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राष्ट्रीय राजमार्ग एवं अवसंरचना विकास निगम लिमिटेड

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

FINAL DETAILED PROJECT REPORT
SUDHMAHADEV - DRANGA TUNNEL

CONSULTANCY SERVICES FOR PREPERATION OF DETAILED PROJECT REPORT AND PROVIDING PRE-CONSTRUCTION ACTIVITIES IN RESPECT OF THE FOLLOWING STRETCH ON NH-244 (OLD NH-1B) IN THE STATE OF JAMMU AND KASHMIR.

(1) SUDHMAHADEV- DRANGA TUNNEL OF APPROX. LENGTH 4.5 KM AND ITS APPROACH ROAD ON CHENANI - SUDHMAHADEV- GOHA ROAD PORTION.

(2) VAILOO TUNNEL OF APPROX. LENGTH 10.0 KM UNDER SINTHAN PASS AND ITS APPROACH ROAD ON GOHA-KHELLANI- KHANABAL ROAD PORTION.

(3) ROAD PORTION FROM 82.675 TO 82.925 AT KM 83 ON BATOTE-KISHTWAR ROAD SECTION OF NH-244.

(4) EXTENDED ROAD SECTION FROM GOHA TO KHELLANI OF 30 KM LENGTH

PACKAGE-1 – KM 0+000 TO KM 6+405
PACKAGE-2 – KM 6+405 TO KM 12+850
VOLUME - I - MAIN REPORT

FEBRUARY 2020

IN ASSOCIATION WITH

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VOLUME INDEX

The detailed project report consists of the following nine volume

VOLUME- 1. MAIN REPORT

VOLUME- 2. DESIGN REPORT

VOLUME- 3. MATERIAL REPORT

VOLUME- 4. ENVIRONMENTAL ASSESSMENT REPORT INCLUDING ENVIRONMENTAL MANAGEMENT PLAN (EMP) & RESETTLEMENT ACTION PLAN (RAP)

VOLUME- 5. TECHNICAL SPECIFICATIONS

VOLUME- 6. RATE ANALYSIS

VOLUME- 7. COST ESTIMATE

VOLUME- 8. BILL OF QUANTITIES

VOLUME- 9. DRAWINGS

Sr. No.	Description	Revision No.	Date
01	Final Detailed Project Report	R0	March 2019
02	Final Detailed Project Report	R1	September 2019
03	Final Detailed Project Report	R2	November 2019
03	Final Detailed Project Report	R3	February 2019

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NHIDCL has been assigned the work of Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on NH-244 (old NH-1B) in the state of Jammu & Kashmir.

Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on NH-244 (old NH-1B) in the state of Jammu & Kashmir.

(i) Sudhmahadev- Dranga Tunnel of approx. length 4.5 Km and its approach roads on Chenani - Sudhmahadev – Goha road portion.

(ii) Vailoo Tunnel of approx. length 10.00 Km under Sinthan Pass and its approach roads on Goha- Khellani- Khanabal road portion.

NHIDCL has entrusted the M/s Getinsa-Eurostudios in association with Rodic Consultants Private Limited to carry out Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of Sudhmahadev–Dranga Tunnel of approximate length of 8 Km and its approach roads.

In the west side the portal is on the Chenani-Sudhmahadev road at about 17km from Chenani near Gauri Kund Temple on the west and terminates near Bari Village traversing through Thanda Pani in Assar tehsil in the state of Jammu & Kashmir. The project road and oth Tunnels traverse through many villages and built up areas along its route. On the east side the portal is connected to a new proposed road from Goha to Khellani. Access to this tunnel will also be for the villages located along the existing road at designated locations.

The proposed Goha -Khellani road will meet NH-244 (old NH-1B) near Khellani. As per the RFP the Sudhmahadev tunnel length was 4.5km but after detailed study the final alignment has two tunnels of 5.45 km and 2.64 km. The cumulative length is 8 .08 km. The project road and Tunnel is considered to help in providing better connectivity from Sudhmahadev to Doda and is envisaged to provide better riding quality to the users that reduces the travel time and distance.

1.1 The Salient features:

The Salient features of the Project are:

a. Design Length of Project: 12.850 km (Pkg-I - 6.405 km and Pkg-II- 6.445 Km)
b. Terrain : Hilly
c. Traffic : 4538 PCU (Year 2018)
d. Type of pavement : Flexible Pavement (Road)& Rigid pavement (Tunnel)
e. Realignment : Nil
f. Structure:

Package-I

Tunnel : T1 (5449 tube on LHS /5417m tube on RHS)
Viaduct cum Bridge : 100 m (2 Nos. RHS & LHS)
Viaduct : 75 m 2 Lane bridge on LHS only
Viaduct : 250m (2 Lane on LHS) /125 m (2 Lane on RHS)
Vehicular Underpass : 2 nos.
Culverts : 1 box culverts (RHS & LHS)

Package-II

Tunnel: T2 (2640 tube on LHS /2630 m tube on RHS)
Viaduct cum Bridge: 200m (2 Lane on LHS) & 25m (2 Lane on RHS)
Viaduct cum Bridge: 456m (2 Lane)
Viaduct cum Bridge: 130m (2 Lane)
Viaduct: 285 (2 Lane on LHS) /125 m (2 Lane on RHS)
Culverts :5 box culverts (RHS & LHS)

g. Toll plaza : 1 No. (Package-I)

1.2 Approach road:

The project is comprised of two nos. of unidirectional Tunnel, cross drainage structure, viaduct and road. The alignment is passing through mountainous terrain. Some length of approach road is proposed as 2 lane unidirectional due to twins tube (unidirectional) tunnel and balance length is proposed with 2-lane with paved shoulder. The project alignment is part length of NH-224 which starts from Chenani- Sudhmahadev Road near Gauri Kund. The details proposed scheme is as under:-

- Start of Project – Km 0.000 to km 0.050 – Portal Development

- Start of Tunnel 1 – Km 0.050
- End of Tunnel 1 – Km 5.499 L/S & Km 5.417 R/S.
- Start of Approach Road in including cross drainage (2 lane unidirectional) – Km 5.499 L/S & Km 5.417 R/S.
- End of approach Road (2 lane unidirectional) – Km 6.760
- Start of tunnel 2 – Km 6.760
- End of Tunnel 2 – Km 9.400 L/S & Km 9.390 R/S.
- Start of Approach Road (2 lane unidirectional) – Km 9.400 L/S & Km 9.390 R/S.
- End of Approach Road (2 lane unidirectional) – Km 9.935
- Start of Approach Road (2 lane with PS) – Km 9.935
- Start of Approach Road (2 lane with PS) – Km 12.850

1.3 Tunnel Alignment

Horizontal Alignment

Tunnel 1- 5.449/5.417 km (Tube-1/Tube-2)

Tunnel starts from the west portal located at an EL.1719 on left slope along Chenani-Sudhmahadev National Highway NH-1B (new NH-244). The tunnel is aligned keeping in view of the topography, length and the location such that tunnel passes through the region having adequate cover all around. The western portal is placed at the road level and the tunnel could directly be connected to the existing road which needs to be widen before starting of the construction. There is enough space available for workability. The length of the tunnel with this western portal is about 5.45 km up to the eastern portal. The eastern portal of this tunnel is located at upstream of Thanda Pani Village at an EL. 1635m.

Tunnel 2- 2.64/2.63 km (Tube-1/Tube-2)

The western and eastern portal of the tunnel is located on upstream of Thanda Pani Village and near Kaisar village at an EL. 1585m & 1500m respectively.

East Portal of tunnel 1 and west portal of tunnel 2 is connected through 737m of viaduct,

304 m of road and 220 m of Toll Plaza.

Vertical Alignment

Tunnel 1

Western portal & Eastern portal of tunnel 1 is kept at EL. 1719m and EL. 1635m respectively. In the initial length of 2.3 km, slope of 0.38% from the western portal and in the remaining length, 3% slope has been provided. Elevation of intermediate point (point of changing the grade) is kept higher at EL.1728.

Tunnel 2

Western portal & eastern portal of tunnel 2 is kept at EL. 1585m and EL. 1500m respectively. Slope of 3.2% has been given in tunnel 2.

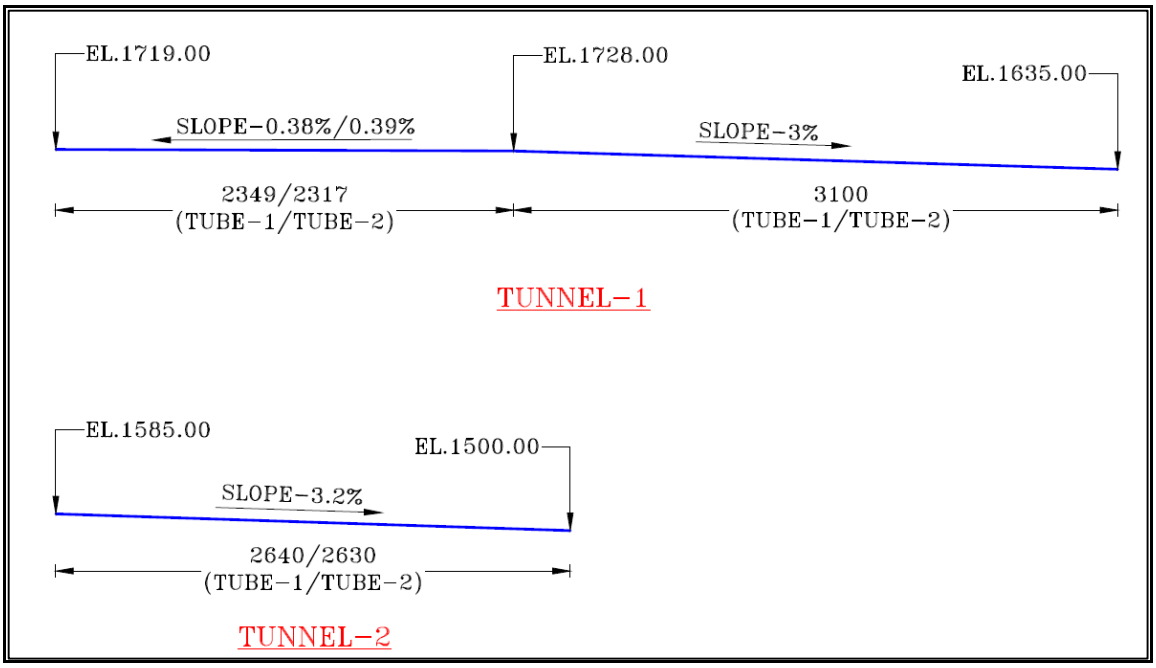


Figure 1: Tunnel Elevations

1.4 Typical Cross Sections

The typical cross section is designed according to Indian and International Standards and Guidelines for road tunnels.

Clearance profile as defined in below Fig.

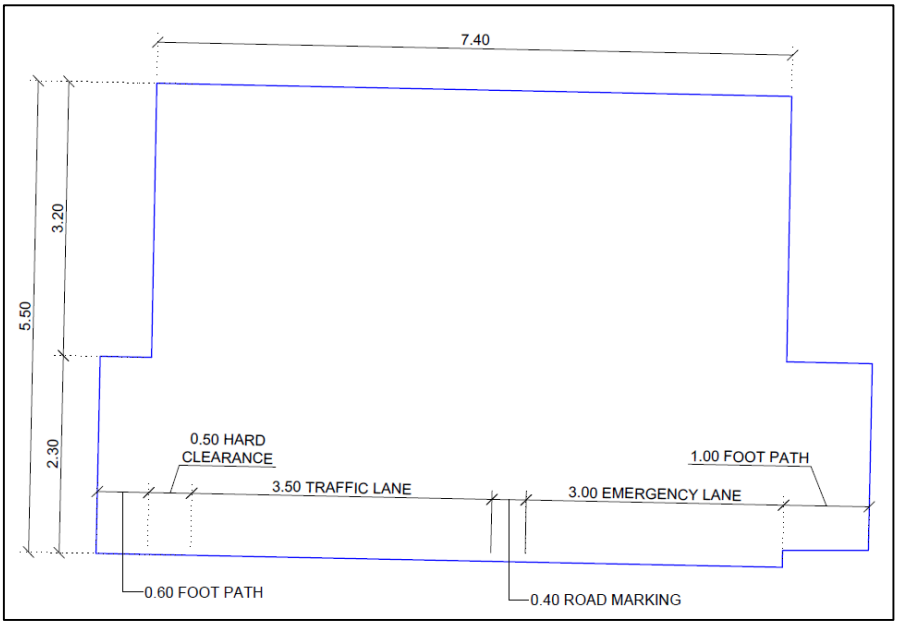


Figure 2: Tunnel Clearance Profile

The typical cross sections for the main tunnel with and without invert are given in below **figures**

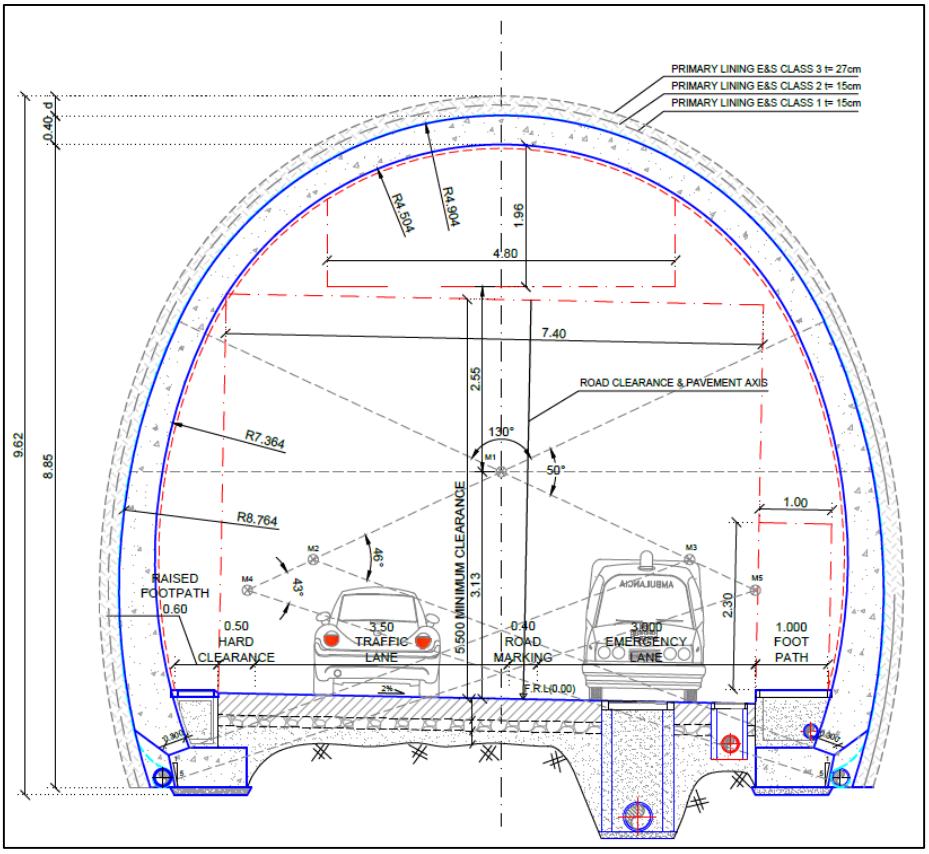


Figure 3: Uni-Directional Tunnel Cross Section without Invert

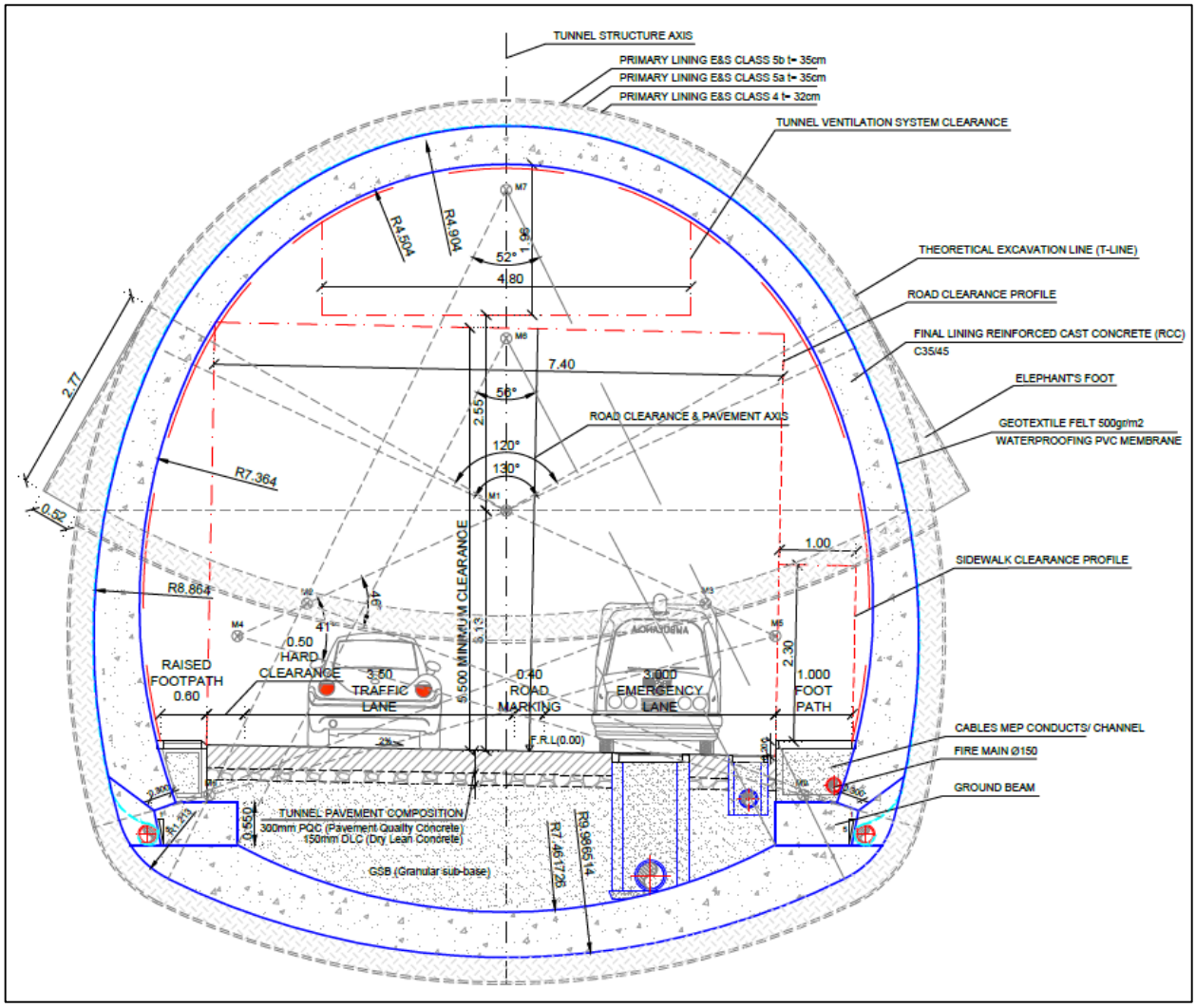


Figure 4: Uni-Directional Tunnel Cross Section with Invert

1.5 Geological/Geotechnical Evaluation

In this valley, the project area around tunnel 1 has exposed limestone, dolomitic limestone, quartzite and calcareous quartzite belonging to Gamir Formation (Raina and Gupta 1985-86).

These are best exposed along the road section between the Gauri Kund Temple and Gau Karan in this valley. The total length of this tunnel is about 5.4km. Western portal of this tunnel is placed at an EL. 1719m and its co-ordinate is N 3654820.29, E 533679.42. Eastern portal of this tunnel 1 is placed at an elevation of El. 1635m and its co-ordinate is N 3658964.85, E 537173.34.

Along the tunnel 1 alignment, grey platy limestone and calcargillite with occasionally thin bands of carbonaceous phyllite of Baila Formation may be encounter after Gamir

Formation. Baila Formation is considered to be Precambrian in age on the basis of its stratigraphic position between Gamir and Ramban formations, both regarded to be Precambrian in age.

Ramban Formation represents an important Lithostratigraphic constituent of the 'Parautochthon' in this part of Lesser Himalaya where it is present throughout the belt. This formation is underlying by Baila Formation. Phyllite, slate, carbonaceous shale and limestone of Ramban Formation is expected to be encountered along tunnel alignment.

Stratigraphically Sincha Formation is the uppermost formation of the 'Parautochthon' in the area. Northern and eastern part of this formation is bounded by the regional tectonic plane namely the Panjal Thrust which juxtaposes it against the Salkhalas. Its contact with the underlying Ramban Formation is inferred to be disconformable, though in the Ramban and Chenab valley section it is a tectonic contact (Digdaul Thrust) (Raina and Gupta, 1985-86). Dolomite, dolomitic limestone, limestone and quartzite of this formation may be encountered along the tunnel alignment.

Highly crushed, fragmented, disturbed zone etc. are usually associated Panjal Thrust in the Chenab valley is observed and projected in tunnel alignment. This plane has a NW-SE trend, moderate to steep dip due northeast and juxtaposed the Salkhalas of the Kashmir Synclinorium zone against the Sincha Formation to the south.

Entire length of Tunnel- 2 falls in Salkhala formation. The total length of this tunnel is about 2.6km. Western portal of this tunnel is placed at an elevation of El. 1585m and its co-ordinate is N 3659481.70, E 538248.46 Eastern portal of this tunnel is placed at an elevation of El. 1500m and its co-ordinate is N 3659358.82, E 540885.57.

Rock types expected to be encountered are mica schist, phyllite, carbonaceous phyllite, quartzite with patches of metavolcanis of Salkhala formation.

1.6 Rock Mass Classification

Estimate of rock mass classes (based on RMR & Q-system) considered as baseline for different rock types that are likely to be encountered in the tunnel 1 & 2 are given in below tables,

Table 1: Estimate of Rock mass Classes along Tunnel-1

Rock Class	Percentage (%)
II	25
III	57
IV	8
V	10

Table 2: Estimate of Rock mass Classes along Tunnel-2

Rock Class	Percentage (%)
II	30
III	60
IV	10

1.7 Pavement

The road pavement consists (from bottom to top) of the following layers:

- 300 mm PQC
- 450 mm GSB
- 150 mm dry lean cement concrete sub-base layer

1.8 Ventilation

There are different systems for tunnel ventilation, each one with its own advantages and disadvantages. A complete description of the possible systems can be found in NFPA 502.

The following lines will serve as a simple introduction, with the minimum concepts necessary for the comprehension of the document.

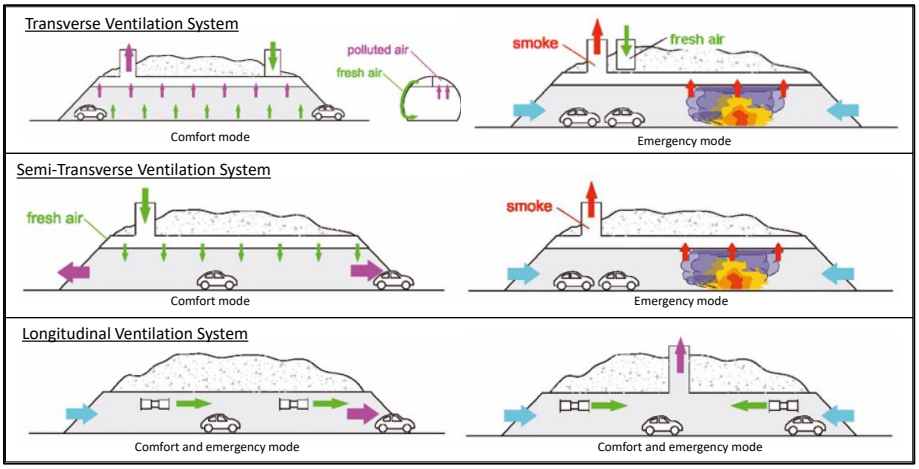


Figure 5: Types of Ventilation Systems. Source: PIARC

Transverse Ventilation

A fully transverse system consists in 2 different ducted ventilation systems, one for fresh air injection (preferable at floor level) and another for exhaust (at the ceiling), evenly distributed along the tunnel. In case of fire, only the exhaust dampers close to the fire are remotely opened, and fresh air injection must be stopped.

This system is the best for contaminants control and the safest in case of fire if correctly operated, as it exhausts the smoke locally near the fire, maintaining clear of smoke the rest of the tunnel. Its main disadvantage is the high cost involved due to the complex and large civil infrastructures needed (shafts, ventilation buildings, ducts).

Semi-Transverse Ventilation

In this case there is only a ventilation duct along the tunnel, which can work either injecting fresh air for contamination control or exhausting smoke in a similar way as a transverse system.

The problem of this system is that normal operation is usually fresh air injection, as it works better than exhausting polluted air. In case of fire the system has to stop, open/close the adequate dampers and reverse the flow. This can take some time, and during that period the system is working in the worst possible way for a fire: injecting fresh air at the smoke layer, thus feeding oxygen to the fire and breaking stratification of the smoke.

Longitudinal Ventilation

This is the simplest tunnel ventilation system, and the most used nowadays, and it consist mainly in developing an air flow inside the tunnel by means of jet-fans or Saccardo nozzles, so that fresh air comes in at one side and polluted air / smoke goes out through the other end of the tunnel. On certain occasions, this longitudinal air flow may be achieved by means of exhaust shafts that create flow at both sides of the shaft towards it (maybe with the help of jet-fans); or even with both intake and exhaust shafts that divide the tunnel in ventilation sections (push-pull system). This system is typical in subway infrastructures.

In case of a fire, unlike transverse or semi-transverse systems where smoke is directly extracted by the system regardless of its heat release rate (HRR), the main objective of a

longitudinal ventilation system is usually reaching the Critical Ventilation Velocity (VC), or the velocity that just impedes back layering of smoke (smoke moving backwards against the airflow), considering that ventilating over that velocity smoke stratification is unlikely.

Ventilation System Selection

- ✓ A longitudinal ventilation system has been proposed for Sudhmahadev Tunnels 1&2. Longitudinal ventilation is the most adequate ventilation system from a cost-effective point of view, provided the following assumptions are met: Unidirectional tunnel, so that vehicles would only stop inside the tunnel at one side of an accident
- ✓ No traffic jams expected inside the tunnel, because of low traffic is expected or a traffic control system at entrance (barriers) is provided
- ✓ Relatively short distance between emergency exits (500 m maximum, preferable about 300 m)
- ✓ Appropriate control system to avoid counter flow due to unfavorable weather conditions (high wind at exit portal, high atmospheric pressure difference between portals)
- ✓ Pollutants concentration design levels can be maintained for normal operation (sanitary ventilation). This is limited by the length of the tunnel and the traffic expected, unless air can be renewed by means of intermediate ventilation shafts.
- ✓ Sudhmahadev Tunnels comply with these assumptions, so a longitudinal ventilation system is considered to be adequate at these infrastructures.

Ventilation System Design

The design of the ventilation system has been performed according to 2 different criteria:

- ✓ Pollutants concentration below design levels for sanitary ventilation
- ✓ Critical velocity (VC) achieved for emergency ventilation

In order to calculate the number of jet-fans needed, several simulations have been performed with the help of the software CAMATT 2.20. This software developed by CETU (France) is internationally recognized and widely used for the dimensioning of this kind of infrastructures.

Jet-Fan and Tunnel Characteristics

The following image shows the nomenclature used for the tunnels:

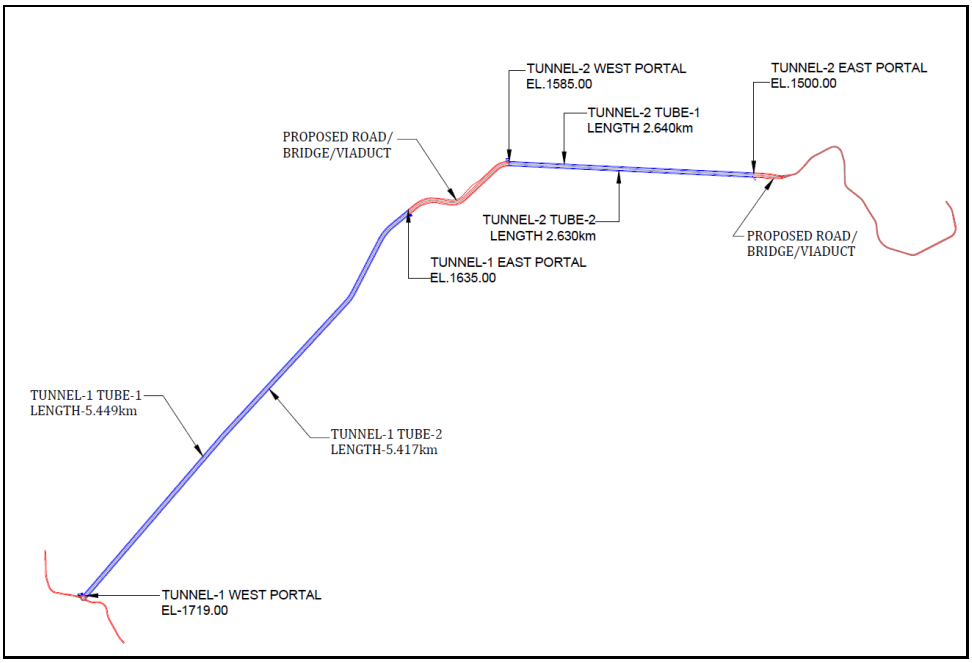


Figure 6: Sudhmahadev Tunnels Nomenclature

The system proposed is based on the installation of jet-fan pairs along the tunnel, preferably near the transformer room due to electrical limitations (entrances or center of tunnel).

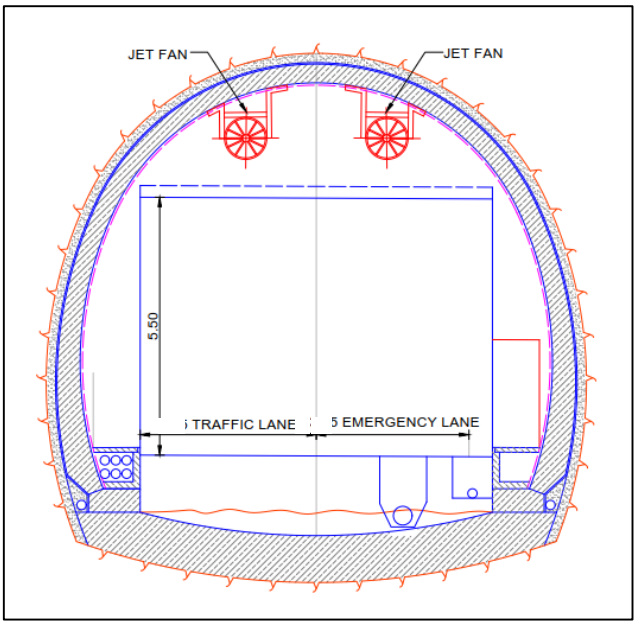


Figure 7: Jet Fan position

The characteristics of the jet-fans proposed are included in the following

Table 3: Characteristics of the Jet-Fans

Internal Diameter	Air Flow (m^3/s)	Jet Velocity (m^3/s)	Area (m^2)	External Diameter (m)	Thrust (N)	Installed Power(kW)
1200	37.5	33.2	64.6	1.4	1441	37

System Design

Emergency ventilation

The following conditions are used for the design:

- 200 MW fire (equivalent to Tanker fire)
- Enough jet fans pairs would be installed to achieve a ventilation velocity over the critical velocity according to NFPA 502 (2017)
- An extra jet fan pair will be installed for redundancy (failure or maintenance)

A sensitivity analysis is made in order to find the most unfavorable fire position for each tunnel/tube. The number of jet-fans at each tunnel is:

Table 4: Number of Jet-Fans in each Tunnel

Tunnel	Length	Number of Jet Fan Pairs
Tube 1	5.449km	14
Tube 2	5.417km	12
Tube 1	2.64km	14
Tube 2	2.63km	4[1]

Sanitary Ventilation

It has been confirmed by simulation that the design of the system according to emergency ventilation is enough to maintain and adequate level of pollutant contaminants without incurring in excessive air velocity in tunnel (< 10m/s).

Different scenarios are considered for pollution ventilation simulation. They take into account the evolution with time of the number of vehicles and the improvement in the vehicle technology according to the reference: PIARC Technical Committee C4 – Road Tunnels: Vehicle Emissions and Air Demand for Ventilation (2011).

[1] Sudhmahadev 2 Tube 2 system has been defined considering that a lower HRR fire would generate much less chimney effect than a tanker fire, and thus may need more ventilation capacity. For example, a 30 MW fire would need 2 pairs of jetfans according to the study performed. 4 jetfans are thus prescribed to ensure enough capacity under any circumstances

1.9 Tunnel Safety Concept

The twin tubes tunnel configuration allows the unidirectional one lane traffic in each tube, which reduces de risk of accident inside tunnel.

The provision of emergency lane (right side) has an advantage regarding vehicle breakdown and other incident involving vehicle emergency stop, which can be done at any point, except cross passage entrance locations.

Also, O&M teams and staff can circulate through emergency lane without disturbance of traffic. In this sense it is convenient to place the drainage access manholes covers &slotted gutters, along with most critical MEP services cables, conducts, pipes in the emergency lane side.

The use of emergency lane by the tunnel customers in case of an emergency could involve complications for the emergency services access, so unless specified in special circumstances, in principle it is not foreseen. In the present situation, this lane will be of exclusive use of O&M authorized vehicles and emergency vehicles.

Cross passages at spacing intervals of 330 m are envisaged in order to allow access to rescue/authorized/emergency vehicle and provide escape pedestrian route to the tunnel users in case of emergency.

The diversion of traffic to the cross passages in case of accident/incident is not contemplated in principle, due to interference with evacuation by emergency/rescue services, risk of smoke propagation from disturbed tube to evacuation tube. Only extreme situations permitted by the competent Authority and checked through risk analysis may allow this emergency operational practice.

As explained before, the unidirectional flow contributes in some extent to longitudinal ventilation.

In the next page tables, extracted from the “Directive 2004/54/EC of the European Parliament and of the Council on minimum Safety requirements for tunnels in the Trans-European road Network” dated 29-04-2004, it has been reflected all recommendable structural conditionings and aspects of geometric design depending on road tunnel length.

As it can be noticed, the maximum spacing between transverse cross galleries for evacuation which has been indicated is 500 m, less exigent than in the case of IRC code, whilst the distance between lay-bays shall not exceed 1,000 m in new bidirectional tunnels longer than 1,500 m, if there is no emergency lane.

The emergency exits, corresponding to cross passages, shall be required as cross connections for emergency vehicles at least every 1500, so cross passages may include both pedestrian and vehicular.

This Directive states also that the main criteria for deciding whether to build a single bidirectional or a twin-tube tunnel shall be projected traffic volume and safety. The traffic Projection of reference corresponds to 15 years forecast with daily traffic volume of 10,000 vehicles/lane, not converted to PCU, but this reflects a mandatory condition for election of unidirectional twin tunnels if the same is exceeded.

It has to be highlighted that in this Project the prevalent criteria has been the safety concept of tunnel, and the predicted future use as National Highway combined with the life span of such structure.

1.10 Tunnel Support System

1.10.1 Tunnel Portal

1.10.2 Construction Method

Generally, two different construction methods are available for the construction of tunnels according to the construction procedure:

TBM Mechanized Methodology of Construction versus Conventional Tunneling by NATM. For the excavation and support/lining of the Sudhmahadev tunnel it could be proposed several Construction methodologies, like following:

Mechanized Tunneling Methods: These include TBM and Shielded machines, which allow removal of excavation by pipes, conveyor belts or rail transport, as well as tunnel support and/or lining in the tail of the advancing machine. In this case it is considered only integral machines with full face excavation capacity, although there are also for partial face excavation. Due to conditioning of geographical and geological features, it may be selected double shield machine.

Conventional Tunneling Methods: Drill & Blast and/or mechanical excavation (except above mentioned) including required cycle of construction activities for excavation, removal of muck and support, also final lining separated by a space/time gap. In this case NATM has been selected as preferred.

The feasibility of use of TBM has been analyzed considering specific limitations, versus the normally adopted NATM for project roads in this region. The factor to account for are listed below:

- **Geology (Hydrogeology Inclusive) and Geotechnical Model**, which involves geological risks identified and rock mass quality variability along tunnel combined with huge overburden
- **Logistics** aspects, like accessibility to site, transportation requirements (for materials, equipment, machinery, etc.), accesses configuration, areas needed for site operation & maintenance workshop, stock materials laydown areas, machinery and vehicle parking, assembling facilities areas, power supply, water sources & ventilation temporary installations, muck separation plant, wastewater treatment installations, concrete batching plants, etc.
- **Functionality and Durability of the Structure**, which intervene on the selection of cross section of tunnel excavation and tunnel clearances
- **Time Schedule**, this depends on the planning previewed by the Client to put in operation the Project road, and not only design and construction developments will influence here, also land acquisition, environmental & construction permits procedures, shifting of utilities & traffic diversions, etc. The estimated saving in construction period for NATM is around 4-6 months as first approximation without the impact of mentioned constraints.
- **Cost and Financing**, Tunneling by TBM and mechanized equipment requires rather higher initial disbursement to development of preconstruction activities (purchase of machinery, set up activities and complex logistics, transportation to site, etc.
- **Environmental Constraints**, allocating aspects like groundwater protection & impact in aquifers, contaminated ground, nature reserves preservation, reuse and management of tunnel excavation muck (disposal areas or dumping yards), etc.

- **Market and Labor Local Conditions**, because this form part of local boundary conditions along with social acceptance of tunnel construction.

