rainfall during South-West monsoon season decreases from south to North, while the distribution of winter rainfall is in the opposite order. The highest annual rainfall for the individual station may exceed 5000 mm. and average number of rainy days (days with rain of 2.5 mm. or more) ranges from 100 at Thangu in north Sikkim to 184 at Gangtok in east Sikkim.
Fog is a common feature in the entire state from May to September.
Biting cold is experienced at higher altitudes of 10,000 ft plus. The temperature rarely rises above 15 degree centigrade and heavy snowfall occurs during the winter months. Some also receive snowfall during April or mid-November.

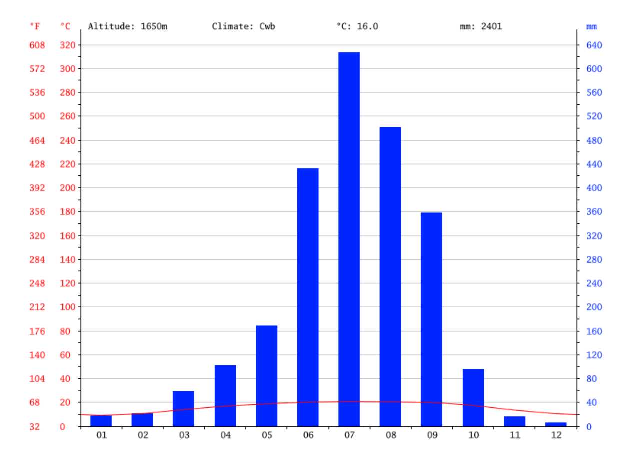


Figure 7: Climate Graph of Chungthang

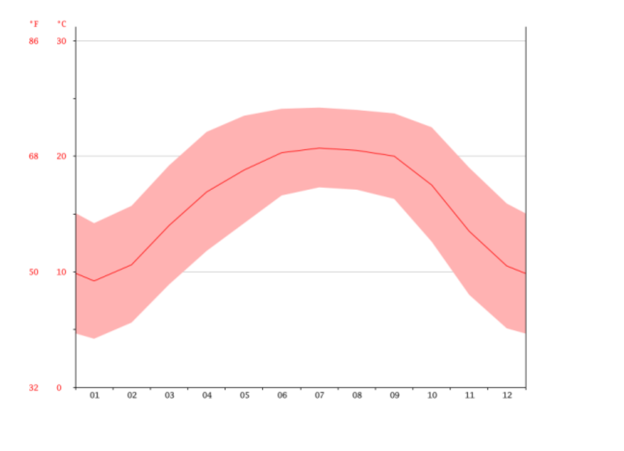


Figure 8: Climate Graph of Chungthang

- **River:**

Another feature possessed by the Sikkim geography is that a vast number of streams that sped across the terrain of Sikkim gave rise to many exquisite river valleys. The water that runs through most of these streams are generally procured by the snow that crowns the stupendous mountains. These newly formed river valleys are confined to the southern and western fringe of the state. The most famous lakes that are found here include Gurudongmar, Tsongmo and Khecheopalri Lake and many more.

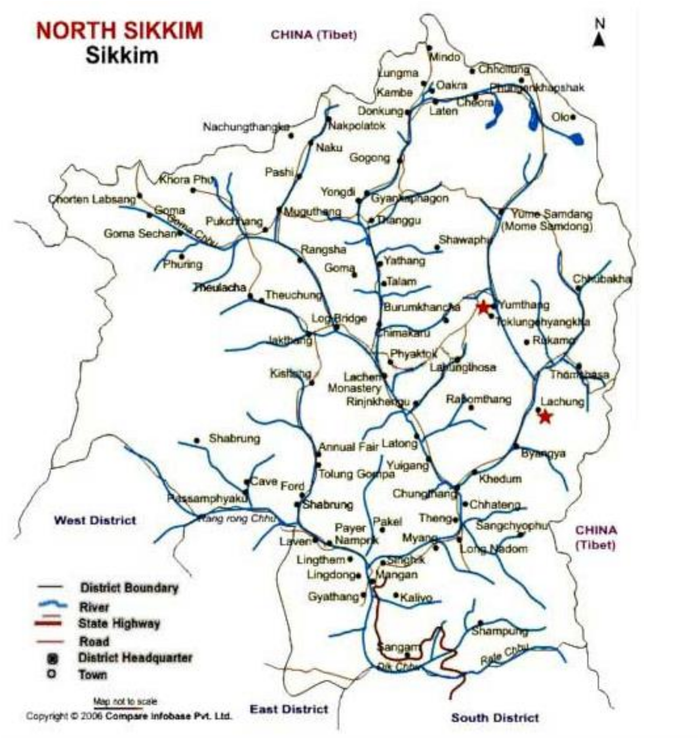
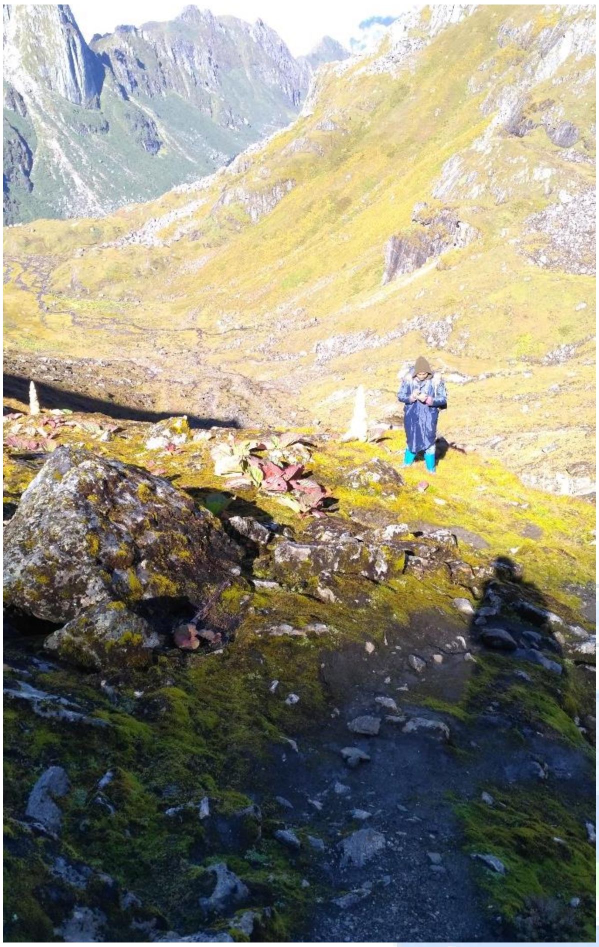
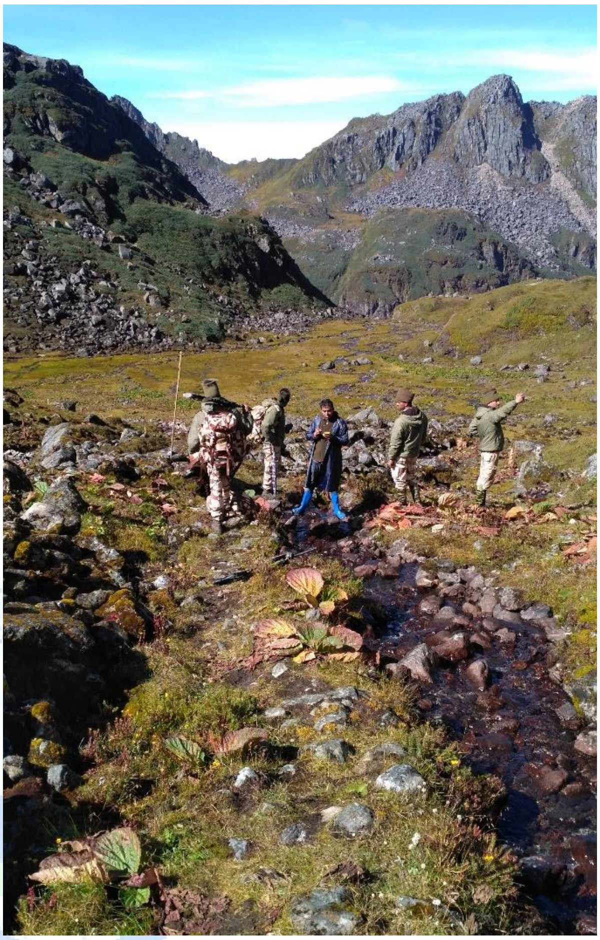


Figure 9: Rivers flowing in North Sikkim





3.2 Details of Villages and Towns

The road does not pass through any settlement. However the project road comes under the influence of few villages like Toong, Kokhir Village, Terse Village, Narem Partem, Salera village and Partem village. The starting section is well known as Toong. The project stretch is under security zone which is only to be used by ITBP personnel. ITBP Camp is found at PT 4865.

3.3 Terrain and Landuse

The terrain along the entire project road is hilly and steep type. The land use pattern along the project corridor is majorly forest.

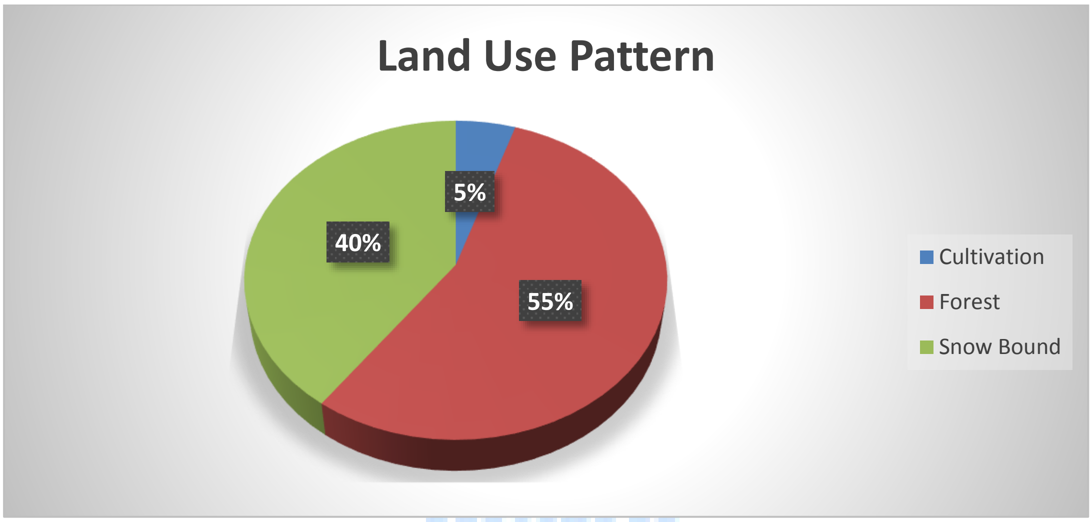


Figure 10: Land-use Pattern of Project Road

Table 5: DETAILS OF TERRAIN & LAND USE PATTERN FOR ROAD

TERRAIN AND LAND USE PATTERN				
Sl. No.	**Chainages (km)**		**Terrain (Plain/ Rolling/ Hilly)**	**Land use (Built up/ Agrt/ Forest/ Industrial/ Barren)**
	From (km)	**To (km)**		
1	0.000	1.000	H	Forest
2	1.000	2.000	H	Cultivation
3	2.000	3.000	H	Cultivation
4	3.000	4.000	H	Forest
5	4.000	5.000	H	Forest
6	5.000	6.000	H	Forest
7	6.000	7.000	H	Forest
8	7.000	8.000	H	Forest
9	8.000	9.000	H	Forest

