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राष्ट्रीय राजमार्ग एवं अवसंरचना विकास निगम लिमिटेड

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

GEOLOGICAL AND GEOTECHINCIAL SUMMARY REPORT

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

KM - 83RD TUNNEL

MAY 2020

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IN ASSOCIATION WITH

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1 INTRODUCTION

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 engaged M/s Rodic Consultants Private Limited in Joint Venture with Getinsa-Eurostudios, as consultants to carry out Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of Chainage-83 from Doda Kishtiwar Highway Road portion in the State of Jammu and Kashmir.

2 GEOMORPHOLOGY AND GEOLOGY

2.1 Physiography and Geomorphology

Jammu and Kashmir State is a mountainous state in north-western Himalaya, except for about five kilometers wide stretch of Terai zone south of Siwalik foot hills and adjoining Indo-Gangetic alluvial plain.

Himalaya, north of Terai region has been classified into four WNW-ESE to NW-SE trending zones parallel to each other, viz.

1. Outer Himalayan Zone or Siwalik Foot Hills;
2. Lesser Himalayan Zone;
3. Great Himalaya; and,
4. Trans-Himalayan Zone differing from one another in well-marked orographical and other geomorphic features.

The Terai zone in the plain adjoining the foot hills have its general slope towards south-west and is dissected by the tributaries of Chenab and Ravi rivers. The flood plains and the associated features (channel bars) of Chenab and Ravi rivers and those of their major tributaries, alluvial lowland, alluvial upland and piedmont alluvial plain are the main geomorphic units in the zone.

2.2 Regional Geology

The stratigraphic succession within the area is given below (Raina & Aalok, 1968-69, GSI) and regional geological map of Jammu & Kashmir is given in **Figure 1**.

The project area comprising gneisses, kyanite bearing garnetiferous mica schists, phyllitic schists, phyllites and slates are the dominant rock types.

Generalized Geological Succession around project area

Formation	Lithological Description	Age
	Alluvium	Recent
	Pegmatite and quartz veins	
	Panjal trap	Permo-Carboniferous
Salkhala Formation	Slate with Agglomeratic slate	Precambrian
	Low grade schist and phyllite	
	Kyanite bearing garnetiferous mica-schists interbedd with paragneiss	
	Gneiss/Granitic Gneiss	