Taking of reference above main factors which may influence on the selection of tunnel construction methodology, following are the observations:

- ✓ The rock formations traversed by Sudhmahadev tunnel/s includes several lithology's which are prone to generate squeezing phenomena with the existing high overburden, especially in the Tunnel-1.
- ✓ Moreover, is expected a fault strip (Panjal thrust), to be traversed in Tunnel 1 for about estimated 500 m.
- ✓ In conclusion, although there are technological adaptations of the machines to tackle with this challenge (also requirement of bypass gallery to reach TBM head) it is not recommendable the use of TBM in normal operational conditions, due to risk of jamming of cutter head. The conventional tunneling can be adapted better due to support flexibility to accommodate changing ground conditions.
- ✓ Regarding geology also, popping (low grade rock bursting) in quartzite, limestone, and dolomite may be expected.
- ✓ In case of tunneling with TBM, it is expected a machine diameter of about 12 m with the accompanying backup. The local existing road for site accesses has a sinuous path and limited carriageway width, which may complicate the transportation of equipment and machinery pieces with special oversized vehicles, with the related risks. This may involve the upgradation of roads to allow special vehicle transit.
- ✓ The platform preferably flat area in the portals (or nearby available zones) required for the logistics during implementation of mechanized tunneling with TBM must be substantially increased in size with reference to NATM facilities. In this area with hilly orography, this involves more land acquisition for ROW and more environmental impact to forest land, and higher slope cuts with the subsequent hill instability hazards.
- ✓ In view of the division of Sudhmahadev tunnel into two tunnels (1 and 2) for the preferred alternative proposed, it is highly advisable to select conventional tunneling method for the shortest tunnel (Tunnel 2, 2.6 km) at least. The length of

Tunnel 1 (5.4 km) wouldn't favor the execution by TBM due to higher cost, so combined tunneling methodology is not likely.

- ✓ The preliminary and tentative construction schedules envisage the execution of NH-244 highway stretches to connect with tunnel portal from existing local roads, which may be used during its construction as haul or temporary access roads to the portals, allowing implantation of logistics and construction facilities easier for conventional tunneling.
- ✓ This increase of time will be summed up to the preconstruction/set up period of activities, which is noticeably longer for TBM methodology, although performance rate of excavation is normally rather higher for TBM.
- ✓ In conclusion, involved total cost (and consequently funding) will be higher for TBM tunneling.
- ✓ Looking into the local tunnel construction experiences, labor and market conditions, except hydropower Projects, the use of conventional tunneling (drill & blast and/or mechanical excavation) is practically the only used in this Northeast region of India.
- ✓ Conventional tunneling has been developed in all long road tunnels, plus of course others shorter: Chenani-Nashri Tunnel (9.0 km, completed below Patnitop range, so in operation), Rohtang tunnel (8.8 km, fully excavated below Rohtang Pass,- Himachal Pradesh: **https://youtu.be/NgioFN4sCwE),** Qazindung-Banihal tunnel (8.5 km, fully excavated below Pir Panjal range, Jammu & Kashmir), Z-Morh tunnel (6.5 km, in progress, near Gagangir J & K), Ramban-Banihal section tunnels (5 No. short tunnels being constructed in NH-44 South bound), Nandni tunnels (short length 5 No. in operation, NH-44 from Jammu to Udhampur). Also, railways tunnels like Banihal tunnel below Pir Panjal range (11.2 km), or Sangaldan tunnel (7.1 km in the Jammu-Baramulla line, near Ramban), are examples of NATM application instead of TBM.
- ✓ The local labor force is then trained mainly in conventional methods, which provides an advantage to logistic and work organization during construction stage. TBM operation training requires high specialization level for dedicated staff.
- ✓ Social acceptance of conventional tunneling has been gained also among local

population, despite the inherent negative aspects of this methodology (use of explosives, safety of workers near excavation face, etc.)

Once analyzed the above considerations, this Consultancy arrives to the conclusion that the Conventional Tunneling Method (Drill & blast combined with mechanical localized excavation whenever required) is in this case the preferred methodology versus TBM methodology.

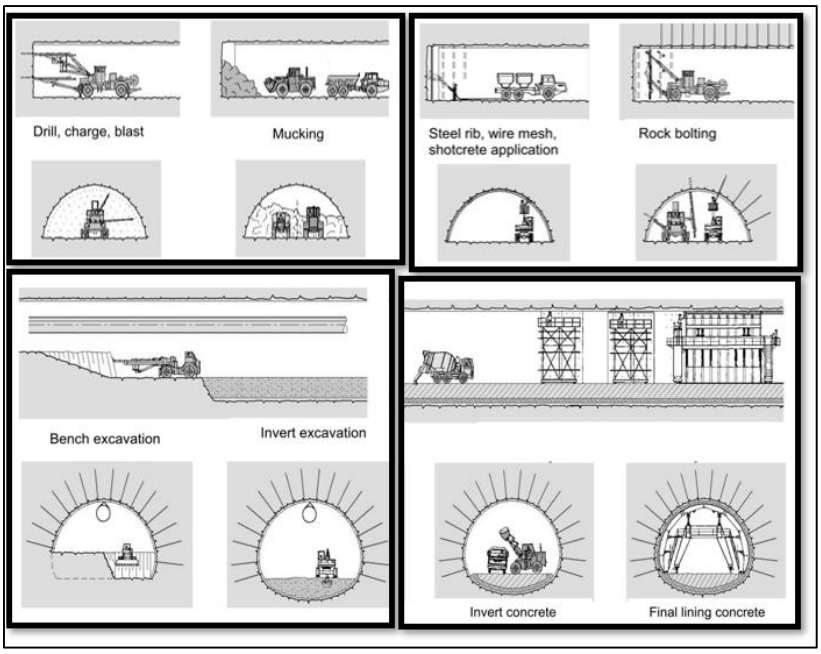


Figure 8: Schematic construction sequence of a typical NATM tunnel in hard rock, from "Austrian Society for Geomechanics, 2010. NATM, the Austrian Practice of Conventional Tunneling"

1.11 Comparison of Unidirectional / Bi-directional Tunnel.

After the analysis with available Project and antecedent data regarding mentioned DPR, below we develop an assessment regarding most convenient tunnel configuration. Observations are as follow:

MEP systems and safety concept in tunneling:

- ✓ According to traffic study and forecast, in case of Bi-directional tunnel solution the traffic inside tunnel will be significantly more, so more vehicle emissions, and in the tunnel 1 (5.4 km long) this solution shall require a transverse ventilation system, instead of longitudinal ventilation system which is feasible in twin tube

unidirectional tunnel solution. The transverse ventilation system will be more costly than longitudinal system.

- ✓ The implication of transverse ventilation system is the requirement of ventilation buildings at portals of tunnel 1 and supplementary civil works (ventilation slab plus partition wall) in the final lining structure to accommodate the ventilation ducts separated from the main tunnel road section.
- ✓ With the ventilation building requirement, it is clear that portal platform needs to be more extended, but in tunnel 1 there is limited space development in the West portal especially, so bidirectional tunnel is not the most convenient solution as per our assessment.
- ✓ The structural connection between the ventilation ducts and the building requires a complex structural design and smooth shaping to match the ventilation parameters, and also the system of ducts should be air-tight, which involves a complication in the treatment of sealing of construction joints.
- ✓ Therefore, these civil works are more sophisticated and sensible during construction stage.
- ✓ In case of unidirectional twin tubes solution, the advantage related to traffic management is that in case of major repairing/maintenance works involving a closure of tunnel, this solution allows the use of the other unidirectional tube with a traffic diversion, and alternate unidirectional traffic flow handled through tricolor lights, flag men or other procedures.
- ✓ Even it can be used the emergency lane under exceptional circumstances under the approval of competent Authority, although this is not recommended in principle. In case of bidirectional tunnel, it is not possible to divert the traffic to the escape tunnel because usually this tunnel is closed and not designed/prepared for commuter's traffic.
- ✓ Nevertheless, the use of unidirectional twin tubes implies a length of transition road of around 140-150 m from only 1 carriageway for surface load to two separated carriageways in the portal entrance to twin tubes. In case of twin tubes as per European Directive there is a transition distance to converge to bidirectional

approach road, which is subject to the design speed (e.g., for 50 km/h the distance is 139 m).

- ✓ For bidirectional tunnel solution, the connection between projected road and emergency gallery may involve complications related to alignment.
- ✓ From the purely safety point of view the unidirectional twin tube solution has less probability of accidents inside tunnel, and there is no possibility of frontal crash between vehicles, which habitually leads to major fatalities. Our concern is that in road tunnels, safety is a must, as reflected in PIARC reports and recommendations.
- ✓ In case of unidirectional twin tubes, the adoption of longitudinal ventilation system simplifies the pressurization of evacuation transverse galleries to avoid smoke propagation to the healthy twin tube in case of fire emergency. The transverse ventilation system along with closed escape tunnel implies more complex pressurization system and consequently an increase of ventilation cost, as it can be deduced from Chenani-Nashri Tunnel.
- ✓ According to European Directive 2004/54/CE it is possible to avoid lay bays inside tunnel in case of presence of emergency lanes, as it is the case of unidirectional twin tube solution. In case of bidirectional tunnel lay bays are required as per national normative/regulations/ recommendations. Nevertheless, to facilitate de maintenance works of MEP teams deployed on ground, it is convenient to include lay bays only at the locations of cross passages equipped with technical rooms (transformer stations, LV rooms, control rooms, etc.) no to create a disturbance for traffic during their intervention.
- ✓ The emergency response team and emergency services can reach more easily and expedited to the accident/incident location inside the tunnel due to the incorporation of emergency lane, which is not in the case of bidirectional tunnel, because only can be in this case the escape tunnel, and better coordination response/evacuation will be required.
- ✓ It has to be accounted for the saving in costs during O&M period in case of safer concept tunnel for unidirectional twin tubes.

Regarding Traffic parameters and Road cross section configuration (indications from codes and regulations):

- ✓ It has to be noticed that the hard clearances (shoulders limited in the outer side by kerb for footpaths, including emergency lane in case of unidirectional) are different for unidirectional and bidirectional tunnels: references for unidirectional tunnels as per PIARC in different countries have a range of 2,00-3,95 m (including emergency lane) and 0,30-2,00 m (without e.l.), while for bidirectional tunnel the range is 0,60-1,50 m, with a recommendation not less than 0.75 m.
- ✓ The IRC codes, specifically IRC:SP:48-1998 Hill Road Manual and IRC:SP:73-2007 Manual for two Lanning of State Highways in BOT basis, also mention recommendations for shoulder's width in case of 1 lane, 0.5-1.25 m (here it is assumed for unidirectional traffic) and two lane, 1,0 (hill side) & 2,0 (valley side) to 0,90 m (as per IRC:SP:73-2007 for NH and State Highways). All the references are for straight stretches.
- ✓ Concerning to lanes configuration, 3.5 m for two lane (bidirectional) and 3,75 m for one lane (unidirectional) are fully recommended by international regulations and Indian codes. The recommendations for emergency lane width is wider, because as per international regulations compiled by PIARC, the "equivalent emergency lane" (difference of hard clearance with and without emergency lane) is in the range between 1, 5 and 3, 0 m normally, with exceptional case above 3 m. The proposed value of 3, 25 m may appear as excessive but has the advantage of future adaptation to unidirectional two lanes tube.
- ✓ In our vision, under the uncertainty of future development of the region and reliability of traffic forecasts due to reasons beyond the control of Consultants, it is advisable to take the solution with more capacity, which will cope with any expectative of future economic and social progress.
- ✓ There are some references to PIARC design manuals for unidirectional and bidirectional configuration in order to analyze unidirectional versus bidirectional tunnel configuration, which are mentioned in the above Design Standards. These reports contain guidelines for normal traffic capacity in bidirectional tunnels, and theoretical versus practical traffic capacity per hour per lane in unidirectional

tubes.

- ✓ Please notice that the European Directive 2004/54/EC, the only recommendation is that for traffic volume more than 10.000 vehicles per lane and day, it is mandatory the configuration of unidirectional twin tubes, but there is no lower limit indicated. Safety assumptions play a main role here.
- ✓ Also, as per Indian Standards, in IRC codes IRC: SP:48-1998 "Hill Road Manual", and in IRC: SP:73-2007 "MANUAL OF STANDARDS & SPECIFICATIONS FOR TWO LANING OF STATE HIGHWAYS ON B.O.T. BASIS", there is a limitation for Design Service Volume in PCU per day for two lane Highway, as an indication of Traffic Capacity. This value is between 7.000 and 9.000 PCUs/day, which means that as per your traffic forecast table, maximum by 2033 (15 years) the values recommended for Design Service have been exceeded. Tunnels are structures with minimum life span of 50 years habitually, so the bidirectional tunnel configuration has this disadvantage. These codes are included in the specifications of the ToR.

Total Cost:

From rough estimate of main civil works (see table below) components, like tunnel excavation & support, concrete lining, Bi-directional tunnel configuration costlier than unidirectional twin tubes.

Table 5: Comparision of Cost for Uni-directional vs Bi-Directional Tunnel

Comparision of Cost for Uni-Directional Tunnel Vs Bi-Directional Tunnel					
S. No.	Description	Unit	Twin Tube Uni-directional	Single Tube Bi-directional	
				With Vertical Shaft	Without Vertical Shaft
	Total Length of tunnel	Km	8.02	8.02	8.02
1	**Total Quantities**				
	Excavation	m^3	1,569,755	1,690,664	1,526,447
	Shotcrete	m^3	111,037	114,022	104,220
	Concrete	m^3	350,506	400,789	376,330
	Reinforcement	MT	10,515	13,736	11,290
	Rock bolts (25mm Dia)	m	948,095	819,768	687,067
2	**Total Civil Cost**	**Crores**	**1,142.2**	**1,236.0**	**1,114.4**
3	MEP cost (15% of Civil cost for Unidirectional & Bidirectional with shaft and 20% without shaft)	Crores	**171.3**	**185.4**	**222.9**
4	Contractor's Profit (@ 10% of Total Cost)	Crores	**131.36**	**142.14**	**133.73**
5	**Total Basic Cost**	**Crores**	**1,444.91**	**1,563.50**	**1,471.01**
6	**Cost per Kilometer**	**Cr/Km**	**180.16**	**194.95**	**183.42**

1.12 Recommendation for Tunnel Type

From above comparative study, it is recommended to use Twin Tube Uni-directional tunnel for Sudhmahadev-Dranga Tunnel.

1.13 Proposed Cross Drainage Structures

There are 04nos. Viaduct cum Bridges, 03nos. Viaducts and 06nos. Box Culverts are proposed on project road. Proposed Bridge at km 12.230 is a precast RCC girder/ Open spandrel steel arch bridge.

Table 6: Summary of Proposed Bridges and Culverts

Sr. No.	Type	No's of structures	
		Pack-I	Pack-II
1	Viaduct cum Bridges	1	3
2	Viaducts	2	1
3	Box Culverts	1	5
Total		**4**	**9**

1.14 Construction Time and Construction Cost

The construction period is 48 months for Package-I and 36-months for Package-II from the date of start and 10 years maintenance period for both packages

The overall construction time is based on the assumptions and calculations. The construction time of Sudhmahadev - Dranga Tunnel is estimated to approx. 48 working months. The estimation of the construction time is based on the assumption of four independent site installations at both tunnel portals and at two construction & ventilation shafts. The construction time is estimated based on the assumption, proposed and decided by the Client that the eastern portal of tunnel is accessible during the entire year, it is also assumed that full independent construction works can be done minimum 10 months per year at all other construction faces.

The construction cost evaluation is based on the unit rates and quantities determined. The Total Project Cost are **determined with Rs. 3789.67Crores INR.** These costs are only the basic construction costs as per detailed rate analysis and cost estimates.

Table 7: Summary of Cost

Item No.	Description	Package-I Total Amount (Rs. in Cr.)	Package-II Total Amount (Rs. in Cr.)
BILL NO. 1	TUNNEL	1497.36	763.29
BILL NO. 2	SITE CLEARANCE	0.04	0.08
BILL NO. 3	EARTH WORKS	47.88	37.74
BILL NO. 4	SUB-BASES AND BASES COURSES	0.69	3.32
BILL NO. 5	BITUMINOUS COURSES	0.69	3.29
BILL NO. 6	TOLL PLAZA	8.40	-
BILL NO. 7	CROSS DRAINAGE WORKS(Culverts)	0.35	1.56
BILL NO. 8	VUP, BRIDGE&VIADUCT	67.34	177.66
BILL NO. 9	TRAFFIC SIGNS AND MARKINGS	0.97	0.61
BILL NO. 9 A	PROTECTION AND DRAINAGE WORK	29.39	120.30
BILL NO. 9 B	MISCELLANEOUS	0.09	0.11
BILL NO. 10	MAJOR/MINOR JUNCTIONS	39.76	0.23
A	***Civil Cost***	***1692.95***	***1108.18***
B	**GST @ 12% Payable on Civil Cost only of (A)**	**203.15**	**132.98**
C	**Sub Total (A+B)**	**1896.11**	**1241.17**
D	Contingencies @ 2.8% of (A)	47.40	31.03
E	Construction Supervision Charges @ 3% of (A)	50.79	33.25
F	Agency Charge @ 3% of (A)	50.79	33.25
G	Escalation @ 5% taken for 2nd, 3rd& 4th year for Pkg.-I and Escalation @ 5% taken for 2nd& 3rd for Pkg.-II during construction payable to Contractor of (C)	116.88	50.42
H	**Total Cost including Centages (C+D+E+F+G)**	**2161.97**	**1389.11**
I	Maintenance During 10 Years @ 0.25% for the First 5 Years, 0.5% for the next 5 Years of (C)	71.10	46.54
J	***Total Project Cost (TPC) (H+I)***	***2233.08***	***1435.65***
K	Land Acquisition, R&R and Cost for forest diversion (NPV & CA)	65.96	44.38
L	Cost of Plantation & Maintenance as per Green Highways policy-2015 @1% of Civil Construction Cost of Road	1.96	3.45
M	Utility Relocation	1.50	1.50
N	Environmental Impact Assessment/ Environmental Management Plan	1.09	1.09
Total Capital Cost (J+K+L+M+N)		**2303.59**	**1486.08**
Grand Total		**3789.67 Cr.**	

2. PROJECT BACKGROUND

The Ministry of Road Transport and Highways (MORT&H) is poised to develop all remote and strategically important roads in hilly terrains to perennial routes. In continuation to these developments National Highways and Infrastructure Development Corporation Limited (NHIDCL) has been appointed by MORT&H, to implement these projects.

NHIDCL has been assigned the work of Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities for the construction of a Road Tunnel and its approaches enabling all weather connectivity along the stretches on NH-244 in the State of Jammu and Kashmir. **NHIDCL has entrusted TPF Getinsa Eurostudios SL in association with Rodic Consultants Private Limited, to carry out Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities to Sudhmahadev – Dranga Tunnel of approx. length 4.5 Km and its approach roads on Chenani – Sudhmahadev – Goha road portion of NH-244 (old NH-1B) in the State of Jammu and Kashmir**.

To carry out the said DPR project the consultant studied 9 alternate alignments in the project area. Number of site visits were done by tunnel specialist, geologist, geotechnical engineer and highway engineers the various alternate tunnel alignments and to suggest the best economically feasible tunnel alignment, the Consultant had visited the project area along with the officials of NHIDCL after doing the detailed desk work for all Tunnel Option shown in Plate-1 of Geotechnical Factual Report. **The consultant's team also had the discussion with senior authorities of NHIDCL that Tunnel option-9 is the best possible alignment for the detailed Geological/Geotechnical studies** shown in Plate-1.

3. SOCIAL ANALYSIS OF THE PROJECT

3.1 Socio Economic Impact on the Project Area

Some of the socio-economic information of Displace Persons (DPs) was collected through the census survey and its findings are presented in the following sections. The analysis of sample baseline socio-economic information of Affected Persons (APs) is discussed in length in the Poverty and Social Analysis Report prepared for the project.

A. Social Categories of the DPs

The social stratification of the project area shows that the dominance of higher caste, (OBC) population with 00 (00.00%) households followed by higher caste with 08 (66.66%), scheduled caste (SC) population with 00 (00.00%) households. There is Scheduled tribe (ST) population with 04 (33.33%) household belong to tribal community is being affected by the project. The detail of social grouping in the project area is presented in the **Table**

Table 8: Social Categories of the DPs

Sr. No.	Description of Caste	No. of Household	%
1	Higher Caste	08	66.66
2	Scheduled Tribe	04	33.33
3	Other Backward Caste	00	00.00
Total		**12**	**99.99**

B. Number of DPs

There are 127 DPs in total being affected by the project which includes 77 (57.68%) males and 50 (42.32%) females. The details of DPs being affected in the project are presented in the **Table**

Table 9: Details of DPs

Sr. No.	Categories of DPs	No. of DPs	%
1.	Male	77	60.63
2.	Female	50	39.37
Total		**127**	**100.00**

C. Vulnerable Households being Affected in the Project

According to project census survey there are 04 households enumerated as vulnerable households. In this project vulnerable group includes 00 SC households, 04 ST

households, 0 women headed households, 0 households headed by physically handicapped persons.

The vulnerable household details are presented in the below Table.

Table 10: Vulnerable Households being affected

Sr. No.	Vulnerable categories	No. of Household	%
1.	Scheduled Caste Household	00	00.00
2.	Scheduled Tribe Household	04	100.00
3.	Women Headed Household	00	00.00
4.	PH Headed Household	00	00.00
Total		**48**	**100.00**

D. Number of DPs considered as Separate family as per LA Act

There are various categories of DPs as summarized in the Table are treated as separate family under Right to Fair Compensation in Land Acquisition and Resettlement Act2013.

Table 11: Number of DPs considered as Separate family as per LA Act

Sr. No.	Vulnerable categories	No. of Household	%
1.	Unmarried Son > 30 years	00	00
2.	Unmarried Daughter/Sister > 30 years	00	00
3.	Physically/Mentally Challenged Person	00	00
4.	Divorcee/Widow	00	00
Total		**00**	**00**

4. SURVEY AND INVESTIGATION

4.1 Topographical Survey

In the today's digital world, Satellite based surveys for hydrological applications are becoming very prominent. These technologies save time, money and also provide a room for validation. With the launch of high-resolution Satellites such as Worldview, KOMPSAT etc., the ground level vertical (heights) and horizontal (spatial) have improved enormously. However, well designed and executed field validation and collection of Ground Control Points are necessary to improve the accuracy of such maps /surveys.

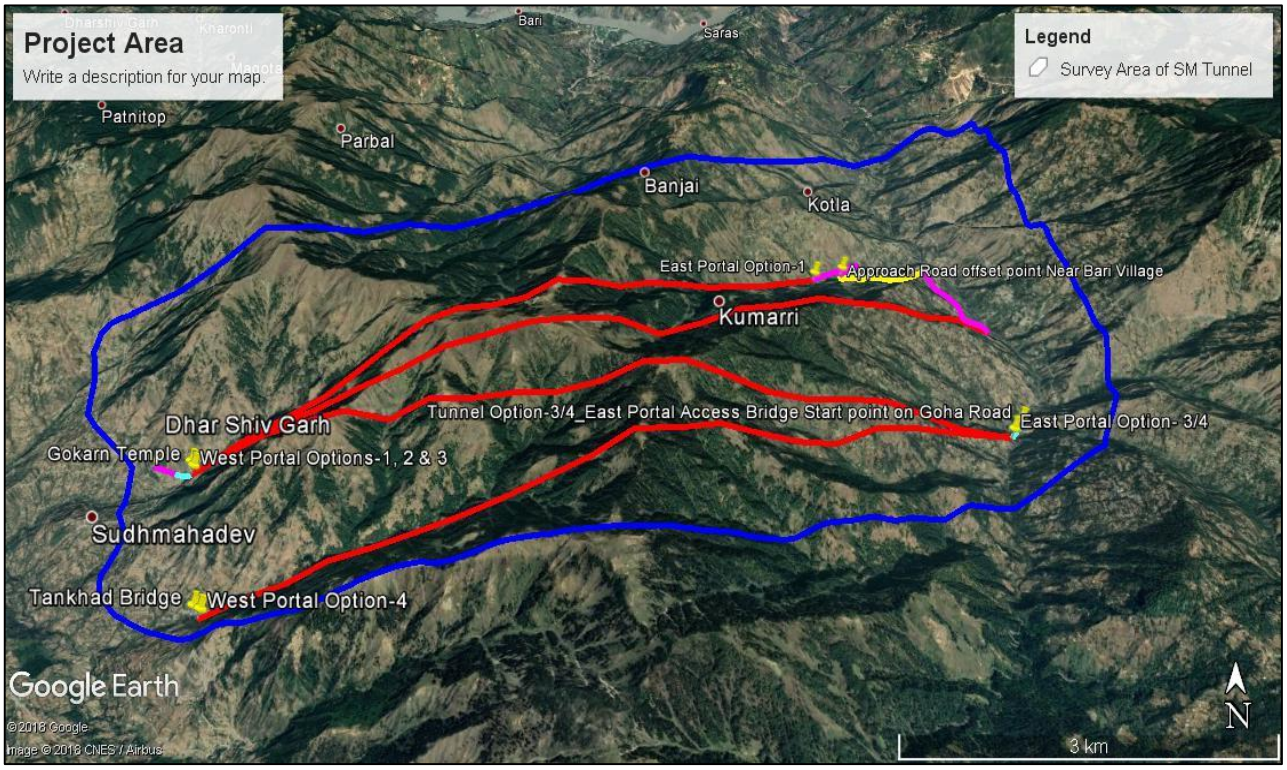


Figure 9: Location Map of SM Tunnel and Road Area

In conjunction with ground-based surveys, satellite data processing, field validation and digital image processing are used in the present study. The present study has four elements:

1. Development of Drainage and Watershed Level Map using Shuttle Radar Topography Mission (SRTM) Satellite Data at 30 meters contour resolution
2. Development of Land Use and Land Cover (LULC) maps using SENTINEL-2 Data at 1:50,000 Scale

3. Conducting field-based surveys using Dual Frequency Differential Global Positioning System (DGPS) for collection ground control points and maps validation
4. Procurement of high-resolution satellite data products for developing Digital Elevation Model (DEM) and generating one-meter interval contour maps (using all the above three inputs)

➢ **Drainage and Watershed Level Map**

DEM hydrological correction should be restricted to situations where it is actually necessary. In this study an adaptive approach is used using Adaptive Heuristic Information (AHI).

With the help of AHI only main drainage lines are extracted form SRTM satellite imagery data for the entire river basin of the study area. AHI is intended for use in regions where existing digital channel network maps are inadequate.

The main purpose of AHI is to process depressions and flat areas with heuristic information in one procedure, so both the depressions and flat areas are called pits. AHI requires three extra data structures, a “closed list”, an “open list” and a “marked stack”. They are initially empty. The closed list stores the checked nodes, the open list keeps the unchecked nodes, and the marked stack stores the pits. The basic workflow includes the following steps and will be discussed in detail in next section.

Step-1. Extract main drainage line from satellite imagery.

Step-2. The main drainage line is registered, rasterized at the resolution of the DEM and skeletonized so as to make sure that it is one node thick. Then, generating main drainage line (MDL) matrix (the corresponding nodes of MDL matrix are set one and the others are set zero).

Step-3. Drop the elevation of the corresponding nodes, whose values in MDL matrix are one, to some suitable values in order to increase flow accumulation value of these nodes.

Step-4. Detect pits from the modified DEM and push them into marked stack.

Step-5. If the marked stack is empty then go to Step 14, else go to Step 6.

Step-6. Pop a node from marked stack and put it into closed list, the node is start node.

Step-7. If the start node is a pit then go to Step 8, else go to Step 5.

Step-8. Inset the start node's eight adjacent nodes into open list and establish pointers from these nodes to the start node

Step-9. Select the node with the minimum heuristic information value in open list. Insert the selected node into closed list and remove it from open list.

Step-10. If the selected node is an outlet then go to Step 12, else go to Step 11.

Step-11. Insert the selected node's adjacent nodes which are neither in open list nor in closed list into open list. Establish pointers from these nodes to the selected node then go to Step 9.

Step-12. Trace from the outlet back to the start node and adjust the elevations for every node along the tracing path.

Step-13. Clear open list and closed list, go to Step 5.

Step-14. Generate flow direction matrix. The flow direction for a node is computed based on the natural law that surface water flow will be directed to the steepest downslope drop.

Step-15. Generate flow accumulation matrix. Each node in flow accumulation matrix represents the sum of the weights of all nodes in the matrix which drain to that node. If the weights of all nodes are set one, then the resulting values of the flow accumulation matrix will give the total contributing drainage area, in number of nodes. Other weight matrices can be used for specific drainage related applications. In this study, the weights of all nodes are set one.

Step-16. Extract drainage network. Flow accumulation matrix can be used to produce drainage network when nodes with values greater than an assigned constant threshold value are selected.

- **Watershed Map:**

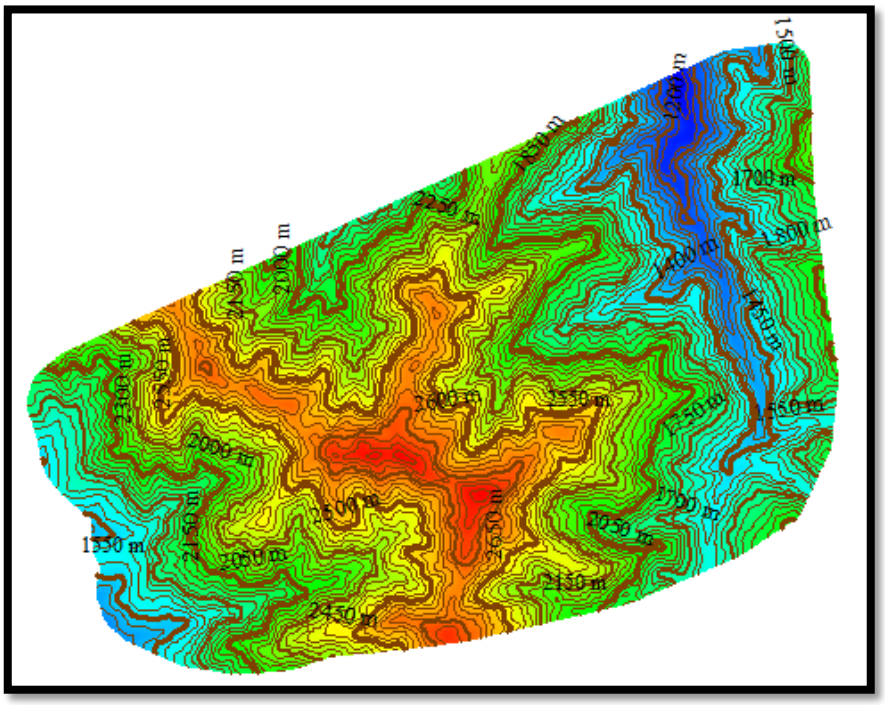


Figure 10: Watershed Map encompassing Sudhmahadev Tunnel and Road Location

- **Development of LU/LC Map**

LU/LC maps are generated through Image Pre-processing and Pan-Sharpening. SENTINEL-2 satellite images were converted to radiance followed by reflectance, using standard Equations (1) and (2).

$L\lambda = Gain \times Pixel\ value + offset$ (1)

$\rho\lambda = \pi L\lambda d\ 2\ ESUN\lambda \sin\theta$ (2)

Where: $L\lambda$ is the radiance in units of watts / (meter squared * ster * μm); d is the Earth-Sun distance in astronomical units; $ESUN\lambda$ is the solar irradiance in units of watts/ (meter squared * μm) and θ is the sun elevation in degrees. Pan-sharpening techniques are useful for enhancing the process and results of image processing and help provide a better understanding of the observed earth surface. There are numerous pan-sharpening methods to use on satellite images: high pass filter (HPF), modified intensity-hue-saturation (M-IHS), Ehlers and Gram-Schmidt. The GS pan-sharpening method has become one of the most prevalent approaches to use on multispectral lower resolution images. These methods can be classified into two main types: pixel-based and object-

based methods. Pixel-based methods can be unsupervised (based on cluster analysis) or supervised. The latter group uses statistical (e.g., maximum likelihood) and non-statistical algorithms (e.g., neural networks and support vector machines) and each of these has its own advantages and disadvantages. We applied both to the images used in this study and chose those which gave the best output. Pixel-Based Classification When recognizing and mapping LCLU change, it is obviously extremely important to determine the number of LCLU classes, and then use the best method to detect them. Based on conditions in the study area and other studies that had used Landsat images, we decided to use six classes, including: built-up areas, farmland, bare land, range land, forests and water bodies. These six classes were subsequently used with both the pixel-based and object-based classification methods.

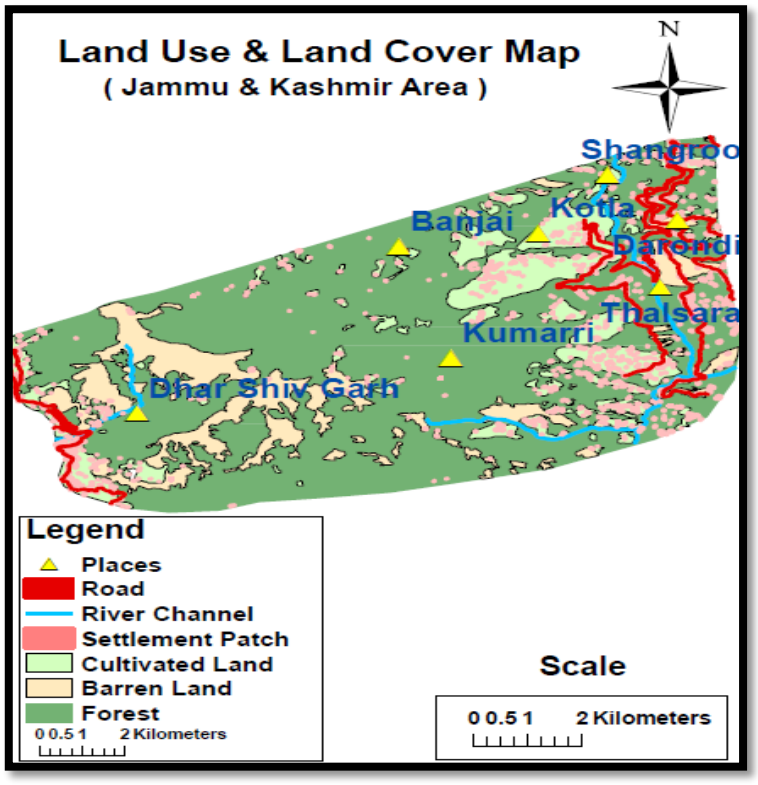


Figure 11: LU/LC Map generated for Sudhmahadev Tunnel and Road Location

- **Topographic Field Survey:**

In this exercise two major activities are undertaken:

a. Establishment of Bench Marks

b. Collection of Ground Control points

➢ Establishment of Benchmarks

A G.T.S. (Great Trigonometrical Survey) benchmark is a permanently fixed reference survey station (or point), having known elevation with respect to a standard datum (mean sea level). These are established all over India by Survey of India department with greater precision. A benchmark value is quite essential at any survey area, especially for reduction of observed sea level with respect to mean sea level or chart datum (CD). While carrying out bathymetric survey of a survey area, the datum referenced values thus obtained are used to compute the final depth contours of the survey area (with respect to CD). So, a benchmark, having known elevation is quite essential at the survey area, without which, preparation of a bathymetric chart is impossible.

In some places, GTS benchmarks are available within a kilometer distance and can be easily transferred to the survey area by fly levelling using an automatic Level instrument and a graduated levelling staff. But in most of the cases, GTS benchmarks may be at far away distance from the area to be surveyed. In these cases, the most common traditional method of transferring the benchmark value using an automatic level instrument is a difficult task, consuming enormous amount of time and labour. To eliminate this process, a method is suggested in this technical report to transfer GTS benchmark from any far distance to the survey area. A latest Differential Geographic Positioning System (DGPS) is the instrument that can be used for this purpose. The main advantage in applying this method is that considerable amount of time can be saved while maintaining the required accuracy.

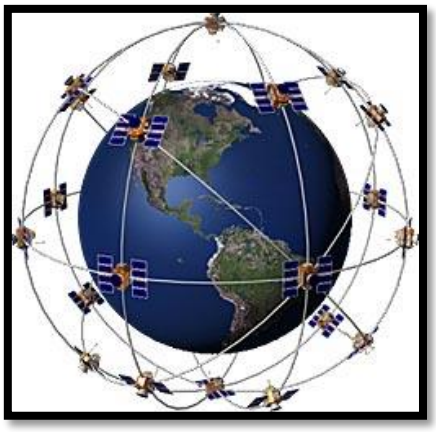
➢ Introduction

A benchmark (B.M.) is defined as a fixed reference point of known elevation with respect to a standard datum. A datum (or plane) is any arbitrarily assumed surface level (or line) from which vertical distances are measured. G.T.S. benchmarks are the ones, which are established at special intervals all over the country, with very high precision by Survey of India (SOI) department. Their geographical position and elevation above the standard datum (mean sea level) are given in catalogues, as well as, on G.T.S. maps, published by SOI. If these G.T.S. benchmarks are available near the survey area, they can be easily used for this purpose.

- **Positioning**

Differential Global Positioning System (RTDGPS) would be deployed for the purpose of positioning and for establishing the control and reference system.

The Global Positioning System is a satellite-based navigation system developed by the United States Department of Defence. It is widely used for civilian navigation and positioning, surveying and scientific applications.



Position accuracy depends on the receiver's ability to calculate accurately the time it takes for each satellite signal to travel to earth. There are various factors affecting the accuracy of GPS signals. The differential mode of operation, also known as DGPS, is an improvement for better accuracy.

DGPS is generally used at the control points to establish accuracy of stations. The control points established through DGPS can be used to start the topographic survey. The observation at this point is taken for a long period of time (24 Hours at times), till the time 2DRMS error is within acceptable limits.

We would be using Dual Freq GPS in differential mode (DGPS), for enhancing the accuracy of measurements and eliminating most of the above-mentioned errors.