TERRAIN AND LAND USE PATTERN

Sl. No.	Chainages (km)		Terrain (Plain/ Rolling/ Hilly)	Land use (Built up/ Agrt/ Forest/ Industrial/ Barren)
	From (km)	To (km)		
10	9.000	10.000	H	Forest
11	10.000	11.000	H	Forest
12	11.000	12.000	H	Forest
13	12.000	13.000	H	Forest
14	13.000	14.000	H	Forest
15	14.000	15.000	H	Forest
16	15.000	16.000	H	Forest
17	16.000	17.000	H	Forest
18	17.000	18.000	H	Forest
19	18.000	19.000	H	Forest
20	19.000	20.000	H	Forest
21	20.000	21.000	H	Forest
22	21.000	22.000	H	Forest
23	22.000	23.000	H	Forest
24	23.000	24.000	H	Forest
25	24.000	25.000	H	Forest
26	25.000	26.000	H	Forest
27	26.000	27.000	H	Forest
28	27.000	28.000	H	Forest
29	28.000	29.000	H	Forest
30	29.000	30.000	H	Forest
31	30.000	31.000	H	Forest
32	31.000	32.000	H	Forest
33	32.000	33.000	H	Forest
34	33.000	34.000	H	Forest
35	34.000	35.000	H	Forest
36	35.000	36.000	H	Forest
37	36.000	37.000	H	Forest
38	37.000	38.000	H	Forest
39	38.000	39.000	H	Forest
40	39.000	40.000	H	Forest
41	40.000	41.000	H	Forest
42	41.000	42.000	H	Forest

TERRAIN AND LAND USE PATTERN

Sl. No.	Chainages (km)		Terrain (Plain/ Rolling/ Hilly)	Land use (Built up/ Agrt/ Forest/ Industrial/ Barren)
	From (km)	To (km)		
43	42.000	43.000	H	Forest
44	43.000	44.000	H	Forest
45	44.000	45.000	H	Forest
46	45.000	46.000	H	Forest
47	46.000	47.000	H	Forest
48	47.000	48.000	H	Forest
49	48.000	49.000	H	Forest
50	49.000	50.000	H	Forest
51	50.000	51.000	H	Forest
52	51.000	52.000	H	Forest
53	52.000	53.000	H	Snow Bound
54	53.000	54.000	H	Snow Bound
55	54.000	55.000	H	Snow Bound
56	55.000	56.000	H	Snow Bound
57	56.000	57.000	H	Snow Bound
58	57.000	58.000	H	Snow Bound
59	56.000	57.000	H	Snow Bound
60	57.000	58.000	H	Snow Bound
61	58.000	59.000	H	Snow Bound
62	59.000	60.000	H	Snow Bound
63	60.000	61.000	H	Snow Bound
64	61.000	62.000	H	Forest
65	62.000	63.000	H	Snow Bound
66	63.000	64.000	H	Snow Bound
67	64.000	65.000	H	Snow Bound
68	65.000	66.000	H	Snow Bound
69	66.000	67.000	H	Snow Bound
70	67.000	68.000	H	Snow Bound
71	68.000	69.000	H	Snow Bound
72	69.000	70.000	H	Forest
73	70.000	71.000	H	Forest
74	71.000	72.000	H	Forest
75	72.000	73.000	H	Forest

TERRAIN AND LAND USE PATTERN

Sl. No.	Chainages (km)		Terrain (Plain/ Rolling/ Hilly)	Land use (Built up/ Agrt/ Forest/ Industrial/ Barren)
	From (km)	To (km)		
76	73.000	74.000	H	Forest
77	74.000	75.000	H	Forest
78	75.000	76.000	H	Forest
79	76.000	77.000	H	Forest
80	77.000	78.000	H	Snow Bound
81	78.000	79.000	H	Snow Bound
82	79.000	80.000	H	Snow Bound
83	80.000	81.000	H	Snow Bound
84	81.000	82.000	H	Snow Bound
85	82.000	83.000	H	Snow Bound
86	83.000	84.000	H	Snow Bound
87	84.000	84.425	H	Snow Bound

3.4 Carriageway and Formation Width

The project road is proposed to be configured to single lane. Pathway of 1 m width is available at some locations.

Figure 11: Existing foot tracks

3.5 Junctions

The project road commence on Chungthng-setam road with a junction

Figure 12: Junction at start of the Project Road

3.6 Landslide Regions

The area comes under high earthquake zone. Landslides are usual in this area. Necessary protection works like breast wall, retaining wall, guard wall, gabions will be proposed for the project stretch to project the proposed road from damage due to cutting for accommodating the road.

3.7 Bridges & CD Structures

The project road falls traverses on a single mountain with many ridges. So, it is observed that the project stretch has many steam crossings. These are needed to be provided with cross drainage structures to avoid landslides in these regions and allow free passage of water across the road.

INDICATIVE DESIGN STANDARDS, METHODOLOGIES AND SPECIFICATION

Chapter 4 Indicative Design Standards, Methodologies and Specifications

4.1 Design Philosophy

The proposed new project road, having formation width of about 10m, includes construction of pavement work for the entire length, construction of culverts and permanent works at essential places construction of pucca side drains throughout stretches, construction of protective structures, provision for slope protection works and installation of traffic/informatory sign and Kilometer stones.

The project road will have single-lane carriageway facility. The design philosophy that will be followed embodies the following:

- ✓ The facility should be of Hill Road Standards
- ✓ The facility must meet the needs for mobility of army vehicles and troops
- ✓ Travel should be safe, with in-built engineering features
- ✓ The facility should be aesthetically pleasing and should not be visually intrusive
- ✓ The facility should meet the environmental conditions

Design Standards for the hill road requirements have been framed for providing the desirable level of service and safety. For this Project it is proposed to follow Design Standards given in IRC Standards, Codes, Guidelines and Special Publications besides MORT&H circulars and specifications as applicable to National Highways.

4.2 Geometric Design Standards

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

- IRC: 73-1980 shall be generally followed.
- IRC: SP: 19-2001: Manual for survey, investigations and preparation of road projects.
- IRC: 52: Recommendations about the Alignment survey and Geometric Design of Hill
- Roads (Second Revision).
- IRC-SP-48-1998: Hill Road Manual

4.2.1 Altitude of the road

Altitude of the Project Road lies between 1339.0 m to 4617.0 m above the MSL

3.2.1.1 Terrain Classification:

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

Table 6: Terrain Classification

Terrain Classification	Percent Cross Slope of Country
Plain	0 to 10
Rolling	>10 upto 25
Mountainous	>25 upto 60
Steep	>60

The project road corridor is in mountainous and steep terrain.

4.2.2 Design Speed

The design speed for various categories of roads is given in Table below.

Table 7: DESIGN SPEED (KM/HR)

Road Classification	Mountainous		Steep	
	Ruling	**Min**	**Ruling**	**Min**
NH & SH	50	40	40	30
MDR	40	30	30	20
ODR	30	25	25	20
VR	25	20	25	20

As generally, ruling design speed should be the guiding criteria for correlating the various geometric standards. Where, site conditions, or economic considerations do not permit the ruling design speed, the design speed shall be reduced to the maximum possible. If changes in the design speed prove unavoidable, such changes will be introduced gradually by means of successive sections of increasing/decreasing design speed so that road user becomes progressively conditioned to the changes. The need for warning signs will also be considered wherever reductions in design speed are unavoidable.

4.2.3 Sight Distance

It is necessary that sight distance of sufficient length is available to permit drivers enough time and distance to control their vehicles to avoid accidents for safety on roads.

Two types of sight distances are considered in design of hill roads which are:

- Stopping sight distance which is the clear distance ahead needed by a driver to see, analyse, and react on seeing an obstacle.
- Intermediate sight distance

The values of both sight distances and criteria for measurement are given in tables below.

Table 8: STOPPING AND INTERMEDIATE SIGHT DISTANCE

SPEED	DESIGN VALUES- METERS	
	STOPPING SIGHT DISTANCE	INTERMEDIATE SIGHT DISTANCE
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120

Table 9: CRITERIA TO MEASURE SIGHT DISTANCE

SL. NO.	SIGHT DISTANCE	DRIVER'S EYE HEIGHT	HEIGHT OF OBJECT
1	Safe Stopping Distance	1.2m	0.15m
2	Intermediate Sight Distance	1.2m	1.2m

The stopping sight distance is the absolute minimum in case of hill rods and shall be ensured regardless of any considerations while designing the road. However, intermediate sight distance shall be tried to achieve while designing the road geometries.

Overtaking sight distance shall be considered for the road stretches in plain terrain and hilly terrain.

4.2.4 Cross sectional elements and proposed configuration:

Guidelines for geometric standards for various types of road categories are followed as per IRC SP 48. A minimum width of 3.75 m width has been planned for development of the road as per Terms of reference with shoulder width of 1.25 m on both sides.

Table 10: WIDTHS OF CARRIAGEWAY AND SHOULDER

ROAD CLASSIFICATION		CARRIAGEWAY	SHOULDER	ROADWAY
National and State Highway	i. Single Lane	3.75	2x1.25	6.25
	ii. Two lane	7.00	2x0.9	8.8
Major District Road and Other District Road		3.75	2x0.5	4.75

ROAD CLASSIFICATION	CARRIAGEWAY	SHOULDER	ROADWAY
Village Road	3.00	2x0.5	4.00

There is no existing ROW along the project road. The width of proposed ROW 18 m as per army department norms. However, for improvement of junctions, relocation, etc., design will be as per functional requirement. Additional land acquisition shall be kept to the minimum for these areas

- Roadway Details
- Total Road Width

Total roadway width shall be 9.00 m (Including the drain and protective structures width.