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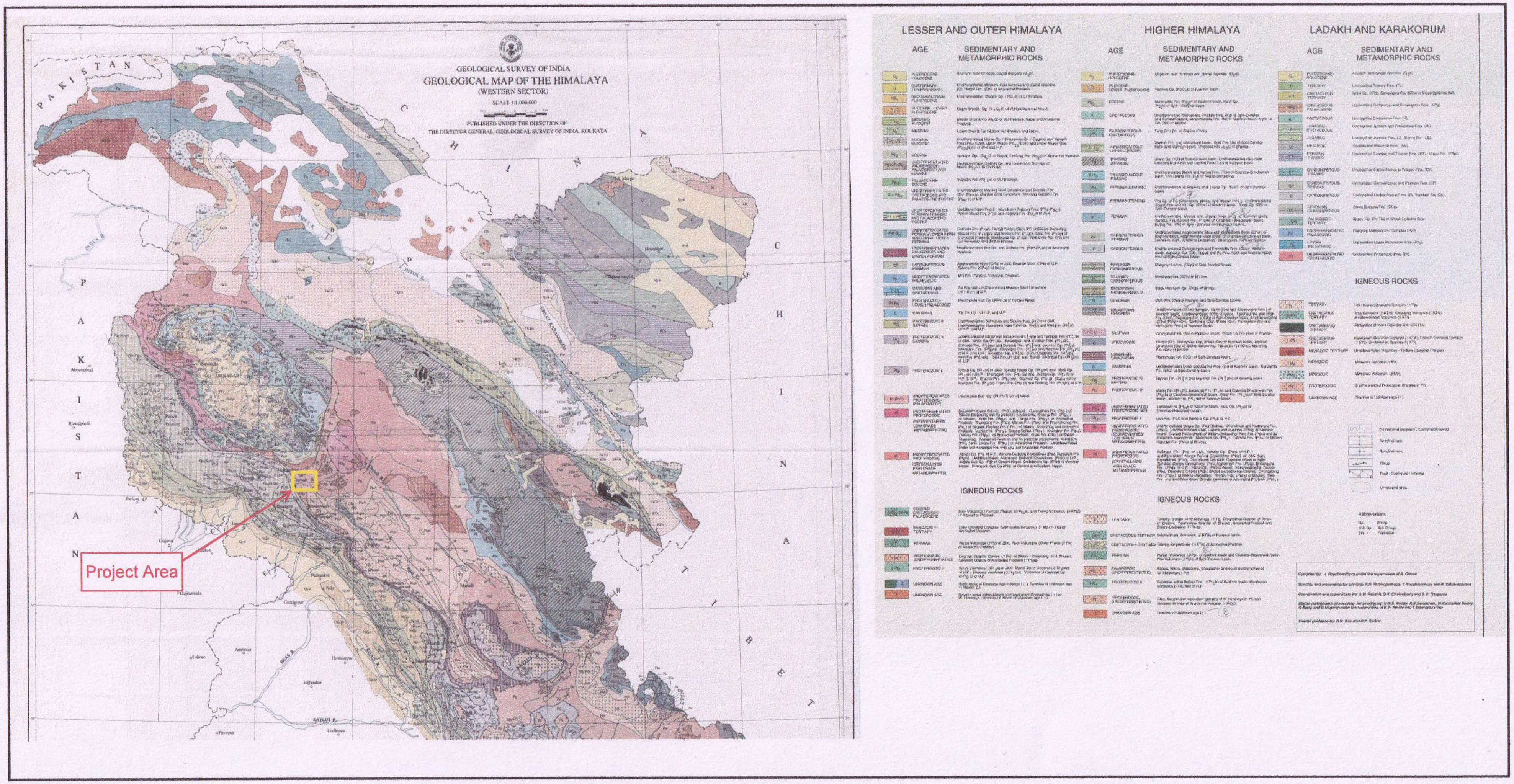

Figure 1: Regional Geological Map of Jammu & Kashmir (GSI,1991-92)

The grade of metamorpgism decreases from north to south from gneisses and schists to low grade phyllites and slates. As the grade of metamorphism decreases, so does the size of garnets, though it is found to persist to some extent even in the slates.

2.3 Seismicity

The project area lies in a seismically active region affected by several earthquakes of varying magnitude. With respect to large magnitude earthquakes, it lies between iso-seismals I and II of the M=7.0 Kashmir Earthquake of 30th May 1885 with the epicenter at Jampur, 19.5 km west of Srinagar. More recently, the project area was affected by the M=7.6 Muzaffarabad Earthquake of 8th October 2005 and it fell between iso-seismals VI and VII. With respect to other important earthquakes in the region, the project area lies close to the iso-seismal VII of 21st November 1939 Great Pamir Earthquake (M=6.9) and iso-seismal VI-VII of the 14th May 1937 Hindukush Earthquake (M=7.2).