Horizontal Control Point Fixing

Horizontal control points will be fixed near the survey area on permanent structure/ pillars with the help of Differential Global Positioning System with the desired accuracy. The survey would be conducted at a time of good satellite visibility, keeping the DOP (Dilution of Precision) at the minimum.

Vertical Control Point Fixing:

Vertical control would be established with respect to the chart datum / sounding datum using DGPS or datums established by various government agencies. Standard method for transfer of datum for would be used.

- **Method of Survey**

The nearest GTS benchmark may be assumed as point "A". In this case it would be existing Benchmark near the project site is considered as starting point. The location and values of all the G.T.S. benchmarks are given in GTS booklets and maps published by Survey of India, Dehra Dun. A baseline point "B" can be selected about 100 meters away from point "A" for azimuth purpose. The geographical positions of both "A" and "B" should be obtained accurately in WGS-1984 UTM co-ordinates using DGPS instrument. DGPS should be set up over Point "A" and all initial settings such as levelling, etc. should be done very accurately. The U.T.M. (Universal Transverse Mercator) co-ordinates and elevations of both "A" and "B" should be entered in the DGPS console. The DGPS pointer should be aimed towards a point "C" on top of a building or any huge structure, which may be about 1500 to 2000 meters away from "A", towards the survey area. By aiming the point "C" accurately and releasing the laser pulse, both geographical position as well as the elevation value are computed by the instrument and recorded into the memory. The elevation of Point "C" is now known with respect to the GTS benchmark point "A". Now the DGPS instrument can be now shifted to point "C". From point "C" another baseline point ("D") can be selected at a distance. Keeping "C" and "D" as the base line points, the above method of surveying can be repeated, simultaneously proceeding towards the survey area. Finally, the DGPS should be kept exactly near the survey area at PBM: 7 (transferred benchmark). The final main point on the survey area (PBM: 7) should be selected in such a way that good line of sight is available throughout the stretch of the area to be surveyed. The geographical position and elevation of point TBM: 10 should be recorded. The elevation thus obtained over PBM: 7 will be with respect to mean sea level. This whole process of transferring G.T.S. benchmark to the survey area should get completed within 6 setups of DGPS ("A","C" and "D" and so on), provided the distance between the GTS benchmark and the survey area is within 15 kilo meters. The whole process may take roughly about 8 hours for completion. In comparison, by using

the traditional method of transferring the benchmark, it may take at least 36 hours for completion using automatic level instrument.

Existing Benchmark Intermediate Point Final Bench Mark

Figure 12: Schematic Representation of Benchmark Shifting

➢ **Permissible Error Limits**

In the old traditional method, while carrying out transfer of benchmark from one place to another using Automatic level and a graduated staff (the traditional old method), closing error tends to occur. The magnitude of the permissible limit of closing error depends on the purpose for which the levelling is required. It wholly depends on the order of the accuracy demanded or the precision of levelling. In general, the permissible closing error in traditional method of surveying is expressed as

E = C√K where

E = the error in millimeters.

C = the Constant and

K = the distance in kilo meters.

The value of "C" depends upon four criteria namely:

1. Quality of the instrument
2. Observer's care and skill
3. The character of the site and
4. The atmospheric conditions.

The closing error "E" and the value of "C" for different types of levelling are given in (Kanetkar, 2006).

4.1.1 Benchmark Depiction

Thus, established Benchmark locations are marked on permanent locations with visible paint and would help the next surveyors to conduct topographical and related surveys.

➢ **Collection of Ground Control Points (GCPs)**

GCPs are collected during the field survey using DGPS equipment. These GCPs play a major role in improving the accuracy of generated contours. In other words, they help in ground truthing of any contour plot generated from Satellite data.

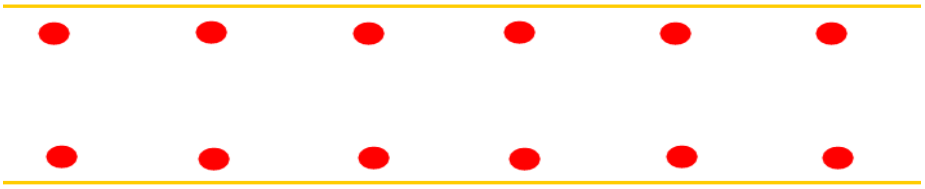


Figure 13: Pictorial Depiction for Selection of GCPs points

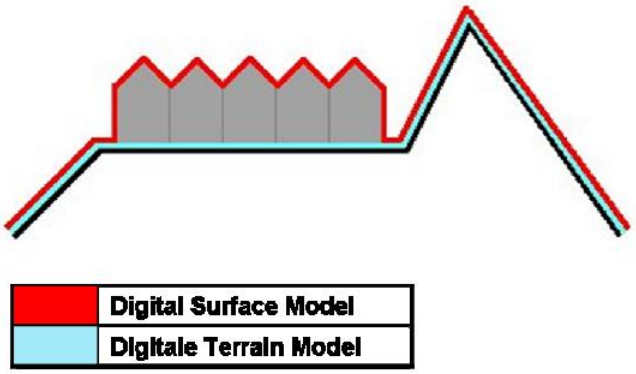
In general terms, it is highly recommended to add GCPs in such projects in order to make DEM model more stable and accurate. The number of GCPs depends on the relative accuracy of the image geolocation. If the images have accurate relative position, then 8-10 GCPs are enough per sq. km. The length of the project also affects the number of the required GCPs. The longer the corridor, then more the GCPs are required in the present case the total river length is not more than 15 kms and average width is about 0.5 km. Hence, about 67 GCPs are collected from the field prior to contour mapping using a team of professional surveyors and DGPS. The details of these GCPs are given in Annexure-1.

Figure 14: GCP Data collection at a project site using DGPS

➢ Development of Digital Elevation Model (DEM) and Contour Generation

- **Introduction**

Digital Elevation Model (DEM) is a regularly spaced raster grid of elevation values of a surface terrain. DEMs can be used to produce maps such as contour maps, orthophoto maps, and perspective maps. DEMs are also useful for irrigation planning dam construction planning, route planning in the construction of highways and railways. In remote sensing, DEMs are used in mapping, ortho-rectification, and land classification.



Surfaces represented by a Digital Surface Model and Digital Terrain Model

Figure 15: Digital Model

The DEM extraction module enables to extract elevation data from push broom stereo images, generated by satellites like ASTER, IKONOS, OrbView-3, Quick Bird, KOMSAT, and Geoeye. It is important that these imageries have associated Rational Polynomial Coefficients (RPCs) which contain necessary information about the sensor model. In addition, RPCs are used in tie point generation and to calculate the stereo image pair relationship, which helps in three-dimensional topography generation.

The DEM extraction process requires a stereo pair of images containing RPC positioning from either along track or across track satellite data acquisition. Along track, stereo images are acquired on the same orbital pass by a satellite, which usually has more than one sensor looking at the Earth from different angles. Across track, stereo images are those taken by the same sensor on multiple orbits.

➢ DEM (Digital Elevation Model)

A digital elevation model is a digital model or 3-D representation of a terrain's surface

commonly for a planet (including Earth), moon, or asteroid - created from terrain elevation data. The term Digital Elevation Model is often used as a generic term for DSMs and DTMs

- **DSM (Digital Surface Model)**

This term stands for Digital Surface Model representing the earth's surface and including all objects exist on its surface. Please see the following figure for details

- **DTM (Digital Terrain Model)**

This term stands for Digital Terrain Model representing the bare ground surface without any objects like plants and buildings. Please see the following figure for details.

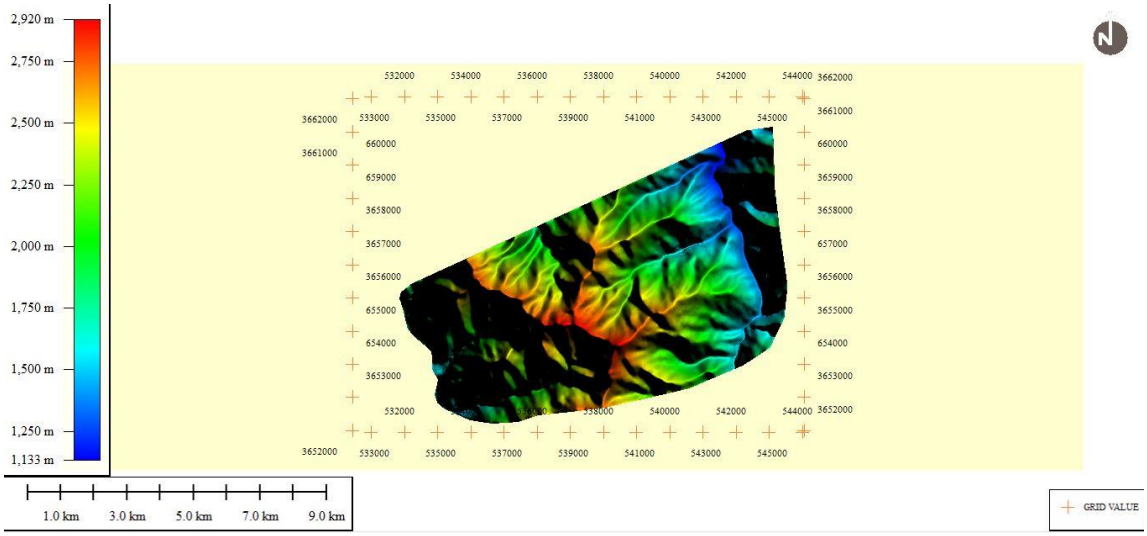


Figure 16: **Digital Elevation Model of Sudhmahadev Tunnel and Road Location**

- **Methodology for Generation of Contours at 5.0 to 1.0 m Spacing from Higher Resolution Satellite Images**

In the present assignment, the following method would be adopted for generation of Contours at 5.0 to 1.0 m spacing from DTM generated from higher resolution KOMPSA-3 satellite images for the study area.

- Ground Control Points (GCPs) – approximately 67 Nos.
- Watershed Maps generated from SRTM-30 satellite data
- Land Use and Land Cover Maps developed from SENTINEL-2 Satellite data

➢ **Process**

Higher resolution KOMPSAT-3 stereo satellite images are used in Digital Terrain Modelling, contouring using Leica Photogrammetry Suite (LPS) project manager.

Prior to performing the photogrammetric tasks within LPS Project Manager, a block is created. This 'Block' is a term used to describe and characterize all of the information that are associated with a photogrammetric mapping project, including:

- Projection, spheroid, and datum information (UTM, WGS 84)
- Imagery to be used within a project (KOMPSAT-3)
- Camera or sensor model information associated with the imagery (Pan sharpened Ortho ready product with RPC, 100 cm spatial resolution)
- GCPs and their measured image positions, and
- Geometric relationships exist between the imagery in a project and the ground.

The following figure illustrates the methodology adopted for DTM generation.

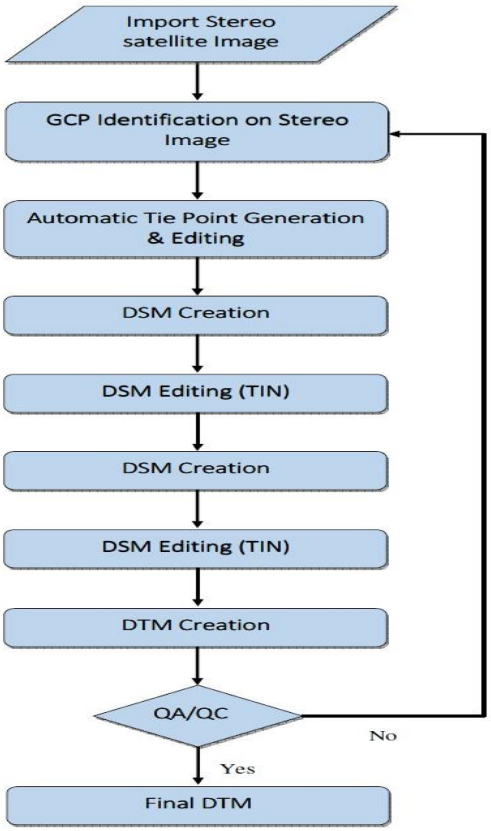


Figure 17: Flowchart showing methodology for DTM creation

➢ Adding Imagery of the Block

As a first step, images are added to the block and followed by creation of pyramid layers. Exterior orientation was created after loading RPC file of respective images. Interior orientation defines the internal geometry of a camera or sensor as it existed at the time of image capture. The variables associated with image space were defined during the process of defining interior orientation.

Interior orientation had been primarily used to transform the image pixel coordinate system or other image coordinate measurement system to the image space coordinate system. About 67 Ground Control Points (GCPs) collected through filed survey are verified from their relative positioning and established on site bench marks (triangulation points and spot heights) for DEM usage purpose and used for better orientation of image with respect of the earth.

The variables defining the position and orientation of an image are referred to as the elements of exterior orientation. The elements of exterior orientation define the characteristics associated with an image at the time of exposure or capture. This process defined the image orientation within the block selected for the study area.

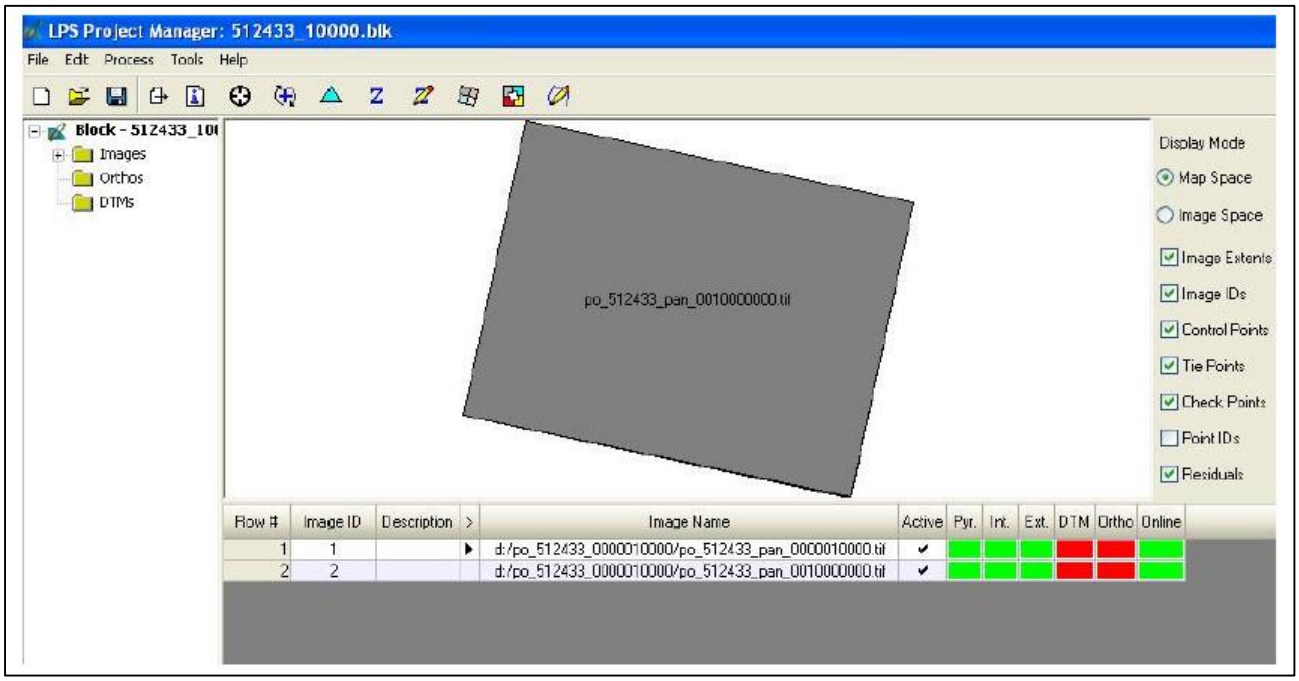


Figure 18: Block and Orientation of the satellite image

In the next step, a TIN model (set of contiguous, non-overlapping triangles) is generated

using Automatic Terrain Extraction (ATE) module of LPS, with quality verification through its analysis under stereoscopic visualization).

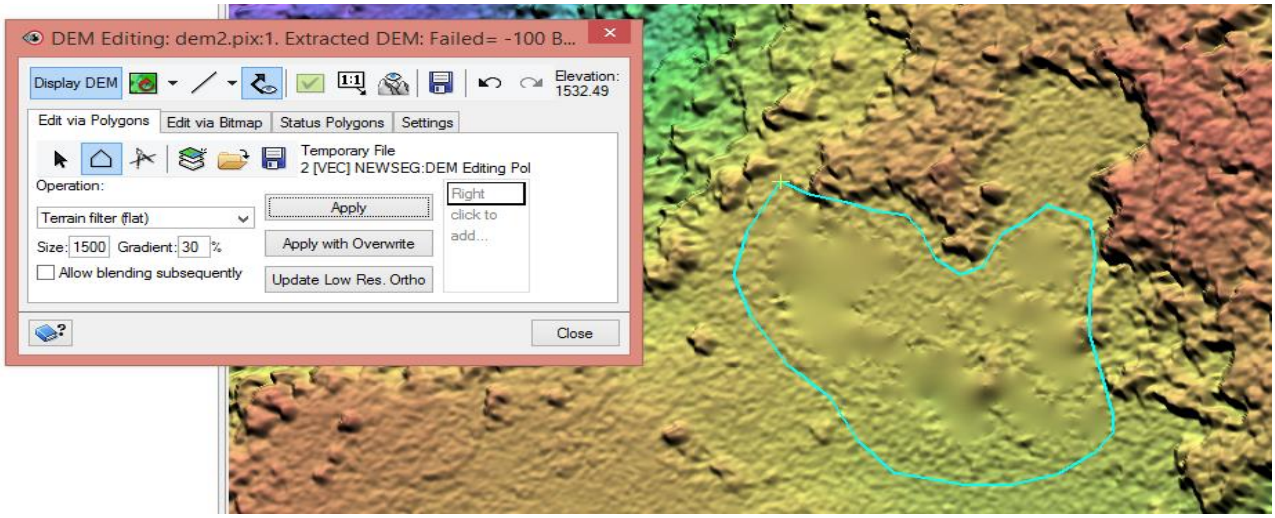


Figure 19: Editing of Elevation Model

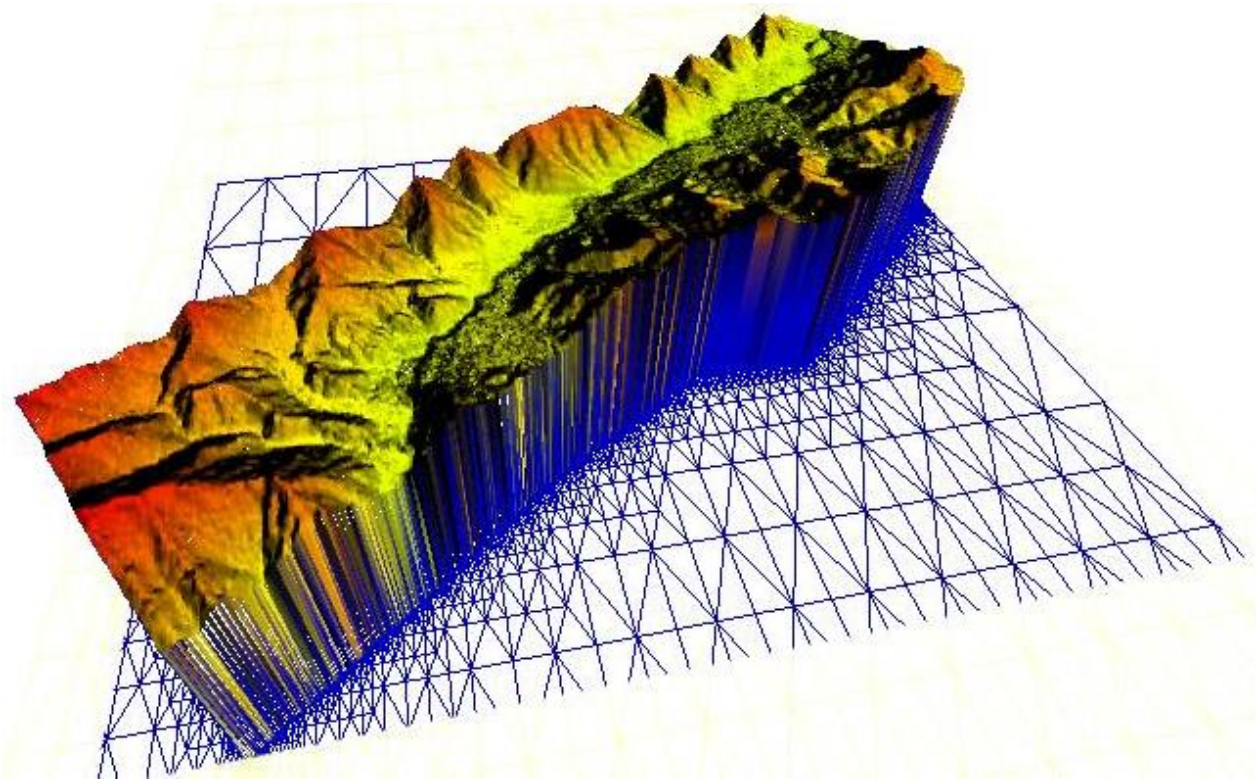


Figure 20: Digital Terrain Model (DTM) - 3D view

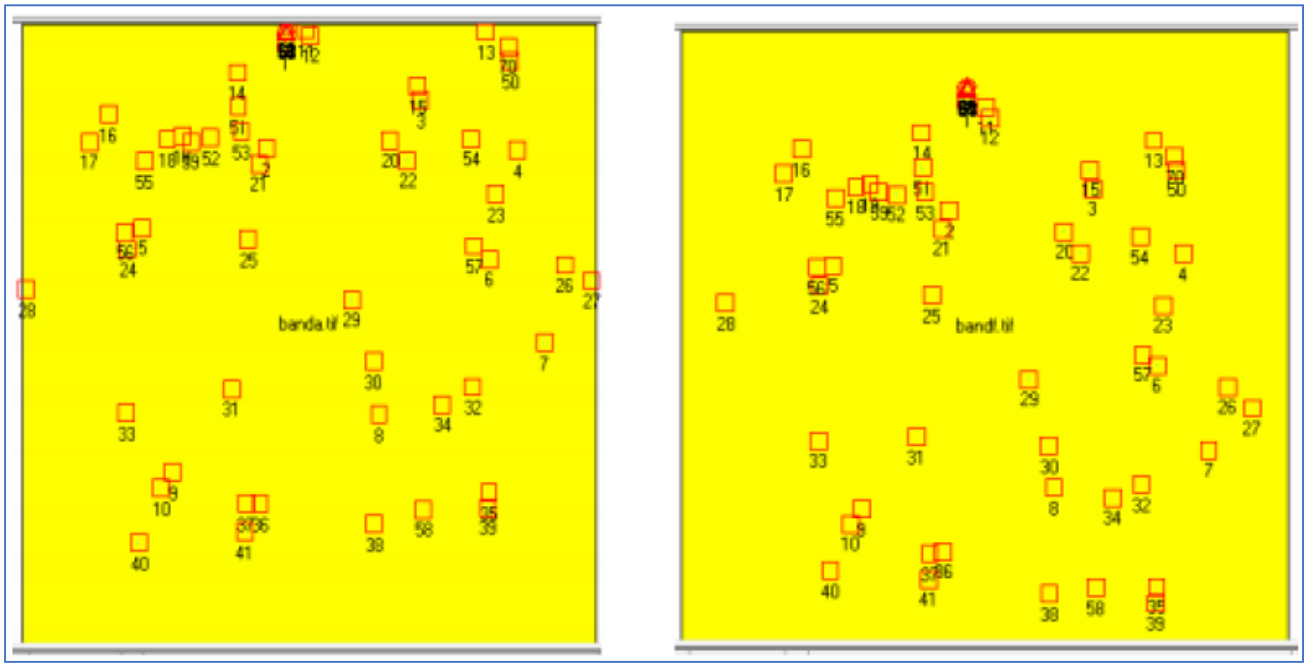


Figure 21: Distribution of GCPs & Tie points

- **DSM Extraction and Editing**

After performing the triangulation, the epipolar images will be generated during the DSM editing process and kept as background in 3D environment. The mass points are overlaid on these epipolar images to check their consistency. Mass points are irregularly distributed sample points, which are used as the basic element to build a Triangulated Irregular Network (TIN). In this process, to obtain required accuracy, the RCPs and mass points are validated against the collected GCPs, spot heights and triangulated points obtained from the field.

- **Automated Contour Generation (at 1.0 m spacing)**

Once the DTM was generated, in the next step, the contours will be delineated at 1.0 m spacing from DTM using Global Mapper software. Finally, the contours are checked for their spacing and configuration and necessary steps were adopted to correct them. The process resulted in generation of higher accuracy (500 to 100 cm vertical accuracy) and about 1.0 m horizontal accuracy.

Thus, generated contour map is again field validated with physical survey using Differential GPS for its accuracy of representation at ground level.

➢ **Conversion to AutoCAD format:**

After the 5.0 to 1.0 m contour map is generated under GIS environment, using an advanced conversion facility the map is converted as AutoCAD compatible format.

➢ **Limitation of the Process**

Though the result obtained through the above process is found to be quite accurate and validated against all available information, however, a set of well-distributed filed captured DGPS points could have been useful in correlation and validation purpose.

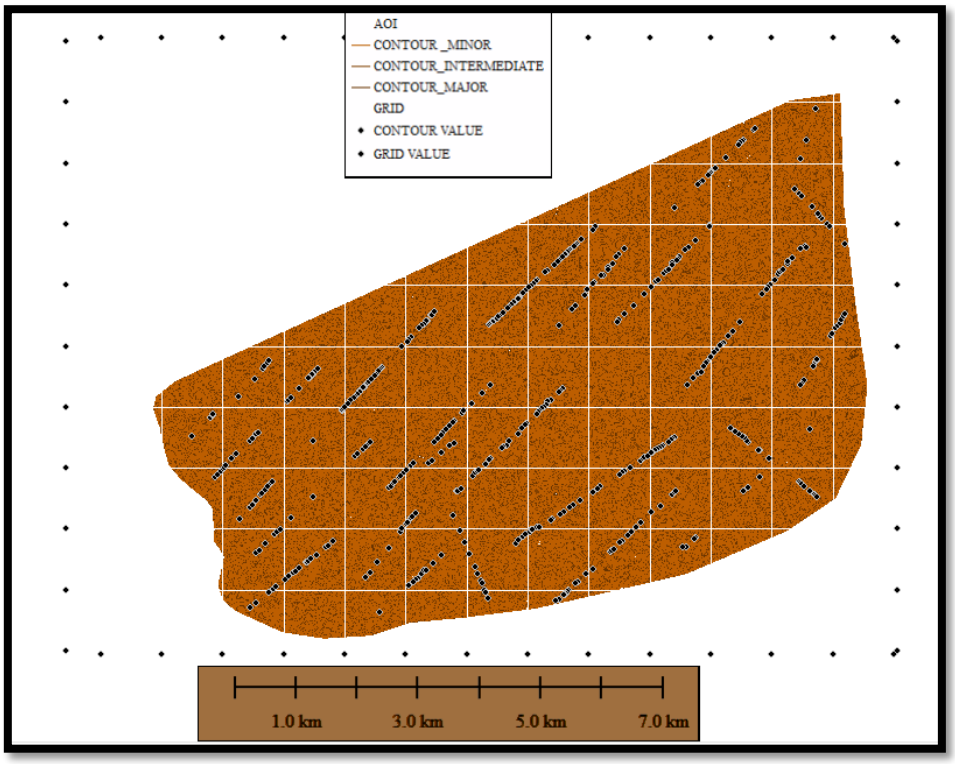


Figure 22: Contour Plot of Sudhmahadev Tunnel and Road Location

4.2 Geological and Geotechnical Investigation

In this valley, the project area around tunnel 1 has exposed limestone, dolomitic limestone, quartzite and calcareous quartzite belonging to Gamir Formation (Raina and Gupta 1985-86).

These are best exposed along the road section between the Gauri Kund Temple and Gau Karan in this valley. The total length of this tunnel is about 5.4 km. Western portal of this tunnel is placed at an elevation of El. 1719m and its co-ordinate is N 3654820.29, E 533679.42. Eastern portal of this tunnel 1 is placed at an elevation of El. 1635m and its

co-ordinate is N 3658964.85, E 537173.34.

Along the tunnel 1 alignment, grey platy limestone and calcargillite with occasionally thin bands of carbonaceous phyllite of Baila Formation may be encounter after Gamir Formation. Baila Formation is considered to be Precambrian in age on the basis of its stratigraphic position between Gamir and Ramban formations, both regarded to be Precambrian in age.

Ramban Formation represents an important Lithostratigraphic constituent of the 'Parautochthon' in this part of Lesser Himalaya where it is present throughout the belt. This formation is underlying by Baila Formation. Phyllite, slate, carbonaceous shale and limestone of Ramban Formation is expected to be encountered along tunnel alignment.

Stratigraphically Sincha Formation is the uppermost formation of the 'Parautochthon' in the area. Northern and eastern part of this formation is bounded by the regional tectonic plane namely the Panjal Thrust which juxtaposes it against the Salkhalas. Its contact with the underlying Ramban Formation is inferred to be disconformable, though in the Ramban and Chenab valley section it is a tectonic contact (Digdaul Thrust) (Raina and Gupta, 1985-86). Dolomite, dolomitic limestone, limestone and quartzite of this formation may be encountered along the tunnel alignment.

Highly crushed, fragmented, disturbed zone etc. are usually associated Panjal Thrust in the Chenab valley is observed and projected in tunnel alignment. This plane has a NW-SE trend, moderate to steep dip due northeast and juxtaposed the Salkhalas of the Kashmir Synclinorium zone against the Sincha Formation to the south.

Entire length of tunnel 2 falls in Salkhala formation. The total length of this tunnel is about 2.6 km. Western portal of this tunnel is placed at an elevation of El. 1585m and its co-ordinate is N 3659481.70, E 538248.46. Eastern portal of this tunnel is placed at an elevation of El. 1500m and its co-ordinate is N 3659358.8211, E 540885.57. Rock types expected to be encountered are mica schist, phyllite, carbonaceous phyllite, quartzite with patches of metavolcanis of Salkhala formation.

4.2.1 Field Investigation

The field investigation carried out at different sites of tunnel include detailed surface geological mapping on different scales and subsurface investigation including

exploratory drilling (Plates 2 and 6) at the portals of both the tunnel.

Surface Geological Mapping

The project area has a very rugged topography characterized by sharp crested ridges and narrow valleys. The altitude varies between 1650m to about 2770m and most of the area is covered by thick vegetation. In general, the project area has a hostile terrain. In spite of all these adverse conditions, geological mapping was carried out at the sites by an experienced Geologist. Traverse was taken along maximum possible tunnel alignment for tunnel 1 and all along the alignment along tunnel 2. Mapping of engineering properties of maximum possible joints and other structures were done. All the rock types along with their disposition were recorded for further analysis. Contacts were recorded. The detailed geological mapping of the highway tunnel and all tunnel portals was carried out on 1:1000 scale. However, the drawings have been reproduced on 1:5000 in Volume IX (Drawings).

Sub-surface Investigations

The subsurface investigations planned at all four portals of the Tunnel 1 & 2 include drilling with a view to delineate the overburden-rock interface and to assess the condition of the rock mass in the sub-surface. So far, all portals have been explored through 5 drill holes. (Plates 2 & 6). The locations and depth of the holes are given in Table. The brief summary of drill holes is given in below Table. and the detail drillhole logs have been provided in Annexure-II of Geotechnical Factual Report.

Table 12: Details of Exploratory Drill Holes

Drill Hole No.	Location of Holes	Co-ordinates		Ground Elevation(m)	Remarks
		N	E		
BH 1	Western Portal of Tunnel 1 (Alt. 1)-Discarded	3655957.08	532968.54	1740	Completed
BH 2	Western Portal of Tunnel 1	3654809.61	533666.26	1735	Completed
BH 3	Eastern Portal of Tunnel 1	3658830.69	537131.13	1700	Completed
BH 4	Western Portal of Tunnel 2	3659477.28	538249.46	1635	Completed
BH 5	Eastern Portal of Tunnel 2	3659361.89	540842.98	1545	Completed

Table 13: Summarised Details of Exploratory Drill Holes

Drill hole No	Location	Ground elevation (m)	Depth of hole (m)	Bed rock depth (m) with Elevation (m)	Type of Overburden	Type of Bedrock
BH 01	Tunnel 1-Discarded (Old Alignment) (Near Gorikund) N 3655957.08 E 532968.54	1740	48.50	38.0; EL 1702.0	Overburden comprising of angular to sub angular, rounded to sub rounded granules, cobbles, pebbles and boulders of claystone, sandstone, limestone, quartzite and phyllitic rock	Fine grained, reddish coloured, weak to moderately strong Claystone with intercalated quartz bands. Bedrock is moderately to highly weathered up to excavated depth. Bedrock is moderately jointed; Core recovery in the bedrock, general varies between 43.33% & 93.33%. RQD generally varies between 0 to 44%. Water table is not encountered up to excavated depth. Standard penetration test (SPT) in soil was also conducted at four locations at different elevations. Result of SPT is refusal.
BH 02	Tunnel 1 (Near Western Portal) N3654809.61 E 533666.26	1735.0	40.0	0.50; EL 1734.50	Overburden comprises top soil and boulders of claystone and dolomite	Bedrock encountered below 0.5m depth (El 1734.5m) comprises reddish coloured, fine grained, weak, moderately to highly jointed, slightly weathered Claystone down to 3.5m depth. Below this light greyish coloured, moderately strong to strong, slightly to moderately jointed, fresh to slightly weathered Dolomite with uneven

Drill hole No	Location	Ground elevation (m)	Depth of hole (m)	Bed rock depth (m) with Elevation (m)	Type of Overburden	Type of Bedrock
						bands of silica/calcite are emplaced in bedrock. Foliation/bedding dips by 35° to 70°. Joints are closely spaced at places. Core recovery varies between 32.67% & 100%. RQD in general ranges from nil to 80%. Permeability of bedrock ranges between 4.464 Lugeon and 5.545 Lugeon. Partial loss of drill water was observed up to excavated depth.
BH 03	Tunnel 1 (Near Eastern Portal) N 3658830.69 E 537131.13	1700.0	40.0	0.50; EL 1699.50	Overburden comprises top soil and broken core pieces of schistose and quarzitic boulders	Bedrock encountered below 0.5m depth (El 1699.5m) comprises grey to black coloured, fine to medium grained, weak to moderately strong, slightly to moderately jointed, fresh to slightly weathered Mica Schist with intercalation of quartz vein. Due to high schistosity core are broken into small pieces. Foliation dips by 35° to 70°. Joints are closely spaced at places. Core recovery varies between 40.6% & 93%. RQD in general ranges from nil to 76.6%. Permeability of bedrock ranges between 6.536 Lugeon

Drill hole No	Location	Ground elevation (m)	Depth of hole (m)	Bed rock depth (m) with Elevation (m)	Type of Overburden	Type of Bedrock
						and 9.770 Lugeon. Partial loss of drill water was observed up to excavated depth.
BH 04	Tunnel 2 (Near Western Portal) N 3659477.28 E 538249.46	1635.0	40.0	1.50; EL 1633.50	Overburden comprises top soil and broken core pieces of schistose and quarzitic boulders	Bedrock encountered below 1.5m depth (El 1633.5m) comprises grey to black coloured, fine to medium grained, weak to moderately strong, slightly to moderately jointed, fresh to slightly weathered Mica Schist with intercalation of quartz vein. Due to high schistosity core are broken into small pieces. Foliation dips by 35° to 70°. Joints are closely spaced at places. Core recovery varies between 50% & 100%. RQD in general ranges from nil to 100%. Permeability of bedrock ranges between 7.350 Lugeon and 8.815 Lugeon. Partial loss of drill water was observed up to excavated depth.
BH 05	Tunnel 1 (Near Eastern Portal) N 3659361.89 E 540842.98	1545.0	40.0	0.50; EL 1544.50	Overburden comprises top soil and boulders of phyllite, quartzite, schistose gneiss	Bedrock encountered below 0.5m depth (El 1544.5m) comprises Greyish Colour, Medium Strong to strong, slightly to moderately jointed, medium to fine grained Phyllitic quartzite with bands of quartz,

Drill hole No	Location	Ground elevation (m)	Depth of hole (m)	Bed rock depth (m) with Elevation (m)	Type of Overburden	Type of Bedrock
						staining and weathering along the Joint Planes. Foliation dips by 40° to 65°. Joints are closely spaced at places. Core recovery varies between 20.66% & 93.33%. RQD in general ranges from nil to 52.66%. Permeability of bedrock ranges between 4.848 Lugeon and 5.215 Lugeon. Partial loss of drill water was observed up to excavated depth.