4.2.4.1 Carriageway Width

The project road shall be designed as single lane carriageway. The width of lane shall be 3.75 m.

4.2.4.2 Shoulder

By the side of the carriageway there shall be 1.25 m of earthen shoulder on both side.

4.2.4.3 Camber

Camber cross fall on straight sections shall be

- 3 to 4 percent for earth roads
- 2.5 to 3 percent for gravel or WBM surface
- 2 to 2.5 percent for thin bituminous surfacing
- 1.7 to 2 percent for high type bituminous surfacing

Cross falls would be 2.5% for the bituminous concrete carriageways and 3 % for shoulders. Steeper gradients are provided as the roads lie in high intensity rainfall. As the provision of cross fall and super elevation tend to oppose each other in re- entrants and drainage gets affected, appropriate transition and drainage arrangements shall be made.

4.2.5 Horizontal Alignment

Uniformity of design standards is one of the essential requirements of any road alignment .In any given section, there must be consistent application of design criteria to avoid creation of unexpected situations for the drivers. As a general rule, the horizontal alignment should be fluent and blend well with the surrounding topography. The alignment shall be co-ordinated carefully with the longitudinal profile. Breaks in alignment at cross drainage structures and sharp curves at the end of long tangents/straight sections shall be avoided. Short curves, reserve curves, broken back curves, compound curves etc. shall be avoided. The horizontal curves for this project will be designed in accordance with the requirements stipulated in IRC: 38 (Design Table for

Horizontal curves for highways) and each curve will consist of a circular arc with spiral transitions between the arc and the straights.

The spiral transitions ensure that vehicles progress smoothly from the straight to the circular curve or between curves of different bend or radius. The transition curves also facilitate the gradual application of super-elevation and any widening of the carriageway, which may be required for the horizontal curves.

Super-elevation is required to be provided at horizontal curves to counter the effects of centrifugal force and is calculated from the formula:-

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

Where;

e = super-elevation in meter per meter width of roadway

V = Speed of vehicle in km/hr

R = radius of curve in meters

The super-elevation applied to the curves will be limited to 7%.

Table 11: RADII BEYOND WHICH SUPER-ELEVATION IS REQUIRED

Design Speed (km/h)	Radii (meters) for camber of				
	4%	3%	2.5%	2%	1.7%
20	50	60	70	90	100
25	70	90	110	140	150
30	100	130	160	200	240
35	140	180	220	270	320
40	180	240	280	350	420
50	280	370	450	550	650

On a horizontal curve, the centrifugal force is balanced by the combined effect of super-elevation and side friction. The minimum radius for horizontal curves is as tabulated below.

Table 12: MINIMUM RADII OF HORIZONTAL CURVE

ROAD CLASSIFICATION	MOUNTAINOUS TERRAIN		STEEP TERRAIN	
	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)
National and State Highway	80	50	50	30

Major District Roads	50	30	30	14
Other District Roads	30	20	20	14
Village Roads	20	14	20	14

Minimum length of the transition curves shall be provided as per formula stipulated in IRC SP 48.

Curve Radius (m)	**Design Speed**				
	50	**40**	**30**	**25**	**20**
15				NA	30
20				35	20
25			NA	25	15
30			30	25	15
40		NA	25	20	15
50		40	20	15	15
55		40	20	15	15
70	NA	30	15	15	15
80	55	25	15	15	NR
90	45	25	15	15	
100	45	20	15	15	
125	35	15	15	NR	
150	30	15	15		
170	25	15	NR		
200	20	15			
300	15	NR			
400	15				
500	NR				

Widening of curves: At sharp horizontal curves it is necessary to widen the carriageway to facilitate smooth passage of vehicles. The widening has two components namely mechanical widening and psychological widening. In our case as the proposal is for single lane road, mechanical widening shall be taken care of. However, at blind curves single laning may be considered.

Table 13: WIDENING OF PAVEMENTS AT CURVES

RADIUS OF CURVE (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
Single-Lane	0.9	0.6	0.6	Nil	Nil	Nil

4.2.6 Vertical Alignment

Parabolic vertical curves shall be provided at all changes in grade except where the change is 0.5% or less. The recommended gradients for different terrain conditions except at hair pin bends are as given in below.

Table 14: RECOMMENDED GRADIENTS

CLASSIFICATION OF GRADIENTS	MOUNTAINOUS TERRAIN AND STEEP TERRAIN MORE THAN 3000 M ABOVE MSL	STEEP TERRAIN UPTO 3000 M HEIGHT ABOVE MSL
Ruling Gradient	5% (1 in 20)	6% (1 in 16.7)
Limiting Gradient	6% (1 in 16.7)	7% (1 in 14.3)
Exceptional Gradient	7% (1 in 14.3)	8% (1 in 12.5)

Gradients up to the ruling gradient shall be used as a matter of course of design.

The limiting gradients may be used where the topography of the place compels but the length shall not exceed 100 m at a stretch. Each successive strength of limiting gradient shall be separated by a 100 m smooth gradient.

At horizontal curves, the gradients shall be eased by an amount known as grade compensation which is intended to offset the extra tractive effort at curves.

Vertical curves are introduced for smooth transition at grade changes. The minimum lengths of vertical curves are as provided in Table 17.

Table 15: MINIMUM LENGTHS OF VERTICAL CURVES

DESIGN SPEED (KM/H)	MAXIMUM GRADE (PERCENT) CHANGE NOT REQUIRING A VERTICAL CURVE	MINIMUM LENGTH OF VERTICAL CURVE (M)
Up to 30	1.5	15
40	1.2	20
50	1.0	30

4.2.7 Drawings

Plans and profile at a scale of 1:2500 horizontally and 1:250 vertically showing all the information necessary for setting out and construction of the alignment will be produced.

Cross sections showing the proposed carriageways, earthworks and existing ground level between the ROW boundaries have been prepared at 100 m intervals or such other reduced intervals as may be appropriate to take account of irregularities in the terrain and at the start and end points of the transition and circular curves.

4.2.8 Hair pin bends

Hair pin bends where unavoidable, may be designed either as a circular curve with transition at each end or as a compound circular curve. The following criteria shall be followed for the design:

- Minimum design speed 20 km/hr
- Minimum roadway width at apex 6.5 m
- Minimum radius for the inner curve 14 m
- Minimum length of transition curve 15 m
- Gradient maximum 1 in 40
- Gradient minimum 1 in 200
- Super elevation 1 in 10

4.3 Right Of Way (RoW)

The desirable Right of Way for the project road as per IRC SP: 48 is tabulated below. Objective of the study is to carry out the improvement within the available RoW. However if L.A is required as per the approved cross section and the site requirement.

TABLE 16: CODAL PROVISION FOR ROW

Sl. No.	Road Classification	Open Areas		Built-up Areas	
		Normal	Exceptional	Normal	Exceptional
1	NH & SH	24	18	20	18
2	MDR	18	15	15	12
3	ODR	15	12	12	9

4.4 Bridge & Drainage Structure

The design of bridges and cross drainage structures will be done as per IRC: 13:2004 and Hill Road Manual. The profile of the bridges shall be kept straight as far as possible.

4.5 Road Safety Measures

Following Guidelines will be followed:

- IRC SP 44 - 1994: Highway Safety Code.

- IRC 79 - 1981: Recommended Practice for Road Delineators.

Among others, the following measures will be considered for ensuring safety: -

- Segregation of traffic;
- Restriction / specific lane for slow moving heavy commercial vehicles;
- Protection measures like guard walls and crash barriers shall be planned along the road
- Appropriate delineators, roadway indicators, hazard / object markers with reflectors, road markings, traffic signals, barricades, left side refuge, passage in median for police and fire brigades, and intersection channelization
- The safety measures also include Metal Beam crash Barriers for protection of road users from falling into deep valley

These include Signage, Road Signs / Hoardings, Road Markings, Traffic Signals and Lighting for interchanges, and raised carriageway, long bridges and urban and populated areas.

(a) Signage

- For safety and guidance of a driver, proper signage and delineators are critical. Signage drawings will show guide signs and regulating signs at appropriate locations. The signs will be of reflector type to be easily visible in the dark.
- Guide signs at major junctions will be illuminate type and mounted to be visible; lettering size and location of signposts will be for the design speed and clear visibility. Reflectors will be used so that lanes are visible at night time and different reflectors for median and lane striping will be proposed to properly guide opposite traffic, and markings to indicate safe distance between vehicles at different speeds.

(b) Road Signs

- All road signs shall be in conformity with the provision of IRC SP 32 - 1992 New Traffic Signs and IRC 67 - 1977 Code of Practice for Road Signs. The signs are Mandatory / Regulatory, Cautionary / Warning and Informatory.
- The bottom of the housing of a signal face will be 2500mm above footpath when not suspended over roadway or 5500mm above pavement grade at CL when suspended over roadway.

(c) Road Marking

The road markings will be in conformity with the IRC Standards (latest versions):

- IRC 35-1997: Code of Practice for Road Markings with Paint;

- IRC 30-1968: Standard Letters and Numerals of Different Heights Use in Highway Signs and
- IRC 31-1969: Route Marker Signs for State Roads

Hot applied thermoplastic paints will be proposed for better visibility at night and longer service life.

4.6 Road-Side Drains

The project road consists of two different roads and of different terrain type. So, the drainage system shall be planned keeping in mind the terrain type and the land use pattern of the road. The project road of Toong-Partem-PT 4865 comes under hilly and steep terrain. Road side drains shall comply with IRC: SP: 48-1998 which should be generally uniform throughout the section irrespective of the location of road on the hill slope. Roadside drains are constructed to parabolic (Saucer shape), trapezoidal, triangular, V-Shape, kerb and channel or U-shaped cross-sections. The parabolic section is hydraulically the best and most erosion resistant.

Generally drains are made of size 60 cm x 60 cm and should have a gradient of 1:20 to 1:25 to develop self-cleansing velocity to disperse floating debris conveniently. Other units and features are to be in accordance with codal provisions.

4.7 Geotechnical Design

4.7.1 arth Embankment

i. The fill material, compaction and other requirements shall conform to IRC: 36-1970 where these specifications are in variance with the MORT&H specifications, the later shall govern and accordingly followed
ii. Side slope of 2:1 is provided

Side Slopes Formation in Cutting

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

Table 17: Side Slope in Cutting

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

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

4.8 Design of Pavement

The road shall be studied and analysed with respect to site conditions to determine the type of pavement required.

The flexible pavement for the project road has been designed to serve for the life of 15 years with routine maintenance and periodic strengthening. Flexible pavements for the single lane carriageway have been designed for the traffic homogeneous sections. IRC: 37-2012 guidelines have been primarily used for the design of flexible pavement.