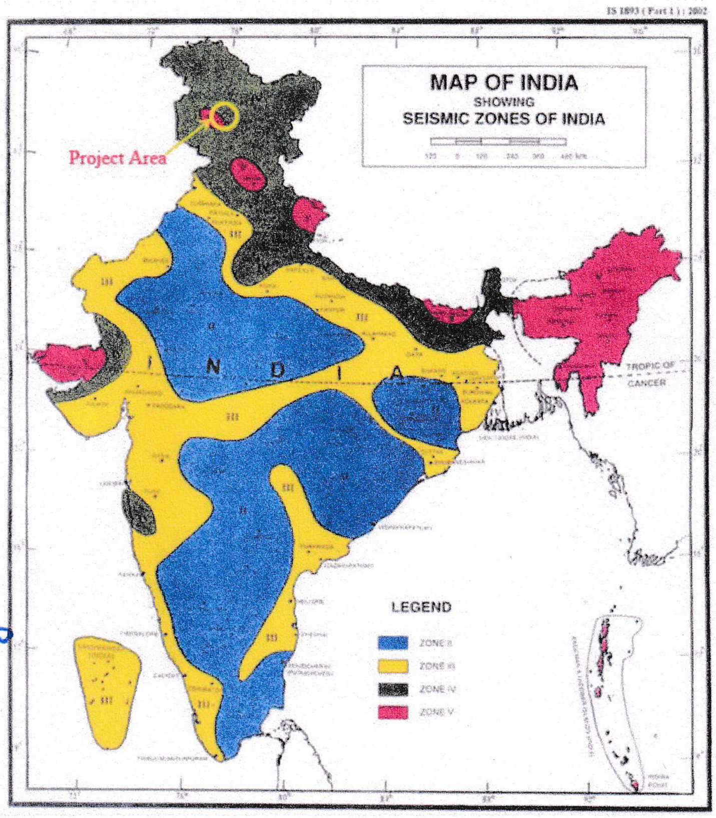

Figure 2: Seismic zoning map of India

As per Seismic Zoning Map of India, [IS: 1893 (Part – I) 2002], the project area lies in the Seismic Zone-IV **(Figure 2).**

An appropriate seismic coefficient based on seismicity as discussed in preceding paragraphs is proposed to be considered for designing the project components.

2.4 Geomorphology of Project Area

The topography of the area forming the southerly slopes of the NW-SE trending Pir Panjal range, is extremely rugged and is characterized by high peaks and deep ravines.

The elevation above mean-sea-level ranges from as low as 900m near the confluence of Kal Nai with Chenab at Thatri to as much as 4,700m in the locality south of Dharat Pass (4,576). The Panjal range forms the water-shed of Chenab and Kal nai and Kagune Gad. There are a number of peaks having altitudes exceeding 4,000m and they are snow-clad throughout the year. The Dudher, Dharat and Gointrer Nalas form the major drainage in the eastern part of the area. These *nalas* merge to form, the westerly flowing Kal Nai stream which join the Chenab near Thatri. The Bahallesh area is drained by the northerly flowing Kagune Gad. Which joins the Kal Nai near Donalli. The major tribularies of Kagune Gad are Jai Gad, Champal-da-Nal and Ludu Nal. Both Kal Nai and Kagune Gad are fed by numerous *nalas* which often cut deep gorges that are difficult to negotiate. Springs are not uncommon in the area and they form a source of drinking water.

Climate: The climate of the area on the whole is temperate, though the low lying parts experience severe summers. The precipitation is in the form of snow and rain. The snowfall is generally confined to the months between December and March. The monsoon commences here in late June and continue upto early September.

2.5 Geology of Project Area

In this valley, the project area around tunnel alignment, mica schist with intercalation of quartz veins and quartz pophyries and schistose gneiss/ biotite gneiss of Salkhala Formation of Precambrian age (Raina & Aalok, 1968-69, GSI). These are best exposed along the main highway and connecting road to main highway. Exposed rock is observed all along the tunnel alignment.

3 FIELD INVESTIGATIONS & LABORATORY TESTS

The field investigation carried out at different sites of tunnel include detailed surface geological mapping on different scales. Laboratory tests of rock samples include density, Uniaxial Compressive Strength with Modulus of Elasticity & Poisson's Ratio, Brazilian tensile strength and Triaxial shear strength. Petrography of rock sample from the project site is also done.

3.1 Surface Geological Mapping

The project area has a very rugged topography characterized by sharp crested ridges and narrow valleys. The altitude varies between 930m to about 1660m and most of the area is exposed by in-situ rock. In general, the project area has a hostile terrain. In spite of all these adverse conditions, geological mapping was carried. Traverse was taken along tunnel alignment and cut & cover area. Mapping of engineering properties of joints and other structures were done. All the rock types along with their disposition were recorded for further analysis. The detailed geological mapping of the highway tunnel and both tunnel portals was carried out on 1:1000 scale.