Laboratory Test of Drill Core Samples

Rock core samples were collected from drill holes and tested in laboratory to determine the physico-mechanical properties. The details of test results of laboratory test of core samples carried out for the project are also annexed as Annexure-III. The summarized Laboratory Test Results are given below:

A. Density as per IS 13030:1991

Table 14: Summarized Laboratory Test Results

Sl. No.	Sample ID	Depth (m)	Unit Weight (g/cm^3)
1	BH-02/WP/Tunnel-01	6.30	2.760
2	BH-02/WP/Tunnel-01	14.50	2.690
3	BH-02/WP/Tunnel-01	31.50	2.697
4	BH-05/EP/Tunnel-02	21.00-22.50	2.842
5	BH-05/EP/Tunnel-02	27.00-28.50	2.799
6	BH-05/EP/Tunnel-02	36.00-37.50	2.789
7	BH-04/WP/Tunnel-02	34.50-36.00	2.661
8	BH-04/WP/Tunnel-02	39.00-40.00	2.683
9	BH-04/WP/Tunnel-02	39.00-40.00	2.670

B. Uniaxial Compressive Strength as per IS: 9143-1979 (Reaffirmed 2016) with Modulus of Elasticity & Poisson's Ratio as per IS 9221-1979 (Reaffirmed 1996)

Sample No.	Source of Sample	Location	Depth (m)	Type of Machine Used	No. of Specimens Tested	Stress Rate (MPa/s)	Specimen No.	Lithological Description of Rock As per Client / Laboratory Observation (Visual Examination)	Orientation of Loading Axis	Mode of Failure	Duration of Test (min)	Diameter (mm)	Height (mm)	Modulus of Elasticity(Gpa)	Poisson's Ratio	UCS (Mpa)
BH-02/WP/Tunnel-01	Sudhmahadev Tunnel	Tunnel No. 1, (Western Portal)	6.30	500 kN CTM	1	0.5	26.00	Light grey color quartz vein intruded dolomite	Vertical	Wedge Shear	3.0	51.21	99.00	51.6	0.23	89.302
BH-02/WP/Tunnel-01			14.50		2		87.00	Grey color weathered iron stained dolomite		Wedge Shear	0.8	51.21	102.24	17.1	0.25	23.793
BH-02/WP/Tunnel-01			31.50		3		198.00			Wedge Shear	1.0	50.98	100.68	28.8	0.25	29.719
BH-05/EP/Tunnel-02		Tunnel No. 2, (Eastern Portal)	21.00-22.50		1		112.00	Light brown color fine to medium grain quarzitic Phyllite		Wedge Shear	1.3	51.28	104.36	37.4	0.24	39.585
BH-05/EP/Tunnel-02			27.00-28.50		2		160.00			Wedge Shear	2.2	51.60	100.18	41.2	0.23	64.507
BH-05/EP/Tunnel-02			36.00-37.50		3		209.00			Wedge Shear	0.9	50.90	100.74	24.1	0.26	27.570
BH-04/WP/Tunnel-02		Tunnel No. 2, (Western Portal)	34.50-36.00		1		154.00	Grey color week schistose rock		Wedge Shear	0.3	50.98	101.26	5.3	0.27	8.281
BH-04/WP/Tunnel-02			39.00-40.00		2		171.00			Wedge Shear	0.5	51.27	99.53	14.4	0.26	16.140
BH-04/WP/Tunnel-02			39.00-40.00		3		171.00			Wedge Shear	0.5	51.20	103.00	14.1	0.26	16.475

C. Brazilian Tensile Strength as per IS:10082-1981 (Reaffirmed 1996)

Sample ID	Depth (m)	Source of sample	Location	Specimen No.	Rock Type (As per Client)	Diameter (mm)	Thickness (mm)	Tensile Strength (MPa)
BH-02/WP/Tunnel-01	6.30	Sudhmahadev Tunnel	Tunnel No. 1, (Western Portal	26	Dolomite	51.20	27.80	7.85
BH-02/WP/Tunnel-01	6.30			26		51.20	26.50	7.78
BH-02/WP/Tunnel-01	14.5			87		51.20	28.20	8.21
BH-05/EP/Tunnel-02	21.00-22.50		Tunnel No. 2, (Eastern Portal)	112	Phyllite quarzitic	51.28	29.14	4.64
BH-05/EP/Tunnel-02	33.00-34.50			192B		50.50	29.52	5.81
BH-05/EP/Tunnel-02	33.00-34.50			192B		50.50	34.22	3.81
BH-04/WP/Tunnel-02	34.50-36.00		Tunnel No. 2, (Western Portal	154	Grey color week schistose rock	50.77	27.25	2.66
BH-04/WP/Tunnel-02	36.0-37.50			155		50.73	27.5	2.35
BH-04/WP/Tunnel-02	36.00-37.5			155		50.95	27.2	2.84

D. Triaxial Shear Strength (Natural Condition) as per IS: 13047-1991 (Reaffirmed 2016)

Sample No.	Source of Sample	Location	Depth (m)	Moisture Content (%)	Specific Gravity	Porosity	Type of Machine Used	No. of Specimens Tested	Specimen No.	Lithological Description of Rock As per Client / Laboratory Observation (Visual Examination)	Orientation of Loading Axis	Mode of Failure	Diameter (mm)	Height (mm)	Confining Pressure (MPa)	Axial Pressure (MPa)	c (MPa)	φ (°)
BH-02/ WP/Tunnel-01	Sudhmahadev Tunnel	Tunnel No. 1, (Western Portal)	28.50	-	-	-	500 kN Load frame	03	1	Light grey color quartz vein intruded dolomite	Vertical	Wedge Shear Failure	51.02	79.22	5.884	44.79	3.39	42.58
				-	-	-			2				51.04	79.20	7.845	58.41		
				-	-	-			3				51.10	80.82	9.807	65.12		
BH-05/EP/Tunnel-02		Tunnel No. 2, (Eastern Portal)	33.00-34.50	-	-	-		03	1	Light brown color fine to medium grain Phyllite quarzitic	Vertical	Wedge Shear Failure	50.48	86.36	5.884	38.12	2.03	41.53
				-	-	-			2				50.50	86.40	7.845	47.66		
				-	-	-			3				50.48	86.42	9.807	57.48		
BH-04/ WP/Tunnel-02		Tunnel No. 2, (Western Portal)	31.50 - 33.00	-	-	-		03	1	Grey color week schistose rock	Vertical	Wedge Shear Failure	50.94	91.32	5.884	19.80	0.53	30.53
				-	-	-			2				50.96	91.63	7.845	26.51		
			34.50 - 36.00	-	-	-			3				50.90	91.47	9.807	31.83		

Chemical Test of Water Sample

Water samples were collected from different locations and tested in laboratory to determine the chemical properties. The details of test results of laboratory test of water samples carried out for the project are also annexed as Annexure-IV. The summarized Laboratory Test Results are given below:

Test Name	Sample ID			Specification As per IS:456-2000(Max)
	Thandha Pani	Singpora	Vaildo	
pH	7.5	8.2	7.8	>6
Chloride Content (mg/l)	332	282	405	500 mg/l for R.C.C. 2000 mg/l for P.C.C.
Sulphate Content (as SO_4) (mg/l)	103	219	232	400 mg/l
Organic (mg/l)	101	70	85	200 mg/l
Inorganic (mg/l)	213	150	198	2000 mg/l
Total Suspended Solids (mg/l)	12	22	17	2000 mg/l
Acidity as mg/l $CaCo_3$	15	20	12	Not require more than 5ml of 0.02 normal NaOH
Alkalinity as mg/l $CaCo_3$	32	40.5	27	Not require more than 25ml of 0.02 normal H2SO4

Petrography

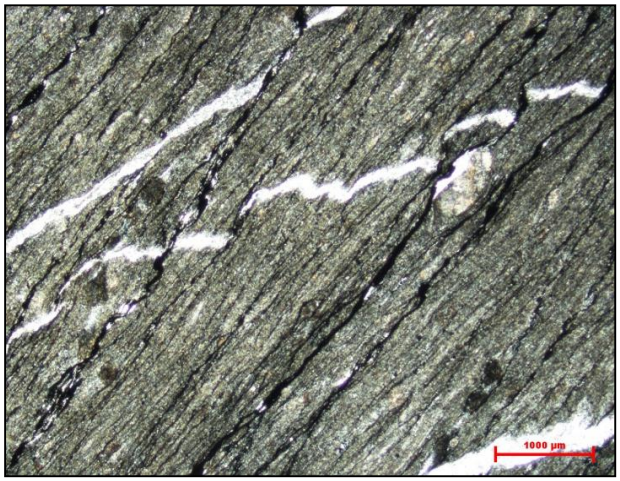
In order to determine the microstructures, mineral contents, shears and alteration of minerals and presence of deleterious minerals, the specimens from the drill cores and field were selected from various depths and locations for petrographic analysis. The collected samples have been sent for necessary lab tests.

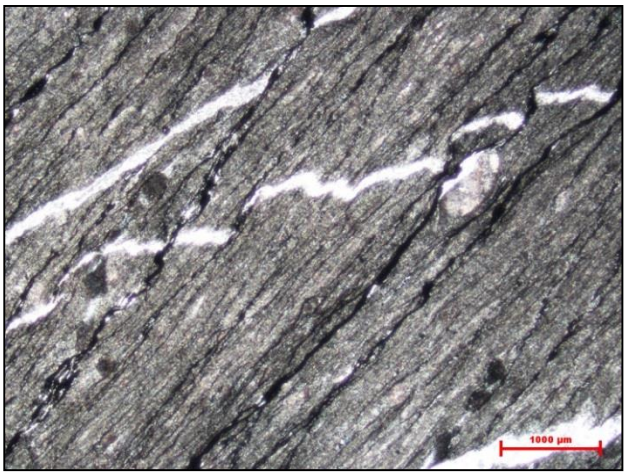
Sample No: 1 (WP T-1)

Rock description- Very fine-grained laminated rock dissected by straight and folded calcite veins

Microscopic Observations- There is ~80% calcite and ~20% opaques present in this rock. It is a fine grained thinly laminated sedimentary rock mainly made up of calcite (Figures). The calcite is generally micritic (Figure). Calcite is re-precipitated in the form of coarser grained veins and some of the cross-cutting veins show tygmatic folding (Figures). Opaques are either aligned parallel to the major S-fabric or are at low angle to it and suggest a deformation related alignment.

Name**: Fine grained marble**



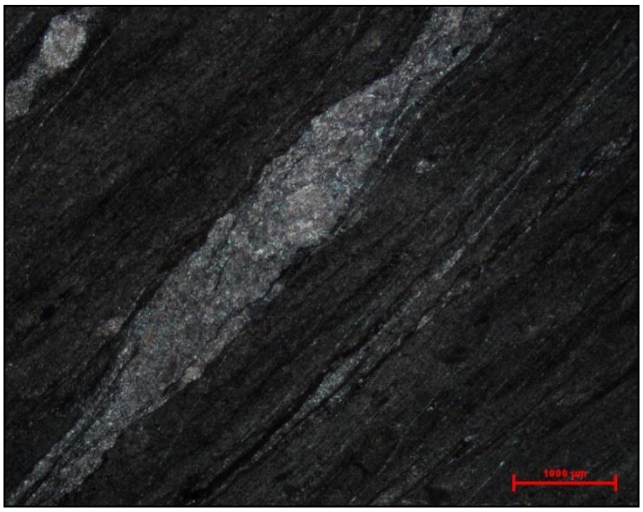


Sample No: 2(WP T-1)

Rock description- Fine grained grey coloured foliated rocks, sub mm foliation, anastomosing nature, Fine mica present.

Microscopic Observations- There is >90% calcite and the rest are mainly opaque minerals (Figures). It is a very fine grained thinly laminated rock with few calcite veins exhibiting a low angle discordant relation with the major fabric. Oriented oapques suggest an effect of deformation. Two variety of calcite is present with the dominant being the microcrystalline and the coarser calcite confined to the recrystallized veins (Figures).

Name: **Fine grained marble**

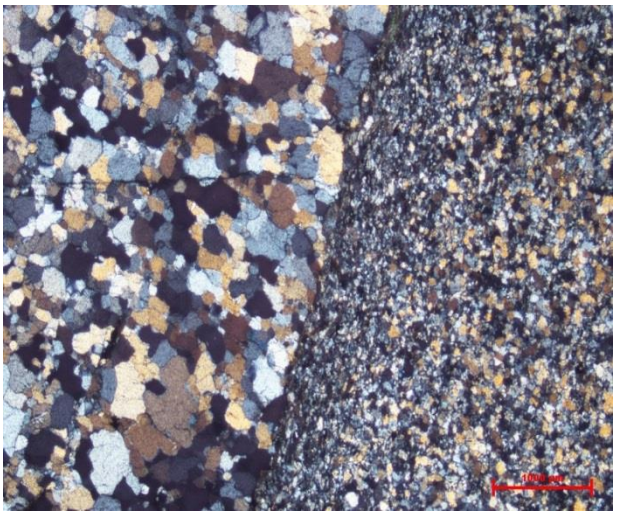


Sample No: 3 (EP T-1)

Rock Description- Fine grained thinly bedded rock with few coarser bands

Microscopic Observations-The dominant mineral is quartz (85%) with subordinate feldspars (5%), mica (5%) and calcite (5%). Two different grain size are prominently segregated with coarser quartz bearing band having mica (biotite and muscovite) along a very narrow zone (Figures). The coarser band is relatively in-equigranular while the finer band is of equigranular nature. Just at the contact between the two, calcite grains are also present indicating that the coarser bands may represent quartz reprecipitation as quartz veins. Extinction angle of quartz in coarser domains is ~16o while grains in the finer band are generally unstrained.

Name**: Fine grained quartzite**

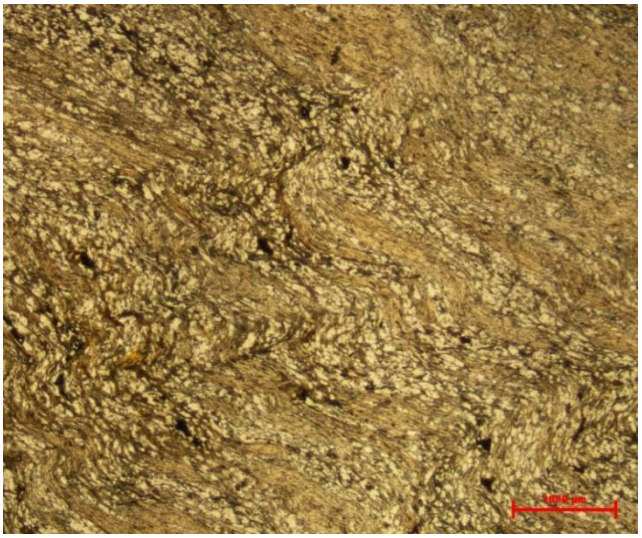


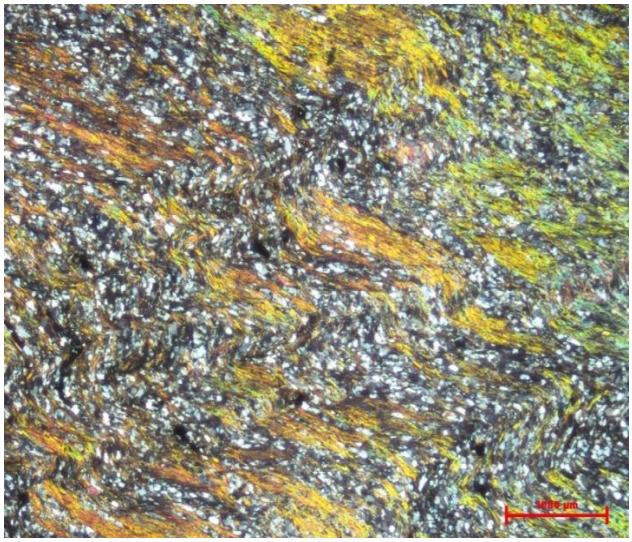
Sample No: 4(EP T-1)

Rock description- This is a fine-grained grey-green colored schistose rock.

Microscopic Observations- The rock is dominantly made up of quartz (~60%) and mica (~37%) with chlorite and opaques constituting the rest (Figures). It is a strongly foliated rock rich in mica and exhibits development of crenulation cleavages implying post foliation deformation (Figures). Biotite is the major mica mineral (Figure). The quartz grains are fine and generally depict not very strong wavy extinction despite textural evidence suggesting that the strain is mainly apportioned to the mica.

Rock name: **Mica schist**



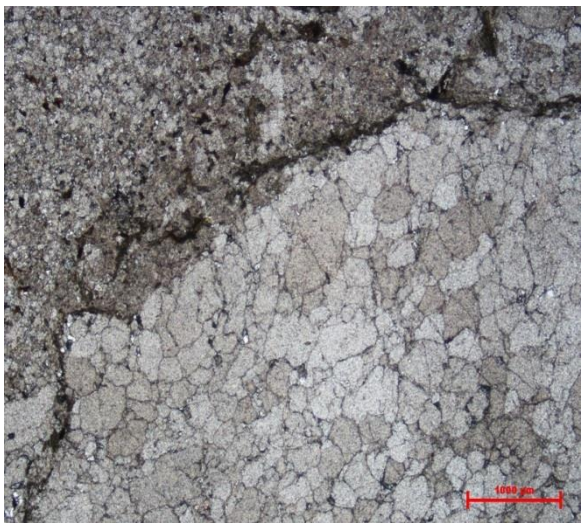


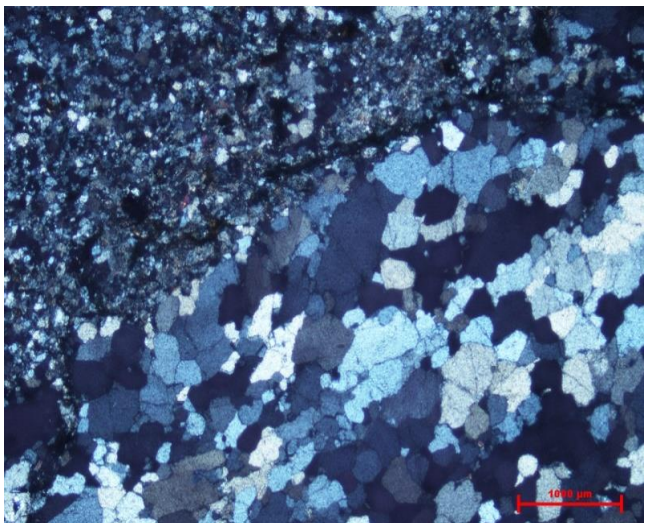
Sample No: 5(WP T-2)

Rock description-Very fine-grained grey-green colored hard and compact rock.

Microscopic Observations- Quartz (~95%) constitutes the major mineral of the rock with the rest made up of mica-dominantly biotite (Figures). The thin section examined contains the host rock which is a fine-grained micaceous quartzite intruded by relatively coarse-grained vein quartz (Figure). The mica is confined to the fine-grained matrix (Figure). Most of the quartz grains are strained with the extinction angles varying between 13-19o.

Rock name: **Micaceous quartzite with quartz vein**



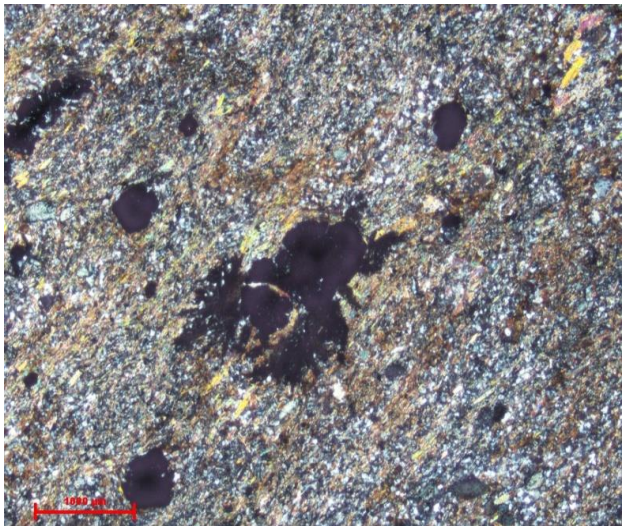


Sample No: 6(WP-T2)

Rock Description- Fine grained, green coloured schistose rock.

Microscopic Observations- This rock contains ~15% garnets, 20% biotite, 10% muscovite, 45% quartz, 5% staurolite and rest as opaques (Figures). Staurolite is present as fine yellow coloured pleochroic grains (e.g. in the south eastern quadrant of Figure). Two stage growth of garnets is evident by an inclusion filled core and a relatively inclusion free rim (Centre of Figure). There is a pronounced in equigranularity in the rock with garnet occurring as the main porphyroblast (Figure). The schistosity is well developed. Quartz is generally fine grained, and it is difficult to assess the extinction angle.

Rock name: **Garnet-staurolite schist**



5. ACCESS ROADS

5.1 Prelude

TPF Getinsa Eurostudios S.L. In Association with Rodic Consultants Pvt. Ltd., New Delhi have been appointed as Consultant to carry out the Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on NH-244 (old NH-1B) in the State of Jammu & Kashmir.

(i) Sudhmahadev – Dranga Tunnel of approx. length 4.5 Km and its approach roads on Chenani – Sudhmahadev – Goha road portion. (ii) Vailoo Tunnel of approx. length 10.00 Km under Sinthan Pass and its approach roads on Goha – Khellani – Khanabal road portion & the extended road section from Goha side approach road of Sudhmahadev Dranga tunnel up to Khellani town.

The entire proposed project road is in the state of Jammu and Kashmir. The state occupies a total area of 222,236 square kilometers. Jammu and Kashmir borders with the states of Himachal Pradesh and Punjab to the south. Jammu and Kashmir has an international border with China in the north and east, and the Line of Control separates it from the Pakistan. Jammu and Kashmir consist of three divisions: Jammu, Kashmir Valley and Ladakh, and is further divided into 22 districts.

The project road starts at approach road of Sudhmahadev – Dranga Tunnel at 33.031009°E and 75.360311°N and runs north east till Dranga village at 33.069396°E and 75.460246°N.

Approach road:

The project is comprised of two nos. of unidirectional Tunnel, cross drainage structure, viaduct and road. The alignment is passing through mountainous terrain. Some length of approach road is proposed as 2 lane unidirectional due to twins tube (unidirectional) tunnel and balance length is proposed with 2-lane with paved shoulder. The project alignment is part length of NH-224 which start from Chenani Sudhmahadev Road near Gauri Kund . The details proposed scheme is as under-

Start of Project – Km 0.000 to km 0.050 – Rotary has been proposed

Start of Tunnel 1 – Km 0.050

End of Tunnel 1 – Km 5.499 L/S & Km 5.417 R/S.

Start of Approach Road in including cross drainage (2 lane unidirectional) – Km 5.499 L/S & Km 5.417 R/S.

End of approach Road (2 lane unidirectional) – Km 6.760

Start of tunnel 2 – Km 6.760

End of Tunnel 2 – Km 9.400 L/S & Km 9.390 R/S.

Start of Approach Road (2 lane unidirectional) – Km 9.400 L/S & Km 9.390 R/S.

End of Approach Road (2 lane unidirectional) – Km 9.935

Start of Approach Road (2 lane with PS) – Km 9.935

Start of Approach Road (2 lane with PS) – Km 12.850

Road Junctions

There are only 1 major junction and 1 minor junctions in the project stretch

Table 15: Details of Junction

Sr. No.	Chainage	Link	Type	
1	0+000	To Sudhmahadev	Major	Y
2	12+800	New proposed road to Goha Town	Minor	T

Proposed Cross Drainage Structures

There are 04nos. Viaduct cum Bridges, 03nos. Viaducts and 06nos. Box Culverts are proposed on project road. Proposed Bridge at km 12.230 is a precast RCC girder/ Open spandrel steel arch bridge.

Table 16: Summary of Proposed Bridges and Culverts

Sr. No.	Type	No's of structures	
		Pack-I	Pack-II
1	Viaduct cum Bridges	1	3
2	Viaducts	2	1
3	Box Culverts	1	5
Total		**4**	**9**

Traffic Survey Analysis and Forecast

It is very important, that the existing information on traffic flow, commodity movement and traffic pattern is required to assess the traffic behaviour on a project road.

After construction of both tunnels of Sudhmahadev – Dranga project and road stretch from Chenani to Sudhmahadev, there could be increase in the traffic enroute to Doda town and beyond. However, the proposed road configuration shall cater to the design service volume of 4538 (PCU). Further the road has been designed for 20 MSA against the projected 9.448 MSA as per clause no. 5.4.1 of IRC: SP:73-2018.

Table 17: MSA Calculation

								Khellani on NH-244	
Year	**Standard Bus**	**LCV**	**2 Axle**	**3 Axle**	**MAV**	**Yearly Design ESA**	**Cumulative Design ESA**	**MSA**	**Design Period**
VDF	**0.62**	**0.46**	**4.93**	**0.76**	**3.93**				
2019	114	370	358	308	36	347906			
2020	120	407	376	323	38	366541			
2021	126	448	395	340	40	386231			
2022	132	488	414	357	42	406742			
2023	139	532	435	374	44	428387	428387	**0.428**	**1-year**
2024	145	580	457	393	46	451232	879619		
2025	153	632	480	413	48	475347	1354966		
2026	160	689	504	433	51	500808	1855774		
2027	168	744	529	455	53	527233	2383007	**2.383**	**5-year**
2028	177	803	555	478	56	555090	2938096		
2029	186	868	583	502	59	584459	3522555		
2030	195	937	612	527	62	615426	4137981		
2031	205	1012	643	553	65	648081	4786062		
2032	215	1083	675	581	68	681841	5467903	**5.468**	**10-year**
2033	226	1159	709	610	71	717384	6185287		
2034	237	1240	744	640	75	754806	6940093		
2035	249	1327	781	672	79	794208	7734300		
2036	261	1420	821	706	83	835696	8569996		
2037	274	1505	862	741	87	878431	9448427	**9.448**	**15-year**

To collect such information to satisfy the Terms of Reference (TOR) and project requirements, following various types of traffic surveys were carried out:

- Classified Traffic Volume Count Survey
- Axle Load Spectrum Survey
- Origin – Destination (OD) Survey and commodity movement Surveys
- Speed and Delay Survey

Classified Continuous Volume Count Survey

A comprehensive traffic survey plan has been prepared for the project road after considering traffic intensity on homogeneous sections and travel characteristics. Detailed site visit of project road and its influence/alternative transport network has

been carried out. Traffic survey locations were finalized by consultation with client officials.

Table 18: Summary of Classified Volume Count Survey at all count stations

Sr.No.	Location	Justification/Rational
Classified Volume Count Surveys (CVC)		
1	**Khellani on NH-244**	Khellani village has been selected to get the idea of traffic in homogeneous section for Sudhmahadev – Dranga Tunnel

Annual Average Daily Traffic (AADT)

The seasonal correction factors are used to convert Average Daily Traffic (ADT) to Annual Average Daily Traffic (AADT). The Annual Average Daily Traffic for all traffic survey locations is presented vide Table below:

Table 19: Summary of Annual Average Daily Traffic (AADT)

Sr. No.	Location	Fast Moving Vehicles (PCU)	Slow Moving Vehicles (PCU)	Total AADT (PCU)
1	Khellani on NH-244	4538	-	4538

Axle Load Survey

To estimate vehicle loading spectrum on project road, and to determine vehicle damage factor for the commercial vehicles, the axle load surveys have been carried out at identified locations. The data collected from the Axle Load Survey has been compiled and analyzed through "Fourth power" pavement damage rule to arrive at the vehicles damage factor (VDF). The survey is analyzed to obtain Vehicle Damage Factor (VDF) and is presented below:

Table 20: Adopted VDF by Homogeneous Sections

SUMMARY of VDF near Khellani Village	
Vehicle Type	**VDF**
LCV	0.460
2 Axle Truck	4.930
3 Axle Truck	0.764
Bus	0.620
Multi axle	3.930

Vehicle Damage Factor of 2 Axle Truck is more because there were maximum empty number of 3 Axle and Multi Axle Trucks whose weights were measured during Axle Load Survey.

Table 21: Axle Load Survey

2 - Axle		
Total	**60**	
Empty	2	3.33%
Loaded	58	96.67%
3-Axle		
Total	**68**	
Empty	64	94.12%
Loaded	4	5.88%
Multi -Axle		
Total	**5**	
Empty	3	60%
Loaded	2	40%

The equivalent single axle loads (ESALs) have been calculated assuming that the project road will be opened to traffic in the beginning of year 2023. MSA for the homogeneous sections is worked out for 15 years excluding construction period:

Table 22: Summary of MSA

Section	Existing Chainage		Design MSA (2023-2037)
	From	To	
Sudhmahadev – Dranga Tunnel	0/000	12/850	20

Growth Rate

The various methods specified vide IRC 108: 2015 are taken into consideration for arriving at reasonable growth rate for traffic in future. The results of such methods along with proposed growth rate for each type of vehicle are presented vide Table below:

Table 23: Comparative Analysis

Growth Rate of Economic Indicators for the State of Jammu and Kashmir													
Sr. No.	Year	Per Capita Income (PCI)			Population			NSDP			GSDP		
		Rs.	Growth	Gr. rate (%)	In 000's	Growth	Gr. rate (%)	Rs. (In crores)	Growth	Gr. rate (%)	Rs. (In crores)	Growth	Gr. rate (%)
1	2004-05	21734			10717			23292			27305		
2	2005-06	22406	672	3.09	10877	160	1.49	24371	1079	4.63	28883	1578	5.78
3	2006-07	23375	969	4.32	11035	158	1.45	25794	1423	5.84	30602	1719	5.95
4	2007-08	24470	1095	4.68	11192	157	1.42	27387	1593	6.18	32561	1959	6.40
5	2008-09	25641	1171	4.79	11350	158	1.41	29102	1715	6.26	34664	2103	6.46
6	2009-10	26518	877	3.42	11506	156	1.38	30512	1410	4.85	36225	1561	4.50
7	2010-11	27666	1148	4.33	11659	153	1.33	32256	1744	5.72	38270	2045	5.65
8	2011-12	28790	1124	4.06	11806	147	1.26	33990	1734	5.38	41203	2933	7.66
9	2012-13	30035	1245	4.32	11952	146	1.24	35898	1908	5.61	43402	2199	5.34

Growth Rate of Economic Indicators for the State of Jammu and Kashmir													
Sr. No.	Year	Per Capita Income (PCI)			Population			NSDP			GSDP		
		Rs.	Growth	Gr. rate (%)	In 000's	Growth	Gr. rate (%)	Rs. (In crores)	Growth	Gr. rate (%)	Rs. (In crores)	Growth	Gr. rate (%)
10	2013-14	31448	1413	4.70	12096	144	1.20	38039	2141	5.96	45847	2445	5.63
11	2014-15	30612	-836	-2.66	12235	139	1.15	37453	-586	-1.54	45126	-721	-1.57
12	2015-16	35034	4422	14.45	12261	26	0.21	42955	5502	14.69	51757	6631	14.69
Average yearly Growth rate (%)				**4.50**			**1.23**			**5.78**			**6.05**

Table 24: Adopted of Growth Rates

Growth Rates of Vehicular Traffic for the state of Jammu and Kashmir							
Sr. no.	**Description**	**2 Wheelers**	**Cars/ jeeps**	**Buses**	**Trucks**		**LCV and Mini LCV**
1	Trend Growth of Vehicles	9.04	15.56	3.66	4.16		17.62
2	Growth from regression analysis	9.45	14.95	3.31	3.33		17.21
3	Considered for Revenue/Capacity	9.24	15.26	3.49	3.75		17.42
Sr. no.	**Period**	**2 Wheelers**	**Cars/ jeeps**	**Buses**	**Trucks**		**LCV and Mini LCV**
					2 Axle	**3 Axle**	**M Axle**	
1	Up to 2020	10.0	10.0	5.0	5.0	5.0	5.0	10.0
2	2021 -2025	9.0	9.0	5.0	5.0	5.0	5.0	9.0
3	2026 – 2030	8.0	8.0	5.0	5.0	5.0	5.0	8.0
4	2031 – 2035	7.0	7.0	5.0	5.0	5.0	5.0	7.0
5	Beyond 2035	6.0	6.0	5.0	5.0	5.0	5.0	6.0

Table 25: Summary of Projected Total AADT Traffic PCU Volume / day

Homogeneous Section	Year 2019	Year 2023	Year 2029	Year 2039	Year 2046
Sudhmahadev - Dranga (Ch.0+000 to km 12+850)	4538	6448	10404	20471	30752

Capacity Analysis

Capacity analysis is fundamental to the planning, design and operation of roads. It is a valuable tool for evaluation of the investment needed for the future improvements. The capacity figures used for determining the desired carriageway width in differing terrain w.r.t. traffic volume and composition are as per IRC: 64-1990. As per IRC 64:1990, it is recommended that on major arterial routes LOS B should be adopted for the design

purpose. On other roads under exceptional circumstances, LOS C could also be adopted for design. For LOS C, Design service volume can be taken as 40 % higher than those for LOS B.

For two lane highway, as per IRC: SP:73-2018 and MoRT&H circular dated 26th May 2016, the traffic at which the upgradation from two lane to four lanes will trigger is shown in table below.

For four lane highway, as per IRC:SP:84-2014, the project highway shall be widened to six lane when total traffic including the traffic of service road, if any, reaches the design service volume corresponding to Level of Service 'C' of 4-lane highway is also shown in table below.

Table 26: Design Service Volume for Different Lane Configurations

Lane Configuration	**Terrain**	**Design Service Volume (PCUs per day)**
2-Lane with 2.5 m Paved Shoulder	Plain	10000
	Rolling	8500
	Mountainous/Steep	6000

Lane Configuration	**Terrain**	**Design Service Volume (PCUs per day)**	**Design Service Volume (PCUs per day)**
		Level of Service B	***Level of Service C***
4-Lane with 1.5m Paved Shoulder	Plain/Rolling	40000	60000
	Mountainous/Steep	20000	30000

Lane Requirements

Based on the assessment of the traffic demand on the various homogeneous sections of the Project Highway, the Consultant have carried out detailed option analysis for Two-laning with paved shoulders. Based on the estimated Capacity & Design Service Volume, the number of lanes required for the project road is worked out for LOS B & LOS C which is presented in Table below.

Table 27: Lanning Requirement for the Project Corridor

Homogeneous Sections	Terrain	2-Lane with Paved Shoulder	4-Lane with Paved Shoulder	4-Lane with Paved Shoulder
		Design Service Volume (PCUs per day)	LOS B	LOS C
Sudhmahadev – Dranga Tunnel (Km 0+000 – Km 12+850)	Mountainous	Up to 2022	Up to 2038	Up to 2045

It is revealed after considering future traffic growth, the Project road requires four lane configurations in the year 2023 up to the horizon year of 2038.

- **Design Standards**

Following table is a summary of the recommended design standards proposed to be adopted for the project road other than service road and intersections:

Table 28: Summary of Recommended Design Standard

Design Standards			
(i)	Design Speed (Km/hr) as per IRC SP:48-1998 Mountainous Terrain	:	50 (Ruling), 40(Minimum)
(ii)	Level of Service	:	B
(iii)	Roadway Widths (m) as per IRC SP:73-2018 for 2-Lane and IRC SP:84-2014 for 4-Lane. Mountainous Terrain	:	2-lanes with paved and earthen shoulder (Modified Fig. 2.8) 4-lanes with paved and earthen shoulder. (Modified Fig. 2.7 and 2.8)
(iv)	Camber as per IRC SP:73-2018	:	<u>Carriageway</u> Flexible- 2.50% Rigid - 2.00 % <u>Paved Shoulder</u> Flexible- 2.50% Rigid - 2.00 % <u>Unpaved Shoulder</u> Flexible- 3.50% Rigid - 3.00 %
(v)	Right of Way	:	As per Plan and Profile
(vi)	Embankment/ Cutting Slope		
	Fill height, up to 3.0 m	:	In filling- 1V: 2 H

	Fill height from 3.0 m to 6.0 m	:	In filling- 1V: 1.5 H
	To be designed based on soil parameters, (IRC:75-1979)		
	Fill height exceeding 6.0 m		In cutting- 1V:1H
(vii)	Stopping Sight Distance	:	20 m for design speed of 20 km/hr 25 m for design speed of 25 km/hr 30 m for design speed of 30 km/hr 40 m for design speed of 35 Km /hr 45 m for design speed of 40km/hr 60 m for design speed of 50km/hr
	Intermediate sight distance	:	40 m for design speed of 20 km/hr 50 m for design speed of 25 km/hr 60 m for design speed of 30 km/hr 80 m for design speed of 35 Km /hr 90 m for design speed of 40km/hr 120 m for design speed of 50km/hr
(viii)	**Super-elevation** Mountainous Terrain (As per IRC: SP:48-1998) Clause No-6.8.2.2		With snow bound area Maximum 7% Without snow bound area Maximum 10% **Adopted maximum 7%**
(ix)	Radii for Horizontal Curves as per IRC SP:48-1998 Mountainous Terrain	:	(Areas not affected by Snow) Ruling Minimum 80 m Absolute minimum 50 m (Snow Bound Area) Ruling Minimum 90 m Absolute minimum 60 m
(x)	**Gradient** (As per IRC: SP:48-1998) Table 6.11		
	Mountainous Terrain		
	Ruling	:	5.00%
	Limiting	:	6.00%
	Steep Terrain		
	Ruling	:	6.00%
	Limiting	:	7.00%
(xi)	**Minimum k factor**		
	Summit Curve		
	Mountainous Terrain	:	Ruling: 15
		:	Minimum: 8.4
	Valley Curve		
	Mountainous Terrain	:	Ruling: 15
		:	Minimum: 6.6
(xii)	**Vertical Clearance** as per IRC: SP:48-1998 (Clause no-6.7.2.1)	:	5.0 m

	Minimum Vertical Clearance of 5 mts should be given over the entire roadway at all underpasses and similarly at overhanging cliffs and semi tunnel sections.		
(xiii)	Design Flood Frequency		
	Bridges	:	100 years
	Sewers and Ditches	:	60 years

5.2 Improvement Proposals

The improvement proposals for proposed new road including viaduct, bridges and Cross drainage structures in the tunnel approaches include the provisions for the following major items:

a) Construction of New Road in Tunnel approaches

b) Geometric Design as per IRC

c) Proposed Pavement Design

d) Traffic Control and Safety Measures

e) Viaduct, Bridge and Cross Drainage Structures

- **Major Bridge/ Minor Bridge & Cross Drainage Structures**

There are 4nos. Viaduct cum Bridges and 3nos. Viaducts are proposed. The Brief summary of improvement proposal of bridges are given in Table below. The brief detail of cross drainage structures is described in Table below.