4.9 Design of Bridge/ Structures

Design standards have been clearly identified and enumerated for evolving a comprehensive design philosophy, which covers all aspects of design for various parts of the bridges/structures viz. superstructure, substructure, Foundations, protection works and repair and rehabilitation. The design philosophy is primarily based on relevant IRC codes of practice (prescribed for design, execution, maintenance and safety during construction and service), IRC special publications, latest guidelines and circulars of MORT&H and relevant Bureau of Indian standards, (BIS). For aspects not covered by IRC and BIS Standards, relevant recommendations of the international standards or sound engineering practices have been followed.

The design philosophy includes the following but not to be limited to this:-

- Materials – concrete, steel etc.
- Live loads
- Width of carriageway and number of lanes
- Design speed
- Requirement of footpaths
- Temperature gradient and climatic data
- Wind effect
- Seismic effect
- Safe bearing capacity and soil parameters
- Differential settlement
- Methodology for analysis and design
- Bearings, expansion joints and wearing coat
- Construction techniques
- Protection works
- Repair / rehabilitation techniques

Based on inventory, GADs for bridges and other structures will be prepared. GADs shows salient features of the structures such as overall length, span arrangement, carriageway width, deck level, foundation level, type of superstructure, substructure and foundations; bearings, expansion joints, return walls, ground levels, HFL,LWL, vertical clearance, design loading, cross and longitudinal profile etc. and will be submitted to CPWD, Sikkim authorities for approval. The bridges shall be developed as double lane at the time when the road shall be developed as single lane as it is easier to widen the roads in future but widening of bridges is difficult.

4.10 Methodologies and Specifications

The work will be executed as per MORT&H Specifications for Road & Bridge Works 5th Revision 2013

IMPROVEMENT & ENGINEERING PROPOSALS

CHAPTER 5 Improvement & Engineering Proposals

5.1 General

This chapter deals with detailed design of various elements of project road, based on the findings of survey and investigations and design standards in the preceding chapters. The proposals include provision for the major items as given in Table.

Table 18: PROJECT PROPOSALS-MAJOR ITEM

Sl. No.	ITEM
1	Site Clearance
2	Earthwork
3	Pavement Works
4	Slope Protection Works
5	Culverts
6	Bridges
7	Miscellaneous Works
8	Facilities for Engineers
9	Provision for land Acquisition & Forest Clearance

5.2 Traffic

The design consideration has been based on future traffic which is expected to be the para military forces patrolling to the LOC of Indo-China Border. The maximum axle load of an Army Vehicle is 20, 000 lbs. So, considering the army vehicles to be traversing the project road 5 msa traffic is considered for designing the road.

5.3 Soil Parameters

The soil in the project stretch is found to be gravelly type containing rock pieces. The soil composition and property of the soils are presented below:

Table 19: SOIL PROPERTIES OF THE PROJECT STRETCH

Sl. No.	Soil sample collected at Chainage	Grain size analysis					Atterberg's Limits in %			Proctor Compaction		California bearing ratio test (Remoulded at MDD and OMC)				
		Fine Gravel In % (20mm To 4.75mm)	Coarse Sand In % (4.75mm To 2.00 mm)	Medium Sand In % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075 mm)	Silt & Clay in % (0.075mm To 0.001mm)	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %	Max .Dry Density in gm/cc	Optimum Moisture Content in %	C.B.R Unsoaked in %	C.B.R Soaked for 4dayss in %	Moisture content after 4 days Soaking in %	DFS in %	Group of soil as per IS 1498 – 1970
1	Sample-1	10.35	15.91	22.38	20.52	30.84	29	17	12	1.982	9.8	18.6	10.4	12.6	0	SC
2	Sample-2	12.71	14.73	20.18	19.63	32.75	30	18	12	1.987	9.7	18.9	10.7	12.8	0	SC
3	Sample-3	11.48	13.72	21.49	23.49	29.82	29	17	12	1.985	9.5	18.8	10.6	12.5	0	SC
4	Sample-4	10.97	14.86	23.49	19.89	30.79	29	17	12	1.983	9.8	18.5	10.3	12.6	0	SC

From the laboratory experiment, the CBR is computed to be 10.12. Moisture content is seen to be high to the climatic and terrain condition. The soil in the project stretch is found to be clayey gravel type.

5.4 Pavement Alternatives

Various alternatives are taken into consideration and evaluated for the project road construction. The alternatives considered are as follows:

1. Flexible Pavement
2. Flexible Pavement with High Viscous grade Bitumen
3. Rigid Pavement
4. Paver Blocks

5.4.1 Flexible Pavement

Bitumen has been widely used in the construction of flexible pavements for a long time. This is the most convenient and simple type of construction.

In hilly areas, due to sub zero temperature, the freeze thaw and heave cycle takes place. Due to freezing and melting of ice in bituminous voids, volume expansion and contraction occur. This leads to pavements failure. So, considering the climatic condition of the project location VG 10 grade bitumen is suggested for the road construction.

5.4.2 Flexible Pavement with High Viscous grade Bitumen

Certain additives or blend of additives called as bitumen modifiers can improve properties of Bitumen and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen. Polymer modified bitumen (PMB)/ crumb rubber modified bitumen (CRMB) should be used only in wearing course depending upon the requirements of extreme climatic variations. The detailed specifications for modified bitumen have been issued by IRC: SP: 53-1999. It must be noted that the performance of PMB and CRMB is dependent on strict control on temperature during construction.

The advantages of using modified bitumen are as follows

- Lower susceptibility to daily and seasonal temperature variations
- Higher resistance to deformation at high pavement temperature
- Better age resistance properties
- Higher fatigue life for mixes
- Better adhesion between aggregates and binder
- Prevention of cracking and reflective cracking

5.4.3 Rigid Pavement

Rigid pavements, though costly in initial investment, are cheap in long run because of low maintenance costs. There are various merits in the use of Rigid pavements (Concrete pavements) are summarized below:

- Major advantage of concrete roads is the savings in fuel by commercial vehicles to an extent of 14-20%. The fuel savings themselves can support a large programme of concreting.
- Cement concrete roads save a substantial quantity of stone aggregates and this factor must be considered when a choice pavements is made,
- Concrete roads can withstand extreme weather conditions – wide ranging temperatures, heavy rainfall and water logging.

5.4.4 Paver Blocks

Interlocking Concrete Block Pavement (ICBP) has been extensively used in a number of countries for quite some time as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints.

There are many distinct features of ICBP as compared to the conventional methods of pavement construction and hence make it a suitable option for application in the specified areas. Some of these are:

- Mass production under factory conditions ensures availability of blocks having consistent quality and high dimensional accuracy.

- Good quality of blocks ensures durability of pavements, when constructed to specifications.
- ICBP tolerates higher deflections without structural failure and will not be affected by thermal expansion or contraction.
- ICBP does not require curing, and so can be opened for traffic immediately after construction.
- Construction of ICBP is labour intensive and requires less sophisticated equipment.
- The system provides ready access to underground utilities without damage to pavement.

Comparing all the alternatives the following points were concluded:

1. The flexible pavements with high viscous properties are best alternatives as they provide high strength and durability. But considering the traffic projection of the future in the project stretch, the rate of growth of traffic will be very less and investing a large amount of in the pavement quality in such areas will not be economical. As the cost these bitumen are very high.
2. Similarly, rigid pavement are a good alternate for the roads in these climatic condition in comparison but the cost is very high and the investment won't be feasible considering the traffic growth.
3. The paver blocks require high maintenance so the alternate is discarded.
4. So, the best alternates which is proposed for this project is to use VG 10 in base course and PMB Bitumen in Surface Course.

5.5 DESIGN OF PAVEMENT

It is based upon CBR-10%, Traffic msa -5, Design period – 15 years, VDF-1.5, Annual Growth of traffic rate 5% and minimum Design speed 20.00 Km/h. However the proposed pavement composition is based on CBR-10% and msa -5.

Pavement composition is designed as under:

Table 20: Proposed Pavement Crust

Crust Provided	Thickness (mm)
PMB	30
DBM	50
CRM in 2-layers	250
GSB in 1 Layer	150

Crust Provided	Thickness (mm)
Subgrade	500
Total	975

5.6 Cross Section Elements & Alignment

a) Cross Section Elements

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

Sl. No.	Design Elements	Dimension in m
1.	Roadway width	6.25
2	Roadway width at Bridges (including width of side drain and parapet wall)	12.00
3	Carriageway width	3.75
4	Cross-slopes / camber (%)	2.5

b) Geometric Design

The general alignment of the road under this project is as:

- The project road from Km 0 /000 to 84/425 Km as per design Chainage alignment: 84.425 Km
- Road is designed for single lane (6.25 m roadway with 3.75 m carriageway)

Gradient, being the most important parameter, has been the guiding factor. Ruling gradient less than 6% has been achieved in most point of the road and the maximum gradient being 7% due to terrain constraints.

d) Horizontal Alignment

The project corridor passes through steep and mountainous terrain. The design speed adopted is minimum 20km/hour (IRC SP: 48). Along the proposed alignment, there are hair-pin bend. However minimum design speed has been considered on technical grounds.

e) Vertical Alignment/Gradient

Gradient, being the most important parameter, has been the guiding factor. Ruling gradient (less than 7%) has been achieved, the maximum gradient being 7% at few selected stretch.

5.7 Design of Embankment / Hill Cutting

Considering the physical features, particularly the terrain, soil classification and hill slope line, typical cross-section (Type 1 to Type 8) have been developed for hill road cutting / embankment building.

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

Compaction of disposal material

Spreading & Compaction of Roadway cutting and excavation from drain and foundation of other structures surplus material in layers not exceeding 300mm thickness at selected disposal location as specified by forest department by Dozer at least four passes including construction of approach road to dumping site.

5.8 Pavement Proposal

The provision for pavement includes different layers of sub-base, base, and surfacing course as appropriate throughout the whole stretch of the road.

- ✓ Granular Sub-base (GSB): 150mm thick sub-base layer of crushed stone aggregate has been proposed. The sub-base course has been extended up to full width of the formation.
- ✓ Extra quantities for widening at curves, major and minor junction locations are calculated separately and final quantities are worked out.
- ✓ Crusher Run Macadam Base (CRM): 250 mm thick base layer of Crusher Run Macadam is proposed for 4.25m width.
- ✓ Dense Bituminous Macadam of 50 mm thick and 20mm thick of Polymer Modified Bitumen as surfacing course has been proposed.