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3.2 Laboratory Test of Rock Samples

Rock samples were collected from project site and tested in laboratory to determine the physico-mechanical properties. The summarized Laboratory Test Results are given below:

A. Density as per IS 13030:1991

Sample ID	Rock Type	Saturated Density (g/cc)	Dry Density (g/cc)
01. CH-83 Tunnel	Mica Schist	2.69	2.65
01. CH-83 Tunnel	Mica Schist	2.71	2.68
02. CH-83 Tunnel	Schistose Gneiss	2.75	2.71

B. Unconfined Compressive Strength (UCS)

The UCS of different rock types in the project area are determined in laboratory. Subsequently, the mean and mode values are calculated and given below.

Mode and Mean Values of Unconfined Compressive Strength

	Unconfined Compressive Strength (Mpa)	
Rock Type	Mica Schist	Schistose Gneiss
Mode	31.57	59.43
Mean	30.17	56.9

C. Tensile Strength

The Tensile Strength of different rock types in the project area are determined in laboratory. Subsequently, the mean and mode values are calculated and given below.

Mode and Mean Values of Tensile Strength

	Tensile Strength (Mpa)	
Rock Type	Mica Schist	Schistose Gneiss
Mode	4.98	6.73
Mean	4.66	6.21

D. Modulus of Elasticity

The modulus of elasticity (Young's modulus) of different rock types in the project area is determined in laboratory. Subsequently, the mean and mode values are calculated and given below.

Mode and Mean Values of Modulus of Elasticity

	Modulus of Elasticity (Gpa)	
Rock Type	Mica Schist	Schistose Gneiss
Mode	27.21	39.47
Mean	26.37	37.12

E. Poisson's Ratio

The Poisson's Ration of different rock types in the project area is determined in laboratory. Subsequently, the mean and mode values are calculated and given below.

Mode and Mean Values of Poisson's Ratio

	Poisson's Ratio	
Rock Type	Mica Schist	Schistose Gneiss
Mode	0.26	0.24
Mean	0.25	0.235

F. Triaxial Shear Strength (Natural Condition)

The Triaxial Shear Strenght of different rock types in the project area is determined in laboratory. Avereage values are given below.

Triaxial Shear Strength of different rocks

Rock Type	Triaxial Shear Strength	
	Mica Schist	**Schistose Gneiss**
C (Mpa)	1.71	3.91
Ø (°)	36.73	42.84

4 GEOTECHNICAL APPRAISAL OF PROJECT COMPONENTS

The nothern portal of the tunnel is located on the way of Chamoti village from main existing highway NH-1B. Exposed bedrock is observed along entire portal and tunnel alignment **(Photo 1)**. The southern portal is located on existing highway NH-1B (Doda-Kistwar road) i.e left bank of Chenab river. Thinly foliated mica schist **(Photo 3)** and schistose gneiss with intercalation of quartz veins **(Photo 4)** is observed in and around southern portal **(Photo 2)**. Exposed bedrock is observed all along the hill slope during detailed surface geological mapping. At some places surficial overburden is also observed. Slope around the portal is moderately steep to steep.