Culverts

Improvement proposal for culvert are given in *Table below*:

Table 29: Summary of Structures Proposed

Sr. No.	Description	No. of Structures		Remarks
		Pack-I	Pack-II	
1	Tunnel	1	1	Uni-directional
2	New Proposals	1	5	Box Culverts
3	New proposal	2	1	Viaducts
4	New proposals	1	3	Viaduct cum Bridges

Table 30: General Arrangement Drawings Structures

S. No	Type of Structure	Chainage	Total Length (m)	Proposed Span Arrangement No.xL	Type of Superstructure	Deck Width (m)	Remarks
Package-I							
1	**Tunnel - T1**	**2+749.5**	**5449**	-	-	**9.00M**	**Tunnel tube on LHS**
		2+733.5	**5417**			**9.00M**	**Tunnel tube on RHS**
2	Viaduct cum Bridge	5+585	100	4X25	Precast PSC Girder with cast in situ deck slab	2 x 10	2 Lane bridge on LHS
		5+563	110	1X25+2X30+ 1X25			2 Lane bridge on RHS
3	Viaduct	05+713	75	3X25	Precast PSC Girder with cast in situ deck slab	10	2 Lane bridge on LHS only
4	Viaduct	5+993	250	10X25	Precast PSC Girder with cast in situ deck slab	2 X 12.50	2 Lane bridge on LHS
		06+007	125	5X25			2 Lane bridge on RHS
Package-II							
1	Viaduct	6+577	285	3X45+6X25	Steel Composite I Girder with cast in situ deck slab	2 x 10	2 Lane bridge on LHS
		6+544	125	5X25	Precast PSC Girder with cast in situ deck slab		2 Lane bridge on RHS
2	**Tunnel - T2**	**8+080**	**2640**	-	-	**9.00M**	**Tunnel tube on LHS**
		8+075	**2630**			**9.00M**	**Tunnel tube on RHS**
3	Viaduct cum Bridge	9+650	200	8X25	Precast PSC Girder with cast in situ deck slab	2 X 12.50	2 Lane bridge on LHS
		9+552	25	1X25			2 Lane bridge on RHS
4	Viaduct cum Bridge	12+230	456	3X24+1x300+3X24	Precast RCC Girder /Open spandrel steel arch bridge	12.5	2 Lane bridge
5	Viaduct cum Bridge	12+600	130	2X25+2X40	Steel Composite I Girder with cast in situ deck slab	12.5	2 Lane bridge

Table 31: Culvert List

S. No.	Proposed cross drainage Structure	Chainage in km	Proposed Span arrangement (No.xlxht.) in m
1	Box culvert	6+155	1X2X2(LHS)
			1X2X2(RHS)
2	Box culvert	6+725	1X3X3
3	Box culvert	10+290	1X4X4
4	Box culvert	10+845	1X4X4
5	Box culvert	12+715	1X2X2
6	Box culvert	12+780	1X4X4

- **Proposal for New Construction**

To meet future traffic requirement, new alignment is proposed to achieve high speed of travel with comfort and safety. The details length of typical cross section schedule is given in the table below-

Table 32: Proposed Cross Section

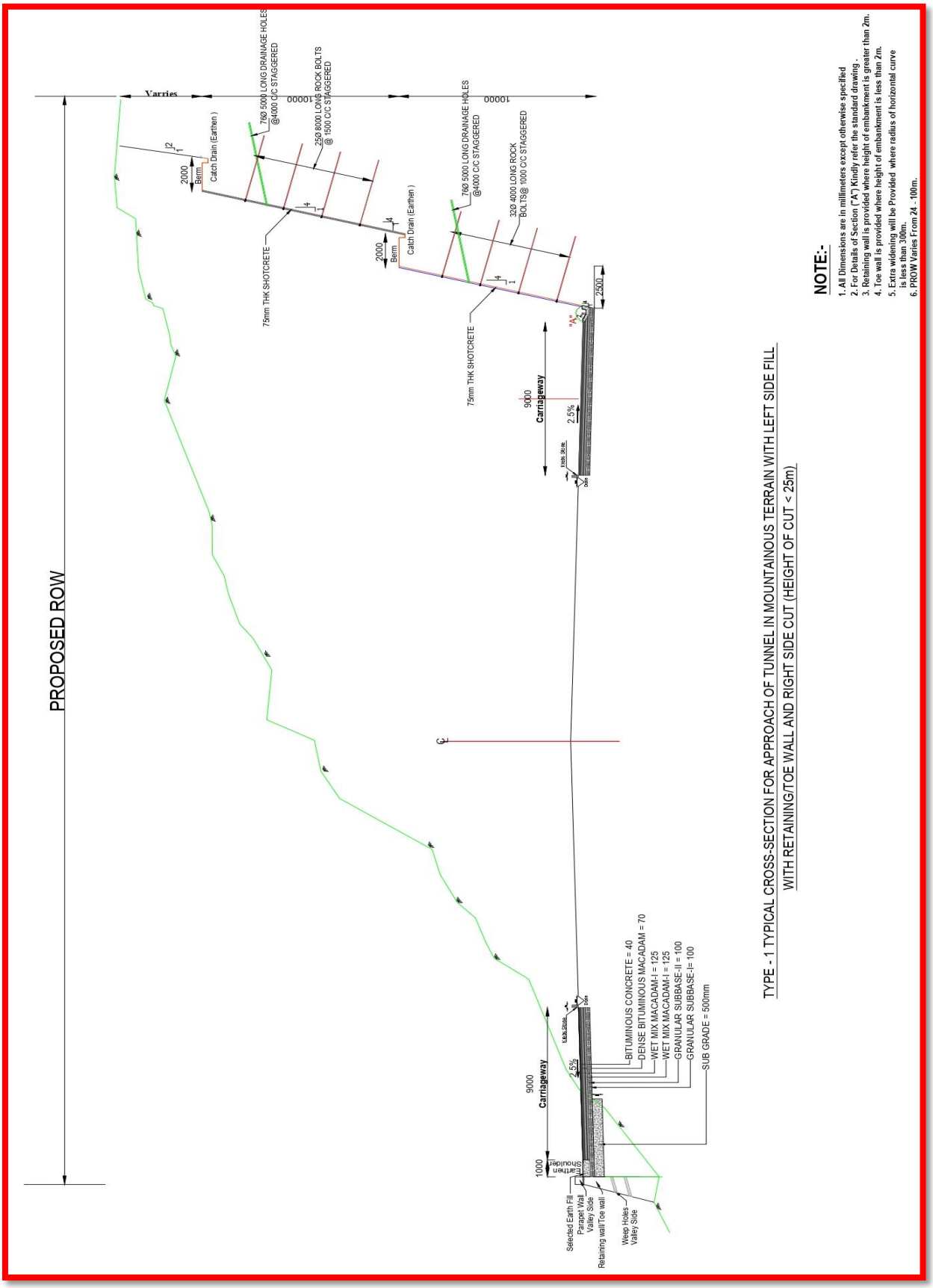
Sr. No.	Start Chainage	End Chainage	Length in m	TCS Type	Remarks
2 lane unidirectional configuration from Km 0 to Km 9+935					
1	00+000	00+020	20	TCS-7	Both side Fill
2	00+020	00+030	10	TCS-1	Left side Fill Right Cut
3	00+030	00+050	20	TCS-2	Both side Cut
4	**00+050**	**05+499**	**5449**	**TUNNEL**	**TUNNEL**
5	05+499	05+508	9	TCS-2	Both side Cut
6	05+508	05+535	27	TCS-6	VIADUCT Right
7	05+535	05+618	83	VIADUCT	VIADUCT both
8	05+618	05+635	17	TCS-5	VIADUCT left
9	05+635	05+660	25	TCS-3	Both side Cut
10	05+660	05+676	15.5	TCS-4	Left side Fill Right Cut
11	05+676	05+751	75	TCS-5	VIADUCT left
12	05+751	05+765	14.5	TCS-4	Left side Fill Right Cut
13	05+765	05+868	103	TCS-3	Both side Cut
14	05+868	05+945	76.5	TCS-5	VIADUCT left
15	05+945	06+070	125	VIADUCT	VIADUCT both
16	06+070	06+118	48.5	TCS-5	VIADUCT left
17	06+118	06+190	72	TCS-4	Left side Fill Right Cut
18	**06+190**	**06+410**	**220**	**TCS-3**	**TOLL PLAZA**
19	06+410	06+435	24.5	TCS-4	Left side Fill Right Cut
20	06+435	06+482	47	TCS-5	VIADUCT left
21	06+482	06+607	125	VIADUCT	VIADUCT both
22	06+607	06+720	113	TCS-6	VIADUCT left
23	06+720	06+740	20.5	TCS-1	Left side Fill Right Cut
24	06+740	06+760	20	TCS-2	Both side Cut
25	**06+760**	**09+400**	**2640**	**TUNNEL**	**TUNNEL**
26	09+400	09+490	90	TCS-2	Both side Cut
27	09+490	09+510	20	TCS-1	Left side Fill Right Cut
28	09+510	09+540	29.5	TCS-7	Both side Fill
29	09+540	09+550	10.5	TCS-6	VIADUCT left
30	09+550	09+565	14.5	VIADUCT	VIADUCT both
31	09+565	09+750	185.5	TCS-6	VIADUCT left
32	09+750	09+935	185	TCS-1	Left side Fill Right Cut
2-lane configuration from Km 9+935 to km 12+850					
33	09+935	10+220	285	TCS-8	Both side Cut
34	10+220	10+340	120	TCS-9	Both side Fill

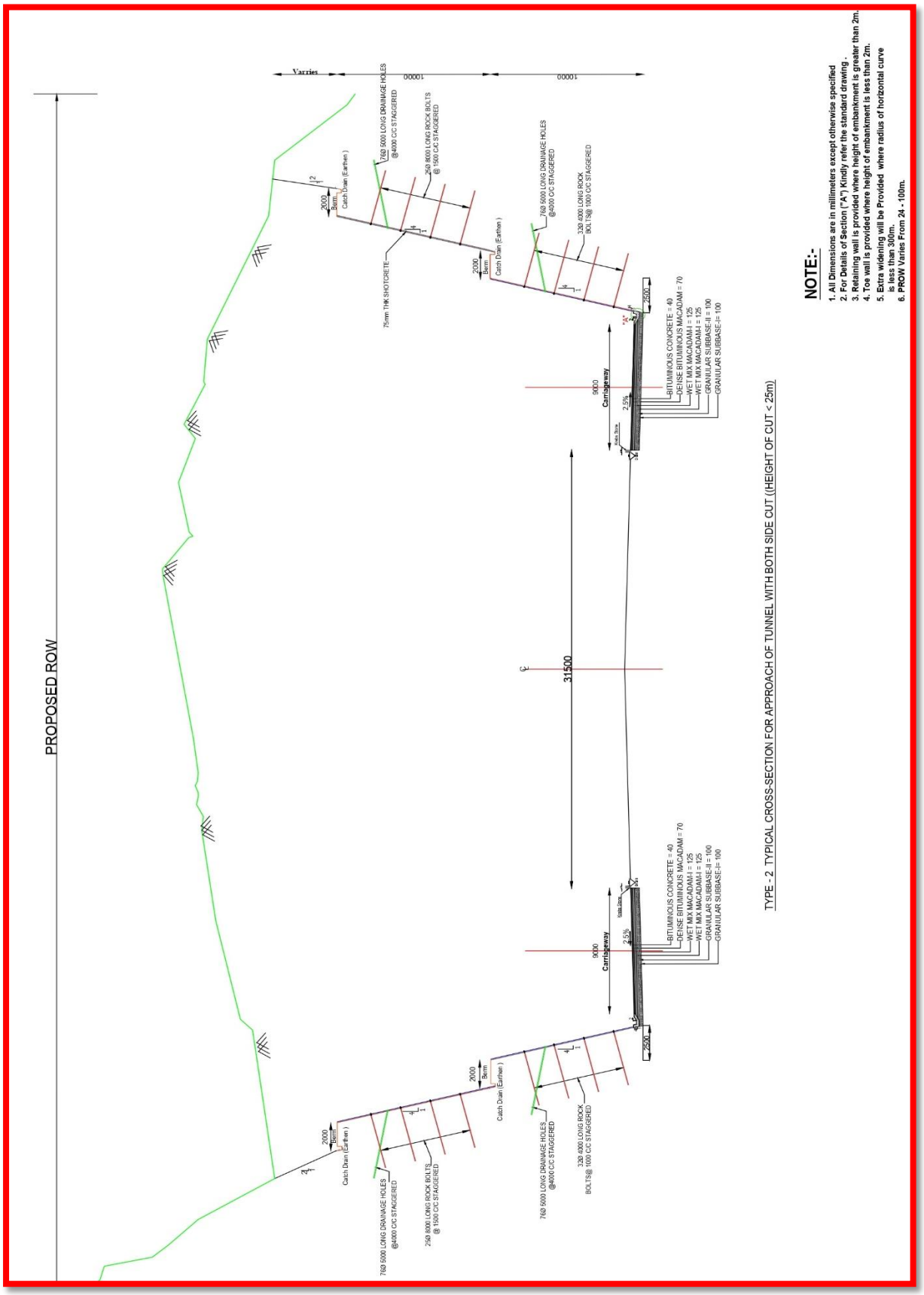
Sr. No.	Start Chainage	End Chainage	Length in m	TCS Type	Remarks
35	10+340	10+370	30	TCS-10	Left side Fill Right Cut
36	10+370	10+430	60	TCS-8	Both side Cut
37	10+430	10+470	40	TCS-10	Left side Fill Right Cut
38	10+470	10+500	30	TCS-9	Both side Fill
39	10+500	10+740	240	TCS-10	Left side Fill Right Cut
40	10+740	10+780	40	TCS-8	Both side Cut
41	10+780	10+830	50	TCS-10	Left side Fill Right Cut
42	10+830	10+880	50	TCS-9	Both side Fill
43	10+880	11+020	140	TCS-10	Left side Fill Right Cut
44	11+020	11+050	30	TCS-8	Both side Cut
45	11+050	11+070	20	TCS-10	Left side Fill Right Cut
46	11+070	11+555	485	TCS-8	Both side Cut
47	11+555	12+002	447	TCS-11	Both side Cut
48	**12+002**	**12+458**	**456**	**VIADUCT**	**2Lane VIADUCT**
49	12+458	12+510	52	TCS-8	Both side Cut
50	12+510	12+535	25	TCS-10	Left side Fill Right Cut
51	12+535	12+665	130	VIADUCT	2Lane VIADUCT
52	12+665	12+690	25	TCS-9	Both side Fill
53	12+690	12+710	20	TCS-8	Both side Cut
54	12+710	12+770	60	TCS-10	Left side Fill Right Cut
55	12+770	12+850	80	TCS-9	Both side Fill
Total Length in km			**12850**		

Length of proposed typical cross section summary are shown in table given below.

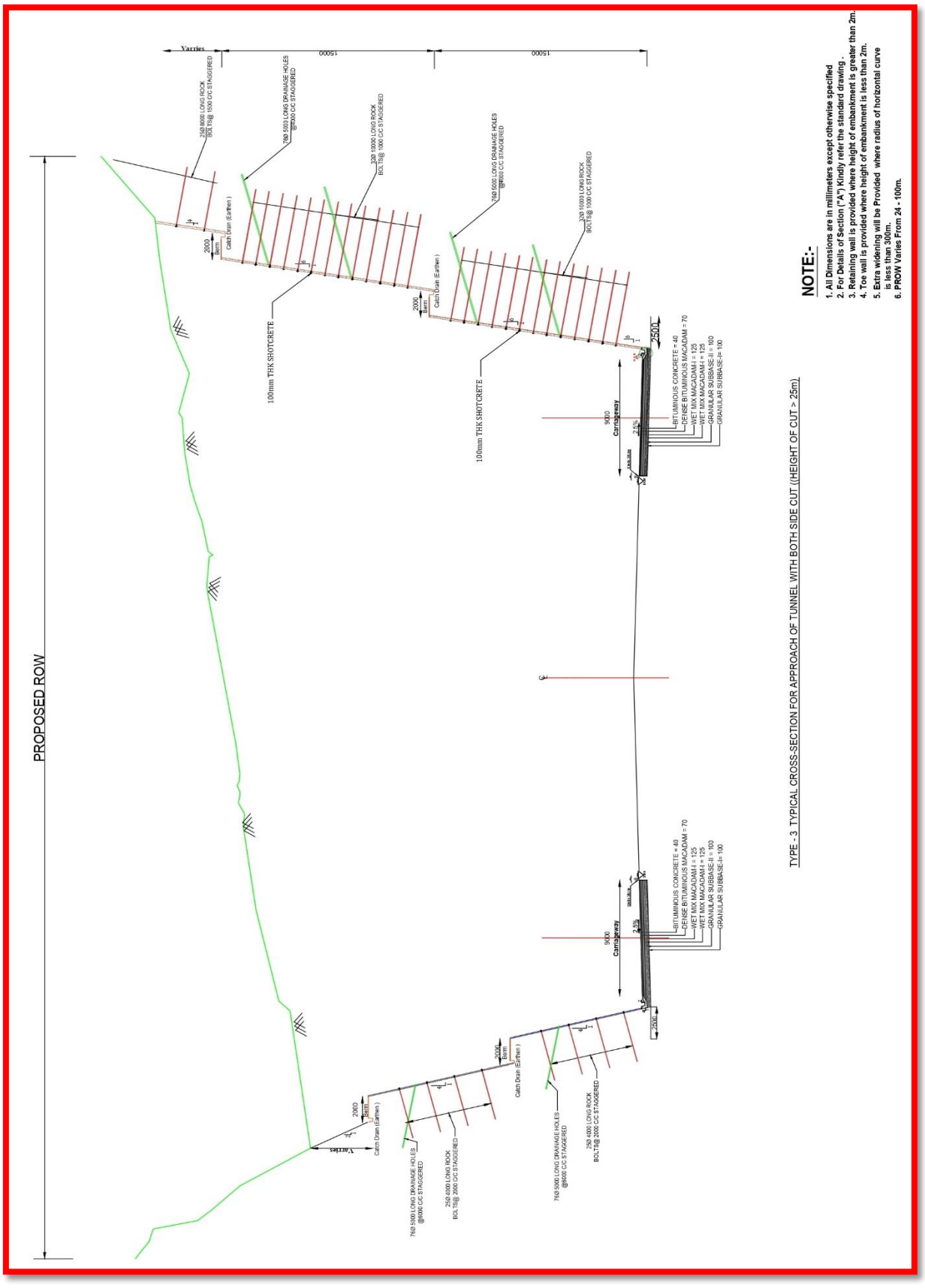
Table 33: Summary of TCS

Sr. No.	Detail	TCS	Length	
			(m)	Kms
1	Left side Fill Right Cut	**1**	235.5	0.236
2	Both side Cut	**2**	139.0	0.139
3	Both side Cut	**3**	128.0	0.128
4	Left side Fill Right Cut	**4**	126.5	0.127
5	VIADUCT left	**5**	264.0	0.264
6	VIADUCT left	**6**	336.0	0.336
7	Both side Fill	**7**	49.5	0.050
8	Both side Cut	**8**	972.0	0.972
9	Both side Fill	**9**	305.0	0.305
10	Left side Fill Right Cut	**10**	605.0	0.605
11	Both side Cut	**11**	447.0	0.447
12	TOLL PLAZA		220.0	0.220
13	Tunnel		8089.0	8.089
14	Via Duct		933.5	0.934
Total Design Length			**12850.0**	**12.850**


PROPOSED ROW
Varries
10000
10000
760 5000 LONG DRAINAGE HOLES @4000 C/C STAGGERED
250 8000 LONG ROCK BOLTS @ 1500 C/C STAGGERED
760 5000 LONG DRAINAGE HOLES @4000 C/C STAGGERED
320 4000 LONG ROCK BOLTS@ 1000 C/C STAGGERED
2000 Berm
Catch Drain (Earthen)
75mm THK SHOTCRETE
9000 Carriageway
2.5%
2500
"A"
BITUMINOUS CONCRETE = 40
DENSE BITUMINOUS MACADAM = 70
WET MIX MACADAM-I = 125
WET MIX MACADAM-I = 125
GRANULAR SUBBASE-II = 100
GRANULAR SUBBASE-I= 100
SUB GRADE = 500mm
1000 Earthen Shoulder
Selected Earth Fill
Parapet Wall Valley Side
Retaining wall Toe wall
Weep Holes Valley Side
TYPE - 1 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL IN MOUNTAINOUS TERRAIN WITH LEFT SIDE FILL WITH RETAINING/TOE WALL AND RIGHT SIDE CUT (HEIGHT OF CUT < 25m)
NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.



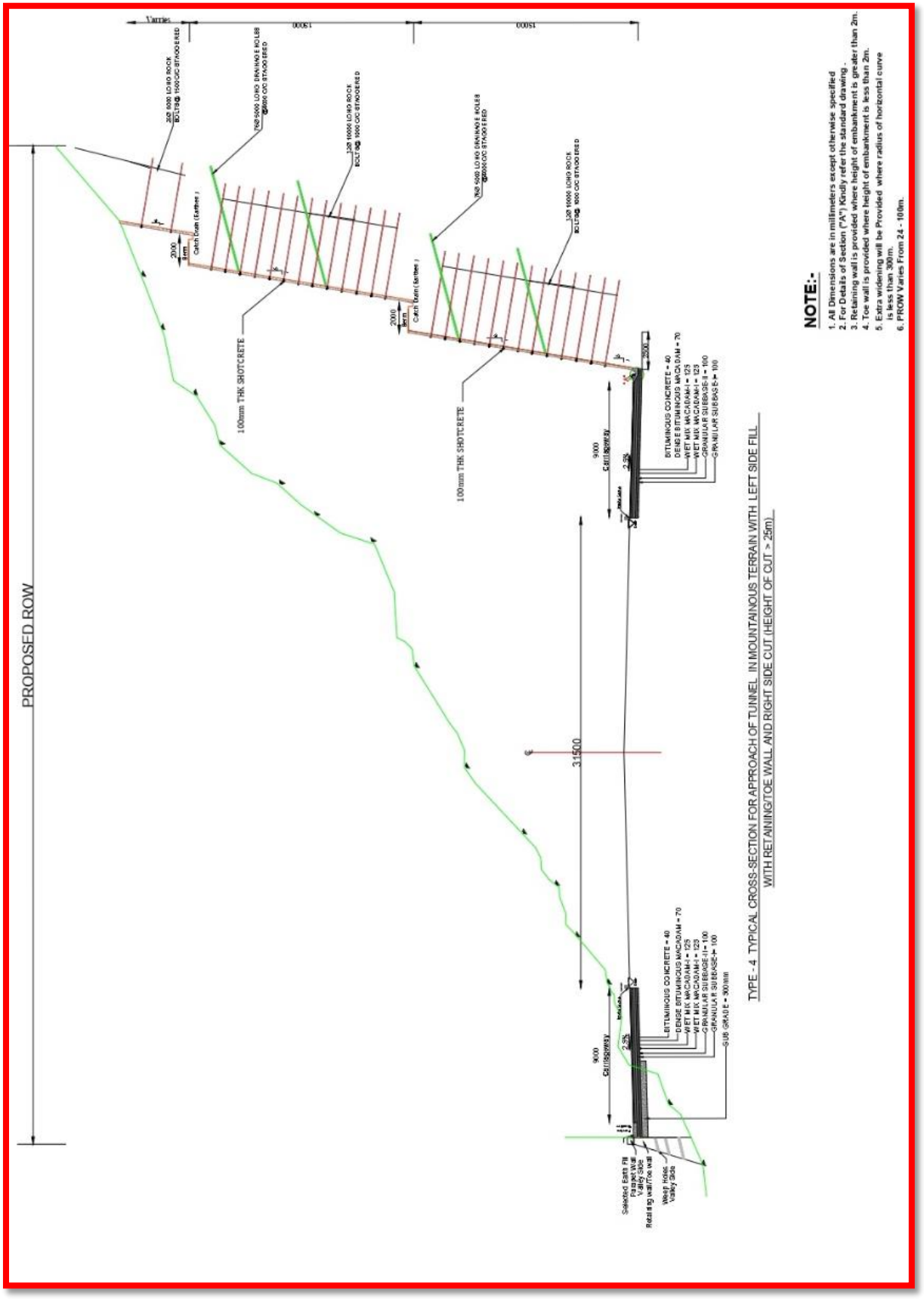
TYPE - 2 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL WITH BOTH SIDE CUT ((HEIGHT OF CUT < 25m)



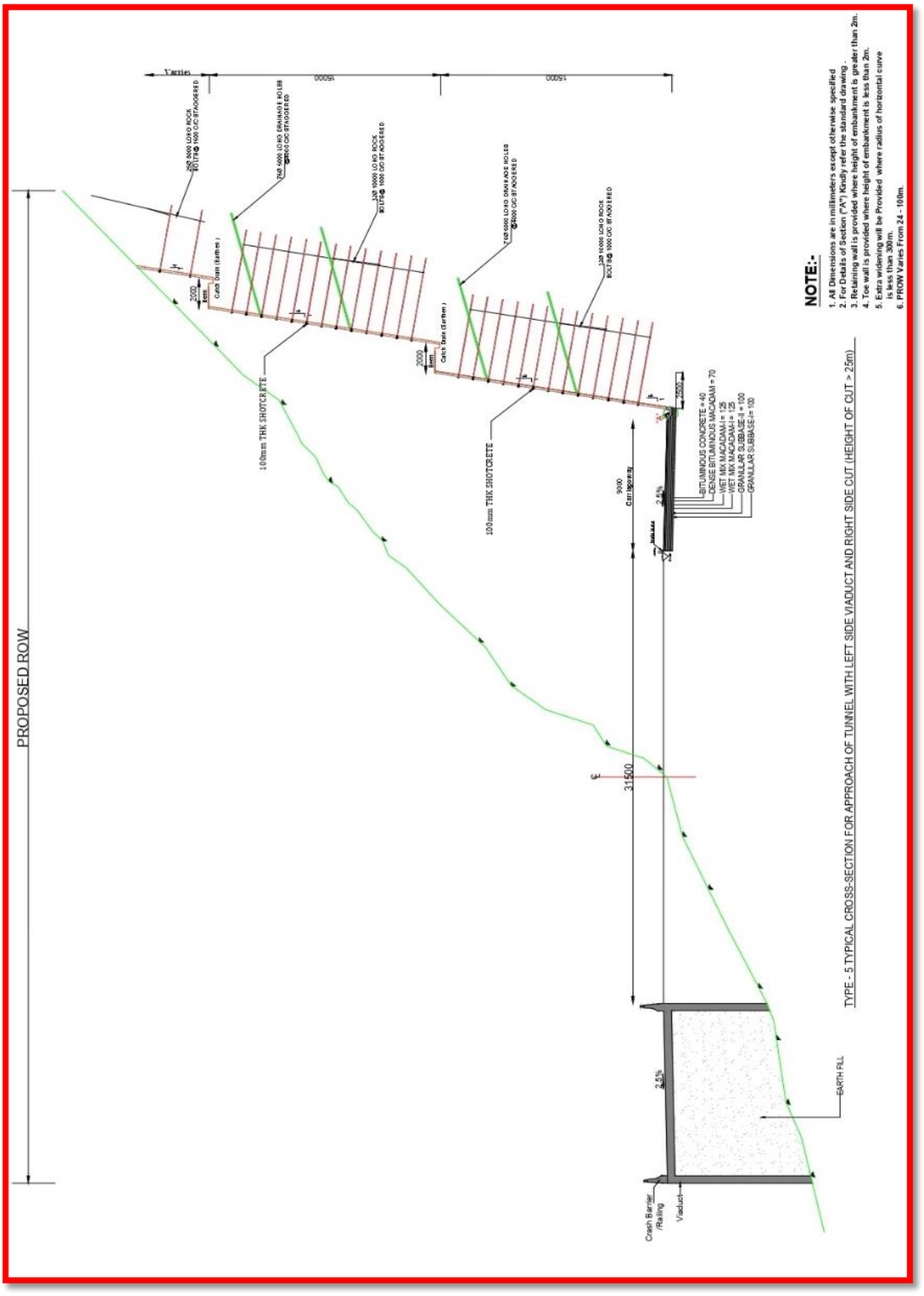
TYPE - 3 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL WITH BOTH SIDE CUT ((HEIGHT OF CUT > 25m)

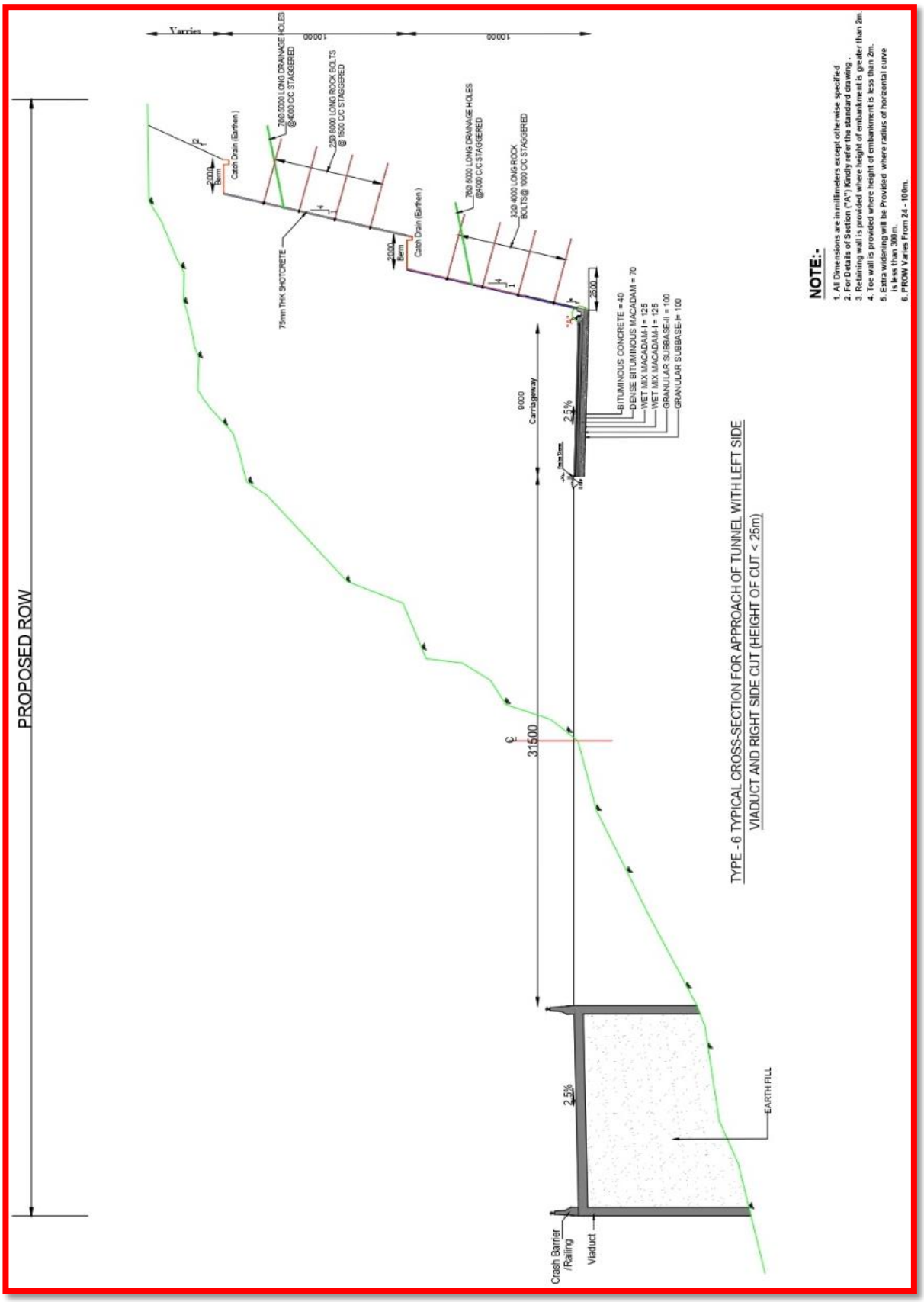
NOTE:-

1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.