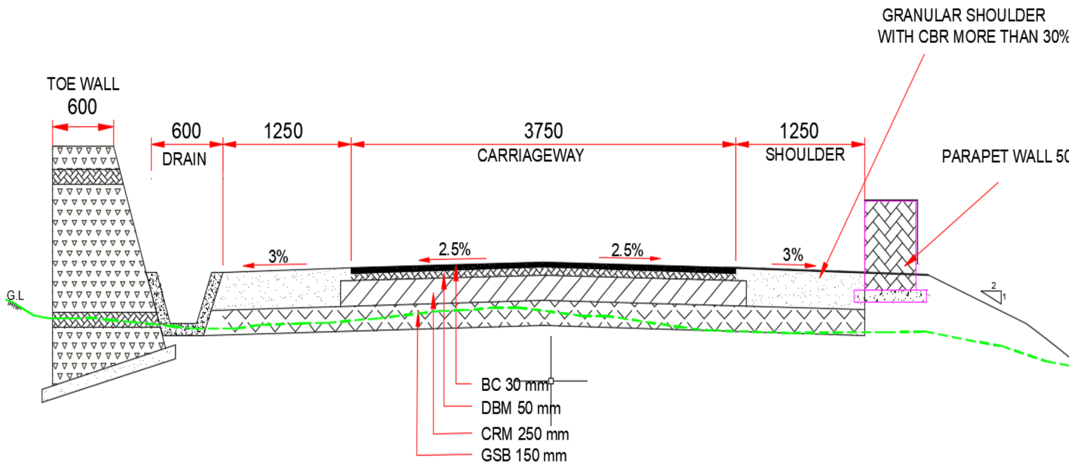
5.9 Shoulder Design

The carriageway width of 3.75m and earthen shoulder width of 1.25 m on both side. The remaining 1.0m on each side shall be used to accommodate side drain on hill side or parapet/soft shoulder on valley side.

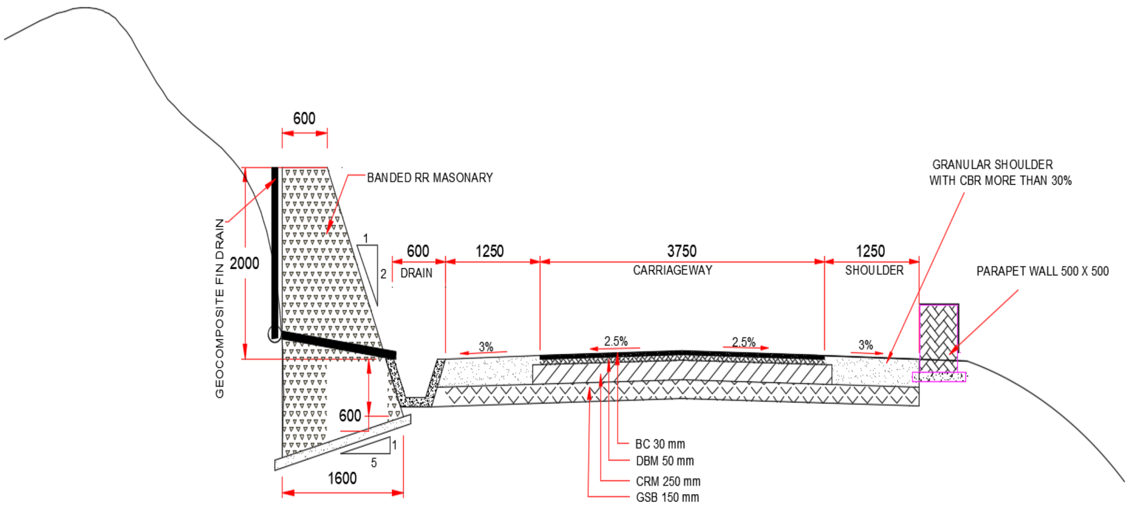
Table 21: DEVELOPMENT SCHEME

Sl. No.	Design Chainage From	To	Length	Typical Cross-section
1	0.000	84.425	84.425	Single Carriageway (3.75 m), with 1.25 m earthen shoulder on both sides, provision of drain on hill side and required protection works on both hill side and valley side.

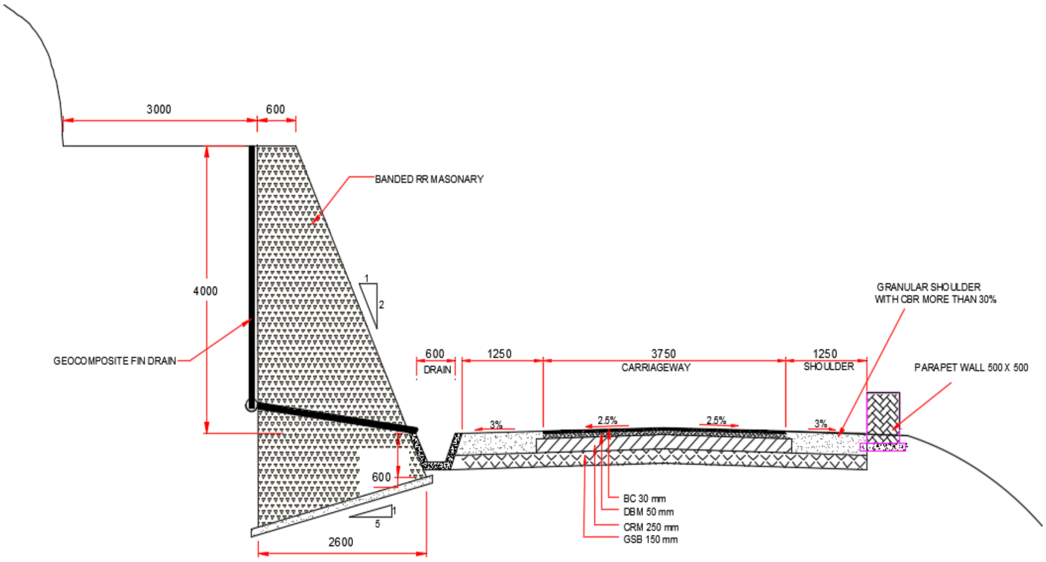
Figure 13: Proposed Typical Cross-section



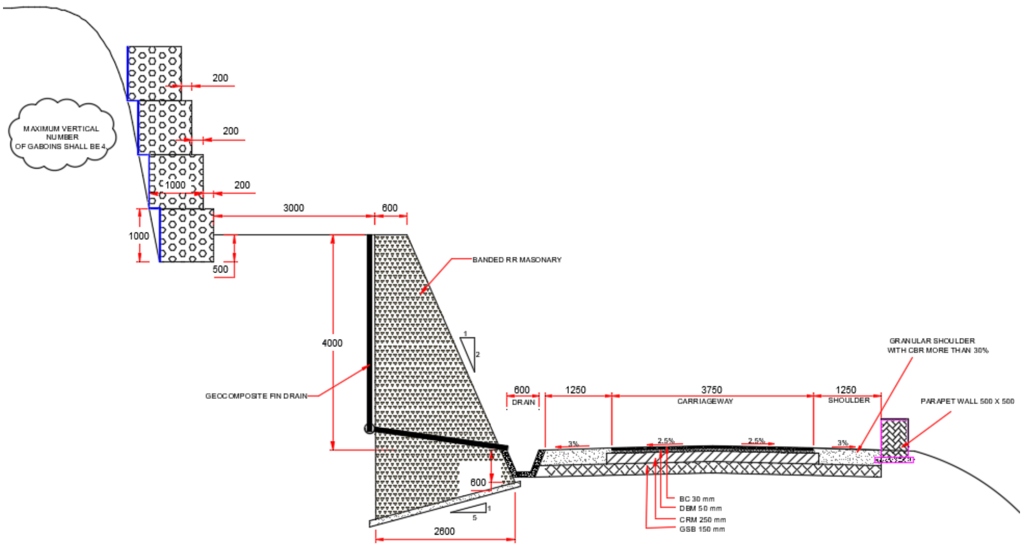
TYPICAL CROSS-SECTION 1



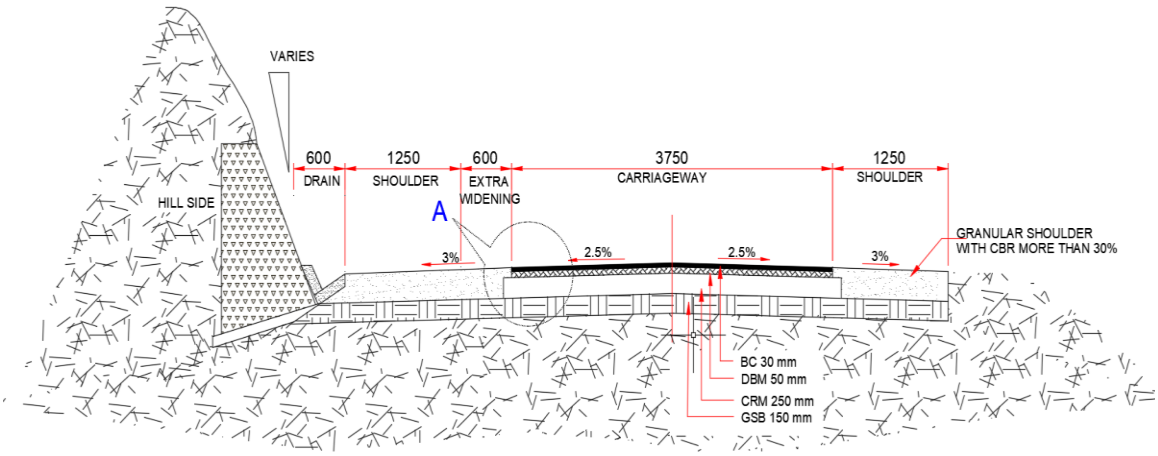
TYPICAL CROSS-SECTION 2



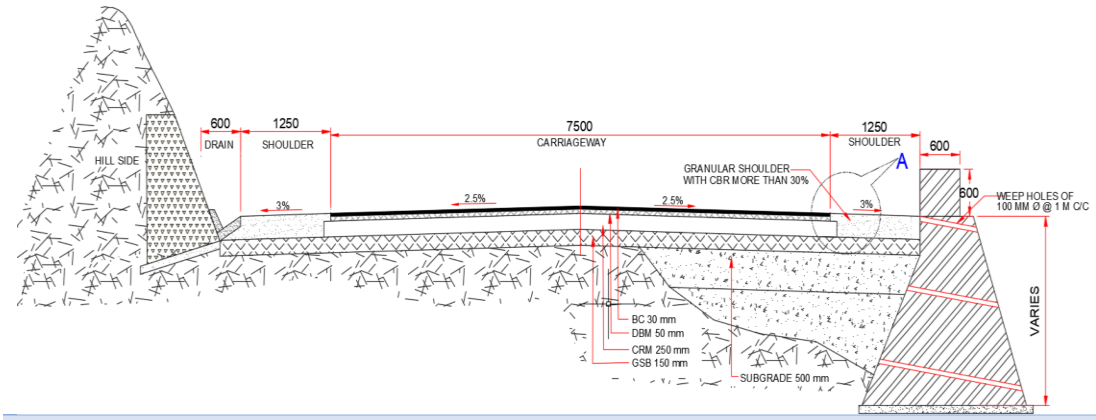
TYPICAL CROSS-SECTION 3



TYPICAL CROSS-SECTION 4



TYPICAL CROSS-SECTION 5 (Extra Widening Section)