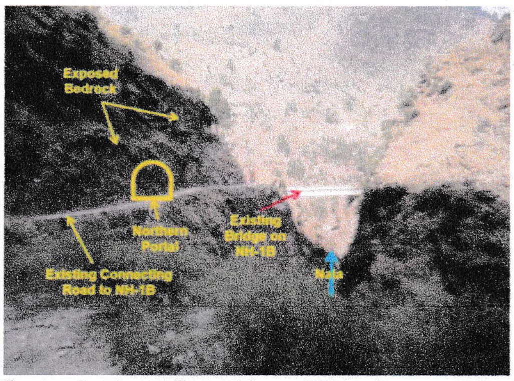

Photo 1: Broader view of Northern portal area

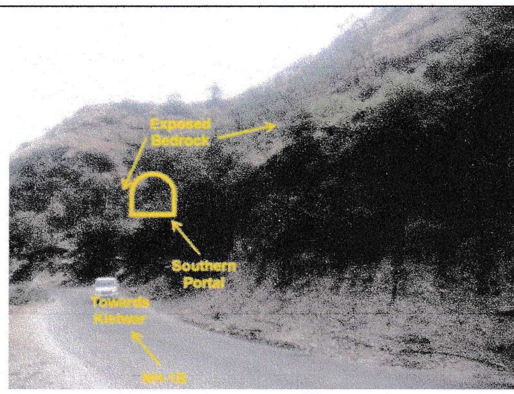

Photo 2: Broader view of Southern Portal area

Photo 3: Mica schist with intrusion of quartz veins

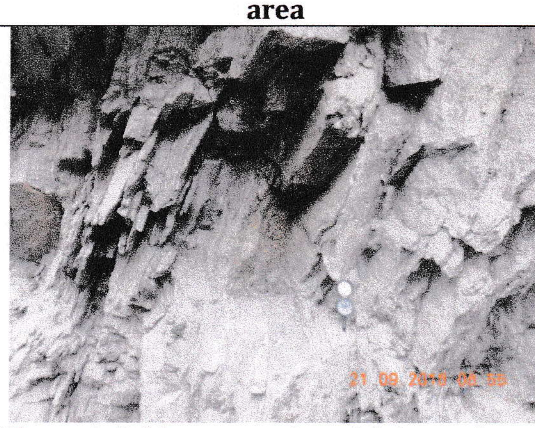

Photo 4: Schistose gneiss with intrusion of quartz veins

4.1 Analysis of Discontinuity Data

The discontinuity data collected during the time of detailed geological mapping from rock outcrops has been analyzed with the help of "DIPS" software.

The rock is traversed by three sets of joints including foliation (310°/60°) with few random joints. Foliation is the most prominent discontinuity. Inter-folial shears and shear seams of thickness 1-5cm along joint set J1 and J2 have been observed during detailed surface geological mapping. The details of the joint sets are given below.

Details of Discontinuities along Tunnel alignment

Set	Strike	Dip Amount	Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Roughness	Alteration	Filling
J1*	040°-220°	60°	310°	>20	Closely to widely spaced	Tight-Partly open	SU*/SL U*	Slight on surface	NIL to clay
J2	025°-205°	30°	115°	03-20	10-50	Tight to 5.0	RU*/RP*	Slight on surface	NIL to Clay
J3	125°-305°	67°	215°	03-10	50 to 200	Tight	RU*/ RP*	NIL	NIL

J1* *oriented along foliation,* ***SU*** *Smooth Undulating,* ***SL U*** *Slickensided, Undulating,* ***RU*** *Rough Undulating,* ***RP*** *Rough Planar*

It is observed from above table that the joints belonging to set J1 have high persistence are closely to widely spaced and have smooth planar and undulating as well as slickensided undulating surface with tight to partly open aperture and occasionally clay filling & surface staining on surface. Along the road cutting of National Highway (NH-1B), due to high schistosity and smooth planer surface along the major joint set, planar failure along this joint set is observed **(Photo 5 & 6)**. Joints belonging to set J2 medium to high persistent with tight to partly open and staining on surface. Joint sets belonging to J3 is low to medium persistent, moderately to widely spaced with tight aperture, no filling & alteration.

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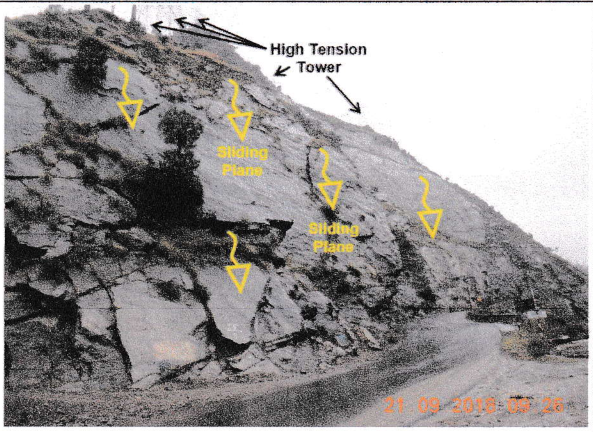