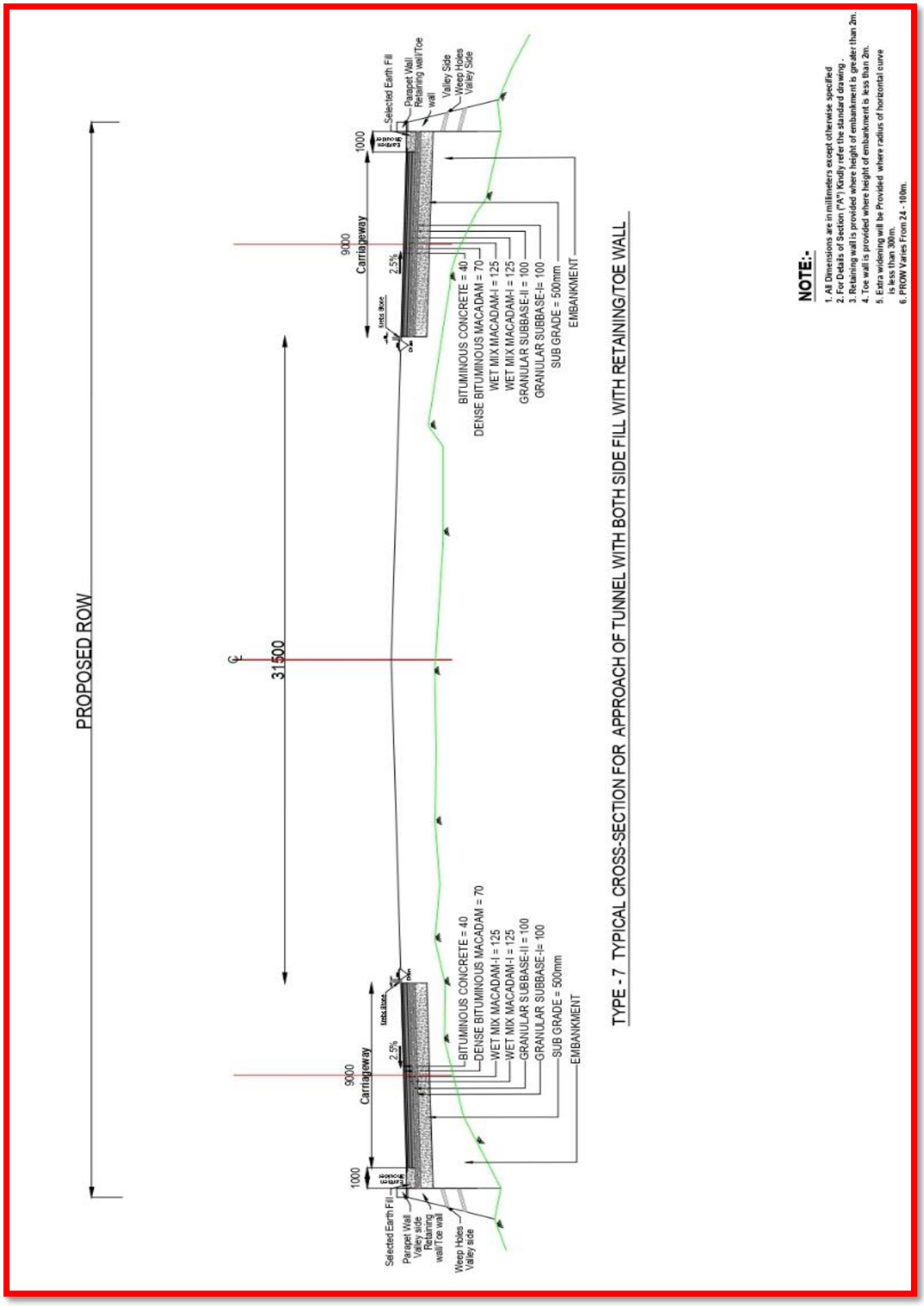


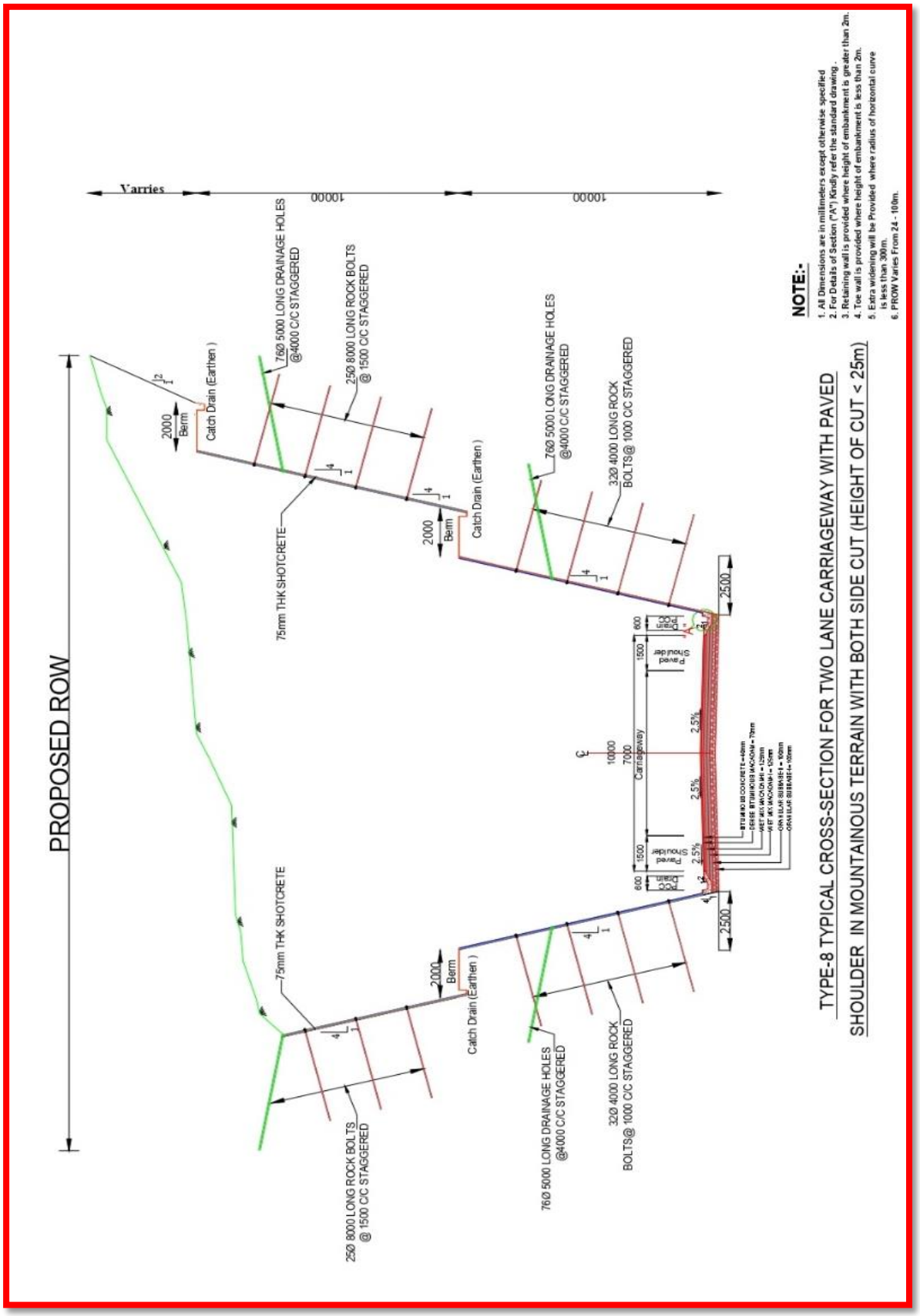
TYPE - 4 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL IN MOUNTAINOUS TERRAIN WITH LEFT SIDE FILL WITH RETAINING/TOE WALL AND RIGHT SIDE CUT (HEIGHT OF CUT > 25m)

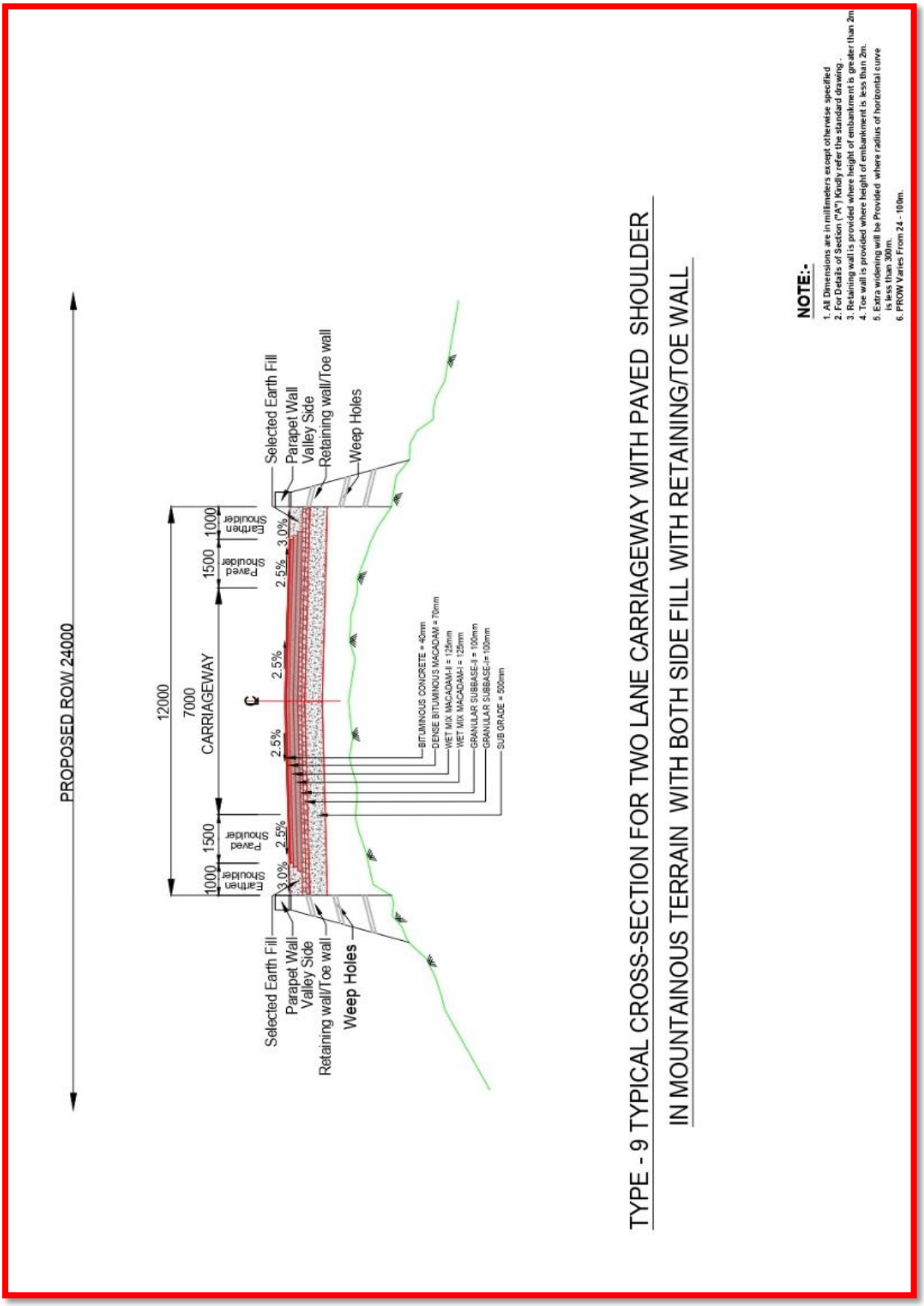

PROPOSED ROW
100mm THK SHOTCRETE
100mm THK SHOTCRETE
BITUMINOUS CONCRETE = 40
DENSE BITUMINOUS MACADAM = 70
WET MIX MACADAM-I = 125
WET MIX MACADAM-II = 125
GRANULAR SUBBASE-II = 100
GRANULAR SUBBASE = 100
EARTH FILL
Crash Barrier /Railing
Viaduct
NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.
TYPE - 5 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL WITH LEFT SIDE VIADUCT AND RIGHT SIDE CUT (HEIGHT OF CUT > 25m)

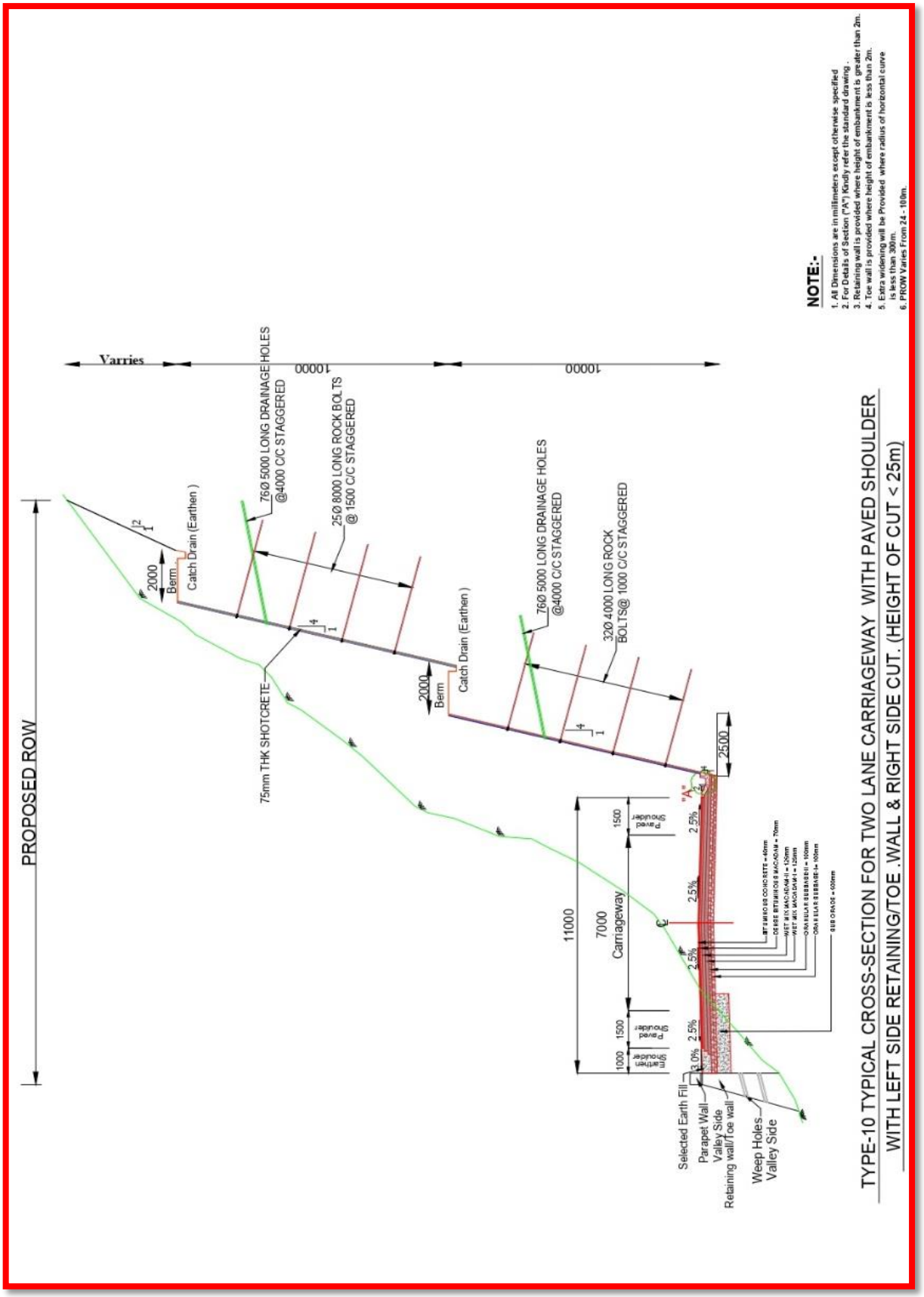


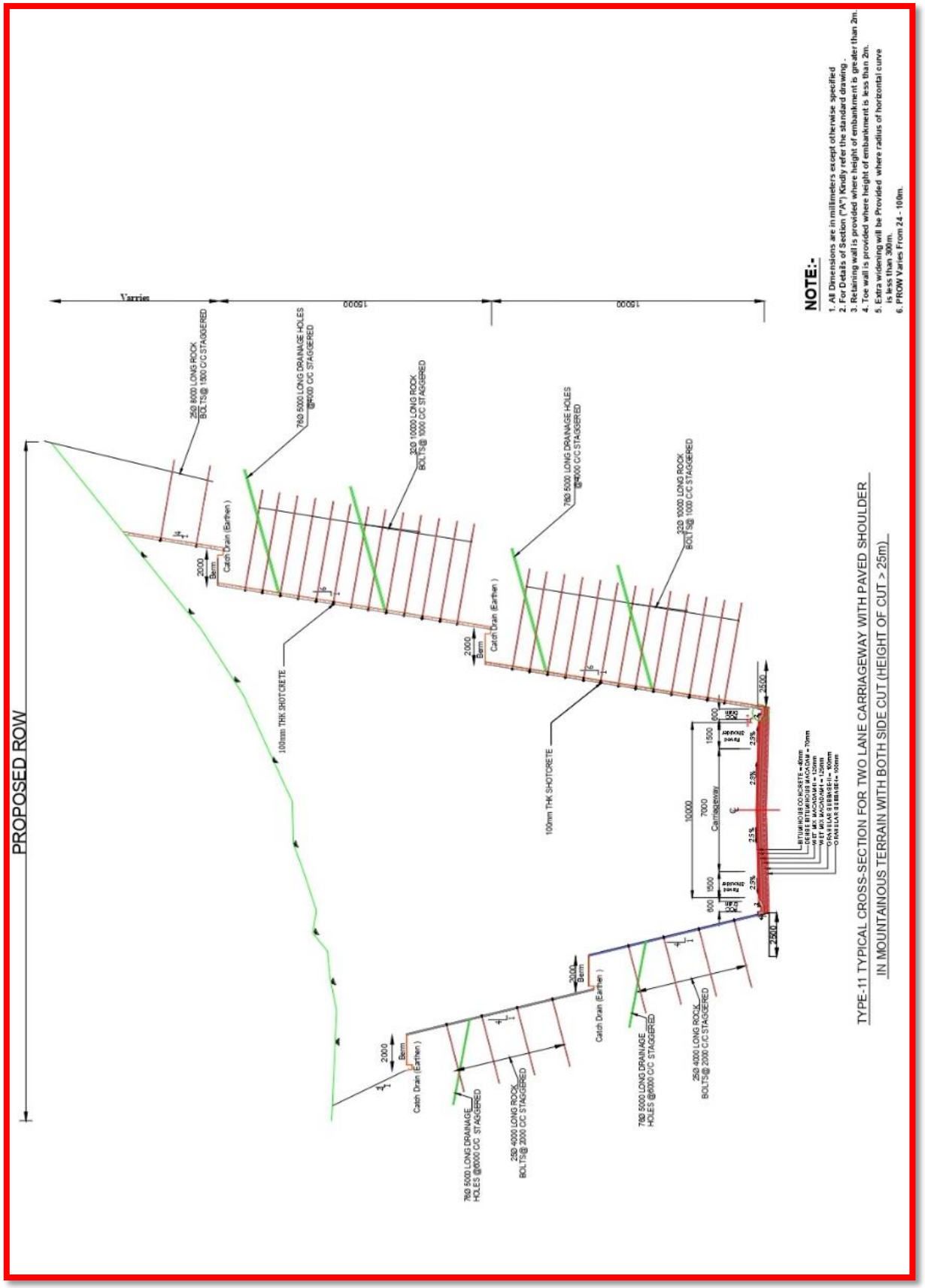
TYPE - 6 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL WITH LEFT SIDE VIADUCT AND RIGHT SIDE CUT (HEIGHT OF CUT < 25m)


PROPOSED ROW
31500
1000
9000
Carriageway
2.5%
Selected Earth Fill
Parapet Wall
Retaining wall/Toe wall
Valley Side
Weep Holes
Valley Side
BITUMINOUS CONCRETE = 40
DENSE BITUMINOUS MACADAM = 70
WET MIX MACADAM-I = 125
WET MIX MACADAM-I = 125
GRANULAR SUBBASE-II = 100
GRANULAR SUBBASE-I= 100
SUB GRADE = 500mm
EMBANKMENT
Selected Earth Fill
Parapet Wall
Valley side
Retaining
wall/Toe wall
Weep Holes
Valley side
TYPE - 7 TYPICAL CROSS-SECTION FOR APPROACH OF TUNNEL WITH BOTH SIDE FILL WITH RETAINING/TOE WALL
NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.


Varies
10000
10000
PROPOSED ROW
760 5000 LONG DRAINAGE HOLES @4000 C/C STAGGERED
250 8000 LONG ROCK BOLTS @ 1500 C/C STAGGERED
320 4000 LONG ROCK BOLTS@ 1000 C/C STAGGERED
Catch Drain (Earthen)
2000 Berm
75mm THK SHOTCRETE
Paved Shoulder
Carriageway
2.5%
2500
600
1500
10000
7000
NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.
TYPE-8 TYPICAL CROSS-SECTION FOR TWO LANE CARRIAGEWAY WITH PAVED SHOULDER IN MOUNTAINOUS TERRAIN WITH BOTH SIDE CUT (HEIGHT OF CUT < 25m)


PROPOSED ROW 24000
12000
7000
CARRIAGEWAY
1500
1500
1000
1000
Earthen Shoulder
Paved Shoulder
Paved Shoulder
Earthen Shoulder
3.0%
2.5%
2.5%
2.5%
2.5%
3.0%
Selected Earth Fill
Parapet Wall
Valley Side
Retaining wall/Toe wall
Weep Holes
BITUMINOUS CONCRETE = 40mm
DENSE BITUMINOUS MACADAM = 70mm
WET MIX MACADAM-II = 125mm
WET MIX MACADAM-I = 125mm
GRANULAR SUBBASE-II = 100mm
GRANULAR SUBBASE-I= 100mm
SUB GRADE = 500mm
TYPE - 9 TYPICAL CROSS-SECTION FOR TWO LANE CARRIAGEWAY WITH PAVED SHOULDER
IN MOUNTAINOUS TERRAIN WITH BOTH SIDE FILL WITH RETAINING/TOE WALL
NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.


NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 108m.
Varries
10000
10000
760 5000 LONG DRAINAGE HOLES @4000 C/C STAGGERED
25Ø 8000 LONG ROCK BOLTS @ 1500 C/C STAGGERED
760 5000 LONG DRAINAGE HOLES @4000 C/C STAGGERED
320 4000 LONG ROCK BOLTS@ 1000 C/C STAGGERED
Catch Drain (Earthen)
Berm
2000
Catch Drain (Earthen)
Berm
2000
75mm THK SHOTCRETE
PROPOSED ROW
2500
"A"
11000
7000
Carriageway
1500
Paved Shoulder
1500
Paved Shoulder
1000
Earthen Shoulder
2.5%
2.5%
2.5%
2.5%
3.0%
Selected Earth Fill
Parapet Wall
Valley Side
Retaining wall/Toe wall
Weep Holes
Valley Side
TYPE-10 TYPICAL CROSS-SECTION FOR TWO LANE CARRIAGEWAY WITH PAVED SHOULDER
WITH LEFT SIDE RETAINING/TOE .WALL & RIGHT SIDE CUT. (HEIGHT OF CUT < 25m)


NOTE:-
1. All Dimensions are in millimeters except otherwise specified
2. For Details of Section ("A") Kindly refer the standard drawing .
3. Retaining wall is provided where height of embankment is greater than 2m.
4. Toe wall is provided where height of embankment is less than 2m.
5. Extra widening will be Provided where radius of horizontal curve is less than 300m.
6. PROW Varies From 24 - 100m.
PROPOSED ROW
Varries
15000
15000
100mm THK SHOTCRETE
100mm THK SHOTCRETE
2000 Berm
Catch Drain (Earthen)
2500
10000
7000 Carriageway
1500
600
2.5%
TYPE-11 TYPICAL CROSS-SECTION FOR TWO LANE CARRIAGEWAY WITH PAVED SHOULDER
IN MOUNTAINOUS TERRAIN WITH BOTH SIDE CUT (HEIGHT OF CUT > 25m)

Pavement Design

Flexible pavement is proposed for new carriageway from km 0+000 to Km 12+850. Design period of 15 years considered for new carriageway. The Pavement design proposal for entire project road is presented in Table below:

Table 34: Improvement Proposal for New Pavement

Crust Composition for New Pavement as per IRC: 37: – 2018										
Homogeneous Section	Design Chainage		CBR	MSA	Crust				Sub- Grade	Total Thickness
	From	To			BC	DBM	WMM	GSB		
1	0/000	12/850	10	20	40	70	250	200	500	**1060**

Traffic control and Safety Measures

Road Marking & Traffic Signs

Road markings will be made for center and edge lines using reflective thermoplastic paints. Appropriate road markings will also be provided at junctions and crossings. Road signs are to place according to IRC: 67-2012. The signs are to be placed on embankment so that extreme edge of sign would be 2.0 m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines there in.

Cost Estimate

The project cost estimates have been prepared based on various items of works required for the new construction work. The item rate for road works and bridge works have been worked out based on prevailing **J&K Schedule of Rates,** for Civil works of all Engineering Departments, sanctioned vide **Govt. Order no. 198-PW(R&B) of 2013 dated 13.06.2013** with escalation considered up to year 2019-20 from WPI and MORT&H Standard Data Book for Analysis of Rates.

Table 35: Cost of Civil Works

Section	Design Length (km)	Civil Cost (Cr)	Total Project Cost (Cr)
From Km 0 to km 6.405	6.405	1692.95	2233.08
From Km 6.405 to km 12.850	6.445	1108.18	1435.65

List Clearances required for the Project

Following clearances are required before the commencement of construction work. Out of these, few are critical and need to be obtained immediately to avoid the time lag at

later date

Table 36: Project Clearances

S No.	Item	Agency
1	Forest Clearance	Jammu and Kashmir Forest Department.
2	Pollution Clearance - No Objection Certificate (NOC) (Exempted)	Jammu and Kashmir State Pollution Control Board.
3	Shifting of services and utilities including underground water pipeline sewerage line and optical fiber cables	BSNL, BSEB, Public Health Engineering department, Optical fiber cable operator.
4	Clearance for cutting trees and transporting	Forest Department, Department of Horticulture.
5	Dismantling of structure falling within right of way	Competent Land Acquisition Authority.

Recommendations

- Based on the lane capacity analysis results, the project road requires 2 lanes with paved shoulder for capacity augmentation and efficient movement of traffic up to project common concession period of 15 years i.e. horizon year 2038.
- The proposed approach road is 2 lane unidirectional in tunnel approaches due to Twins tube(unidirectional) tunnel. The proposed road alignment from km 9.935 to km 12.850 is 2 lane with Paved Shoulder.
- The project road can be improved without causing significant adverse environmental impacts to the natural, social, economic or cultural environments.

The project road can be constructed within 48 months period with strategic planning and through one construction package.

6. TRAFFIC SURVEYS AND ANALYISIS

6.1 General

Traffic surveys, analysis and demand forecast are an important element of any feasibility /detailed project report preparation. Traffic analysis and demand forecasting are directly related to several important aspects of project road planning and design i.e. capacity augmentation proposals, geometric design features, planning and design of toll plaza, pavement design, economic and financial analysis etc. Towards this the consultant has undertaken detailed traffic surveys, analysis, forecasting and carry out lanning requirements. Various steps followed in this regard are described in the subsequent paragraphs.

6.2 Objectives

To carry out traffic surveys and estimation of base year traffic demand;

Identification of travel pattern and influence area of project road;

Traffic demand forecasting up to project life; and

Assess capacity requirement of project road, to estimate tollable traffic & to identify toll plaza locations.

6.3 Project Road & Alternate Transport Network

Project road section falls in the Udhampur and Doda Districts of Jammu and Kashmir. The project road starts at approach road of Sudhmahadev – Dranga Tunnel and runs north east till Dranga village.

The project road traverses through Mountainous terrain and is new alignment. The soil in the district is generally loose and sandy with very low moisture. The rate of soil erosion is very high and roads blockage is frequent during the rainy season. The land-use pattern for the major part of the project road is open area.

6.4 Traffic Homogeneous Section

The traffic homogeneous sections have been identified based on the major traffic generators and diversion at Khellani locations along the project corridor. The propose road is new alignment starting from Sudhmahadev and all the traffic survey assessments have been carried out at Khellani Village. The passenger traffic has been observed to vary

with respect to the influence of village/towns falling along the project corridor. The major traffic generators settlements and its connections (diversion) points are:

Sudhmahadev – Dranga.

Traffic surveys locations were selected to capture representative traffic volume on the homogeneous sections with a view to capture section wise traffic flow characteristics, the total stretch has been segmented in to two homogeneous sections, based upon the major intersections that act as main collectors or distributors (diversion) of traffic along the project road. The traffic homogeneous section in the road section is as follows:

Table 37: Traffic Homogenous Section

Sr. No.	Homogeneous Section	Proposed Chainage	
		From (Km)	To (km)
1	Sudhmahadev - Dranga	0+000	12+850

6.5 Traffic Survey Planning and Selection of Survey Location

A comprehensive traffic survey plan has been prepared for the project road after considering traffic intensity on homogeneous sections and travel characteristics. Detailed site visit of project road and its influence/alternative transport network has been carried out between on **26th October 2018 to 1st November 2018**.

Traffic survey locations were finalized by consultation with client officials. Reasoning with detailed justification for selection of each traffic survey location is given in below Table

Table 38: Traffic Survey Locations Justification/Rational

Sr. No.	Location	Justification/Rational
Classified Volume Count Surveys (CVC)		
1	**Khellani on NH-244**	Khellani has been selected to get the idea of traffic in homogeneous section of Sudhmahadev Dranga tunnel up to Khellani town

6.6 Traffic Surveys Schedule

It is very important, that the existing information on traffic flow, commodity movement and traffic pattern is required to assess the traffic behavior on a project road. To collect such information to satisfy the Terms of Reference (TOR) and project requirements, following various types of traffic surveys were carried out:

I. Classified Volume Count (CVC) Survey

II. Axle Load Spectrum Survey

III. Origin –Destination and Commodity Movement Surveys

IV. Speed and Delay surveys

V. Truck Terminal Survey

Traffic survey locations were selected after detailed reconnaissance survey and in line with the TOR. All the traffic surveys were carried out as per the IRC guidelines given in IRC: SP 19-2001, IRC 37:2018, IRC: 108-2015, IRC SP: 41-1994, IRC: 102-1988, IRC 103-2012 and IRC: 09-1972 etc.

All the above surveys were carried out manually by employing sufficient number of trained enumerators recording information in the pre-designed formats. The enumerators were selected from locally available educated people familiar with traffic characteristics and condition of the project road. They were properly briefed and trained about the survey work before putting them on actual survey work in field. An experienced supervisor was kept in-charge for all the locations.

The locations for the various surveys were so selected that all vehicles can be viewed and interpreted easily without endangering the safety of enumerators and drivers. The most important part of all traffic survey was to exercise adequate quality control. The quality assurance was achieved through:

- Proper briefing and demonstration to enumerators before the start of work;
- Continuous independent checking by Traffic engineers / supervisor in the field during the survey work;
- Checking of filled in survey formats by Traffic engineer; and
- Validation of computer data entry with raw surveyed data

The survey data were recorded in the pre-designated approved formats for each type of survey. All the above traffic surveys were carried out as per the schedule finalized after considering requirements of TOR and project requirements as presented below.

Table 3.3: Traffic Survey Schedule

Type of Survey	Location	Survey Date		Duration
		From	To	
Classified Traffic Volume Count Survey	Khellani on NH-244	26-10-2018	01-11-2018	7 days (24 Hrs)
O-D Survey	Khellani on NH-244	27-10-2018		24 Hrs
Axle load survey	Khellani on NH-244	27-10-2019		24 Hrs

6.7 Traffic Surveys Methodology

➢ Classified Volume Count Survey

The objective of classified traffic volume count survey is to estimate traffic intensity on the project road. The classified volume count surveys at two strategic locations have been carried out for 7 days, @ 24 hours/day. The traffic is counted in number of vehicles by vehicle category-wise in each direction in a 15- minute interval over 24 hrs. a day for 7 days. The counts were recorded in the approved formats as per IRC specifications.

➢ Origin-Destination and Commodity Movement Survey

In a transportation study, it is necessary to estimate the number of trips with respect to origin and destination. These calculations help in studying travel trends of passenger and commercial vehicles.

The trend pattern determines the basis for adopting techniques for estimating traffic growth projections. O-D surveys were carried out at one location to get travel and loading patterns.

The Origin-Destination survey was carried out to study the travel pattern of goods and passenger traffic along the project road. O-D surveys shall help calculate future diverted traffic on project roads once a better transportation facility is made available. The location of origin and destination zones has been determined in relation to each individual station and the possibility of traffic diversion to the project road from/to other routes including bypasses.

Roadside Interview Method was adopted for conducting the survey. A sample proportion of vehicles were interviewed from the total traffic. Randomly picked vehicles were stopped and interviewed. Designated trained enumerators interviewed the drivers.

Variable sampling flow requires a classified hourly count of all vehicles that pass in the direction being studied while interview is in progress. A volume count survey was carried out simultaneously to get the number of vehicles passing in both the directions. The O-D survey was limited to cars/Jeeps, bus, LCV, and 2 axles / 3 axles, Multi Axle. The following information on travel was collected during the O-D and commodity movement surveys

- Origin and destination of trips;
- Trip Purpose
- Travel Route
- Trip length;
- Vehicle Occupancy;
- Type of commodity and loading in case of the goods vehicles; and
- Frequency of trips etc.

Appropriate zoning system was adopted, and coding was done for zones and type of vehicle & commodity being carried.

➢ **Axle Load Survey**

To estimate vehicle loading spectrum on project road, and to determine vehicle damage factor for the commercial vehicles, the axle load surveys are carried out at identified locations. The data collected from the Axle Load Survey has been compiled and analyzed through "Fourth power" pavement damage rule to arrive at the vehicles damage factor (VDF). The survey is analyzed to obtain Vehicle Damage Factor (VDF).

➢ **Speed and Delay Survey**

The purpose of the travel time and delay study is to evaluate the quality of traffic movement along a route and to determine the locations, types and extents of traffic delays.

The efficiency of flow is measured by travel and running speeds. In the actual study, total travel and running times are observed and then converted into speed measures.

Before starting the test runs, major intersections or suitable control points were selected

along the study route as reference/control locations. The project road was divided into one section based on the traffic characteristics and pavement condition of the corridor. Time readings are taken at these locations to permit the development of travel speeds by sections along the travelled route.

A test vehicle is driven along the study route in accordance with moving car technique, in which, a safe level of vehicular operation is maintained by observing proper following and passing distances and by changing speed at reasonable rates of acceleration and decelerations. Delay information is recorded when the traffic flow is stopped or greatly impeded. The duration of traffic delay is measured in units of time along with notations of the corresponding location, cause and frequency of delay to travel. Following information was collected during the survey:

- Number of vehicles in the opposite direction of test car;
- Number of vehicles overtaken by the test car;
- Number of vehicles overtaking the test car;
- Amount of delay occurred; and
- Reasons for the delay etc.

➢ **Truck Terminal Surveys**

The survey is normally conducted at major truck parking locations using patrolling method. In this method registration number of vehicles parked were noted down in each 30-minute interval.

The data collected is analyzed to assess the parking accumulation and duration. This would form an input to the planning of truck lay byes and wayside amenities along the improved corridor. Truck terminal survey was conducted at strategic location near Khellani.

6.8 Analysis of Traffic Surveys - Base Year Traffic Estimation

➢ **General**

The base year traffic pattern is the primary input for checking existing level of service and determination of future traffic demand of project influence area.

The consultant has conducted Classified Volume Count Surveys, Intersection Volume Count, O-D and commodity, Axle load and speed & delay surveys to examine the base year traffic intensity, travel characteristics, loading patterns and travel speed on project road. For traffic estimation and projection, the year 2018 has been taken as base year.

The following section provides detailed traffic analysis and important observations about traffic pattern along the project corridor. The data collected during traffic surveys was entered into the computer for further analysis and to obtain information about traffic characteristics and travel pattern along the project road.

The results of the analysis can be further used for designing the pavement crust, road cross-section, planning and designing of toll plaza & way side amenities, and for economic and financial analysis. The traffic analysis was carried out as per the guidelines given in IRC: SP 19-2001, IRC: 108-2015, IRC: 64-1990, IRC SP: 41-1994.

- **Classification of Vehicles and PCU Values**

To convert recorded vehicles into a common scale, the Passenger Car Units (PCU) equivalent factor as per IRC: 64-1990 has been adopted. The PCU equivalent factors adopted are as given in **Table**.

Table 39: Classification of Vehicles Recommended PCU Equivalents Factors

Sr. No.	Vehicle Type	PCU Value
Fast Moving Vehicles		
1	Cars/Utility Vehicles/Jeeps/Vans & 3 Wheelers	1.0
2	2 Wheelers	0.5
3	LCV Passenger/LCV Goods/Minibus	1.5
4	Standard Bus	3.0
5	Two and 3 Axle Truck	3.0
6	Multi Axle Truck/Heavy Construction Machinery/Trailer	4.5
7	Agricultural Tractor (with Trailer)	4.5
8	Agricultural Tractor (without Trailer)	1.5
Slow Moving Vehicles		
1	Bicycle	0.5
2	Cycle Rickshaw	2.0
3	Animal Drawn Vehicle (Bullock cart)	8.0
4	Animal Drawn Vehicle (Horse drive)	4.0
5	Hand cart	3.0

6.9 Analysis of Classified Volume Count Survey

➢ Average Daily Traffic (ADT)

7-Day, 24 hrs. Continuous volume counts were undertaken to obtain a realistic picture of the current volume and composition of the traffic. The analysis of traffic counts provided an estimate of the Average Daily Traffic (ADT) and the analysis has been carried out in terms of total number of vehicles as well as in respect to Passenger Car Unit (PCU). Location wise results of traffic analysis are discussed below:

➢ Khellani on NH-244

Classified Volume count survey was carried out at Khellani on NH-244.

Total ADT at this station were recorded as 3024 in terms of number and 4657 in terms of PCU. Fast moving vehicles were recorded as 100% of the total traffic (in No.). The directional distribution for all vehicles observed is 49.70 percent flow towards up direction and 50.30 percent towards down direction.

Summary of classified traffic volume count survey results is shown in Table below.

Table 40: Summary of Classified Volume Count Survey at all count stations

Sr. No.	Location	Total AADT (No.)	Total AADT (PCU)	Directional Distribution (%)		Total ADT (No.)	Total ADT (PCU)	Directional Distribution (%)	
				Up	Down			Up	Down
1	Khellani on NH-244	2947	4538	49.50	50.50	3024	4657	49.70	50.30

Survey has been carried out for seven days 24 hours continuously; the traffic flow on all the days in the week will not be same. There will be variation of traffic for each day.

6.10 Traffic Composition

The traffic compositions observed in survey locations are presented graphically in Figure.

At location Near Khellani vehicle's compositions by type and percentage of volume are 2-wheelers (10%), car/jeep/van (17%), Mini Bus (2%), LCV (13%), 2 Axle (25%), 3 Axle (21%), Multi Axle Truck (21%).