TYPICAL CROSS-SECTION 6 (Overtaking Zone Section)

5.10 Culverts & Bridge:

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

Table 22: Culvert Details

Sl. No	Chainage	Span Arrangement	Type
1.	0+090	1 x 3.0	Slab Culvert
2.	0+200	1 x 3.0	Slab Culvert
3.	0+340	1 x 3.0	Slab Culvert
4.	0+405	1 x 3.0	Slab Culvert
5.	0+420	1 x 3.0	Slab Culvert
6.	0+430	1 x 3.0	Slab Culvert
7.	0+460	1 x 3.0	Slab Culvert
8.	1+260	1 x 3.0	Slab Culvert
9.	1+640	1 x 3.0	Slab Culvert
10.	1+720	1 x 3.0	Slab Culvert
11.	2+160	1 x 3.0	Slab Culvert
12.	2+280	1 x 3.0	Slab Culvert
13.	2+320	1 x 3.0	Slab Culvert
14.	2+900	1 x 3.0	Slab Culvert
15.	2+940	1 x 3.0	Slab Culvert
16.	3+140	1 x 3.0	Slab Culvert
17.	3+380	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
18.	3+400	1 x 3.0	Slab Culvert
19.	3+500	1 x 3.0	Slab Culvert
20.	4+180	1 x 3.0	Slab Culvert
21.	4+300	1 x 3.0	Slab Culvert
22.	4+390	1 x 3.0	Slab Culvert
23.	4+450	1 x 3.0	Slab Culvert
24.	4+480	1 x 3.0	Slab Culvert
25.	4+680	1 x 3.0	Slab Culvert
26.	5+260	1 x 3.0	Slab Culvert
27.	5+380	1 x 3.0	Slab Culvert
28.	5+680	1 x 3.0	Slab Culvert
29.	5+750	1 x 3.0	Slab Culvert
30.	5+920	1 x 3.0	Slab Culvert
31.	5+930	1 x 3.0	Slab Culvert
32.	5+980	1 x 3.0	Slab Culvert
33.	6+140	1 x 3.0	Slab Culvert
34.	6+260	1 x 3.0	Slab Culvert
35.	6+300	1 x 3.0	Slab Culvert
36.	6+340	1 x 3.0	Slab Culvert
37.	6+600	1 x 3.0	Slab Culvert
38.	6+660	1 x 3.0	Slab Culvert
39.	6+670	1 x 3.0	Slab Culvert
40.	6+710	1 x 3.0	Slab Culvert
41.	6+880	1 x 3.0	Slab Culvert
42.	7+240	1 x 3.0	Slab Culvert
43.	7+560	1 x 3.0	Slab Culvert
44.	7+960	1 x 3.0	Slab Culvert
45.	8+020	1 x 3.0	Slab Culvert
46.	8+080	1 x 3.0	Slab Culvert
47.	8+135	1 x 3.0	Slab Culvert
48.	9+215	1 x 3.0	Slab Culvert
49.	9+540	1 x 3.0	Slab Culvert
50.	9+920	1 x 3.0	Slab Culvert
51.	9+945	1 x 3.0	Slab Culvert
52.	10+220	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
53.	10+260	1 x 3.0	Slab Culvert
54.	10+540	1 x 3.0	Slab Culvert
55.	10+820	1 x 3.0	Slab Culvert
56.	11+100	1 x 3.0	Slab Culvert
57.	11+380	1 x 3.0	Slab Culvert
58.	11+460	1 x 3.0	Slab Culvert
59.	11+720	1 x 3.0	Slab Culvert
60.	12+000	1 x 3.0	Slab Culvert
61.	12+220	1 x 3.0	Slab Culvert
62.	12+415	1 x 3.0	Slab Culvert
63.	12+420	1 x 3.0	Slab Culvert
64.	12+600	1 x 3.0	Slab Culvert
65.	12+660	1 x 3.0	Slab Culvert
66.	13+240	1 x 3.0	Slab Culvert
67.	13+600	1 x 3.0	Slab Culvert
68.	13+640	1 x 3.0	Slab Culvert
69.	13+800	1 x 3.0	Slab Culvert
70.	14+980	1 x 3.0	Slab Culvert
71.	15+080	1 x 3.0	Slab Culvert
72.	15+450	1 x 3.0	Slab Culvert
73.	15+620	1 x 3.0	Slab Culvert
74.	15+780	1 x 3.0	Slab Culvert
75.	15+820	1 x 3.0	Slab Culvert
76.	16+020	1 x 3.0	Slab Culvert
77.	16+100	1 x 3.0	Slab Culvert
78.	16+260	1 x 3.0	Slab Culvert
79.	17+050	1 x 3.0	Slab Culvert
80.	17+140	1 x 3.0	Slab Culvert
81.	17+350	1 x 3.0	Slab Culvert
82.	17+830	1 x 3.0	Slab Culvert
83.	17+840	1 x 3.0	Slab Culvert
84.	18+080	1 x 3.0	Slab Culvert
85.	18+240	1 x 3.0	Slab Culvert
86.	18+300	1 x 3.0	Slab Culvert
87.	18+400	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
88.	18+660	1 x 3.0	Slab Culvert
89.	18+980	1 x 3.0	Slab Culvert
90.	19+370	1 x 3.0	Slab Culvert
91.	19+460	1 x 3.0	Slab Culvert
92.	19+500	1 x 3.0	Slab Culvert
93.	19+600	1 x 3.0	Slab Culvert
94.	19+680	1 x 3.0	Slab Culvert
95.	19+960	1 x 3.0	Slab Culvert
96.	20+010	1 x 3.0	Slab Culvert
97.	20+020	1 x 3.0	Slab Culvert
98.	20+320	1 x 3.0	Slab Culvert
99.	20+360	1 x 3.0	Slab Culvert
100.	20+850	1 x 3.0	Slab Culvert
101.	20+870	1 x 3.0	Slab Culvert
102.	21+160	1 x 3.0	Slab Culvert
103.	21+220	1 x 3.0	Slab Culvert
104.	21+460	1 x 3.0	Slab Culvert
105.	21+690	1 x 3.0	Slab Culvert
106.	21+730	1 x 3.0	Slab Culvert
107.	22+270	1 x 3.0	Slab Culvert
108.	22+620	1 x 3.0	Slab Culvert
109.	22+680	1 x 3.0	Slab Culvert
110.	22+690	1 x 3.0	Slab Culvert
111.	22+720	1 x 3.0	Slab Culvert
112.	22+940	1 x 3.0	Slab Culvert
113.	22+960	1 x 3.0	Slab Culvert
114.	23+040	1 x 3.0	Slab Culvert
115.	23+060	1 x 3.0	Slab Culvert
116.	23+450	1 x 3.0	Slab Culvert
117.	23+810	1 x 3.0	Slab Culvert
118.	23+930	1 x 3.0	Slab Culvert
119.	24+040	1 x 3.0	Slab Culvert
120.	24+150	1 x 3.0	Slab Culvert
121.	24+320	1 x 3.0	Slab Culvert
122.	24+360	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
123.	24+600	1 x 3.0	Slab Culvert
124.	24+660	1 x 3.0	Slab Culvert
125.	24+760	1 x 3.0	Slab Culvert
126.	24+770	1 x 3.0	Slab Culvert
127.	24+780	1 x 3.0	Slab Culvert
128.	24+920	1 x 3.0	Slab Culvert
129.	25+020	1 x 3.0	Slab Culvert
130.	25+100	1 x 3.0	Slab Culvert
131.	25+300	1 x 3.0	Slab Culvert
132.	25+400	1 x 3.0	Slab Culvert
133.	25+800	1 x 3.0	Slab Culvert
134.	25+805	1 x 3.0	Slab Culvert
135.	25+820	1 x 3.0	Slab Culvert
136.	25+825	1 x 3.0	Slab Culvert
137.	25+980	1 x 3.0	Slab Culvert
138.	26+060	1 x 3.0	Slab Culvert
139.	26+200	1 x 3.0	Slab Culvert
140.	26+380	1 x 3.0	Slab Culvert
141.	26+420	1 x 3.0	Slab Culvert
142.	26+460	1 x 3.0	Slab Culvert
143.	26.680	1 x 3.0	Slab Culvert
144.	26+920	1 x 3.0	Slab Culvert
145.	26+980	1 x 3.0	Slab Culvert
146.	27+280	1 x 3.0	Slab Culvert
147.	27+300	1 x 3.0	Slab Culvert
148.	27+480	1 x 3.0	Slab Culvert
149.	27+560	1 x 3.0	Slab Culvert
150.	27+600	1 x 3.0	Slab Culvert
151.	27+680	1 x 3.0	Slab Culvert
152.	27+860	1 x 3.0	Slab Culvert
153.	27+880	1 x 3.0	Slab Culvert
154.	28+240	1 x 3.0	Slab Culvert
155.	28+520	1 x 3.0	Slab Culvert
156.	28+540	1 x 3.0	Slab Culvert
157.	28+560	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
158.	28+660	1 x 3.0	Slab Culvert
159.	28+700	1 x 3.0	Slab Culvert
160.	28+900	1 x 3.0	Slab Culvert
161.	28+980	1 x 3.0	Slab Culvert
162.	29+120	1 x 3.0	Slab Culvert
163.	29+360	1 x 3.0	Slab Culvert
164.	29+520	1 x 3.0	Slab Culvert
165.	29+560	1 x 3.0	Slab Culvert
166.	30+020	1 x 3.0	Slab Culvert
167.	30+080	1 x 3.0	Slab Culvert
168.	30+440	1 x 3.0	Slab Culvert
169.	30+520	1 x 3.0	Slab Culvert
170.	30+540	1 x 3.0	Slab Culvert
171.	30+720	1 x 3.0	Slab Culvert
172.	30+740	1 x 3.0	Slab Culvert
173.	31+060	1 x 3.0	Slab Culvert
174.	31+150	1 x 3.0	Slab Culvert
175.	31+420	1 x 3.0	Slab Culvert
176.	31+460	1 x 3.0	Slab Culvert
177.	31+480	1 x 3.0	Slab Culvert
178.	31+780	1 x 3.0	Slab Culvert
179.	31+800	1 x 3.0	Slab Culvert
180.	31+880	1 x 3.0	Slab Culvert
181.	32+300	1 x 3.0	Slab Culvert
182.	32+340	1 x 3.0	Slab Culvert
183.	32+600	1 x 3.0	Slab Culvert