Photo 5: Planar failure along foliation due to high schistosity & unfavourable joint set

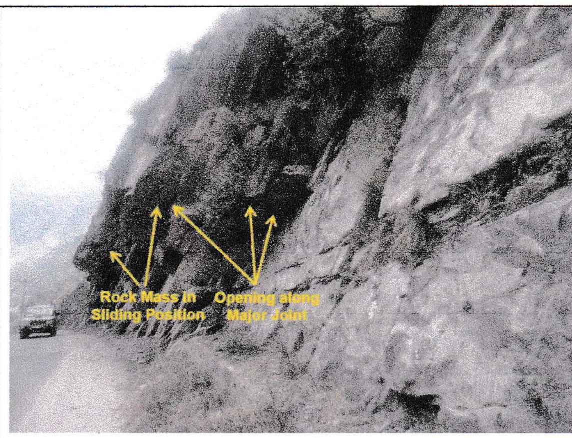

Photo 6: Rock mass is in sliding position along foliation

4.2 Geotechnical Appraisal of Tunnel

This highway tunnel is proposed on left bank of Chenab river. Total length of the tunnel is about 495m. The northern and southern portals of the tunnel is located at an elevation of about El. 1007.0m and El. 1007.5m respectively. The tunnel is initially aligned for about 150m in the direction of N004° and N184° (Sector 1) to obtain adequate rock cover over the tunnel. Finally the tunnel is aligned N059° and N239° direction for the rest of their length (Sector 2) till their southern portal.

Rock cover over the overt of this 10.2m diameter tunnel varies between 10m and 144m, in general, which can be considered adequate. The tunnel at its initial reach from northern portal and 115m is aligned in 004° – 184. It is observed that the tunnel is aligned askew to the strike of foliation joints (J1) by 36°, with strike of joints belonging to set J2 by 21° and by 59° with the strike of joints belonging to set J3. In this sector the alignment is fair with respect to the foliation, unfavourable to fair with respect to joints belonging to set J2 and is favourable with respect to joints belonging to set J3. After the bend the tunnel is aligned in 059° - 239° direction upto southern portal of the tunnel. In this case, the orientation of tunnel is askew to the strike of foliation by 19° and the alignment is askew by 34° with the strike of joint set J2 and by 66° with the strike of joint set J3. So, the orientation of tunnel is favourably disposed with respect to joint set belonging to J3, unfavourably with respect to the foliation joint J1 and fairly with respect to joint set J2. It is, therefore, concluded that the tunnel is oriented favourably, i.e. So, the possibility of forming small wedges in the crown and side wall can not be ruled out and has to be taken care of during construction planning.

4.3 Geotechnical Appraisal along Cut & cover

About 229m long cut & cover is proposed towards northern side to approach the main highway after viaduct. Slope along the cut & cover, the ground slopes in initial reach i.e. upto 25m is steep and exposed rock is observed. Beyond this the slope is gentle to slightly steep and is partly covered by overburden in general with isolated outcrops of bedrock. Bedrock exposed in this area comprises fresh to moderately weathered, weak to strong and jointed mica schist and schistose gneiss with intercalation of quartz veins. The cut & cover is initially aligned in the direction of 004° – 184° upto 95m length. Beyond that, it is aligned in the direction of 025° – 205°.

The maximum side slope along the structure is about 31m. The slope cuts and stability measures have to be planned accordingly. On eastern wall the intersections of J1 & J3 could result in formation of a few unstable wedges. There is a chance of planar failure along the major joint set i.e. foliation plane. These have to be taken care of while designing the slope cuts and stability measures. Similarly, on western wall, the intersections of J2 & J3 could result in formation of few unstable wedges and these have to be taken care of if required through properly designed slope cuts and spot bolting. The cut slopes in overburden reaches may be designed keeping the characteristic of the material in view.