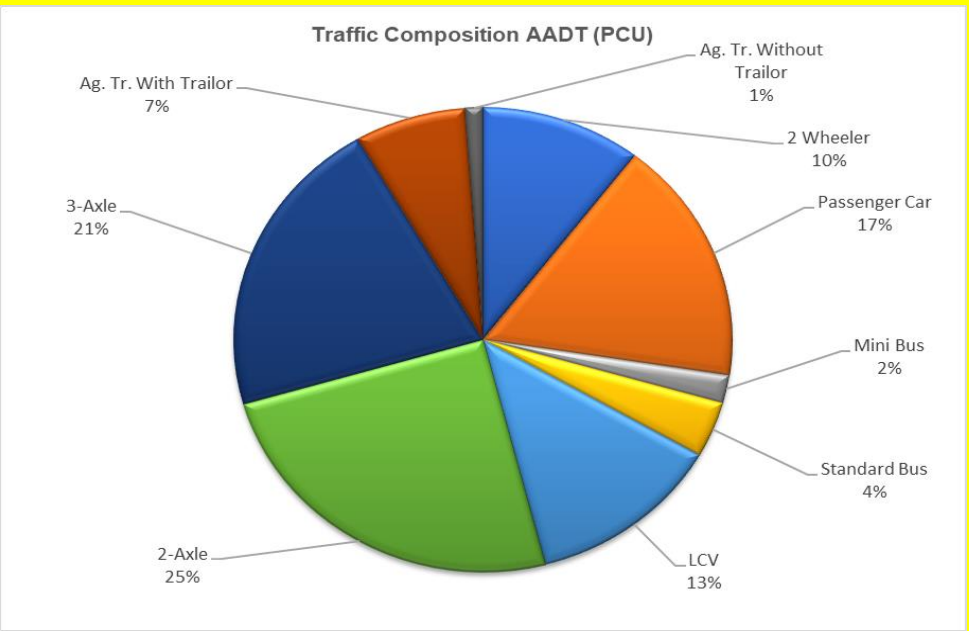


Figure 23: Composition of Traffic by PCU at Khellani Town

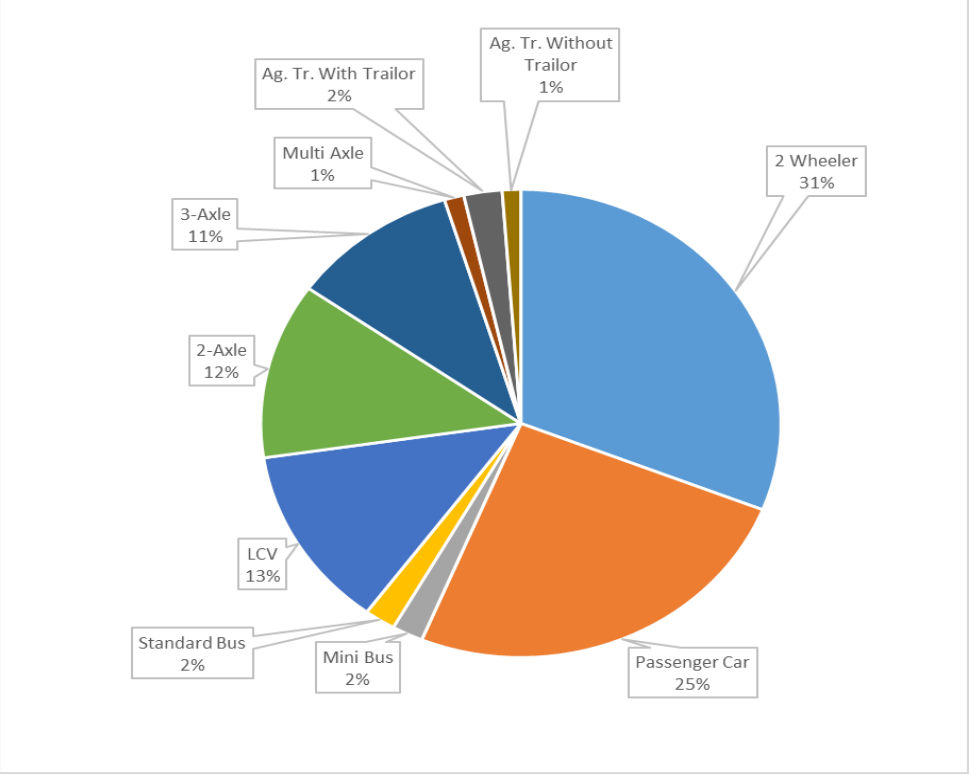


Figure 24: Composition of Traffic by Volume at Khellani Town

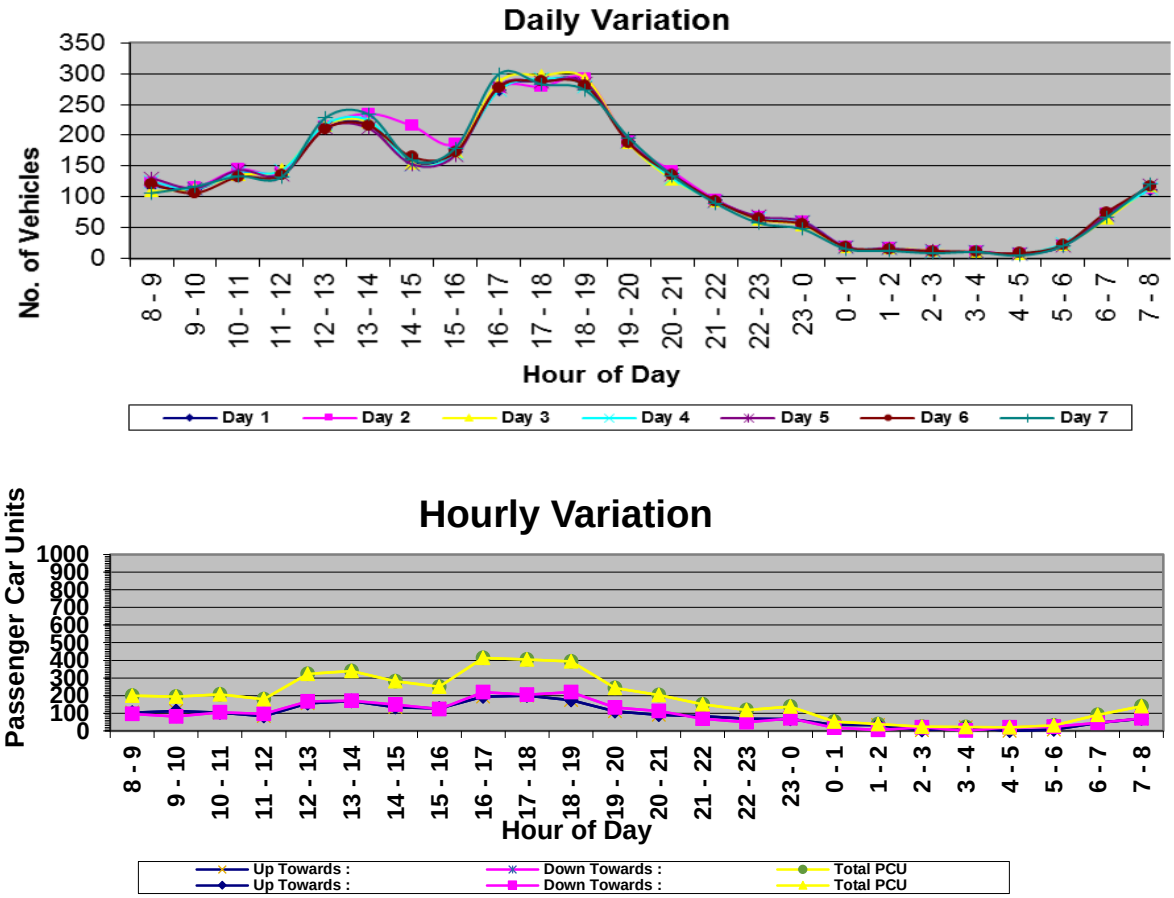


Figure 25: Daily and Hourly Variation of Traffic at Khellani Town

6.11 Estimation of Seasonal Correction Factor

Seasonal Correction factors by vehicle types are required to account for variations in the pattern of traffic volume on the project road sections over different seasons of the year. Seasonal correction trends were assessed based on the sale of automobile fuels i.e. petrol and diesel data along the project road. Seasonal correction factors were worked out to arrive at Annual Average Daily Traffic (AADT). The monthly petrol and diesel sales data were collected from fuel station on the project road. The SCF was calculated separately for petrol and diesel driven vehicles. The calculated SCF based on monthly fuel consumption are presented in the following Table.

Table 41: Seasonal Correction Factors (SCF) Based on Fuel Consumption

	Petrol	Diesel
For Whole Section	0.95	1.04

Since traffic volume count surveys were carried out in the month of October 2018, the

computed seasonal variation factors of 1.04 for Diesel driven and 0.95 for Petrol driven vehicles have been adopted for estimation of AADT.

6.12 Annual Average Daily Traffic (AADT)

The seasonal correction factors presented above are used to convert Average Daily Traffic (ADT) to Annual Average Daily Traffic (AADT).

Table 42: Annual Average Daily Traffic (AADT)

PCU Equivalents	0.5		1		1.5		3		1.5		3		3		4.5		4.5		1.5		Total All Vehicles	
Vehicle Type	FAST MOVING VEHICLES																					
	2 Wheeler		Passenger Car		Bus				LCV		Truck						Agricultural Tractor					
					Mini Bus		Standard Bus		4 Tyre		2-Axle		3-Axle		Multi Axle		With Trailor		Without Trailor			
Direction	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN
Day 1	445	463	392	369	27	29	27	23	184	195	171	176	146	156	18	12	31	37	16	19	1457	1478
Day 2	478	477	386	370	28	30	22	28	185	192	172	178	152	153	18	20	33	36	19	17	1493	1501
Day 3	463	461	370	358	27	29	28	26	175	194	182	189	149	156	16	18	36	32	14	19	1460	1482
Day 4	412	478	367	379	27	29	36	28	188	182	180	188	141	163	21	12	37	36	16	18	1426	1513
Day 5	453	464	360	379	24	30	31	36	184	182	172	175	160	145	20	21	36	35	17	18	1457	1486
Day 6	465	439	351	388	27	30	23	28	175	178	185	182	163	144	20	19	36	34	16	17	1462	1460
Day 7	461	438	371	358	29	25	28	26	192	182	175	181	160	166	19	17	33	35	18	16	1485	1444
Total	3178	3219	2595	2600	191	204	197	197	1283	1307	1236	1269	1072	1083	131	117	243	246	113	121	10238	10363
Total Up/Down	6397		5196		395		394		2590		2506		2155		248		488		234		20602	
Average	453	459	370	371	27	29	28	28	183	186	176	181	153	154	18	16	34	35	16	17	1458	1476
AADT No.	914		743		57		57		370		358		308		36		70		34		2947	
AADT PCU	457		743		86		171		555		1074		924		162		315		51		4538	

6.13 Axle Load Survey

To estimate vehicle loading spectrum on project road, and to determine vehicle damage factor for the commercial vehicles, the axle load surveys have been carried out at identified locations. The data collected from the Axle Load Survey has been compiled and analyzed through "Fourth power" pavement damage rule to arrive at the vehicles damage factor (VDF). The survey is analyzed to obtain Vehicle Damage Factor (VDF) and is presented below:

Table 43: Adopted VDF by Homogeneous Sections near Khellani Village

Vehicle Type	VDF
LCV	0.459
2 Axle Truck	4.932
3 Axle Truck	0.765
Bus	0.619
Multi axle	3.930

Vehicle Damage Factor of 2 Axle Truck is more because there were maximum empty number of 3 Axle and Multi Axle Trucks whose weights were measured during Axle Load Survey.

Table 44: Weights were Measured during Axle Load Survey

2 - Axle		
Total	**60**	
Empty	2	3.33%
Loaded	58	96.67%
3-Axle		
Total	**68**	
Empty	64	94.12%
Loaded	4	5.88%
Multi -Axle		
Total	**5**	
Empty	3	60%
Loaded	2	40%

Table 45: Adopted MSA as per IRC Recommendation

Section	**Existing Chainage**		**Design MSA (2022-2036)**
	From	**To**	
Sudhmahadev – Dranga Tunnel	0/000	12/850	20

The equivalent single axle loads (ESALs) have been calculated assuming that the project road will be opened to traffic in the beginning of year 2023. VDF and MSA Details are provided in table below:

Note – As per clause no. 5.4.1 of IRC: SP:73-2018, It says that flexible pavement shall be designed for a minimum design period of 15 years, subject to the condition that design traffic shall not be less than 20 MSA.

So, we have adopted 20 MSA for design works against the projected 9.448 MSA.

Table 46: MSA Calculation

								Khellani on NH-244	
Year	**Standard Bus**	**LCV**	**2 Axle**	**3 Axle**	**MAV**	**Yearly Design ESA**	**Cumulative Design ESA**	**MSA**	**Design Period**
VDF	0.62	0.46	4.93	0.76	3.93			Base Year	
2019	114	370	358	308	36	347906			
2020	120	407	376	323	38	366541			
2021	126	448	395	340	40	386231			
2022	132	488	414	357	42	406742			

								Khellani on NH-244	
Year	**Standard Bus**	**LCV**	**2 Axle**	**3 Axle**	**MAV**	**Yearly Design ESA**	**Cumulative Design ESA**	**MSA**	**Design Period**
2023	139	532	435	374	44	428387	428387	**0.428**	**1-year**
2024	145	580	457	393	46	451232	879619		
2025	153	632	480	413	48	475347	1354966		
2026	160	689	504	433	51	500808	1855774		
2027	168	744	529	455	53	527233	2383007	**2.383**	**5-year**
2028	177	803	555	478	56	555090	2938096		
2029	186	868	583	502	59	584459	3522555		
2030	195	937	612	527	62	615426	4137981		
2031	205	1012	643	553	65	648081	4786062		
2032	215	1083	675	581	68	681841	5467903	**5.468**	**10-year**
2033	226	1159	709	610	71	717384	6185287		
2034	237	1240	744	640	75	754806	6940093		
2035	249	1327	781	672	79	794208	7734300		
2036	261	1420	821	706	83	835696	8569996		
2037	274	1505	862	741	87	878431	9448427	**9.448**	**15-year**

6.14 Analysis of Origin-Destination (O-D) & Commodity Movement Survey

General

Origin and Destination survey was conducted by roadside interview method at one location. This survey has been used to obtain the travel characteristics of goods and passenger vehicles and to determine the through and local traffic.

The purpose of the OD survey is to determine the existing travel pattern of the road user on the corridor & the project influence area. The road users were asked questions to determine their flow path along the project corridor, trip purpose, trip length, commodity type. Axle load survey was also carried along with the OD survey to analyse the loading pattern and Vehicle Damage Factor, VDF.

The survey has been carried out by deploying a group of enumerators under the supervision of engineers. The questionnaire prepared for the O-D survey was filled up by the enumerators by stopping the vehicles and interviewing the road users. Resentment to answer the questions was observed at location.

6.15 Zoning System

To analyse O-D Data the entire study corridor has been divided into local traffic zones and rest of the locations had been divided into external zones. The number of trips originating from and destined to any zone represents the influence of that zone in traffic generation/attraction. Based on the study of collected O-D data, project corridor was divided into 7 zones. Table below represents O-D Zoning system used for the analysis.

Figure represents the OD Zoning map for the project.

Table 47: Traffic Area Zoning System

Sr. No	Places	Type of OD Zone	Zone Code
1	Khellani, Tarowa, Sudhmahadev, Goha	Internal	1
2	Chhatroo, Kishtwar, Doda, Chingam, Charote	External	2
3	New Thatri, Thathri, Bhaderwah, Surangani, Chamba	External	3
4	Anantnag, Sri Nagar, Kokernag, Achabal, Vailoo	External	4
5	Batote, Chenani, Patnitop, Udhampur, Jammu	External	5

6.16 Discussion

Internal to internal zones means trips origin and destination with in the project corridor and immediate surroundings. Internal to External zones means trips originating from project corridor and destined to beyond the project corridor. External to Internal zones means trips originating from outside the project corridor and destined to within the project corridor, and External to External zones means trips originating and destined form outside the project corridor.

6.17 Development of Origin-Destination Matrices and travel Characteristics

It is important to analyse the trip characteristics with respect to the project road and its surroundings by development of vehicle category wise trip matrices and desire lines. After coding of Origin and Destination from the raw data, expansion factors were calculated by comparing sample size of each vehicle type with the traffic classified volume count data of the same day at the same location of O-D Survey. These expansion factors were applied to O-D Data and vehicle wise O-D matrices were developed.

O-D matrices for different vehicle types for each survey station on the project road are presented below based on O-D matrices, travel pattern of the vehicles moving on the project road is discussed below.

Commodity Analysis

During the O-D surveys, information of goods pertaining to commodity and tonnage were recorded along with the origin destination details. The information so collected was analysed to assess the kind of goods movement the project road caters to. The commodity distribution of goods traffic at each of the survey locations across different

type of freight vehicles is presented. Data obtained from the O-D survey has been analysed and commodity wise movement pattern. The following Table shows the coding adopted for various commodities.

Table 48: Vehicle Wise Commodity Distribution at Khellani on NH-244 (in %)

Commodity	LCV	2 Axle	3 Axle	MAV	Total	Average
Food Grains	30.6	0.0	0.0	0.0	11.5	7.6
Fruits and Vegetables	25.0	0.0	0.0	0.0	9.4	6.3
Iron	0.0	0.0	12.5	33.3	5.2	11.5
Petroleum	0.0	0.0	0.0	50.0	3.1	12.5
Building material (Hardware, paint, tanker water)	5.6	23.3	12.5	0.0	12.5	10.3
Tyres	5.6	20.0	8.3	0.0	10.4	8.5
Household Goods	5.6	6.7	16.7	0.0	8.3	7.2
Mineral Oils	11.1	3.3	0.0	0.0	5.2	3.6
Heavy Machinery	5.6	20.0	25.0	0.0	14.6	12.6
Empty	0.0	16.7	0.0	16.7	6.3	8.3
New Vehicle	11.1	10.0	25.0	0.0	13.5	11.5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

6.18 Goods Vehicle – Trip Length Analysis

The survey data was analysed to assess the frequency of movement of commercial vehicles. The distribution observed for different vehicle types is grouped into various ranges. The frequency analysis is presented in Table.

Table 49: Distribution of Goods Vehicles by Trip Length (In %)

Trip Length	LCV	2-Axle	3-Axle	MAV
0 - 25	2.78	0.00	8.33	0.00
25 - 50	5.56	20.00	4.17	0.00
50 - 100	33.33	20.00	33.33	50.00
100 - 250	44.44	43.33	50.00	33.33
250 - 500	13.89	16.67	4.17	16.67
500 - 750	0.00	0.00	0.00	0.00
750 - 1000	0.00	0.00	0.00	0.00
1000 - 1500	0.00	0.00	0.00	0.00
> 1500	0.00	0.00	0.00	0.00
Total	**100.00**	**100.00**	**100.00**	**100.00**

Passenger Vehicle – Trip frequency, Occupancy and Trip Purpose

O-D data for passenger vehicles was collected and further analysed for trip frequency,

occupancy and trip purpose.

Trip purpose at location show varied behaviour for traffic movement in Table; mostly the trips are influenced because of either for personal reasons or work.

Table 50: Trip Purpose of Passenger Vehicles

Purpose	Car/Jeep	Std. Bus	Mini Bus	Others	Total
Work	42.5	65.0	75.0	37.5	57.0
Education	5.0	5.0	6.3	0.0	5.0
Business	32.5	0.0	0.0	50.0	17.0
Social/Shopping/Recreational/ Religious	10.0	20.0	12.5	0.0	12.0
Others	10.0	10.0	6.3	12.5	9.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

The purpose wise percentage distributions of trips at the location are presented in the pie charts below. Distribution at the station varies widely as explained above. Passenger vehicles were analysed for trip frequency along project corridor. Table below shows the details of daily, weekly, monthly and yearly trips along project corridor. At the location buses comply only on daily basis and cars comply comparatively more on longer trips.

Table 51: Trip Length of Passenger Vehicles

Trip Length	Car	Std. Bus	Mini Bus	Others
0-25	2.5	0.0	6.3	0.0
25-50	5.0	20.0	3.1	0.0
50-100	32.5	20.0	31.3	37.5
100-250	47.5	40.0	56.3	37.5
250-500	12.5	20.0	3.1	25.0
500-750	0.0	0.0	0.0	0.0
750-1000	0.0	0.0	0.0	0.0
1000-1500	0.0	0.0	0.0	0.0
>1500	0.0	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**

Development of Origin Destination Matrices

The data collected regarding the origin and destination of the vehicle is coded into different zones. The zonal movement of vehicles is presented as pivot table for quick & easy interpretation of the zone movement and summarizing the zones with maximum movement of vehicles and soon.

The pivot table is prepared for the survey location and for each vehicle category.

Travel pattern of vehicular trips observed at the survey location is studied for the following categories:

- External-to-External Trips: Traffic using Full Length of project road i.e. traffic neither originated nor destined along/near the project corridor.
- Internal-to-Internal Trips: Traffic using Partial length of the project road i.e. traffic either originated or destined along/near the project corridor.
- Internal-to-External Trips: Traffic using either Full or partial Length of project road i.e. traffic either originated or destined along/near the project corridor.

O-D Traffic was analyzed for above category of movements for the location separately for freight and passenger vehicles shown in Tables

Table 52: Travel Pattern for Freight Vehicles

Trip Direction	No. of Trips	%age
Internal - Internal	1	1.04
Internal - External	24	25.00
External - Internal	28	29.17
External - External	43	44.79
Total	**96**	100.00

Table 53: Travel Pattern for Passenger Vehicles

Trip Direction	No. of Trips	%age
Internal - Internal	2	2.00
Internal - External	21	21.00
External - Internal	22	22.00
External - External	55	55.00
Total	**100**	100.00

6.19 Traffic Demand Forecast

➢ Approach

For evaluating the benefits as well as costs incurred by the project roads, it is obvious that a certain period must be considered for the overall project.

Though project once implemented has a long life, if a proper maintenance is carried out from time to time, it is also understood that the project will continue to benefit the society even after the expiry of the project period. For the present project, as mentioned in the TOR, period of 15 years has been considered for traffic demand forecasting.

Traffic demand forecast was carried out up to horizon year 2036. To calculate the growth rate for traffic projections, comparative analysis has carried out for all the methods. The methods used for growth rate calculation are as follows:

I. Past trends in traffic growth (Vehicle registration Method)

II. Econometric Model Method: IRC-108:1996

Past Trends in Traffic growth

There is no permanent count station along the project road.

Past trend in growth of registered vehicle

The vehicle registration growth also gives an indication of the traffic growth. Vehicle Registration data of Jammu and Kashmir State has been taken for period 2004 - 2016. A growth rate for the same has been derived and the same has been shown in the Table below.

Table 54: Growth Rate of Economic Indicators for the State of Jammu and Kashmir

Sr. No.	Year	Per Capita Income (PCI)			Population			NSDP			GSDP		
		Rs.	Growth	Gr. rate (%)	In 000's	Growth	Gr. rate (%)	Rs. (In crores)	Growth	Gr. rate (%)	Rs. (In crores)	Growth	Gr. rate (%)
1	2004-05	21734			10717			23292			27305		
2	2005-06	22406	672	3.09	10877	160	1.49	24371	1079	4.63	28883	1578	5.78
3	2006-07	23375	969	4.32	11035	158	1.45	25794	1423	5.84	30602	1719	5.95
4	2007-08	24470	1095	4.68	11192	157	1.42	27387	1593	6.18	32561	1959	6.40
5	2008-09	25641	1171	4.79	11350	158	1.41	29102	1715	6.26	34664	2103	6.46
6	2009-10	26518	877	3.42	11506	156	1.38	30512	1410	4.85	36225	1561	4.50
7	2010-11	27666	1148	4.33	11659	153	1.33	32256	1744	5.72	38270	2045	5.65
8	2011-12	28790	1124	4.06	11806	147	1.26	33990	1734	5.38	41203	2933	7.66
9	2012-13	30035	1245	4.32	11952	146	1.24	35898	1908	5.61	43402	2199	5.34
10	2013-14	31448	1413	4.70	12096	144	1.20	38039	2141	5.96	45847	2445	5.63
11	2014-15	30612	-836	-2.66	12235	139	1.15	37453	-586	-1.54	45126	-721	-1.57
12	2015-16	35034	4422	14.45	12261	26	0.21	42955	5502	14.69	51757	6631	14.69
Average yearly growth rate (%)				**4.50**			**1.23**			**5.78**			**6.05**

Growth Rate based on Vehicle Registration Method (Based on Road Transport Yearbook)

Table 55: Adopted of Growth Rates

Sr. no.	Period	2 Wheelers	Cars/jeeps	Buses	Trucks			LCV and Mini LCV
					2 Axle	3 Axle	M Axle	
1	Up to 2020	10.0	10.0	5.0	5.0	5.0	5.0	10.0
2	2021 -2025	9.0	9.0	5.0	5.0	5.0	5.0	9.0
3	2026 – 2030	8.0	8.0	5.0	5.0	5.0	5.0	8.0
4	2031 – 2035	7.0	7.0	5.0	5.0	5.0	5.0	7.0
5	Beyond 2035	6.0	6.0	5.0	5.0	5.0	5.0	6.0

- **Econometric Model Method (IRC-108:2015)**

The traffic forecast by vehicle type has been carried out by adopting the transport demand elasticity method, which is a well-established and proven technique and is referred in India.

Elasticity of traffic demand is defined as the rate at which traffic intensity varies due to change in the corresponding indicator selected. Hence, to estimate the elasticity of traffic demand, it is necessary to establish the relationship between the growth in number of a given category of vehicle with one of the economic variables considered, such as NSDP, per capita income and population growth. Then the data can yield econometric model and the form of equation for estimation of traffic demand elasticity as recommended in IRC: 108-1996 of the following type:

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

Where,

P=Number of vehicles

EI= Economic indicator

A_o=Constant

A1= a coefficient (elasticity value)

6.20 Past Trends in Economy and Population

The economic indicators of Jammu and Kashmir State, which are used for the regression analysis, are summed up in Table below:

Table 56: Net State Domestic Products and Growth for J&K State (2004-2012)

YEAR	SECTORS		TOTAL NSDP		
	Population in 000's	Per capita Income			
2004- 2005	10717	21734	23292		
2005 - 2006	10877	22406	24371	1079	4.63
2006 - 2007	11035	23375	25794	1423	5.84
2007 - 2008	11192	24470	27387	1593	6.18
2008 - 2009	11350	25641	29102	1715	6.26
2009 - 2010	11506	26518	30512	1410	4.85
2010 - 2011	11659	27666	32256	1744	5.72
2011 - 2012	11806	28790	33990	1734	5.38

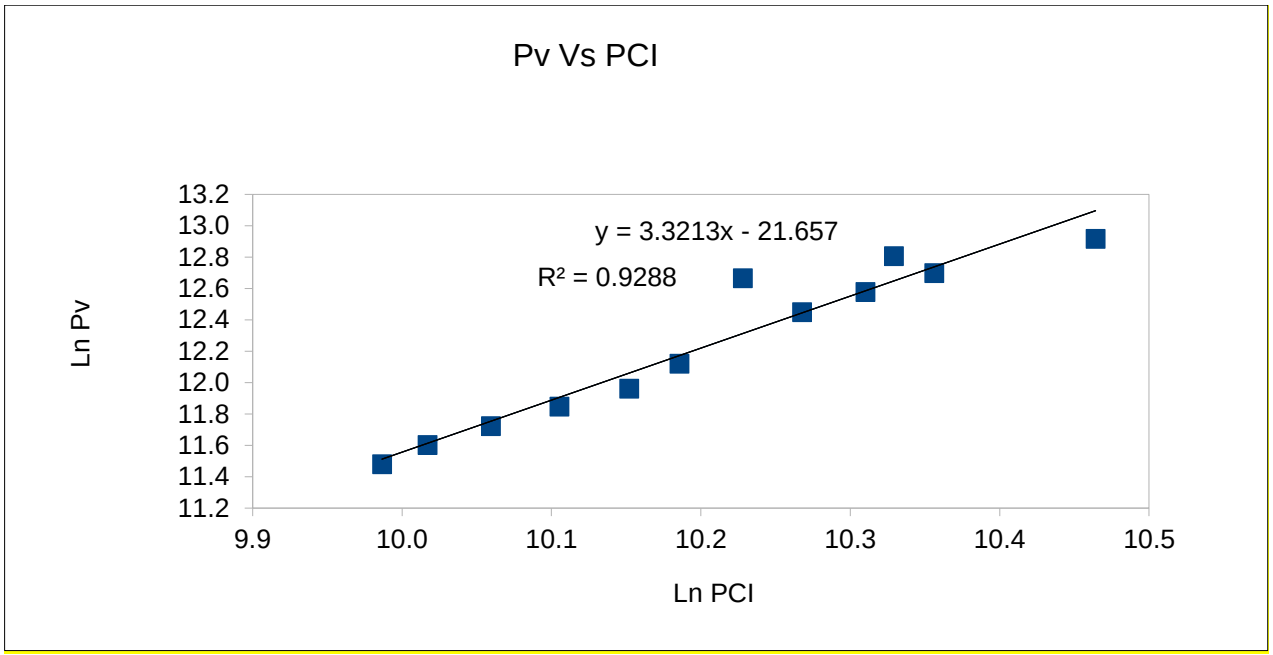
YEAR	SECTORS		TOTAL NSDP		
	Population in 000's	Per capita Income			
2012-2013	11952	30035	35898	1908	5.61
2013-2014	12096	31448	38039	2141	5.96
2014-2015	12235	30612	37453	-586	-1.54
2015-2016	12261	35034	42955	5502	14.69
Average Yearly Growth Rate (%)					**6.05**

As mentioned above, to establish elasticity of traffic growth, we have regressed past vehicle registration data with past economic indicators of the state. The 'e' values for the selected economic variables with respect to different vehicle types are shown in the **Table** and are found with good fit, as reflected in their R2 values.

Table 57: Transport Demand Elasticity's

S. No	Mode	Economic Indicator	Elasticity Value	R^2 Value
1	Car/Jeep	PCI	3.32	0.929
2	Truck	NSDP	0.58	0.730
3	2-Wheeler	PCI	2.10	0.974
4	Bus	Population	2.69	0.962
5	LCV & Mini LCV	NSDP	2.98	0.948

The relationship between different vehicle types and selected Per capita income (PCI) are presented in Figure below.



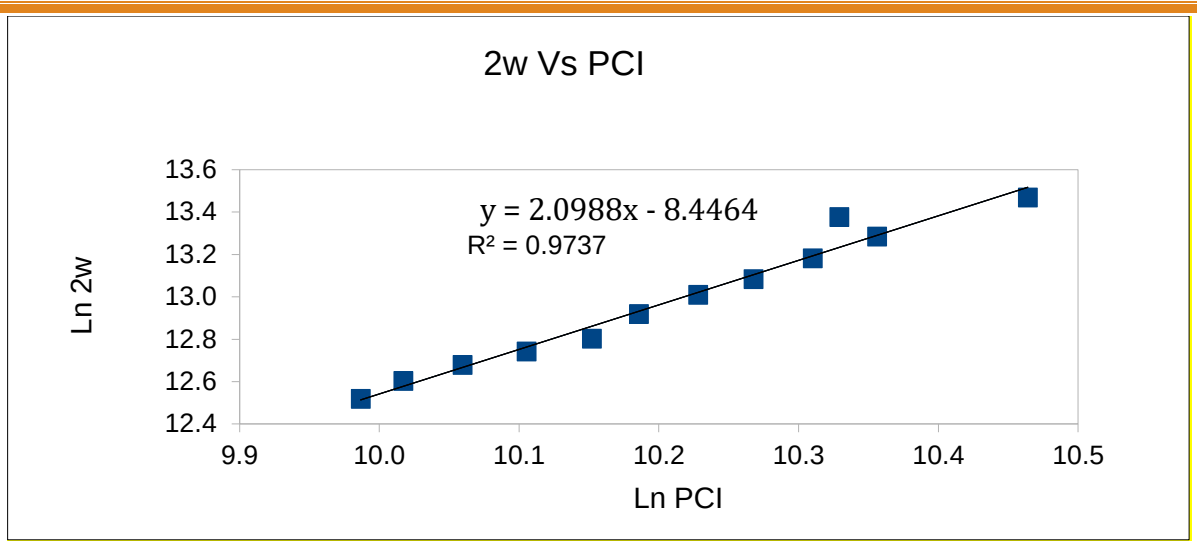


Figure 26: Relationship between Vehicle Types and Per capita Income (PCI)

The comparison of vehicle growth rates by vehicle registration and econometric model is as shown in Table. It is appropriate to use the growth pattern that has emerged out of the economic model, which related the economic growth with the growth in vehicle registration data.

Table 58: Comparative Analysis and adopted of Growth Rates

Growth Rates of Vehicular Traffic for the state of Jammu and Kashmir								
Sr. no.	**Description**	**2 Wheelers**	**Cars /jeeps**	**Buses**	**Trucks**			**LCV and Mini LCV**
1	Trend Growth of Vehicles	9.04	15.56	3.66	4.16			17.62
2	Growth from regression analysis	9.45	14.95	3.31	3.33			17.21
3	Considered for Revenue/Capacity	9.24	15.26	3.49	3.75			17.42
Sr. no.	**Period**	**2 Wheelers**	**Cars /jeeps**	**Buses**	**Trucks**			**LCV and Mini LCV**
					2 Axle	**3 Axle**	**M Axle**	
1	Up to 2020	10.0	10.0	5.0	5.0	5.0	5.0	10.0
2	2021 -2025	9.0	9.0	5.0	5.0	5.0	5.0	9.0
3	2026 – 2030	8.0	8.0	5.0	5.0	5.0	5.0	8.0
4	2031 – 2035	7.0	7.0	5.0	5.0	5.0	5.0	7.0
5	Beyond 2035	6.0	6.0	5.0	5.0	5.0	5.0	6.0

6.21 Estimation of Corridor Traffic and Projection

Consultant has adopted growth rate as given in Table provided that annual rate of growth of commercial vehicles shall not be less than 5% for traffic projection and pavement design.

Traffic demand projections for the horizon year (2036) on homogeneous sections are shown in **Table** shows the summary of projected traffic volume for homogeneous sections as per adopted realistic growth rates.

Table 59: Summary of Projected Total AADT Traffic PCU Volume/ day

Homogeneous Section	Year 2018	Year 2023	Year 2029	Year 2039	Year 2046
Sudhmahadev - Dranga (Ch.0+000 to km 12+850)	4538	6448	10404	20471	30752

6.22 Capacity Analysis and Level of Services

Capacity analysis is fundamental to the planning, design and operation of roads. It is a valuable tool for evaluation of the investment needed for the future improvements. The capacity figures used for determining the desired carriageway width in differing terrain w.r.t. traffic volume and composition are as per IRC: 64-1990. As per IRC 64:1990, it is recommended that on major arterial routes LOS B should be adopted for the design purpose. On other roads under exceptional circumstances, LOS C could also be adopted for design. For LOS C, Design service volume can be taken as 40 % higher than those for LOS B.

For two lane highway, as per IRC: SP:73-2018 and MoRT&H circular dated 26th May 2016, the traffic at which the upgradation from two lane to four lane will trigger is shown in table.

For four lane highway, as per IRC:SP:84-2014, the project highway shall be widened to six lane when total traffic including the traffic of service road, if any, reaches the design service volume corresponding to Level of Service 'C' of 4-lane highway is also shown in table.

Table 60: Design Service Volume for Different Lane Configurations

Lane Configuration		Terrain	Design Service Volume (PCUs per day)
2-Lane with 2.5 m Paved Shoulder		Plain	10000
		Rolling	8500
2-Lane with 1.5 m Paved Shoulder		Mountainous/Steep	6000
Lane Configuration	**Terrain**	**Design Service Volume (PCUs per day)**	**Design Service Volume (PCUs per day)**
		Level of Service B	***Level of Service C***
4-Lane with 1.5m Paved Shoulder	Plain/Rolling	40000	60000
	Mountainous/Steep	20000	30000

6.23 Lane Requirements

Based on the assessment of the traffic demand on the various homogeneous sections of the Project Highway, the Consultant have carried out detailed option analysis for Two-laning with paved shoulders. Based on the estimated Capacity & Design Service Volume, the number of lanes required for the project road is worked out for LOS B which is presented in Table below.

Table 61: Lanning Requirement for the Project Corridor

Homogeneous Sections	Terrain	2-Lane with Paved Shoulder	4-Lane with Paved Shoulder	4-Lane with Paved Shoulder
		Design Service Volume (PCUs per day)	LOS B	LOS C
Sudhmahadev – Dranga Tunnel (Km 0+000 – Km 12+850)	Mountainous	Up to 2022	Up to 2038	Up to 2045

6.24 Lane Improvement Proposals

Capacity analysis and lanning requirements have been carried out separately for the homogeneous sections as per the traffic demand and travel characteristics. Lane capacity of the Sudhmahadev – Dranga will exhaust for 4 lane in year 2023. It is revealed from the capacity analysis results and considering future growth, the project road requires 4 lanes for capacity augmentation and efficient movement of traffic up to project horizon year 2038 for the above-mentioned Homogeneous sections.

7. COST ESTIMATION

The project cost estimates have been prepared based on various items of works required for the new construction work. The item rate for road works and bridge works have been worked out based on prevailing J&K Schedule of Rates, for Civil works of all Engineering Departments, sanctioned **vide Govt. Order no. 198-PW(R&B) of 2013 dated 13.06.2013 with escalation considered upto year 2019-20** from WPI and MORT&H Standard Data Book for Analysis of Rates.

7.1 Estimation of Quantities and Cost

The quantities of major items of works have been worked out based on inventory and other pavement investigations data. The pavement quantities have been worked out based on the geometrics and cross sections, pavement design done based on traffic and laboratory investigations.

Site Clearance: The area considered for Site Clearance is the area within the proposed Right of Way.

Earth Works: This item provides for roadway excavation, earthwork in embankment, sub-grade and shoulders including disposal of surplus earth and unsuitable material. The earthwork quantities are calculated from MX-Road software. Sub-grade soil having a CBR > 10 % will be taken from borrow areas.

Sub-base and Base Courses: This sub-head provide for the items of Granular sub-base, Wet Mix Macadam for the main carriageway and quantity are calculated via MX-Road software.

Bituminous Works: For flexible pavement, the subhead for bituminous works provides for all items of bituminous courses and estimation of quantities are calculated based on the pavement design and via MX-Road software. Pavement option flexible has been considered for the project road.

Culverts: The estimation of quantities for culverts were based on site inventory and improvement proposal given in the Feasibility Report.

Bridges and structures: The estimation of quantities and cost for bridges has been worked out based on the site inventory, and improvement proposal given in the

Feasibility Report & GADs in Drawing volume.

Junctions Improvement: This item includes quantities of sub-grade, GSB, WMM, DBM, BC kerbs, railings, island etc. at the location of junctions. The cost for junctions includes the cost for at grade junctions, which needs improvement along the project roads.

Traffic Signs and Markings: Proper traffic signs were selected at required locations along the project corridor as per IRC: 67:2012 and IRC: 35:2015. It is reviewed considering the traffic and pedestrian safety and the number of traffic signs shall be minimum and modified if required. Centre line and edge markings required from safety point of view were considered in the quantity estimate.

Drainage and Protection works: Provision under this sub-head has been made for surface and roadside drains and protection work considered at approaches of bridges and structures locations.