184.	32+640	1 x 3.0	Slab Culvert
185.	32+780	1 x 3.0	Slab Culvert
186.	32+880	1 x 3.0	Slab Culvert
187.	32+900	1 x 3.0	Slab Culvert
188.	32+980	1 x 3.0	Slab Culvert
189.	33+020	1 x 3.0	Slab Culvert
190.	33+100	1 x 3.0	Slab Culvert
191.	33+140	1 x 3.0	Slab Culvert
192.	33+420	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
193.	33+640	1 x 3.0	Slab Culvert
194.	34+000	1 x 3.0	Slab Culvert
195.	34+240	1 x 3.0	Slab Culvert
196.	34+280	1 x 3.0	Slab Culvert
197.	34+440	1 x 3.0	Slab Culvert
198.	34+520	1 x 3.0	Slab Culvert
199.	34+540	1 x 3.0	Slab Culvert
200.	34+600	1 x 3.0	Slab Culvert
201.	34+680	1 x 3.0	Slab Culvert
202.	34+800	1 x 3.0	Slab Culvert
203.	34+900	1 x 3.0	Slab Culvert
204.	34+940	1 x 3.0	Slab Culvert
205.	34+960	1 x 3.0	Slab Culvert
206.	34+980	1 x 3.0	Slab Culvert
207.	35+000	1 x 3.0	Slab Culvert
208.	35+010	1 x 3.0	Slab Culvert
209.	35+660	1 x 3.0	Slab Culvert
210.	35+820	1 x 3.0	Slab Culvert
211.	36+100	1 x 3.0	Slab Culvert
212.	36+140	1 x 3.0	Slab Culvert
213.	36+200	1 x 3.0	Slab Culvert
214.	36+900	1 x 3.0	Slab Culvert
215.	37+060	1 x 3.0	Slab Culvert
216.	37+160	1 x 3.0	Slab Culvert
217.	37+180	1 x 3.0	Slab Culvert
218.	37+500	1 x 3.0	Slab Culvert
219.	37+505	1 x 3.0	Slab Culvert
220.	37+560	1 x 3.0	Slab Culvert
221.	38+000	1 x 3.0	Slab Culvert
222.	38+120	1 x 3.0	Slab Culvert
223.	38+160	1 x 3.0	Slab Culvert
224.	38+260	1 x 3.0	Slab Culvert
225.	38+600	1 x 3.0	Slab Culvert
226.	38+660	1 x 3.0	Slab Culvert
227.	38+860	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
228.	39+260	1 x 3.0	Slab Culvert
229.	39+460	1 x 3.0	Slab Culvert
230.	39+500	1 x 3.0	Slab Culvert
231.	39+540	1 x 3.0	Slab Culvert
232.	39+650	1 x 3.0	Slab Culvert
233.	40+060	1 x 3.0	Slab Culvert
234.	40+440	1 x 3.0	Slab Culvert
235.	40+450	1 x 3.0	Slab Culvert
236.	40+500	1 x 3.0	Slab Culvert
237.	40+560	1 x 3.0	Slab Culvert
238.	40+680	1 x 3.0	Slab Culvert
239.	41+080	1 x 3.0	Slab Culvert
240.	41+240	1 x 3.0	Slab Culvert
241.	41+400	1 x 3.0	Slab Culvert
242.	41+680	1 x 3.0	Slab Culvert
243.	41+700	1 x 3.0	Slab Culvert
244.	41+930	1 x 3.0	Slab Culvert
245.	41+950	1 x 3.0	Slab Culvert
246.	41+980	1 x 3.0	Slab Culvert
247.	42+000	1 x 3.0	Slab Culvert
248.	42+040	1 x 3.0	Slab Culvert
249.	42+100	1 x 3.0	Slab Culvert
250.	42+260	1 x 3.0	Slab Culvert
251.	42+340	1 x 3.0	Slab Culvert
252.	42+560	1 x 3.0	Slab Culvert
253.	42+580	1 x 3.0	Slab Culvert
254.	43+060	1 x 3.0	Slab Culvert
255.	43+140	1 x 3.0	Slab Culvert
256.	43+700	1 x 3.0	Slab Culvert
257.	43+740	1 x 3.0	Slab Culvert
258.	43+800	1 x 3.0	Slab Culvert
259.	43+830	1 x 3.0	Slab Culvert
260.	44+100	1 x 3.0	Slab Culvert
261.	44+500	1 x 3.0	Slab Culvert
262.	44+560	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
263.	44+680	1 x 3.0	Slab Culvert
264.	44+900	1 x 3.0	Slab Culvert
265.	45+000	1 x 3.0	Slab Culvert
266.	45+060	1 x 3.0	Slab Culvert
267.	45+300	1 x 3.0	Slab Culvert
268.	45+480	1 x 3.0	Slab Culvert
269.	45+820	1 x 3.0	Slab Culvert
270.	46+220	1 x 3.0	Slab Culvert
271.	46+300	1 x 3.0	Slab Culvert
272.	46+305	1 x 3.0	Slab Culvert
273.	46+380	1 x 3.0	Slab Culvert
274.	46+620	1 x 3.0	Slab Culvert
275.	46+640	1 x 3.0	Slab Culvert
276.	46+800	1 x 3.0	Slab Culvert
277.	46+840	1 x 3.0	Slab Culvert
278.	47+200	1 x 3.0	Slab Culvert
279.	47+220	1 x 3.0	Slab Culvert
280.	47+360	1 x 3.0	Slab Culvert
281.	47+540	1 x 3.0	Slab Culvert
282.	47+620	1 x 3.0	Slab Culvert
283.	47+640	1 x 3.0	Slab Culvert
284.	47+730	1 x 3.0	Slab Culvert
285.	47+740	1 x 3.0	Slab Culvert
286.	48+020	1 x 3.0	Slab Culvert
287.	48+100	1 x 3.0	Slab Culvert
288.	48+280	1 x 3.0	Slab Culvert
289.	48+860	1 x 3.0	Slab Culvert
290.	48+940	1 x 3.0	Slab Culvert
291.	48+960	1 x 3.0	Slab Culvert
292.	49+120	1 x 3.0	Slab Culvert
293.	49+180	1 x 3.0	Slab Culvert
294.	49+280	1 x 3.0	Slab Culvert
295.	49+350	1 x 3.0	Slab Culvert
296.	49+540	1 x 3.0	Slab Culvert
297.	49+700	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
298.	49+880	1 x 3.0	Slab Culvert
299.	50+040	1 x 3.0	Slab Culvert
300.	50+300	1 x 3.0	Slab Culvert
301.	50+380	1 x 3.0	Slab Culvert
302.	50+720	1 x 3.0	Slab Culvert
303.	50+950	1 x 3.0	Slab Culvert
304.	51+160	1 x 3.0	Slab Culvert
305.	51+360	1 x 3.0	Slab Culvert
306.	51+800	1 x 3.0	Slab Culvert
307.	52+140	1 x 3.0	Slab Culvert
308.	52+600	1 x 3.0	Slab Culvert
309.	52+720	1 x 3.0	Slab Culvert
310.	53+280	1 x 3.0	Slab Culvert
311.	53+500	1 x 3.0	Slab Culvert
312.	54+100	1 x 3.0	Slab Culvert
313.	54+200	1 x 3.0	Slab Culvert
314.	54+230	1 x 3.0	Slab Culvert
315.	54+300	1 x 3.0	Slab Culvert
316.	54+500	1 x 3.0	Slab Culvert
317.	55+160	1 x 3.0	Slab Culvert
318.	55+260	1 x 3.0	Slab Culvert
319.	55+320	1 x 3.0	Slab Culvert
320.	55+420	1 x 3.0	Slab Culvert
321.	55+560	1 x 3.0	Slab Culvert
322.	55+700	1 x 3.0	Slab Culvert
323.	56+120	1 x 3.0	Slab Culvert
324.	56+200	1 x 3.0	Slab Culvert
325.	56+260	1 x 3.0	Slab Culvert
326.	56+605	1 x 3.0	Slab Culvert
327.	57+080	1 x 3.0	Slab Culvert
328.	57+440	1 x 3.0	Slab Culvert
329.	57+920	1 x 3.0	Slab Culvert
330.	59+260	1 x 3.0	Slab Culvert
331.	59+920	1 x 3.0	Slab Culvert
332.	60+560	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
333.	61+120	1 x 3.0	Slab Culvert
334.	61+160	1 x 3.0	Slab Culvert
335.	61+340	1 x 3.0	Slab Culvert
336.	61+660	1 x 3.0	Slab Culvert
337.	62+800	1 x 3.0	Slab Culvert
338.	63+000	1 x 3.0	Slab Culvert
339.	63+180	1 x 3.0	Slab Culvert
340.	64+080	1 x 3.0	Slab Culvert
341.	64+920	1 x 3.0	Slab Culvert
342.	65+280	1 x 3.0	Slab Culvert
343.	65+800	1 x 3.0	Slab Culvert
344.	65+870	1 x 3.0	Slab Culvert
345.	65+980	1 x 3.0	Slab Culvert
346.	67+110	1 x 3.0	Slab Culvert
347.	67+460	1 x 3.0	Slab Culvert
348.	67+840	1 x 3.0	Slab Culvert
349.	68+000	1 x 3.0	Slab Culvert
350.	68+820	1 x 3.0	Slab Culvert
351.	68+920	1 x 3.0	Slab Culvert
352.	69+120	1 x 3.0	Slab Culvert
353.	69+420	1 x 3.0	Slab Culvert
354.	69+600	1 x 3.0	Slab Culvert
355.	70+560	1 x 3.0	Slab Culvert
356.	70+890	1 x 3.0	Slab Culvert
357.	71+100	1 x 3.0	Slab Culvert
358.	71+360	1 x 3.0	Slab Culvert
359.	71+600	1 x 3.0	Slab Culvert
360.	72+320	1 x 3.0	Slab Culvert
361.	72+700	1 x 3.0	Slab Culvert
362.	73+480	1 x 3.0	Slab Culvert
363.	73+840	1 x 3.0	Slab Culvert
364.	74+120	1 x 3.0	Slab Culvert
365.	74+400	1 x 3.0	Slab Culvert
366.	74+540	1 x 3.0	Slab Culvert
367.	74+620	1 x 3.0	Slab Culvert