4.4 Wedge Analysis of Northern Portal

The Northern portal of tunnel is located on the left bank of nala (tributary of Chenab river) and in the direction of 004° - 184° with its portal located on rock facing towards 004° **(Figure 3)**. The slope cut at portal face would be 1 in 6 in the rockmass and the angle of internal friction of the rockmass has been considered as 37°. From the stereo plot it is observed that while excavating portal slope failure may take place on joint plane J1. Thus, the excavation profile and design support above portal is to be designed accordingly.

The northern portal is oriented in the direction of 004° - 184°. With this orientation and disposition of joint sets it indicates that wedge failure from eastern wall may take place along the line of intersection of joints 1 and 3. From western wall of the tunnel, the planar failure may take place on joint plane 2. Support design has to be taken up accordingly.

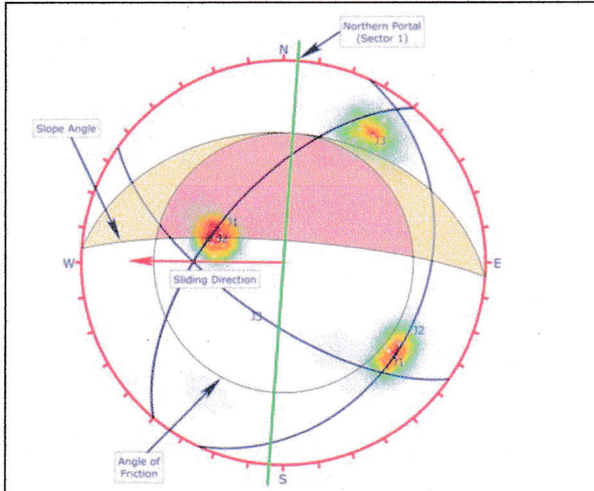

Figure 3: Wedge analysis along nothern portal of tunnel

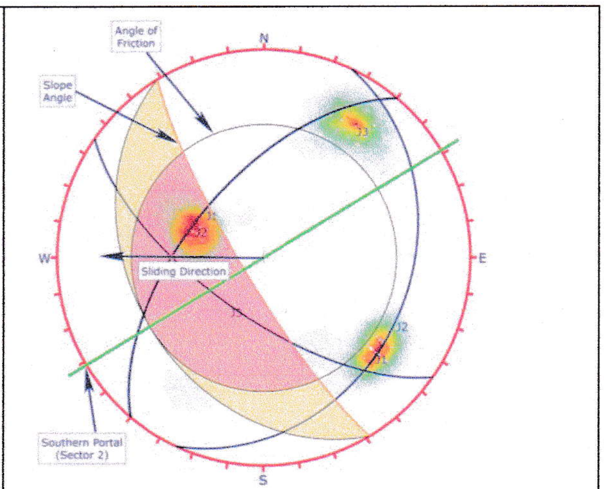

Figure 4: Wedge analysis along southern portal of tunnel

4.5 Wedge Analysis of Southern Portal

This tunnel is aligned in the direction of 059° – 239° direction with its portal facing towards 239°. The co-efficient of internal friction for the rock mass has been considered as 37°. From the stereo-plot it is observed that while excavating portal slope failure may takes place on joint plane 3 and wedge failure may take place with the intersections of joints J1 and J3. Thus, the excavation profile and design support above portal is to be designed accordingly.

The tunnel is oriented in the direction of 059° – 239°. With this orientation and disposition of joints indicates that wedges failure from SE wall may takes place along the line of intersection of joints 1 and 3 **(Figure 4).** From south-east wall of the tunnel, the planar failure may take place on joint plane 1 and from north-west wall of the tunnel, planar failure may take place on joint plane J2. Design support is to be evolved keeping the sliding movements to contain the wedges.

The possibility of forming small wedges in the crown and side walls cannot be ruled out and has to be taken care of during construction. Q and RMR values were assessed for every possible out crops encountered along the traverse. This indicates that rock mass belonging to Class II, Class III, Class IV and Class V is likely to be encountered. From the surface geology it may be anticipated that the rock type to be encountered along the tunnel would be tentatively 15.75% good (Class II), 53.75% fair (Class III) and 30.5% poor (Class IV) quality. These factors will be kept in view while designing the supports.