Other Charges: Other charges include Centages for the civil works are taken as follow:

- Contingencies @ 2.8% of (b)
- Supervision Consultancy Charges @ 3% of (b)
- Agency Charge @ 3% of (b)
- Escalation @ 5% taken for 2nd, 3rd& 4th year for Pkg.-I and Escalation @ 5% taken for 2nd& 3rd for Pkg.-II during construction payable to Contractor of (C)
- Maintenance During 10 Years @ 0.25% for the First 5 Years, 0.5% for the next 5 Years (on b)
- Environmental Impact Assessment
- R & R Cost
- Land Acquisition

Table 62: Cost of Civil Works

Section	Design Length (km)	Civil Cost (Cr)	Total Project Cost (Cr)
Km 0.000 to km 6.405	6.405	1692.95	2233.08
Km 6.405 to km 12.850	6.445	1108.18	1435.65

Table 63: General Abstract of Cost

General Abstract of Cost for Km 0.000 to Km 6.405						
Sr. No	**Detail**	**Unit**	**No**	**Length in km**	**Rate in Rs.**	**Cost in Rs.**
1	**Road Work**					
	Site Clearance					**422030.69**
(a)	Typical Cross Section Type- 1	Km	1	0.010	34,368,044	343680.44
(b)	Typical Cross Section Type- 2	Km	1	0.029	34,125,056	989626.62
(c)	Typical Cross Section Type- 3	Km	1	0.128	34,125,056	4368007.14
(d)	Typical Cross Section Type- 4	Km	1	0.067	34,597,481	2318031.19
(e)	Typical Cross Section Type- 5	Km	1	0.217	17,082,193	3706835.85
(f)	Typical Cross Section Type- 6	Km	1	0.027	17,068,558	460851.07
(g)	Typical Cross Section Type- 7	Km	1	0.020	35,210,020	704200.40
(h)	Cutting & Filling					478665286.79
(i)	Extra Widening					1124454.72
2	**Culvert**					
(i)	Construction of Culvert					**3452903.78**
Total Road Works Cost						**496555908.67**
3	**Bridges Cum Via Duct**					
(i)	Construction of VUP, Bridges & Viaduct					673367964.99
Total Bridge Works						**673367964.99**
4	**Tunnel**					
(i)	Construction of Tunnel					14973600000.00
Total Tunnel Works						**14973600000.00**
5	**Toll Plaza**					
(i)	Construction of Toll Plaza					83962285.46
Total Toll Plaza Works						**83962285.46**
6	**Other Works**					
(i)	Protection Works including Drain					293910524.63
(ii)	Traffic Signs					9652890.97
(iii)	**Junction**					
a)	Major Junction					397622999.09
(iv)	Miscellaneous					869029.92
Total Other Works						**702055444.61**
Grand Total						**16929541603.73**

General Abstract of Cost for Km 6.405 to Km 12.850						
Sr. No	**Detail**	**Unit**	**No**	**Length in m**	**Rate in Rs.**	**Cost in Rs.**
1	**Road Work**					
	Site Clearance					**759551.476**
(a)	Typical Cross Section Type- 1	Km	1	0.226	34,089,131	7687099.046
(b)	Typical Cross Section Type- 2	Km	1	0.110	33,844,344	3722877.799
(c)	Typical Cross Section Type- 3	Km	1	0.030	34,314,915	1012290.000

General Abstract of Cost for Km 6.405 to Km 12.850						
Sr. No	**Detail**	**Unit**	**No**	**Length in m**	**Rate in Rs.**	**Cost in Rs.**
(d)	Typical Cross Section Type- 4	Km	1	0.047	16,941,638	796256.998
(e)	Typical Cross Section Type- 5	Km	1	0.309	16,928,095	5230781.278
(f)	Typical Cross Section Type- 6	Km	1	0.030	34,936,460	1030625.570
(g)	Typical Cross Section Type- 7	Km	1	0.972	19,320,612	18779634.621
(h)	Typical Cross Section Type- 8	Km	1	0.305	20,033,250	6110161.146
(i)	Typical Cross Section Type- 9	Km	1	0.593	19,479,807	11551525.255
(j)	Typical Cross Section Type-10	Km	1	0.445	19,305,544	8590967.191
(k)	Cutting & Filling					376569224.425
(l)	Extra Widening					2415190.568
2	**Culvert**					
(i)	Construction of Culvert					**15626931.210**
Total Road Works Cost						**459883116.582**
3	**Bridges Cum Via Duct**					
(i)	Construction of Bridges & Viaduct					1776631565.435
Total Bridge Works						**1776631565.435**
4	**Tunnel**					
(i)	Construction of Tunnel					7632900000.000
Total Tunnel Works						**7632900000.000**
5	**Other Works**					
(i)	Protection Works including Drain					1202977030.918
(ii)	Traffic Signs					6052832.690
(iii)	**Junction**					
a)	Minor Junction					2328060.006
(iv)	Miscellaneous					1076235.690
Total Other Works						**1212434159.305**
Grand Total						**11081848841.321**

Table 64: Summary of Cost

Item No.	Description	Package-I Total Amount (Rs. in Cr.)	Package-II Total Amount (Rs. in Cr.)
BILL NO. 1	TUNNEL	1497.36	763.29
BILL NO. 2	SITE CLEARANCE	0.04	0.08
BILL NO. 3	EARTH WORKS	47.88	37.74
BILL NO. 4	SUB-BASES AND BASES COURSES	0.69	3.32
BILL NO. 5	BITUMINOUS COURSES	0.69	3.29
BILL NO. 6	TOLL PLAZA	8.40	-
BILL NO. 7	CROSS DRAINAGE WORKS(Culverts)	0.35	1.56
BILL NO. 8	VUP, BRIDGE &VIADUCT	67.34	177.66
BILL NO. 9	TRAFFIC SIGNS AND MARKINGS	0.97	0.61

Item No.	Description	Package-I Total Amount (Rs. in Cr.)	Package-II Total Amount (Rs. in Cr.)
BILL NO. 9 A	PROTECTION AND DRAINAGE WORK	29.39	120.30
BILL NO. 9 B	MISCELLANEOUS	0.09	0.11
BILL NO. 10	MAJOR/MINOR JUNCTIONS	39.76	0.23
A	***Civil Cost***	***1692.95***	***1108.18***
B	**GST @ 12% Payable on Civil Cost only of (A)**	**203.15**	**132.98**
C	**Sub Total (A+B)**	**1896.11**	**1241.17**
D	Contingencies @ 2.8% of (A)	47.40	31.03
E	Construction Supervision Charges @ 3% of (A)	50.79	33.25
F	Agency Charge @ 3% of (A)	50.79	33.25
G	Escalation @ 5% taken for 2nd, 3rd& 4th year for Pkg.-I and Escalation @ 5% taken for 2nd& 3rd for Pkg.-II during construction payable to Contractor of (C)	116.88	50.42
H	**Total Cost including Centages (C+D+E+F+G)**	**2161.97**	**1389.11**
I	Maintenance During 10 Years @ 0.25% for the First 5 Years, 0.5% for the next 5 Years of (C)	71.10	46.54
J	***Total Project Cost (TPC) (H+I)***	***2233.08***	***1435.65***
K	Land Acquisition, R&R and Cost for forest diversion (NPV & CA)	65.96	44.38
L	Cost of Plantation & Maintenance as per Green Highways policy-2015 @1% of Civil Construction Cost of Road	1.96	3.45
M	Utility Relocation	1.50	1.50
N	Environmental Impact Assessment/ Environmental Management Plan	1.09	1.09
Total Capital Cost (J+K+L+M+N)		**2303.59**	**1486.08**
Grand Total		**3789.67 Cr.**	

8. ENVIROMENTAL ASPECTS

Since it is an expansion and new project, stress on existing natural resource viz, land, water, soil and aggregates are not significant. Further, the project is outside any legally protected, eco-sensitive, or critical habitat areas. Most of the adverse impacts are co-terminus with the construction stage, site specific, limited within the ROW, and are easily mitigated through good engineering and environmentally acceptable practices. Hence, classified as environment Category B in accordance with the MOEF EIA notification 2006 and its amendment/ ADB's Safeguards Policy Statement 2009.

Significant environmental impacts anticipated are:

1) **pre-construction phase:** permanent loss of trees, increase in road crashes from inadequate road alignment and design,
2) **Construction phase:** loss of productive soil for embankment, increased dust, generation of noise, accidents risk and health hazard to construction workers due to poor camp and site management. Inadequate clean-up operation, restoration and rehabilitation prior to decommissioning may cause disturbances to local community. Potential impacts during pre-construction may be minimized through design changes like permanent loss of some trees can be avoided by minor adjustments/eccentric widening and residual impacts are compensated through mandatory compensatory plantation and additional plantation.

During construction phase, adequate guidance and resources are provided by NHIDCL to the Contractor to comply with the borrow area management requirements, suppress dust, control noise, and implement proper closure. NHIDCL, through its Project Implementation Units (PIUs), will ensure the effective implementation of the environmental management plan. To provide regular monitoring information and technical advice to the Project implementation Unit, PIUs a Construction Supervision Consultant (CSC), will be engaged who will be responsible to examine environmental compliances and suggest corrective actions and guide contractors to enhance the environmental performance of the project.

The initial environmental examination ascertains that the project is unlikely to cause any significant environmental impacts. Need of undertaking detailed EIA is not envisaged at

this stage. NHIDCL shall ensure that EMP and EMoP are included in Bill of Quantity (BOQ) and forms part of bid document and civil works contract. The same shall be revised if necessary, during project implementation or if there is any change in the project design and with approval of NHIDCL.

9. ECONOMIC AND FINANCIAL ANALYSIS

Financial Study is carried out for Sudhmahadev-Dranga Tunnel with Approach Road from km 0+000 (from Chenani – Sudhmahadev road section) to Km. 12+850.

This section is of 12+850 km proposed length consist of tunnel (T1) length 5449 m and tunnel (T2) length of 2640 m. The commercial viability is assessed for 20 years concession period by making financial analysis (BOT / Annuity analysis) as given below.

Construction Cost – 2858.835 at 4 Years Concession Period

For above alternatives viability has been assessed for all possible modes i.e. BOT & PPP.

9.1 Approach

The viability of any BOT / Annuity package depends on working cash flows available to service the debt and equity. This working cash flow is basically dependent upon the following:

a) Capital Cost

b) Traffic Forecast

c) User Fee Structure

d) Operation and Maintenance Expenses

e) Interest on Debt

f) Tax

Infrastructure projects are typically capital intensive and are characterized by long payback periods. To look at such projects on a commercial format, it becomes necessary to adopt measures, which significantly improve the financial viability of the project. Such steps include optimizing capital costs and drawing up a user fee structure based on benefit analysis and revenue optimization principles.

In this ultimate analysis, the extent to which such projects raise non-budgetary resources depend on the ability of the project to service investments at commercial terms. Presently, average returns on equity are structured to range from 12% to 13% per annum on an IRR basis. Likewise, debt instruments placed with financial institutions provide an average return of around 9% to 12% per annum. To raise the resources for

such project, it is necessary that the project is expected to give the lucrative returns at healthy debt-equity ratio.

The main objective of Financial Analysis is to examine the viability of implementing the project on a BOT / PPP basis. The analysis attempts to ascertain the extent to which the investment can be recovered through toll revenue and the gap, if any, be funded through Grant / Subsidy. This covers aspects like financing through debt and equity, loan repayment, debt servicing, taxation, depreciation, Annuity etc. The viability of the project is evaluated on the basis of Project FIRR (Financial Internal Rate of Return on total investment). The FIRR is estimated on the basis of cash flow analysis, where both costs and revenue have been indexed to take account of inflation. Financial analysis has been carried out for debt equity ratio of 60:40.

9.2 Capital Cost

The construction is expected to be executed completely in 48 months; year-wise progress will be 20% in first year, 30% in Second year, 30% in Third year and 20% in fourth year.

A. Base Cost

The civil construction cost for the project road is considered as base cost. The construction is expected to be executed completely in 48 months; year-wise progress will be 20% in first year, 30% in Second year, 30% in Third year and 20% in fourth year. Total Project cost showing these additional provisions are tabulated below:

Table 65: Phasing of Cost

Section	Proposed Length(km)	Base Cost (Rs.)	Phasing of Cost
I	12.850 including tunnel length of about 8.089 km	2801.13	20% In First Year, 30% in Second Year, 30% in Third Year and 20% In Fourth Year

B. Cost Escalation

The project cost estimates have been prepared based on various items of works required for the new construction work. The item rate for road works and bridge works have been worked out based on prevailing J&K Schedule of Rates, for Civil works of all Engineering Departments, sanctioned **vide Govt. Order no. 198-PW(R&B) of 2013 dated**

13.06.2013 with escalation considered upto year 2019-20 from WPI and MORT&H Standard Data Book for Analysis of Rates.

C. Landed Project Cost

In base construction cost, provision for physical contingency (2.8% of the base construction cost) has been made to arrive at the Engineering procurement cost (EPC). In addition to the above, a provision of 12% GST and other centages charges as per MORTH circular no. RW/NH-24036/27/2010-PPP dated 10.08.2016 and Escalation charges as WPI on total cost have been made to get the project cost.

Table 66: This Financial Implication Increases the TPC of Civil Construction Cost

Sr. No.	Item of Works	Cost (cr.)
A	Civil Works	2801.13
	Civil Construction Cost (A)	2801.13
B	Financial Cost (B)	988.54
Project Cost with LA & utility (A + B)		**3789.677**

9.3 Operation and Maintenance Costs

Operation and maintenance cost have been considered as per new EPC agreement.

9.4 Project Revenue

Infrastructure project like Highways are generally having two types of revenue generation.

- Toll Revenue
- Advertisement Revenue

A. Toll Revenue

1. Basic Toll Rates

In assessing the financial viability of a user fee model road project, the willingness of people to pay user fees is a key issue. The standard approach to this issue is to estimate the generalized or perceived cost of trip making. To standardize the toll structure MORT&H has recommended that basic rate per km for National Highways are adopted for analysis purpose.

Table 67: Official Toll Rates April 2007-08

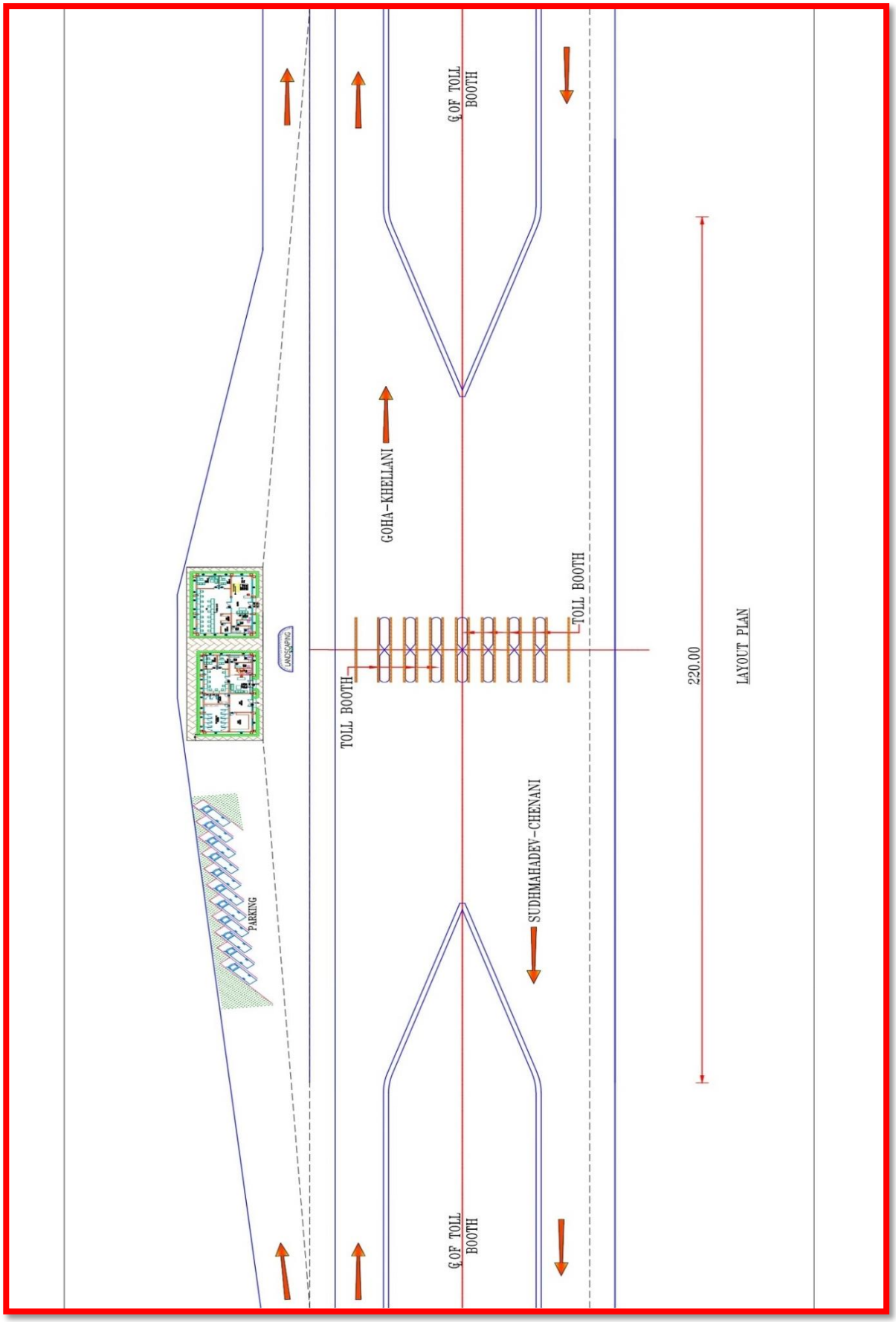
Vehicle Type	Two lane Carriageways (Base Fee Rate) per km
Car	0.39
Mini Bus/LCV	0.63
Bus/ 2 axle	1.32
3 - Axle / MAV	2.07
Oversize Vehicle	2.52

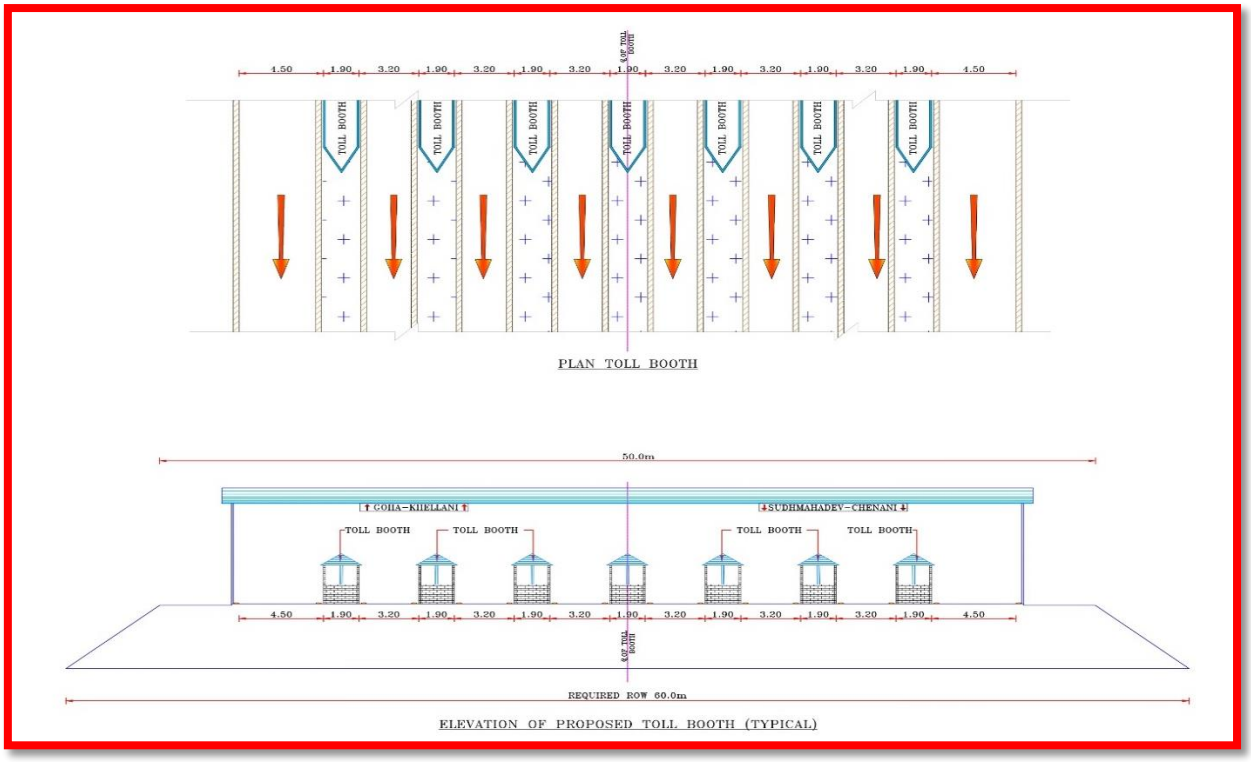
The base rates given in **Table** shall be increased without compounding by three percent each year and such increased rate shall be deemed to be the base rate for next year. Such applicable base rate shall be revised annually to reflect the increase in wholesale price index; but restricted to forty percent of the increase in wholesale price index.

The toll rates are allowed with 3% inflation at every year interval and shall be rounded off to nearest 5 rupees. User fees are revised once in every two years.

2. Location of Toll Plazas

Toll Plaza of length 220 mt is proposed at Km 6+300.


G.OF TOLL BOOTH
GOHA-KHELLANI
TOLL BOOTH
TOLL BOOTH
220.00
LAYOUT PLAN
SUDHMAHADEV-CHENANI
PARKING
G.OF TOLL BOOTH



3. Traffic Assumptions and Forecast

Light vehicles especially Two/Three wheelers and slow-moving vehicles are exempted from user fee as per guidelines for toll roads. Tollable traffic has been assessed leaving slow moving and light vehicles except light commercial vehicles, car, mini buses, trucks and Tractor with trailers.

To workout tollable traffic for toll plaza continuous traffic volume count survey has been carried out at 1 location for seven days. To calculate future traffic growth rate as per traffic growth criteria has been applied to base year tollable traffic.

4. Concession Period

The guiding principle for determining project specific concession period is the carrying capacity of the respective highway at the end of the proposed concession period. As such, the concession period is proposed based on volume of present and projected traffic. In other ways concession period ends in the year when capacity of respective highway exhaust to cater project traffic volume.

Table provided below shows existing traffic and the year when traffic exceeds the capacity of the highway, calculated for **"DESIGN SERVICE VOLUME and LEVEL OF**

SERVICE B (LOS B) and warrants capacity augmentation.

Table 68: Lane Capacity and Augmentation Required for the Project Corridor

Homogeneous Sections	Terrain	2-Lane with Paved Shoulder	4-Lane with Paved Shoulder	4-Lane with Paved Shoulder
		Design Service Volume (PCUs per day)	LOS B	LOS C
Sudhmahadev – Dranga Tunnel (Km 0+000 – Km 12+850)	Mountainous	Up to 2022	Up to 2038	Up to 2045

B. Advertisement Revenue

The advertisement has been not recommended on the project road due to safety concern to the road users. So, revenue generation from the advertisement is not taken into consideration for this project.

9.5 Financial Model Input and Analysis

A. Grant and Its Treatment

It shall be equal to the sum specified in the bid and as accepted by the authority but in no case greater than the equity and shall be further restricted to a sum not exceeding 40% of TPC i.e. maximum 40% of TPC (Total Project Cost). It shall be due and payable to the Concessionaire as per PPP guidelines. Further it shall be disbursed proportionately along with the loan funds. For analysis, VGF of 40% have been adopted to ensure minimum 12% IRR.

B. Proposed Sources of Finance

In general, the developer shall crystallize the sources of finance by optimizing his equity returns keeping in view the project cash flows, terms, and conditions of various financing options available. Further the market standing, and financial strength of the Developer would largely determine the terms and conditions of finance offered to the Developer by various lending agencies. For the study, following sources of finance have been taken:

- Equity: To be provided by the Developer
- Subsidy / Grant for viability of funding, to be provided by the client.

- Debt: To be arranged by the Developer / Concessionaire

C. Expenses

Expenses can broadly be classified based on the phases in which they are incurred, viz. construction period expenses and operation & maintenance period expenses.

D. Construction Period Expenses

- Preliminary and pre-operative expenses
- Contingency allowance
- Interest during construction period
- Finance Charges

E. Operation and Maintenance Period Expenses

- Toll collection expenses
- Administrative expenses for day-to-day operation including insurances
- Maintenance expenses, which include routine and periodic maintenance
- Interest expenses incurred for servicing term loans
- Tax

F. Financial Viability

To assess whether the project is a profitable proposition, the returns to investors are measured by the post-tax project FIRR and the equity FIRR, which is estimated from the cash-flow statements, based on discounted cash-flow technique. The returns expected by the investors are a function of the value of equity issues on the Indian stock Markets, Interest rates on commercial loans, the risk profile of the investment and alternative investment opportunities. To qualify the project in terms of attractive financial returns, the following criteria are adopted:

- Post tax IRR on Project Investment : minimum 12%
- Post tax IRR on Equity : minimum 12%
- DSCR : >1.0

- BCR : >1.3
- NPV @ 12% : must be positive

9.6 Recommendation & Conclusion on Type of Financing

Project road section is financially not viable based on the forecasted traffic and MORT&H user fee with 40% government subsidy and maximum concession period of 30 years.

Therefore, EPC contract option is being proposed for the entire project section with single package.

9.7 Economic Analysis

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. It is therefore important that decisions about investments in roads are made on objective judgments and therefore, Economic appraisal has been carried out for each traffic homogenous section of entire Project road.

The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the project is worthy of investment keeping in view the benefits to the society.

The Proposal for project road i.e. Sudhmahadev-Dranga tunnel with approach road section is new road alignment of length 12.850 km including two tunnel of combined length 8089 m. The proposed tunnel is Uni-directional twin tube tunnel. In order to assess the benefits accrued to the society; both the options of 'Existing' and 'Proposed' must be compared, if there any. For this purpose, the entire Road has been considered along with its proposed, maintenance and improvement proposals.

A. Economic Analysis Approach

The economic evaluation has been carried out within the broad framework of social cost benefit analysis. The objective is to determine the best improvement scheme out of several proposals, which will lead to minimizing total transport costs and maximizing benefits to the road users.

The benefits accruing to society from the proposed improvement are mainly reduced vehicle operating cost, reduced travel time cost and reduced accident costs. Total

transport costs comprise of two basic components as shown in **Table.**

Table 69: Total Transport Costs

Road Supplier Costs	Road User Costs
Construction Costs	Vehicle Operating Costs (VOC) both MT & NMT
Maintenance Costs	Travel Time Costs
Replacement Costs: Costs of Environmental Impact Mitigation Measures, Costs of Rehabilitation and Resettlement (R&R) measures	

These costs are generated using HDM – IV for every year of the analysis period (cost-benefit stream) from which economic indicator parameters that essential for viability of project namely Net Present Value (NPV), Economic Rate of Return (EIRR) and Benefit Cost Ratio (B/C) are the final economic outputs.

NPV is the present value of Net Benefits (NB) during the project period. EIRR is the discount rate at which the NPV of the Net Benefit (NB) is zero. Net Benefit is the cumulative sum of the difference between yearly benefit and yearly costs incurred after discounting.

$$NB = \sum_{n=1}^{M} (Benefit(n) - Cost(n))$$

Savings from vehicle emission reduction and less energy consumption due to improved facility are also important economic savings which are possible to calculate but these quantities are not converted to economic cost inside the software. So these benefits are not included.

The appraisal period (including the construction period) has been taken as 30 years after which a residual value of investment is assumed as 10%.

9.8 Project Economic Evaluation using HDM - 4

Economic evaluation for Sudhmahadev - Dranga road section is carried out by consideration of two alternatives In HDM – 4.

A. Alternative 1: Existing

For without project consideration, project road will carry existing traffic on it without any improvement and maintenance in present condition. But here at present scenario

there is no connecting road and the alignment is totally newly proposed.

B. Alternative 2: Proposed

For with project consideration, Project road is newly constructed with Uni-directional twin tube tunnel with approached consist of divided four lane and undivided two lane. In this alternative, project road improvements are made by proposing totally new alignment with tunnel, road, viaducts, bridges and cross drainage structures.

9.9 Project Cost and Scheduling

Project road is proposed to undertake new construction. Accordingly, economic analysis of the project road is being carried out as follows:

Table 70: Section Details

Homogeneous Section	Existing Chainage (Km)		Improvement
	From	To	
Sudhmahadev-Dranga Tunnel	0+000	12+850	Uni-directional twin tube tunnel with approach road of divided four-lane carriageway and undivided two-lane carriageway with paved shoulder

The Economic analysis was carried out for 30-year benefit period (2023-2053). For performing economic evaluation, a 'project' is formulated in which comparison is made proposed.

9.10 Capital Cost

Project Civil cost is **Rs. 2801.13** Crore for project road. For economic evaluation base costs have been taken as factor cost of civil works and other cost related to land acquisition social environmental and utility relocations that mean Capital cost is the total construction cost of civil works for the project improvement. The construction cost for each homogeneous section is tabulated in **Table** for the year 2019 at which Project will start to implement. Therefore, the project cost of present year is increased with 5 % inflation rate for two successive years. The construction cost of project will be utilized in four phases i.e. 20 % in first year and 30 % in second year, 30% in third year and 20% in fourth year as construction period of 4 years. The cost estimate for each section has been calculated separately based on the quantities worked out for major items of work to be

executed in the project on the basis of preliminary engineering design of roads, structures and the adopted rates. A conversion factor of 0.90 has been used to convert financial cost into economic costs.

The economic cost for each package is as under:

Table 71: Project Cost

Homogeneous Section	Civil Cost	Financial Cost	Economical Cost
Sudhmahadev-Dranga Tunnel	2801.13	988.546	861.993

9.11 Maintenance Cost

For Two lanes with Paved shoulder road

Routine maintenance cost - 0.25% & 0.5 % of Civil cost per year

Periodic maintenance cost - 0.25% of Civil cost per year Routine

9.12 Project Benefits

Project Benefits mainly occurs due to Reduction in Vehicle operating cost and travel time savings. The vehicle operating cost (VOC) components are

- Fuel
- Lubricants
- Tyres
- Spare Parts
- Maintenance Labour
- Wages of Crew
- Fixed costs including overheads, administration, interest on borrowed capital
- Depreciations
- Travel time cost

10. VEHICLE FLEET

10.1 Fleet Utilization

Fleet utilization data adopted for the analysis is based on the findings of Road User Cost study in 2001, IRC SP: 30-2009. The adopted values are summarized as shown in table below.

Table 72: Life Norms for Vehicles

Particulars	Km Driven	Life, Year	Working Hour	Passenger
2 Axle Truck	90000	12	1950	-
Multi Axle Truck	75000	12	2100	-
3 Axle Truck	75000	12	2100	-
LCV	45500	10	1050	-
Bus/Mini Bus	125000	10	2400	45
Car / Jeep / Van	87500	10	1750	5
Two-Wheeler	28800	10	636	1.5

10.2 Vehicle Resources

A. Vehicle and Tyre Cost

Economic costs of vehicle and Tyre are derived from the market survey in J&K. Ex-show room price for each category of vehicle have been collected and elements of taxes, duties, freight, dealer's margin and incentives as applicable have been removed to arrive at the economic costs. The adopted economic costs are summarized as presented in table below.

Table 73: Prices of Vehicles

Category	Vehicle (Rs.)	Tyre (Rs.)
2 Axle Truck	900000	7075
3 Axle and Multi Axle Truck	1000000	7075
LCV	500000	3500
Bus	850000	7500
Car / Jeep / Van	450000	2250
Two-Wheeler	41000	750

B. Fuel & Lubricant

Economic Prices fuel and lubricant are arrived based on ratio of WPI for all commodities of August 2010 with respected to March 2009 and applying that ratio to search out actual value.

Table 74: Economic Cost of Fuel & Lubricants

Item	Price/ litre as per SP 30:2009	WPI Ratio	Present Cost/ litre
Petrol	18.55	1.156	21.44
Diesel	18.20	1.156	21.04
Lubricants	56.70	1.156	65.55

C. Maintenance Labour and Crew Wages

Adopted values for Maintenance Labour and Crew Wages are based on the enquiries made by the Consultant with transport operators and workshops in and around the project Road. The adopted values are summarized vide in table below.

Table 75: Labour and Crew Wages (Cost in Rs. per hour)

Category	Maint. Labour	Crew Wage
Truck	100	75
3 Axle and Multi Axle Truck	100	90
LCV	100	45
Bus	125	115
Car / Jeep / Van	60	25
Two-Wheeler	40	-

D. Annual Overhead

Recommendations of the "Study for Updating Road User Cost Data: 2001"and IRC SP: 30-2009 are considered to arrive at annual overhead cost per vehicle and are summarized in table below:

Table 76: Annual Overheads

Category	Annual Overhead Cost (Rs.)
2 Axle Truck	192500
3 Axle and Multi Axle Truck	258000
LCV	128000
Bus	155000
Car / Jeep / Van	80000
Two-Wheeler	6624

E. Annual Interest

An Economic Interest Rate of 12% has been adopted for the analysis.

F. Time Value of Passengers

Time Value of Passenger (Work Trips and Non-Work Trips) is arrived based on "Manual

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

Table 77: Time Value of Passengers

Mode of Travel	Unit	2-Wheeler	Car/ Taxi	Bus
Travel time Value RUCS-March 2009	Rs/Hour	62.5	32.0	39.5
WPI Ratio 2010/ 2009	-	1.156	1.156	1.156
Travel time Value RUCS-august2010	Rs/Hour	31.0	61.0	39.0
Eq. Non-work Time Value in 2010	Rs. /Hour	5.5	10.8	6.8

G. Time Value of Cargo

Average value of commodity is based on "Manual of Economic evaluation of Highway Projects in India (" IRC SP: 30 - 2009)". Equivalent cost of commodity in 2010-2011 is determined using the WPI ratio (1.156 over 2009). Average payload for each category of freight vehicles is based on axle load survey. Time-delay cost is estimated with an economic interest rate of 12% and economic conversion factor of 0.90 and provided in table below:

Table 78: Time Value of Cargo

Vehicle Category	Average Payload (Tonnes)	Average Running Time (hour/Year)	Time-delay Cost (RS. /Hr.)
2Axle Truck	15	1950	32.00
3 Axle and Multi Axle Truck	17	2100	55.00
LCV	8.25	1050	19.0

10.3 HDM Traffic

Following category of fast moving and slow-moving vehicles are considered for carrying out HDM 4 Analysis.

- 2 Axle Truck
- 3 Axle Truck
- Multi Axle Truck
- LCV

- Bus
- Mini Bus
- Car / Jeep / Van
- Two-Wheeler

As HDM-4 does not include 3-Wheeler and Agricultural Tractor Categories of Vehicle therefore these categories are not considered in the analysis. Percentage compositions of assigned traffic in AADT on the project road as on year 2018 and adopted for the analysis for the Project road are summarized as given in table below.

Table 79: Composition of Motorized Traffic assigned on Project road (%)

Section	2-Wheeler + 3-Wheeler	Passenger Car /Jeep	Bus	LCV	2-Axle	3-Axle and Multi Axle	Tractor	AADT (PCU No.)
01	914	743	114	370	358	344	104	4538

Table 80: Traffic growth Rate of Motorized Traffic assigned on Project road (MT) (%)

Description	2 Wheelers	Cars/ jeeps	Buses	Trucks	LCV and Mini LCV
Trend Growth of Vehicles	9.04	15.56	3.66	4.16	17.62
Growth from regression analysis	9.45	14.95	3.31	3.33	17.21
Considered for Revenue/Capacity	9.24	15.26	3.49	3.75	17.42

Period	2 Wheelers	Cars/jeeps	Buses	Trucks			LCV and Mini LCV
				2 Axle	3 Axle	M Axle	
Up to 2020	10.0	10.0	5.0	5.0	5.0	5.0	10.0
2021 -2025	9.0	9.0	5.0	5.0	5.0	5.0	9.0
2026 – 2030	8.0	8.0	5.0	5.0	5.0	5.0	8.0
2031 – 2035	7.0	7.0	5.0	5.0	5.0	5.0	7.0
Beyond 2035	6.0	6.0	5.0	5.0	5.0	5.0	6.0

10.4 Economics Internal Rate of Return

Economic Analysis has been carried out for construction option discussed above. Variables considered in for economic analysis of the project are volatile and depend on various factors. In general, in case of economic analysis is also recommended that analysis period should not be long as it may lead to erroneous results.

However, in order to be able to draw the conclusions on common platform Economic Analysis have also been carried out for 30 years of analysis period. The summary of Economic internal rate of return (EIRR) worked out, for construction option based on life cycle cost analysis is presented below.

Economic Analysis was carried out following the methodology and input data discussed in the preceding paragraphs of this chapter using HDM-4 software.

The EIRR and NPV at 12% discount rate for the construction package as worked out with and without benefits due to travel time savings.

Table 81: Results of Economic Analysis

Homogeneous Sections	Option	Net Economic Benefit (NPV @ 12%)	Economic Internal Rate of Return (12 %)
Sudhmahadev-Dranga Tunnel	With time saving	(1042.64)	(-1.08%)

10.5 Conclusion

The proposed road is required as alternate route in future from Chenani to Srinagar via Sudhmahadev, Goha, Khellani, Kishtwar, Vailoo and Khanabal. The project road is not viable on the basis of PPP or BOT mode of construction; Hence the project road is being proposed on EPC mode of construction.

Annexure 1: Projected Traffic

PCU Factor	0.5	1	1.5	3	1.5	3	3	4.5	4.5	1.5	Total Fast Moving Vehicles	Total All Vehicles (Nos.)	Total All Vehicles (PCU)
Year	Fast Moving Vehicles												
	2-Wheeler	Passenger Car	Mini Bus	Standard Bus	LCV 4 Tyre	2-Axle	3-Axle	Multi Axle	Agricultural Tractor with Trailor	Agricultural Tractor Without Trailor			
2019	914	743	57	57	370	358	308	36	70	34	2947	2947	4538
2020	1005	817	60	60	407	394	339	38	74	36	3229	3229	4952
2021	1106	899	63	63	448	433	373	40	77	37	3539	3539	5406
2022	1217	989	66	66	492	476	410	42	81	39	3878	3878	5903
2023	1338	1088	69	69	542	524	451	44	85	41	4252	4252	6448
2024	1459	1186	73	73	590	571	492	46	89	43	4622	4622	6991
2025	1590	1292	76	76	644	623	536	48	94	46	5025	5025	7580
2026	1733	1409	80	80	702	679	584	51	98	48	5463	5463	8220
2027	1889	1536	84	84	765	740	637	53	103	50	5941	5941	8915
2028	2059	1674	88	88	833	799	687	56	109	53	6447	6447	9630
2029	2244	1824	93	93	909	863	742	59	114	55	6996	6996	10404
2030	2424	1970	97	97	981	932	802	62	120	58	7544	7544	11197
2031	2618	2128	102	102	1060	1007	866	65	126	61	8134	8134	12053
2032	2827	2298	107	107	1144	1087	935	68	132	64	8771	8771	12975
2033	3053	2482	113	113	1236	1163	1001	71	139	67	9438	9438	13908
2034	3298	2681	118	118	1335	1245	1071	75	146	71	10157	10157	14909
2035	3528	2868	124	124	1428	1332	1146	79	153	74	10857	10857	15920
2036	3775	3069	131	131	1528	1425	1226	83	160	78	11606	11606	17000
2037	4040	3284	137	137	1635	1525	1312	87	168	82	12407	12407	18154
2038	4322	3514	144	144	1733	1616	1390	91	177	86	13218	13218	19278
2039	4625	3760	151	151	1837	1713	1474	96	186	90	14083	14083	20471
2040	4903	3985	159	159	1948	1816	1562	100	195	95	14922	14922	21679