Sl. No	Chainage	Span Arrangement	Type
368.	75+700	1 x 3.0	Slab Culvert
369.	76+120	1 x 3.0	Slab Culvert
370.	76+200	1 x 3.0	Slab Culvert
371.	76+640	1 x 3.0	Slab Culvert
372.	76+960	1 x 3.0	Slab Culvert
373.	77+540	1 x 3.0	Slab Culvert
374.	78+660	1 x 3.0	Slab Culvert
375.	78+740	1 x 3.0	Slab Culvert
376.	79+080	1 x 3.0	Slab Culvert
377.	79+640	1 x 3.0	Slab Culvert
378.	80+380	1 x 3.0	Slab Culvert
379.	80+820	1 x 3.0	Slab Culvert
380.	81+460	1 x 3.0	Slab Culvert
381.	81+680	1 x 3.0	Slab Culvert
382.	82+150	1 x 3.0	Slab Culvert
383.	82+440	1 x 3.0	Slab Culvert
384.	82+660	1 x 3.0	Slab Culvert
385.	82+900	1 x 3.0	Slab Culvert
386.	82+940	1 x 3.0	Slab Culvert
387.	83+200	1 x 3.0	Slab Culvert
388.	83+360	1 x 3.0	Slab Culvert
389.	83+520	1 x 3.0	Slab Culvert
390.	83+820	1 x 3.0	Slab Culvert
391.	83+980	1 x 3.0	Slab Culvert
392.	84+360	1 x 3.0	Slab Culvert

Table 23: List of proposed Minor Bridge

Sl. no	NEW CHAINAGE	Proposed Span	Proposed TYPE
1.	2+220	1 x 6.0	RCC Slab
2.	3+920	1 x 6.0	RCC Slab
3.	4+900	1 x 6.0	RCC Slab
4.	7+480	1 x 6.0	RCC Slab
5.	10+420	1 x 10.0	RCC Slab
6.	10+980	1 x 6.0	RCC Slab

Sl. no	NEW CHAINAGE	Proposed Span	Proposed TYPE
7.	19+360	1 x 10.0	RCC Slab
8.	21+320	1 x 10.0	RCC Slab
9.	22+200	1 x 6.0	RCC Slab
10.	24+520	1 x 10.0	RCC Slab
11.	25+480	1 x 10.0	RCC Slab
12.	26+580	1 x 10.0	RCC Slab
13.	27+120	1 x 6.0	RCC Slab
14.	28+060	1 x 10.0	RCC Slab
15.	29+880	1 x 6.0	RCC Slab
16.	33+740	1 x 10.0	RCC Slab
17.	36+500	1 x 10.0	RCC Slab
18.	36+740	1 x 10.0	RCC Slab
19.	39+040	1 x 6.0	RCC Slab
20.	40+800	1 x 6.0	RCC Slab
21.	41+560	1 x 6.0	RCC Slab
22.	47+000	1 x 6.0	RCC Slab
23.	48+420	1 x 10.0	RCC Slab
24.	48+630	1 x 10.0	RCC Slab
25.	50+220	1 x 6.0	RCC Slab
26.	58+460	1 x 10.0	RCC Slab
27.	62+140	1 x 10.0	RCC Slab
28.	63+900	1 x 6.0	RCC Slab
29.	66+320	1 x 10.0	RCC Slab
30.	68+140	1 x 10.0	RCC Slab
31.	68+580	1 x 6.0	RCC Slab
32.	69+240	1 x 10.0	RCC Slab
33.	70+440	1 x 10.0	RCC Slab
34.	71+700	1 x 10.0	RCC Slab
35.	73+000	1 x 10.0	RCC Slab
36.	73+100	1 x 10.0	RCC Slab
37.	74+880	1 x 10.0	RCC Slab
38.	76+500	1 x 10.0	RCC Slab
39.	78+060	1 x 10.0	RCC Slab
40.	79+420	1 x 10.0	RCC Slab

5.11 Slope Protection works:

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

5.11.1 Breast Wall

The soils have been retained with a safe slope by the breast wall which has been provided as per the height of the cutting section. The breast wall provision varies from 0.5 m to 4 m in height. The protection structure composes of RR masonry. The soils above the breast wall are protected soil nailing and seeding mulching.

5.11.2 Retaining Wall

The filling sections towards the valley side are protected with RR masonry retaining walls which vary from 1 m to 10 m height. The structures are provided as per the difference in levels of original ground level (OGL) and formation road level (FRL). The retaining walls are reinforced with geotextiles which provide strength to these protecting structures.

5.12 Drainage

Pavement Drainage includes camber/ cross fall of 2.50%. Slope 3.0 % has been considered for drainage of shoulders.

Roadside drains are designed as Lined drains of 0.6 m width throughout the project stretch. The drains are provided with RR Masonary.

Table 24: Chainages with Drain Provision

Sl.No.	Design Chainage (km)		Length	Side
	From	To		
1.	0.000	84.425	84.425	Hill Side (0.6 m)

Chutes of the culverts form part of the culvert structure to lead the discharge to the catch pit or to natural drainage channel.

5.12 Road Sign and Markings

The project design includes (a) Mandatory / Regulatory Signs, (b) Cautionary / Warning Signs and (c) Information Signs, Route Marker Signs are provided .KM Stones are included as per type design.

5.13 Road Furniture

Traffic Safety Posts and Parapet Walls are included. Traffic Signs Marking & other Road Appurtenances like W-Beam Crash Barriers are provided for protection of works.

5.13.1 W-Beam Crash Barrier

The W-Beam Metal Crash Barriers are provided at the curve location on the radius of the curves.

5.13.2 Parapet cum Guard Wall

The valley side of the project stretch is provided with parapet walls of 0.7 m (PCC type) to provide safety to the road users.

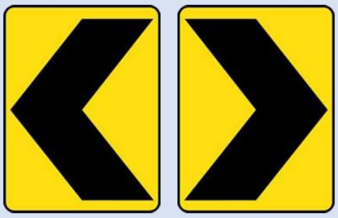
5.13.3 Rock Fall Barrier

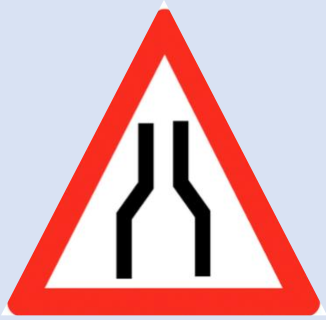
The portions with slope cutting of 15 m or more has been provided with rock fall barriers of 10 m height.

5.14 Communication Facility

The project facility includes wireless telecommunication system with internet facilities for better communication in the hills which is prior necessity for the army personnel using the road.

Table 25: LIST SIGNS TO BEPROVIDED ALONG THE PROJECT CORRIDOR

SL NO	SIGNS	CHAINAGE
1		To be provided at 1. At hairpin bends 2. Sharp Curves Total of 212 x 2=424
2		To be provided at the start of a structure. Total of 432 x 2=864
3		These are provided at curves with very less curvature to show turning of the project road. Total of 212 x 3=636
4		Right Turn Ahead Signs to be provided at curves Total of 458 x 2=916
5		Left Turn Ahead Signs to be provided at curves Total of 445 x 2=890

6		Hairpin Bend Ahead Signs to be provided at hairpin bends Total of 15 x 2=30
7		Narrow Road Ahead to be provided at bridge ends Total of 40 x 2=80
8		Road Studs to be provided on edge of roads
9		This object is to be provided as per the site location near the hairpin curves Total of 15 x 2=30
10		These strips are to be provided on the W-Beam Crash Barriers and structures

11		These signs are to be provided at places where the hill are stiff and are prone to landslide Total of 30 x 2=60
12		The curves and hairpin bends are to be provided with no overtaking sign boards Total of 121 x 2=242
13		Snow markers to be installed on roads laden with snow for easy identification of carriageway Total 350 nos.

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COST
ESTIMATES

Chapter 6 Cost Estimate

6.1 General

The project highway starts from the 0/000 km at Toong and ends at PT 4865 84/425 km. The project stretch is considered as a single homogeneous stretch and is proposed to improve it to single lane carriageway with earthen shoulder throughout the project corridor.

The proposal has been made to provide bridges and culverts at required. The proposal also includes the junction improvement, proposal of safety structures, longitudinal drains and road furniture.

6.2 Quantification

The quantification of most of the items which are uniformly occurring are based on the TCS & pavement design for different homogeneous section and are calculated as per Km basis. The quantification of structures is based only on Square meters of widening, new construction for each structure and lump sum provision for rehabilitation on square meter basis.

The construction items covered in cost estimates are: site clearance, earthwork in case of widening and raised pavement, Pavement in carriageways and shoulders, bridges and culverts, and miscellaneous items such as side drains, road furniture, interchanges / intersections, bus safety structures etc.

6.3 Unit Rates

The rate analysis for the Construction Items has been done based on standard data book published by MORT&H and Sikkim Schedule Rates 2012. For items whose rates are not available in the DSR, market rates shall be adapted for its costing.

6.4 Project Costing

6.4.1 Road

The pavement quantities like GSB, CRM & Bituminous items etc. have been worked out based on Typical Cross Sections, pavement design done based on traffic and with subgrade as CBR 10%

6.4.2 Bridges and Culverts

The cost of new of structures has been calculated in detail with volume calculation of each component of structure.

6.4.3 Maintenance during Construction Period

The flexible pavements require a regular maintenance during its life period. The maintenance cost has been fragmented and reflected in the estimate.

6.4.4 Miscellaneous Items

The cost for providing minor junction, overhead signs, Retaining Wall, Crash Barrier etc. have been worked out and included in the total cost estimate.

6.5 Construction Cost

The overall construction cost of the Project works out to Rs. 1631.42 Crores.

CONCLUSION

Chapter 7 Conclusion

7.1 General

The new project road has been proposed as single lane configuration with paved shoulder on hill side and earthen shoulder on valley side. The design has been based on IRC SP 48: 1998 "Hill Road Manual" and considering the terrain condition of the project road. The provisions made for the project road has following consideration:

- Safety of road user
- Terrain type
- Economics
- Slope protection measures

Considering all the provisions and other necessary requirements, the cost of project comes to be Rs. 1631.42 Crores.